Comparison of blood mercury concentrations in pregnant women who lived in the coastal and non-coastal areas of Makassar, Indonesia

Suci Amaliah Syarief[1], Andi Mardiah Tahir[1], Maisuri Tadjuddin Chalid[1*]

[1]Department of Obstetrics and Gynecology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia

*corresponding author

Abstract

Objectives: This study aims to determine the levels of mercury in pregnant women and their impact on pregnancy outcomes in coastal and non-coastal areas.

Materials and Methods: A case-control study was conducted in several maternal and child hospitals consisting of 138 respondents (69 subjects from coastal areas and 69 subjects from non-coastal areas). Data were collected by questionnaire and examination of the mercury levels of respondents' blood and baby umbilical cord's blood.

Results: The average mercury level of blood of pregnant women in the coastal group was 86.22±105.43 and in the non-coastal group was 71.51±63.06 (p: 0.422). The average mercury level of umbilical cord blood in the coastal group was 114.17±152.79 and in the non-coastal group was 70.80±57.63 (p:0.554). The average mercury level was higher in pregnant women in coastal areas of Makassar (p: 0.036; OR: 2.448).

Conclusions: Mercury levels were higher in pregnant women in coastal group than non-coastal group. Newborn's umbilical cord blood has higher levels of mercury than the blood of pregnant women in coastal group of Makassar.

Keywords: Blood mercury levels, enviromental health, pregnant women, umbilical cord blood

Introduction

Mercury is one of the hazardous and toxic materials that has been known as a global concern because it is a chemical that is persistent and can be bioaccumulative so that it has various negative impacts on human health and the environment.[1] Methyl-mercury is estimated to be a type of mercury. Mercury which has the most toxic effects on humans and is at dominant levels compared to other forms of mercury.[2] Exposure to methyl-mercury during the prenatal period is often associated with poor development, and growth of pregnancy in the form of stunted fetal growth, low birth weight, preterm labor and neurodevelopmental disorders such as cognitive and behavioral disorders.[3–5]

The main route of methyl-mercury into the body is through the consumption of seafood in the form of fish and shellfish. Some types of fish and shellfish have been known to contain quite a lot of methyl-mercury which when consumed in excess can increase the risk of overexposure to methyl-mercury. Several countries have issued guidelines regarding types of fish, and shellfish based on their methyl-mercury content, which are classified as allowed, good and should be avoided for consumption during pregnancy, as well as limits on the number of servings that can be consumed.[6,7]

Several studies conducted in coastal areas where fish consumption is high show a relationship between high levels of fish consumption and increased levels of methyl-mercury.[8–10] Indonesia, which is the country with the largest coastline, based on data from the Ministry of Maritime Affairs and Fisheries in 2018, the national fish consumption rate continues to increase every year, where the fish consumption rate in 2018 reached 50.68 kg/capita.[11] The fish consumption rate in South Sulawesi has reached 49.7 kg per capita in 2015, and this figure continues to increase from year to year.[12]. This is possible because people in South Sulawesi have

a high culture of eating fish and the achievements of capture fisheries and aquaculture are quite supportive.

Various studies have been conducted in several areas in Indonesia, showing the presence of methyl-mercury contamination in marine fish with various levels.[13,14] Research on several aquatic organisms such as fish and blood clams studied in several urban villages in Makassar City, showed that fish and blood shellfish contain high concentrations of mercury (Hg) which exceeds the standard of SNI 7387 in 2009 (fish; 0.5 mg/kg, Shellfish: 1.0 mg). /kg).[15] This is evidence that there has been mercury contamination in fish consumed by people in Makassar City and does not rule out the possibility of pregnant women.

