ISSN: 2714-7045

Hg Intake by Pregnant Women Living Near Gold Mining

[1]Ernawati, [2]Adi Heru Sutomo, [3]Indwiani Astuti, [4] Hasanuddin Husin,[5]Arfriani Maifizar, [6]Dewi Fitria

[1]Faculty of Public Health, Universitas Teuku Umar, Indonesia
[2]Public Health, Medicine, and Nursing Faculty, Universitas Gadjah Mada, Indonesia
[3]Public Health, Medicine, and Nursing Faculty, Universitas Gadjah Mada, Indonesia
[4]Study Program of Food Technology, Faculty of Agriculture, Teuku Umar University, Indonesia
[5]Faculty of Sosial and Political (FISIP) UniversitasTeuku Umar
[6]Faculty of Agriculture, Universitas Teuku
Corresponding author: Ernawati, e-mail: ernawati@utu.ac.id

Abstract

Living near gold mining areas poses a risk of mercury (Hg) exposure. Exposure to Hg in pregnant women is related to consumption patterns. Pregnant women residing near gold mining sites tend to consume vegetables grown around their homes. Commonly consumed vegetables include papaya leaves, cassava leaves, and katok leaves, all of which have Hg levels exceeding the threshold limit (0.03 g/kg). The Hg intake from these vegetables contributes to the Hg levels in the bodies of pregnant women. The aim of this study is to understand the Hg intake by pregnant women from consuming vegetables in the vicinity of gold mining. A longitudinal observational study was conducted to measure the Hg intake from vegetables by pregnant women living near gold mining areas, using semi-quantitative food frequency questionnaires (FFQ) during interviews to determine the consumption patterns and habits of pregnant women during pregnancy and postpartum. This was done to estimate the daily Hg levels ingested, which were then compared with the EPA (Environmental Protection Agency) guideline stating that the daily allowable intake (ADI) of Hg for pregnant and breastfeeding women is 0.1 µg/kg/day. The results show that the average Hg intake from vegetables collected around the home during pregnancy is 2.57 µg/kg/day, postpartum when the baby is 2-14 weeks old is 5.13 µg/kg/day, and when the baby is 14-26 weeks old is 4.47 µg/kg/day. Therefore, the Hg intake by pregnant women is above the ADI, and if not addressed promptly, it could lead to accumulation in the body and transfer to the baby through the placenta.

Keywords: Gold Mining; Mercury (Hg); Pregnant Women; Vegetables

Introduction

Living and residing in areas surrounding gold mining sites poses a risk of high mercury (Hg) levels in the body(Park & Zheng, 2012) . Mercury contamination in humans can occur through food, drink, inhalation, and skin contact (S.J.Widowati.W, 2008). The gold mining activities in Kalirejo Village, Kokap District, Kulon Progo Regency, Yogyakarta, are a contributing factor to the elevated Hg levels in the surrounding environment. The average Hg content in the soil is 182.72 µg/kg, nearly thirty times the Hg concentration in the earth's crust (0.08 ppm = 8 µg/kg) (UNEP & WHO, 2008). The average Hg levels in cassava leaves, papaya leaves, and katuk leaves are 75.16 µg/kg, 89.97 µg/kg, and 66.43 µg/kg, respective (Ernawati, 2021)6. Vegetables are planted and grow well in this soil, and these vegetables are then consumed by pregnant women.

Consuming vegetables with high Hg content can increase Hg levels in the mother's body, consistent with the findings of Kim et al., 2016 (Kim et al., 2016).

