

Impact of Dietary Lead (Pb) on the Human Gastrointestinal Tract: A Review

Erwin Samsul¹, Muhammad Choirul Muzaqi², Yotam², Mitosie Gunarsa Ceasar Putra², Nur Adinda Mutiara², Jevon Ecclesia Gunawan²*, Muhammad Alif Rahman², Syifa Kamila Salsabilla²

1 Faculty of Pharmacy, Universitas Mulawarman, Samarinda, 75119 East Kalimantan, Indonesia.

2 Undergraduate Program of Clinical Pharmacy, Faculty of Pharmacy, Universitas Mulawarman, Samarinda, 75119 East Kalimantan, Indonesia

* Correspondence: jevongunawan50@gmail.com (Jevon Ecclesia Gunamawan)

Citation: Samsul, E.; Muzaqi, M.C.; Yotam; Putra, M.G.C; Mutiara, N.A.; Gunawan, J.E.; Rahman, M.A.; Salsabilla, S.K. Impact of dietary lead (Pb) on the human gastrointestinal tract: A Review. J Pham Nat Sci 2025, 2(2), 47–53. <https://doi.org/10.70392/jpns.v2i2.4753>

Academic Editor: Prof. Dr. Laode Rijai

Received: December 10, 2024

Revised: May 18, 2025

Accepted: May 26, 2025

Publisher's Note: B-CRETA publisher stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2025 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution-NonCommercial-ShareAlike (CC-BY-NC-SA) 4.0 International License (<https://creativecommons.org/licenses/by-nc-sa/4.0/>).

Abstract

Lead (Pb), a toxic heavy metal, frequently contaminates food and beverages due to environmental pollution and industrial processes. This study reviews lead's toxic effects on the human gastrointestinal tract through a narrative literature review from credible databases such as PubMed, Elsevier, and Google Scholar. Findings reveal that lead concentrations vary by food type, processing methods, and storage duration. For instance, lead levels in preserved eggs range from 334–1782 mg/kg, exceeding the safe limit (0.25 mg/kg), causing nausea, vomiting, and abdominal pain. Unwashed pears reached 18.5 mg/kg after 12 days, triggering similar symptoms. In contrast, grapes and vegetables showed low lead levels (<0.04 mg/kg) with no significant clinical effects. Food poisoning cases like contaminated candy in schools highlight the urgent need for strict monitoring. This review emphasizes strengthening food safety regulations, raising public awareness, and promoting further research to reduce exposure in the global food supply chain.

Keywords: Lead (Pb); Gastrointestinal Tract; Lead Toxicity; Food Safety; Environmental Contamination

1. INTRODUCTION

Lead (Pb) is a heavy metal included in group IV A period 6 in the periodic table. This element has the characteristics of a gray-blue soft metal with a shiny surface. Lead has various benefits in the industrial world and has even been used from

ancient Roman times to modern times. Its uses include as an additive to battery plates, sulfuric acid production equipment, cable coatings, soldering materials, shields in atomic reactors, aprons, radioactive material containers, paint industry, ceramics, chemical and construction industries, production of engine bearings, printing fonts, gasoline and so on. Its usefulness in human life makes it an element that is easily found in the life around us [1,2].

But behind its usefulness, lead also has a negative impact on human life. Its abundant presence in industrial waste, such as vehicle fumes, makes lead poisoning rates quite high. In 2019, around 27,000 Indonesians died from lead poisoning and according to the Institute for Health Metrics and Evaluation (IHME) estimates that around 8.2 million to 12 million Indonesian children have blood lead levels (BLL) that exceed 5 µg/dL. Lead is toxic and causes many adverse clinical effects for all groups, from children to adults. Lead places a huge burden on health with its impact on various body systems, including cardiovascular (heart and blood vessels), liver, kidney, reproductive, immune, and neurological (nervous system) [3,4].