Until now, research on methyl-mercury levels in groups of pregnant women in Indonesia and its impact on pregnancy outcomes is still minimal. Even though the current data shows that fish consumption in Indonesia is increasing and there is evidence of methyl-mercury contamination in fish, as well as considering the Regulation of the Minister of Health of the Republic of Indonesia number 57 of 2016 concerning the national action plan control health impacts due to mercury exposure in 2016-2020.[16] This study aims to determine the levels of methyl-mercury in pregnant women and their impact on pregnancy outcomes.

Methods

This research is a retrospective analytic study using a case-control study design. This study was conducted on a group of pregnant women with a gestational age of 37 – 42 weeks who will give birth at a maternal and child hospital and educational network in Makassar city and outside Makassar city in 2021. A case group is a group of pregnant women who live around the coastal area Makassar City and easy access to get and eat fish. A control group is a group of pregnant

women who live around non-coastal areas of Makassar City and have limited access to fish and fish. The inclusion criteria of the study included: women with a single intrauterine pregnancy and a live fetus, 37-42 weeks of gestation, and willing to participate in this study and underwent an examination as evidenced by signing a letter of consent to participate in the study. Exclusion criteria for the study were working in gold or coal mining locations, using dental fillings in the form of amalgam, smoking during pregnancy, alcohol consumption during pregnancy, using mercury-based cosmetic products, and having medical conditions related to fetal growth disorders such as pregestational diabetes mellitus, renal insufficiency, autoimmune diseases, heart disease, hypertension in pregnancy, infectious diseases, placental disorders, and exposure to teratogens.

The daily fish consumption history was carried out using the Food Frequency Questionnaire (FFQ). Methyl-mercury levels were taken from maternal blood samples, and umbilical cord blood after the baby was born. Methyl-mercury levels were measured by Atomic Absorption Spectrophotometry (AAS). Data were analyzed by chi-square test and Mann-Whitney test at 5% confidence level.

Results

The study was conducted on 138 blood samples of pregnant women and 138 samples of umbilical cord blood. This sample was divided into 2 groups, 69 samples of pregnant women's blood and 69 samples of umbilical cord blood in the group of pregnant women living on the coast of Makassar City, and 69 samples of pregnant women's blood and 69 samples of umbilical cord blood in the group of women living in non-coastal cities. Makassar.

Table 1 shows that there were no significant differences in age, length of education, occupation, income, and parity in coastal and non-coastal pregnant women with $p > 0.005$.

Table 2 shows that there is mercury exposure to pregnant women and infants in coastal and non-coastal pregnant women, where the average blood mercury level of all pregnant women in this study was 78.87±86.87 g/L and the average mercury level in the baby's umbilical cord was 92.48. ±117.08. There was no significant difference in mercury levels between coastal and non-coastal pregnant women ($p>0.05$).

Table 3 shows the relationship among the number of pregnant women and baby weight to the average level of mercury, where coastal pregnant women tend to have mercury levels above the average value compared to non-coastal pregnant women ($p < 0.05$), and there is no significant relationship between mercury levels that are above the average value and the incidence of low infant weight ($p > 0.05$).

Discussion

This study obtained the results that the presence of mercury in every pregnant woman. The age of pregnant women, education, occupation, income, and gestational age both in the coastal group of pregnant women and in the non-coastal group of women were not significantly different. Age and pregnancy have no role in mercury levels circulating in the blood.[17]

A study in Brooklyn USA reported that there was no relationship between exposure to methyl-mercury in the baby's umbilical cord blood on infant weight and infant anthropometry, although in this study methyl-mercury levels were found in a low range, with a mean of 2.23ug/L in infants umbilical cord blood. This is because there are strict regulations against the consumption of fish contaminated with mercury.[18] In a study in Nigeria, it was found that the baby's weight, body length, and head circumference were smaller in pregnant women who found mercury in the

blood and umbilical cord, whereas the average blood mercury level of pregnant women in the study was 3.6 ± 1.5 ug/L and 5.1±2.0 ug/L in cord blood.[19]