Hg contains metal ions that are lipid-soluble, enabling it to penetrate cell membranes and eventually accumulate in cells, tissues, or other body organs. Moreover, Hg can cross the placental membrane, allowing it to reach the fetal brain. The fetal brain is more susceptible to methylmercury compared to the adult brain (Widowati, 2008, cited in (Ernawati, 2021).Pregnant women consuming fish or vegetables containing Hg may experience fetal neurodevelopmental disorders, as transplacental exposure is particularly dangerous due to the heightened sensitivity of the fetal brain(UNEP & WHO, 2008). The nervous system is the primary target of Hg toxicity, especially from organic metal compounds (Valent et al., 2013)

Researchers identified three pregnant women living near gold mining areas who experienced hypertension and three cases of low birth weight (LBW) infants (Puskesmas Pembantu, 2017). This indicates an LBW proportion of 13.64%, exceeding the typical LBW incidence of 6–10%. Studies have shown that female workers exposed to Hg in China had a twofold higher risk of pregnancy-induced hypertension and a threefold higher risk of LBW infants compared to those unexposed to Hg (Al-azzawie et al., 2013). Additionally, researchers found one child with developmental disorders and one mother who experienced a miscarriage. These findings, both during preliminary surveys and throughout the study, although not formally recorded, suggest the potential impacts of Hg exposure.

Based on these observations, the researchers aim to examine Hg intake in pregnant women through the consumption of vegetables grown near their homes, considering that the Hg levels in these commonly consumed vegetables exceed the recommended threshold limits.

Methods

A longitudinal observational study with a serial measurement design was conducted in the gold mining area of Kalirejo Village, Kokap District, Kulon Progo Regency, Yogyakarta. Sixteen pregnant women were selected as respondents. The respondents had been living in the area for at least three years, with some residing there for their entire lives. Ethical clearance for this study was obtained from the Medical and Health Research Ethics Committee, Faculty of Medicine, Universitas Gadjah Mada (Ref: KE/FK/1036/EC/2017). Participation was confirmed through the signing of informed consent forms after respondents were provided with detailed explanations about the study, including its objectives, methods, procedures, and potential risks.

The study aimed to assess Hg intake among pregnant women by evaluating their vegetable consumption habits during pregnancy and breastfeeding. Data collection involved the use of a semi-quantitative Food Frequency Questionnaire (FFQ), administered by a trained and experienced nutritionist. Data were collected during two time periods: during pregnancy and at three and six months postpartum, involving the same subjects. These periods are referred to as Phase I and Phase II.

Results

The Hg intake from vegetable consumption among pregnant women in the local environment is summarized in Table 1. The average daily Hg intake from vegetables grown near their homes was 2.57 µg/kg/day. Observations of Hg intake continued postpartum. The average Hg intake from vegetables was 5.13 µg/kg/day during Phase I and 4.47 µg/kg/day during Phase II.

Table 2 shows the percentage of pregnant women exceeding the daily Hg intake limit (≥ 0.1 µg/kg/day) during pregnancy and postpartum (Phase I and Phase II). During pregnancy, 14 women (87.5%) consumed Hg beyond the daily intake limit. Similarly, in both Phase I and Phase II, 14 women (87.5%) exceeded the recommended daily Hg intake from vegetables grown near their homes, surpassing the threshold limit value (TLV):

Table 1. Descriptive Analysis of Hg Intake Data from Vegetables (Homegrown and Market-Sourced) and Drinking Water During Pregnancy and Postpartum (Phase I and II) in Kalirejo Village, Kokap District

Variabel	Mean	Median	SD	Min - Max	95 % CI
Hg Intake from Homegrown Vegetables During Pregnancy (µg/kg/day)	2,57	2,51	2,51	0,00 - 6,23	1,64 - 3,51
Hg Intake from Homegrown Vegetable in Phase I (µg/kg/day)	5,13	2,87	0,59	0,00 - 15,69	2,15 - 8,11
Hg Intake from Homegrown Vegetable in Phase II (µg/kg/day)	4,47	2,38	4,73	0,00 - 15,69	1,95 6,99

(Data primer, 2021)

Table 2. Frequency Distribution of Hg Intake Levels Among Mothers During Pregnancy and Postpartum (Phase I and Phase II)