Cases of lead poisoning in Indonesia, including among schoolchildren due to contaminated food, indicate that public awareness of the dangers of lead remains low. In fact, lead can affect various body systems such as the central nervous system, cardiovascular system, kidneys, and liver, even at low levels of exposure. The high mortality rate and elevated Blood Lead Levels (BLL) among millions of Indonesian children further emphasize the importance of understanding and mitigating lead exposure especially foods contaminant. The abundant presence of lead metal on earth has led to increased lead contamination in the environment and even in food and beverages. Lead is able to enter the digestive system through contaminated food and beverages. As in the case that occurred on August 22, 2022, where 113 children at SDN 02 Turi experienced nausea, vomiting, abdominal pain, dizziness, and diarrhea with the statement that there was a metallic taste in the mouth. They claimed to have felt this after consuming soft candy sold in the area. Based on the results of the investigation, the most common symptoms were nausea and abdominal pain. After being tested at the BPOM lab, the results showed that 25 mg of soft candy contained 0.115 mg/kg of lead. The effect caused is the toxic effect of lead which can irritate the gastric mucosal layer [5].

Based on these problems, it can be concluded that the level of lead poisoning is quite high with harmful effects that can be caused to health. This literature review was created to look deeper into lead poisoning in the context of lead toxicity mechanisms, routes of entry into the body, symptoms, and prevention and treatment of lead poisoning.

2. MATERIALS AND METHODS

The method used in the preparation of this review article is narrative review, which aims to summarize and analyze various scientific literature related to the topic discussed. Literature sources included national and international journals obtained from trusted scientific platforms such as Google Scholar, PubMed, ResearchGate, and Elsevier, to ensure broad and relevant reference coverage.

The literature search process was conducted with a systematic search strategy using keywords such as “Lead,” “Toxicity,” “Heavy Metal,” and “Health Effects.” The selection of these keywords was intended to cover various aspects related to the topic, ranging from lead exposure to health effects and toxicity mechanisms.

The inclusion criteria for this study are reference sources derived from scientific articles, research reports, systematic reviews, and case reports relevant to the effects of lead (Pb) on the human gastrointestinal tract. The focus is on studies that specifically examine lead exposure through food or beverages and its effects on the human gastrointestinal system. Articles must be written in either English or Indonesian, including both national and international publications. Publication year: Studies published between 2014 and 2024. On the other hand, the exclusion criteria for this review include: articles that are only available in abstract form (without full-text access), and studies conducted on animals or in vitro models without relevant data on humans (This can be seen in the following image 1).

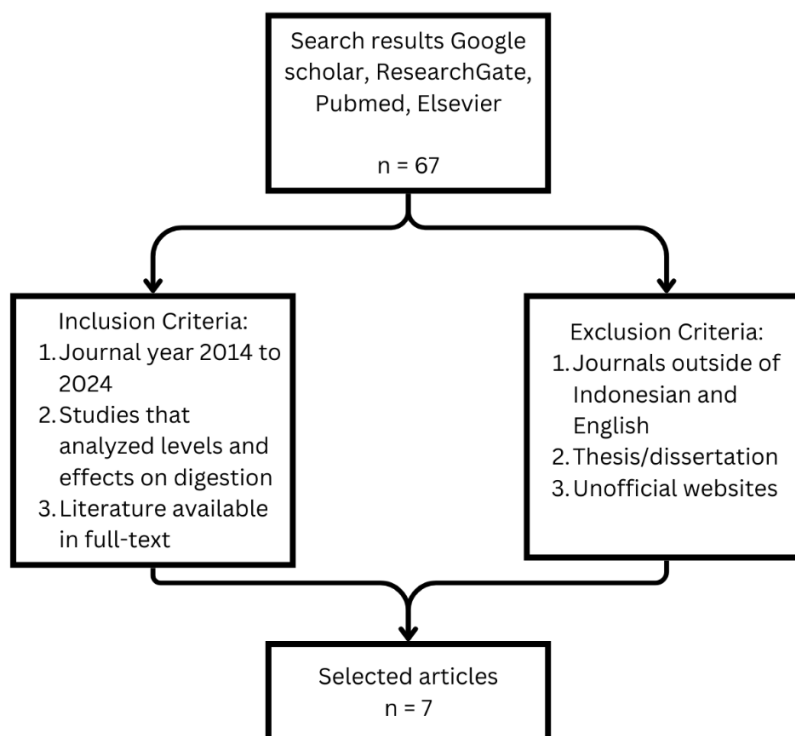


Figure 1. Search Flowchart

3. RESULT AND DISCUSSION

According to the 7 literatures we used, the study of lead levels in various foodstuffs showed significant differences in levels depending on the type of food, processing method, and shelf life. Some samples showed high levels of contamination, while others were within the safe threshold.