Methyl-mercury with levels of 20-40 ug/L in the blood can trigger oxidative stress in placental tissue, where there is a decrease in the expression of glutathione reductase and glutathione peroxidase.[21] Disorders of the balance of antioxidant and oxidant activity in placental tissue play an important role in impaired placental development. Disorders of the placenta can increase the risk of impaired development of the baby.[22]

In this study, mercury levels were measured in pregnant women blood and umbilical cord blood. In terms of fish consumption, 80-95 percent of the total mercury in the blood comes from methyl-mercury. Methyl-mercury derived from fish consumption, 95 percent will enter the blood circulation through the gastrointestinal tract.[23] Thus, the mercury levels obtained in this study can be directly related to the methyl-mercury levels.

In food, fish is the largest source of mercury (especially methyl-mercury). The level of methyl-mercury found in fish is strongly influenced by the age of the fish, the size of the fish and the waters from which the fish originates. In general, methyl-mercury is almost 100 percent found in the meat of fish.[24] In 2014, Mangampe et al showed that mackerel from around the sea in Makassar City contained mercury levels that exceeded the threshold of 1.346 mg/kg, when referring to the FDA, the level of mercury in mackerel which is considered within normal limits is 0.15 mg/kg. and the eating rate of mackerel people living on the coast of Makassar City is 234.62 grams/day.[15,6] Therefore, people living in coastal areas are at risk of being exposed to excessive doses of mercury. The study revealed that mackerel was proven to be contaminated with mercury in levels that exceeded the recommended limit, even though mackerel is one type of fish classified as the "best choice" for consumption during pregnancy because it contains high DHA and PUFA.[6]

The increase in mercury levels in living things in the oceans, especially fish consumed daily occurs due to an increase in ocean pollution, including mercury, which is increasing due to growing industrial waste,[25]

This study found that there was no significant difference between mercury levels in the blood of pregnant women and mercury levels in the umbilical cord blood of infants. Although this difference was not statistically significant, from these data it appears that the baby's umbilical cord blood has higher levels of mercury than the blood of pregnant women. Al-Saleh et al in Saudi Arabia also found greater mercury levels in the umbilical cord than in the blood of pregnant women.[26] The MIREC study in Canada showed that the mercury ratio of umbilical cord blood was 1.89 times that of maternal blood.[27] Research in Ohio also showed higher levels of mercury in the baby's umbilical cord blood (0.72 ug/L) than in the blood of pregnant women (0.64 ug/L). The types of fish that are mostly consumed are tuna, salmon and shellfish.[10] Another study in South Korea showed an increase in mercury levels in the blood of pregnant women and the baby's umbilical cord along with an increase in fish consumption. This study found a lower mean level of mercury in maternal blood (4.46 ug/L) compared to mercury levels in umbilical cord blood (7.35 ug/L). A lot of mercury comes from the consumption of tuna, salons, sharks and whales.[28]

Mercury levels in umbilical cord blood are considered a better marker of intrauterine mercury exposure than maternal blood alone and are evidence of increased fetal mercury exposure during pregnancy.[17] The higher mercury levels in the umbilical cord can be caused because methyl-mercury is lipophilic which is easily able to cross the placental blood barrier and methyl-mercury can bind to hemoglobin (Hb) on erythrocytes.[22,27] This difference in higher Hb levels in the fetus is what causes methyl-mercury levels in umbilical cord blood to be found to be higher than in maternal blood.[29]

The mercury levels found in this study were much higher than in other published studies, both in the blood of pregnant women and in the umbilical cord blood. In population groups with high levels of fish-eating, high levels of methyl-mercury were found in the blood of pregnant women, such as in Japan (5.18 g/L) and Greenland (12.6±16.8 g/L), while in other countries. Those with moderate fish consumption levels tended to lower blood methyl-mercury levels, namely Austria (median 0.7 g/L), Slovakia (median 0.63 g/L) and the USA (0.97 g/L).[30] Ideally, methyl-mercury levels in individuals who consume fish that are classified as less contaminated are around 5 – 10 g/L, while those with limited fish consumption have mercury levels in the blood of less than 2 g/L.[17] The mercury level obtained exceeds the level of Human Biological Material II (HMB II) which is 15 ug/L, where HMB II indicates a value or level that is known to cause health symptoms in humans.[29]