No.	sumber asupan	Saat Hamil		Tahap I		Tahap II	
		n	%	n	%	n	%
	Sayuran sekitar sekitar rumah						
1.	< 0,1 µg/kg/hari	2	12,5	2	12,5	2	12,5
2.	≥ 0,1µg/kg/hari	14	87,5	14	87,5	14	87,5

(Data primer, 2021)

Discussion

Pregnant women living in the gold mining area of Kalirejo Village, Kokap District, Kulon Progo Regency, Yogyakarta, have been exposed to very high levels of mercury (Hg). The average daily Hg intake exceeds the permissible daily intake limit of 0.1 µg/kg/day. This limit is set by the Environmental Protection Agency (EPA), which defines the daily Hg intake threshold for pregnant and breastfeeding women as 0.1 µg/kg/day. The mercury consumed by these pregnant women comes from vegetables they commonly eat around their homes, such as papaya leaves, cassava leaves, and katuk leaves. The tendency to consume these vegetables is supported by the living environment, which is located on the slopes of the hills. This makes vegetables the main daily food consumption. However, vegetables are an important pathway for Hg exposure for people living in gold mining areas (Gibb & Leary, 2014). Research in Soyowan Village, Southeast Minahasa, shows that the tubers of cassava plants grown near gold mining areas contain mercury at

a level of 0.1414 ppm, exceeding the permissible limit (Ali et al., 2019). Continuous consumption of these vegetables leads to the accumulation of mercury (Hg) in the body. Mercury accumulation can cause various health problems, including nervous system damage, impaired kidney function, and developmental issues in fetuses of pregnant women. Therefore, efforts are needed to monitor mercury levels in food crops grown near gold mining areas and to educate the community about the dangers of mercury exposure to health(et al., 2014).

Since mercury may pass through cell membranes, it will gradually build up in cells as well as other bodily tissues or organs. This occurs because Hg can penetrate cell membranes, accumulating in cells, tissues, and other organs (Palar, n.d.; Widowati, 2008).

Pregnant women with high levels of Hg in their bodies will transfer it to the baby they are carrying. As a result, the baby will also have Hg in their body. This accumulation poses a significant risk to fetal development, as Hg can cross the placental membrane, reaching the fetal brain. The fetal brain is more vulnerable to methylmercury exposure compared to the adult brain (Widowati, 2008 in Ernawati, 2021).

Infants carried by mothers with high levels of mercury (Hg) in their bodies may experience developmental disorders. Developmental disorders refer to conditions that occur during a child's development and affect various aspects such as gross motor skills, fine motor skills, language, or social skills. These disorders relate to the failure to meet early developmental milestones, which encompass the five basic areas of development: cognitive development, emotional development, social development, motor development (both gross and fine), and language development.

The most critical period for developmental disorders is the 1000-day window, which spans from conception to two years old. This period includes the prenatal stage (280 days), the first 0–6 months after birth (180 days), and the 6–24 months period (540 days) (Achadi E.l, n.d., 2014). The most vulnerable time for developmental disorders during pregnancy is the embryonic period (from the third to the eighth week of pregnancy), as this is when the baby's development is most sensitive. After the eighth week, the pregnancy enters the fetal stage. During the fetal stage, the risk of structural defects decreases, but organ systems may still be affected (Donkor et al., 2024). For instance, the brain continues to differentiate during the fetal period, and exposure to toxic substances could potentially result in learning disorders.

Conclusion

Pregnant women living around the gold mining area in Kalirejo have been exposed to Hg levels exceeding the permissible daily intake limit of 0.1 µg/kg/day. The Hg intake comes from the consumption of vegetables grown near the gold mining site, which contain high levels of Hg. This poses a risk of fetal developmental disorders, potentially leading to birth defects. Therefore, pregnant women need to minimize these risks by relocating to areas free from Hg exposure and consuming foods rich in antioxidants.

Acknowledgment

This research received funding assistance from the Indonesian Education Funding Agency.