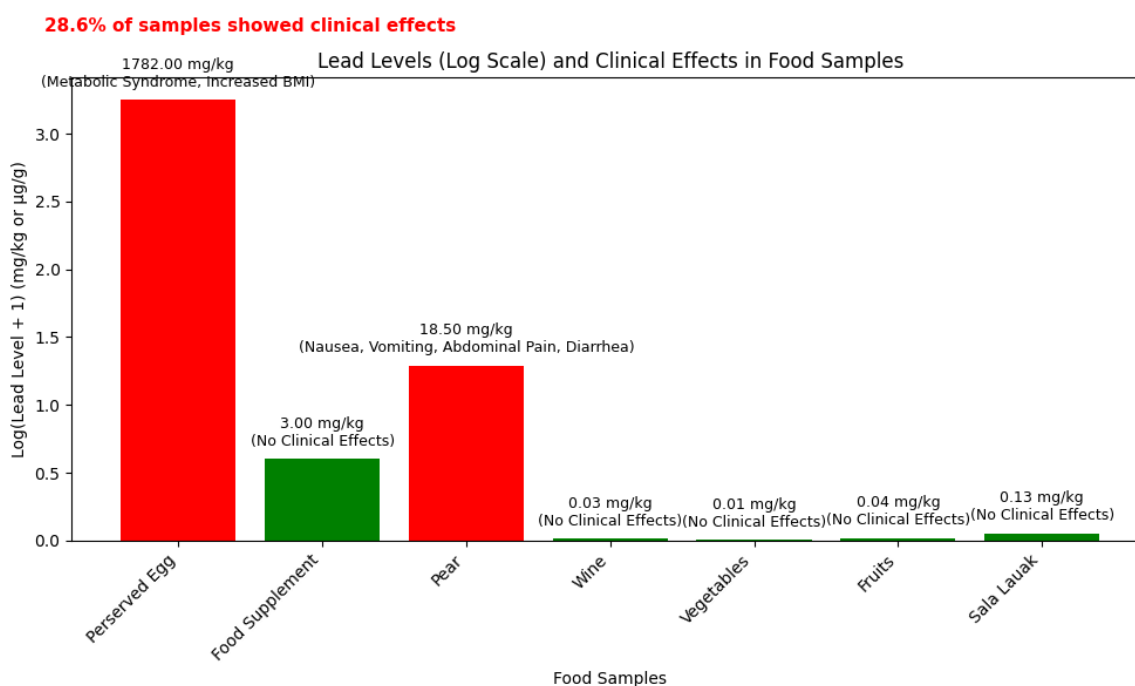


Figure 2. Lead effects on samples

Table 1. Literature review data.

Reference	Samples used	Content Found	Key Findings
Yu, B., et al, 2017 [6]	Bitan egg (Preserved egg)	lead levels in eggs are approximately 1,782 mg – 334 mg/kg (should be $\leq 0,1$ mg/Kg)	Prevalence of metabolic syndrome and increased BMI.
Mustatea, G., et al, 2021 [7]	41 food supplements	All samples were below normal lead levels (<3.0 mg/kg).	No clinical effects caused
Novita et al., 2017 [8]	Pear Fruit	Lead (Pb) levels in pears showed an increase with display time. On day 0, the highest lead levels were found in unwashed fruit (2.1 mg/kg), while peeled fruit had only 0.5 mg/kg. After 6 days, the levels increased to 7.9 mg/kg in unwashed fruit and 2.7 mg/kg in peeled fruit. The peak occurred on day 12, with lead levels reaching 18.5 mg/kg in the unwashed fruit and 8.7 mg/kg in the peeled fruit.	gastrointestinal irritation, metallic taste in the mouth, vomiting, abdominal pain, and diarrhea.
Towle et al., 2017 [9]	Wine	The average Pb level in all grape samples was 30.4 $\mu\text{g/L}$.	Drinkers experience symptoms of acute alcohol poisoning before reaching the number of glasses of wine needed to increase blood lead levels, No clinical effects caused by lead
Nag, R. & Cummins, E. 2021 [10]	Potatoes, carrots, green vegetables and salads	The average weekly intake of lead through food was calculated to be 0.0065 mg/kg body weight (classified as low toxicity risk).	Consumers did not show significant clinical effects with weekly average levels shown.
Petcu et al., 2021 [11]	Fruits	Among the 257 fruit samples, 50.97% showed undetectable lead levels, with a maximum detectable level of 0.04 mg/kg, below the limit of 0.1 mg/kg.	No clinical effects caused
Cita et al., 2020 [12]	Sala lauak	A study proved that the duration of wrapping food using newsprint will affect the wrapped food with the discovery of heavy metal lead levels of 0.129 $\mu\text{g/g}$.	No clinical effects caused