Research on people who regularly consume fish in South Korea (Tuna, Shark, and Shellfish), reported that 81.6% and 6.1% of umbilical cord blood samples exceeded HMB I (5 μg/L) and HMB II (15 μg) levels. /L), while for the blood of pregnant women as much as 33.6% and 0.9% which exceeds the levels of HMB I and HMB II, respectively. There are no reports on the negative impact of mercury exposure that exceeds the HMB II limit on pregnant women and pregnancy outcomes in this study.[28]

This study found that coastal pregnant women tend to have mercury levels exceeding the average value of 2.4 times greater than non-coastal pregnant women. This may be due to the ease of coastal pregnant women in getting fresh fish and the consumption of fish which may be more than non-coastal mothers. However, this does not seem to have a big effect, because the mercury levels between the two groups were not significantly different in the previous statistical analysis. In general, studies related to mercury levels in the blood are mostly carried out in populations that

consume a lot of fish, which tend to be in coastal areas or islands, as described in the previous discussion. In the islands, such as the Faroe Islands and the Seychelles Islands, mercury levels are much higher than in areas that are not on the coast. Research in China shows that mercury levels are higher in communities near the coast than in people not living in coastal areas.[36] This is because marine fish are still the largest and main source of mercury in the blood compared to other sources, such as freshwater fish or rice.[5,10] Even though. studies in areas that have coastlines, reported lower mercury levels, such as in Brooklyn and Ohio, this is due to strict regulations against fish consumption and circulation of fish contaminated with mercury.[10,18]

In this study, it was also found that there was no effect between mercury levels above the average on low birth weight babies, although mercury levels in both the blood of pregnant women and the umbilical cord were found to be very high. The very high levels in this study were probably caused by evidence that mercury levels in fish that were routinely consumed were contaminated with mercury exceeding the permissible limits. This is also exacerbated by the absence of extensive information and local regulations regarding the safety of consuming fish that may have been contaminated with excessive mercury. Although high levels of mercury were found in this study, there were no reports of birth defects in the entire study sample. Allegedly, the type of fish consumed also plays an important role, in addition to the mercury content of a fish in causing disturbances to the baby.[37]

Fish besides containing methyl-mercury, also contain DHA and PUFA, the high content of PUFA and DHA in fish is considered capable of providing good baby development during pregnancy.[38] The selection of fish that is low in mercury, but high in DHA and PUFA levels are preferred in the context of the baby's good neurodevelopment during pregnancy.[39]

This study is the first study in Makassar that provides information on mercury levels in pregnant women with a fairly good number of samples. The mercury levels obtained in this study are much higher than similar studies that have been published, thus revealing a new veil regarding mercury levels during pregnancy, especially in Makassar City. This research has implications for the community, especially in coastal areas to be able to choose more nutritious food sources and have a low risk of harming the fetus in pregnant women.

Some of the limitations of this study, namely the type, diet and origin of fish consumed during pregnancy are still difficult to map specifically because they still rely on the memory of the mother herself. In addition, there are limitations on the division of specific areas in determining the location of residence of coastal and non-coastal pregnant women in the city of Makassar. Then, this study was only limited to assessing umbilical cord blood mercury levels and pregnancy outcomes after the baby was born, where further research is needed to assess future baby development based on existing umbilical cord blood mercury values.