Author Contribution and Competing Interest

All authors contributed to the completion of this article, and the authors report no competing interests

References

Al-azzawie, H. F., Umran, A., & Hyader, N. H. (2013). Oxidative Stress, Antioxidant Status and DNA Damage in a Mercury Exposure Workers. *British Journal of Pharmacology and Toxicology*, *4*(3), 80–88. https://doi.org/10.19026/bjpt.4.5367

Ali, I., Rondonuwu, S. B., & Dapas, F. N. J. (2019). Analisis Kandungan Merkuri Pada Tanah Dan Umbi Tanaman Ubi Kayu (Manihot Esculenta Crantz) Di Daerah Pertambangan Desa Soyowan, Minahasa Tenggara. *Jurnal MIPA*, *8*(3), 227. https://doi.org/10.35799/jmuo.8.3.2019.26208

Donkor, A. K., Ghoveisi, H., & Bonzongo, J.-C. J. (2024). Use of Metallic Mercury in Artisanal Gold Mining by Amalgamation: A Review of Temporal and Spatial Trends and Environmental Pollution. *Minerals*, *14*(6), 555. https://doi.org/10.3390/min14060555

E.l, A. 2014. (n.d.). *Periode Kritis 1000 Hari Pertama Kehidupan dan Dampak Jangka Panjang terhadap Kesehatan dan Fungsinya. Departemen Gizi Kesmas : FKM UI tle*.

Ernawati. (2021). Hubungan PAparan Merkuri Dengan Perubahan Marker Oksidatif dan Perkembangan Anak Desa Kalirejo Kecamatan Kokap Kabupaten Kulon Progo Yogyakarta. *Disertasi*, *140*(1), 6.

Gibb, H., & Leary, K. G. O. (2014). *Review Mercury Exposure and Health Impacts among Individuals in the Artisanal and Small-Scale Gold Mining Community : A Comprehensive Review*. *122*(7), 667–672.

Kim, J. H., Lee, S. J., Kim, S. Y., Choi, G., Lee, J. J., Kim, H. J., Kim, S., Park, J., Moon, H. B., Choi, K., Kim, S., & Choi, S. ran. (2016). Association of food consumption during pregnancy with mercury and lead levels in cord blood. *Science of the Total Environment*, *563–564*, 118–124. https://doi.org/10.1016/j.scitotenv.2016.04.082

Palar. (n.d.). *Pencemaran dan Toksikologi Logam Berat*.

Park, J. D., & Zheng, W. (2012). Human exposure and health effects of inorganic and elemental mercury. *Journal of Preventive Medicine and Public Health*, *45*(6), 344–352. https://doi.org/10.3961/jpmph.2012.45.6.344

Pratiwi, C. A., & Ariesyady, H. D. (2014). Analisis Risiko Pencemaran Merkuri Terhadap Kesehatan Manusia Yang Mengonsumsi Beras Di Sekitar Kegiatan Tambang Emas Tradisional (Studi Kasus: Desa Lebaksitu, Kecamatan Lebakgedong, Kabupaten Lebak, Banten). *Jurnal Tehnik Lingkungan*, *18*(2), 106–114. https://doi.org/10.5614/jtl.2012.18.2.1

S.J.Widowati.W. (n.d.). *efek toksik Logam : Pencegahan dan Penanggulangan Pencemaran*.

UNEP & WHO. (2008). *Children ' s Exposure to Mercury Compounds.*

Valent, F., Horvat, M., Sofianou-Katsoulis, A., Spiric, Z., Mazej, D., Little, D., Prasouli, A., Mariuz, M., Tamburlini, G., Nakou, S., & Barbone, F. (2013). neurodevelopmental effects of low-level prenatal mercury exposure from maternal fish consumption in a mediterranean cohort: Study rationale and design. *Journal of Epidemiology*, *23*(2), 146–152. https://doi.org/10.2188/jea.JE20120030