Research on lead (Pb) levels in various food samples shows variations based on sample type. Studies have examined lead levels in bite-sized eggs [6], dietary supplements [7], pears [8] and various fruits [9,11]. Nag, R., & Cummins, E. (2021) [10] evaluated weekly lead intake from potatoes, carrots, and other vegetables, while Cita et al. (2020) [12] reported lead contamination from using newsprint to wrap sala lauak.

The Figure 2 illustrates the lead levels (in a log scale) across various food samples and their associated clinical effects. Notably, 28.6% of the samples analyzed exhibited lead levels high enough to cause clinical effects. The preserved egg sample displayed the highest lead content at 1782 mg/kg, correlating with severe health outcomes like metabolic syndrome and increased BMI. Similarly, the pear sample had a lead level of 18.5 mg/kg, linked to gastrointestinal symptoms such as nausea, vomiting, abdominal pain, and diarrhea.

In contrast, other food samples, such as wine, vegetables, fruits, and sala lauak, contained lead levels below the tolerable limit of 0.25 mg/kg body weight, showing no clinical effects. The food supplement, despite having 3.0 mg/kg of lead, also demonstrated no apparent clinical effects, possibly due to other mitigating factors [6–13,15].

Lead (Pb) is a highly hazardous heavy metal due to its carcinogenic properties, variable toxicity, and long environmental persistence. According to BPOM, the permissible lead levels in food products include eggs (0.25 mg/kg), fruits (0.03 mg/kg), milk (0.02 mg/kg), and grapes (0.04 mg/kg). Prolonged exposure can cause toxic effects, particularly in the digestive system. Lead enters the body through contaminated food or water, is absorbed in the duodenum and jejunum, and is distributed via the bloodstream to organs such as the kidneys, brain, and bones. Gastrointestinal symptoms of lead toxicity include nausea, vomiting, abdominal pain, diarrhea, and digestive irritation. The daily lead tolerance is 0.25 mg/kg body weight; exceeding this can cause systemic toxic effects [13–15].

Reported lead levels in preserved eggs ranging from 1.782 to 334 mg/kg, far exceeding BPOM limits. And caused clinical effects were more related to metabolic disorders and body mass index which can cause some digestive issues. Novita et al. (2017) [8] found that untreated a pear which contained 18.5 mg/kg of lead after 12 days unwashed. Lead can originate from contaminated dust, especially in areas with high vehicle traffic, metal industries, or fossil fuel combustion. Dust containing Pb can settle on the surface of fruits if they are left in open environments. In addition, high humidity can accelerate the binding of heavy metals from dust particles or soil to the surface of the fruit, leading to gastrointestinal symptoms such as nausea, vomiting, abdominal pain, diarrhea, and a metallic taste. The mechanism by which lead induces nausea, vomiting, and abdominal pain involves disruption of sodium ion transport in the small intestinal mucosa, leading to imbalances in electrolyte and fluid homeostasis within the gastrointestinal tract. Lead may also affect gastric motility through the nitric oxide (NO) pathway. Elevated levels of NO in gastric tissues following lead exposure can impair gastric motility, contributing to symptoms such as nausea and vomiting. Furthermore, lead can interfere with the function of the autonomic nervous system and smooth muscles of the gastrointestinal tract, resulting in altered muscle tone and gastrointestinal motility. This disruption can trigger symptoms such as colicky abdominal pain, nausea, and vomiting. One proposed mechanism is the effect of lead on the visceral autonomic nervous system and intestinal smooth muscle, leading to changes in smooth muscle tone and intestinal motility.

Let me know if you'd like this formatted for a scientific paper or need references included. Towle et al. (2017) [9] measured 30.4 µg/L of lead in grapes, though its clinical impact was overshadowed by high alcohol content in the samples and so was not able to exhibit any lead toxicity symptoms [6,8,13].

Nag and Cummins (2021) [10] noted that weekly lead intake from vegetables (0.0065 mg/kg body weight) was relatively low, causing no clinical effects. Similarly, Petcu et al. (2021) [11] found undetectable or below-threshold lead levels (<0.04 mg/kg) in most compounds, with no significant health consequences. Cita et al. (2020) [12] reported 0.129 µg/g of lead in traditional snacks due to newspaper use but observed no toxic effects. Mustatea et al. (2021) [7] found concentrations in dietary supplements to be below safe limits (<3.0 mg/kg).