Conclusion

This study found that there was no statistically significant difference in blood levels of pregnant women in the coastal group compared to the non-coastal group, and the blood of pregnant women in the coastal group compared to umbilical cord blood in the coastal group, although mercury levels were higher in the blood of pregnant women in the coastal group compared to the non-coastal group, and mercury levels in the umbilical cord blood of infants in the coastal group were higher than in the blood of pregnant women in the coastal group. Further research is needed to assess the impact of the mercury found in this study on infant or child development. Local policies are needed to regulate the consumption of contaminated fish.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

All authors of the manuscript titled **“Comparison of blood mercury concentrations in pregnant women who lived in the coastal and non-coastal area of Makassar, Indonesia”** qualify for authorship because of substantial contribution to the work submitted. The authors undersigned declare that this manuscript has not been published nor is under simultaneous consideration for publication elsewhere. The authors agree to declare the manuscript will not be published elsewhere in any other languagewithout the consent of the International Journal of Women's Health and Reproduction Sciences(IJWHR). The final form of the manuscript has been seen and approved by all the authors.

No	Authors, Name & Surname	Contribution	Date	Signature
1	Suci Amaliah Syarief, M.D.	First author, a medical doctor of the residency program of Obstetrics and Gynecology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia.	08/12/2022	
2	Dr. Maisuri T. Chalid, M.D.	Co-Author and corresponding author, medical doctor, obstetrician and gynecologist, methodological and statistical analysis.	08/12/2022	
3	Dr. Andi Mardiah Tahir, M.D.	Co-Author, obstetrician and gynecologist.	08/12/2022	

Correspondent Author:

Dr. Maisuri T. Chalid, M.D.
Department of Obstetrics and Gynecology, Faculty of Medicine, Hasanuddin University,Hasanuddin University Hospital, Building A, 3rd floor
Jl. Perintis Kemerdekaan Km. 11 Tamalanrea, Makassar 90245, Indonesia.Phone: 62-411-585859, Fax: 62-411-585688, GSM: +62811463780
E-mail: maisurichalid@gmail.com. Orcid ID: https://orcid.org/0000-0001-8790-4915

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Figures/Tables

Table 1. Characteristics of the subjects of study

Characteristic	Coastal *n*	Coastal %	Non-Coastal *n*	Non-Coastal %	Total *n*	Total %	*p*
Age (years)							
< 20	6	8.7	4	5.8	10	7.2	
20 – 35	55	79.7	56	81.2	111	80.4	0.791
> 35	8	11.6	9	13.0	17	12.3	
Education (years)							
< 12	23	33.3	22	31.9	45	32.6	1.000
> 12	46	66.7	47	68.1	93	67.4	
Work							
Not Working	62	89.9	63	91.3	125	90.6	1.000
Work	7	10.1	6	8.7	13	9.4	
Income							
< Regional minimum wage	52	75.4	56	81.2	108	78.3	0.536
≥ Regional minimum wage	17	24.6	13	18.8	30	21.7	
Parity							
< 2	28	40.6	23	33.3	51	37.0	
2 – 5	40	58.0	46	66.7	86	62.3	0.385
> 5	1	1.4	0	0	1	0.7	

Chi Square Test

Table 2. Comparison maternal blood and umbilical cord mercury levels in coastal and non-coastal groups

Variables	Mercury Levels (ug/L) Coastal	Mercury Levels (ug/L) Non-Coastal	*p*
Pregnant Women's Blood	86.22±105.43	71.51±63.06	0.422
Umbilical cord blood	114.17±152.79	70.80±57.63	0.554

Mann Whitney Test

Table 3. Comparison of the number of pregnant women and baby weight to the average mercury level

Variables	High mercury levels (Mercury levels >78.87±86.87 ug/L) *n*	%	Low mercury levels (Mercury levels ≤78.87±86.87 ug/L) *n*	%	*p*	OR	Ci
Pregnant Women							
Coastal	25	36.2	44	63.8	0.036	2.448	1.124 - 5.328
Non-Coastal	13	18.8	56	81.2			
Baby Weight (grams)							
< 2500	2	5.3	6	6.0	1.000	0.870	0.168 - 4.513
≥ 2500	36	94.7	94	94.0			

Chi Square Test