The findings highlight significant variations in lead (Pb) contamination across different food types, emphasizing the need for continuous monitoring and stricter regulatory compliance. Excessive lead levels in preserved eggs and untreated pears underscore potential health risks, particularly gastrointestinal symptoms such as nausea, vomiting, and abdominal pain. In

contrast, lead concentrations in grapes, vegetables, and dietary supplements generally remained within safe limits, with minimal or no reported toxic effects [16].

Children are highly vulnerable to lead exposure because their nervous systems are still developing. Lead can cause cognitive impairments, decreased IQ, neurodevelopmental disorders, hyperactive behaviour, and learning difficulties. Even low-level exposure can have serious effects. In pregnant women, lead can cross the placenta and affect fetal development, increasing the risk of miscarriage, premature birth, and low birth weight. Lead can also interfere with the neurological development of the fetus. In adults, lead exposure can cause kidney damage, hypertension, reproductive system disorders, and effects on the cardiovascular and nervous systems. In addition, proper food processing to prevent lead exposure can be carried out starting with washing under running water, and it is even recommended to use special detergents or ultrasonic cleaning techniques. Peeling fruit skins, boiling or steaming, as well as storing food in safe containers such as glass, can help reduce heavy metal residues, including lead [17–22].

4. CONCLUSION

Lead (Pb) is a heavy metal that has a wide range of industrial uses, but lead can also pose a fatal health risk due to its toxic properties. Exposure to lead such as industrial waste and contaminated food will cause human poisoning, with different impacts depending on the level of lead exposed. The literature used shows that lead levels in food vary with some contamination samples above the safe limit. Symptoms of lead poisoning such as indigestion, nausea and vomiting occur when lead levels exceed the recommended threshold. Although some studies reveal that lead levels in food are still within safe limits, the potential long-term health risks remain a concern. Therefore, it is important to raise awareness of lead hazards and take preventive measures such as monitoring lead levels in food and beverages and educating the public about the health risks of lead exposure. In addition, lead poisoning should be treated appropriately to minimize negative health impacts.

AUTHOR CONTRIBUTION: **Conceptualization**, Erwin Samsul and Jevon Ecclesia Gunawan; **methodology**, Muhammad Choirul Muzaqi; Yotam; **validation**, Mitose Gunarsa Caesar Putra and Nur Adinda Mutiara; **formal analysis**, Muhammad Alif Rahman.; **investigation**, Syifa Kamila Salsabilla; **writing—preparation of original draft**, Erwin Samsul, Muhammad Choirul Muzaqi, Mitose Gunarsa Caesar Putra, Nur Adinda Mutiara, Muhammad Alif Rahman, Syifa Kamila Salsabilla; **writing—reviewing and editing**, Erwin Samsul and Jevon Ecclesia Gunawan.

FUNDING: This research received no external funding.

ACKNOWLEDGMENT: –

CONFLICT OF INTEREST: The author declares no conflict of interest.

REFERENCES

1. Grant, L.D. *Lead and compounds*. In *Environmental toxicants: Human exposures and their health effects*. New York: Wiley Online Library, **2020**.
2. Charkiewicz, A.E., Backstrand, J.R. Lead toxicity and pollution in Poland. *International Journal of Environmental Research and Public Health* **2020**, *17*(12), 4385.
3. Seitz, W.H., Setiawan, I. Ancaman beracun terhadap sumber daya manusia Indonesia: Prevalensi dan dampak cat timbal di rumah Indonesia (Indonesian). *Policy Research Working Paper* **2024**, *1*(1), 1–34.
4. Obeng-Gyasi, E. Sources of lead exposure in various countries. *Reviews on Environmental Health* **2019**, *34*(1), 25–34.
5. Arinta, S.N., Hidajah, A.C., Saifudin, N. Keracunan permen lunak pada siswa sekolah dasar di Kota Blitar, Provinsi Jawa Timur. *Jurnal Kesehatan* **2023**, *16*(2), 86–92.

6. Yu, B., Shao, J., Yu, F., Zhang, Q., Liu, L., Meng, G., Wu, H., Xia, Y., Bao, X., Gu, Y., Shi, H. Consumption of preserved egg, a high-lead-containing food, is strongly associated with depressive symptoms in Chinese adults. *British Journal of Nutrition* **2017**, *118*(9), 737–742.
7. Mustatea, G., Ungureanu, E.L., Iorga, S.C., Ciotea, D., Popa, M.E. Risk assessment of lead and cadmium in some food supplements available on the Romanian market. *Foods* **2021**, *10*(3), 581.
8. Novita, L., Asih, E.R., Aisyah, A. Analisis cemaran logam timbal (Pb) pada buah pir yang dijual di pinggir jalan simpang empat lampu merah Jalan Soekarno Hatta Kota Pekanbaru. *JPK: Jurnal Proteksi Kesehatan* **2017**, *6*(2), 97–103.
9. Towle, K.M., Garnick, L.C., Monnot, A.D. A human health risk assessment of lead (Pb) ingestion among adult wine consumers. *International Journal of Food Contamination* **2017**, *4*, 1–9.
10. Nag, R., Cummins, E. Human health risk assessment of lead (Pb) through the environmental–food pathway. *Science of the Total Environment* **2022**, *810*, 151168.
11. Petcu, C.D., Ciobotaru–Pîrvu, E., Tăpăloagă, D., Mădălina, I., Georgescu, O.V.Z., Negreanu, C.N., Oprea, O.D., Muresan, C.A. A study concerning the lead contamination of some food products marketed in Romania during 2017–2019. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj–Napoca: Food Science and Technology* **2021**, *78*(1), 68–76.
12. Cita, H.M., Asterina, A., Aliska, G. Kandungan timbal pada sala lauak yang dijual di Pasar Raya Padang akibat penggunaan kertas ketikan sebagai pembungkus. *Jurnal Ilmu Kesehatan Indonesia* **2020**, *1*(1), 1–6.
13. Badan Pengawas Obat dan Makanan Republik Indonesia. *Peraturan Badan Pengawas Obat dan Makanan Nomor 9 Tahun 2022 tentang Persyaratan Cemaran Logam Berat dalam Pangan Olahan*. Jakarta, Indonesia: Kepala Badan Pengawas Obat dan Makanan, **2022**.
14. Umar, R.R., Umboh, J.M.L., Akili, R.H. Analisis kandungan timbal (Pb) pada makanan jajanan gorengan di pinggiran Jalan Raya Kec. Girian Kota Bitung Tahun 2021. *Jurnal Kesmas* **2021**, *10*(5), 84–93.
15. Irianti T., Budiyatni A., Kuswandi., Nuranto S. *Logam Berat dan Kesehatan*. Yogyakarta: Universitas Gadjah Mada, **2017**.
16. Anonim. *Toxicological profile for lead*. ATSDR (Agency for Toxic Substances and Disease Registry), **2020**.
17. Irie, F. Commentary on the Risk Assessment of Lead by the Food Safety Commission of Japan. *Food Safety* **2022**, *10*(3), 102–111.
18. Efanny, M., Andarwulan, N., Yuliana, N.D. Dietary exposure assessment and risk characterization of lead based on lead contaminant research (online) in Indonesia and Indonesian Individual Food Consumption Survey (IFCS). In *IOP Conference Series: Earth and Environmental Science* **2019**, *278*(1), 012021.
19. Ardillah, Y. Faktor risiko kandungan timbal di dalam darah. *Jurnal Ilmu Kesehatan Masyarakat* **2016**, *7*(3), 150–155.
20. Awiria, A., Dariyanto, D. Analisis faktor–faktor penyebab Anak menjadi Attention Deficit Hyperactive Disorder di SDN Teluk Pucung 01 Kota Bekasi. *WACANA AKADEMIKA: Majalah Ilmiah Kependidikan* **2020**, *4*(2), 141–147.
21. Pertiwi, S., Setiani, O., Suhartono, S., Utami, R., Rahmiyati, E., Yulizar, Y. Faktor–faktor yang berhubungan dengan kadar timbal dalam darah pada ibu hamil. *Avicenna: Journal of Health Research* **2022**, *5*(2), 38–46.
22. Yang Y, Li S, Wang H, Liu M, Tuo B, Wu H, Deng S, Liu X. Chronic lead poisoning induced abdominal pain and anemia: a case report and review of the literature. *BMC Gastroenterol* **2020**, *20*(1), 335.