EXPOSURE TO CADMIUM AMONG PREGNANT WOMEN FROM INDONESIA: LEVELS AND ASSOCIETED FACTOR

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Abstract

Cadmium can endanger the health of pregnant women and their unborn children. Other factors that affect hair cadmium levels include cigarette smoking and seafood consumption. This study aimed to analyze the impact of cigarette smoke exposure and seafood consumption on pregnant women's hair cadmium levels. This was an quantitative cross-sectional study with a sample of 50 pregnant women. This variable of this study was cadmium in hair, which was quantified using ICP MS. The Food Frequency Questionnaire was used to assess seafood intake. The Fisher Exact Test was used in data analysis to measure the relationship between the independent and dependent variables, and logistic regression was used to calculate the likelihood of its occurrence. The results showed that 18 (36%) of 50 pregnant women had hair cadmium levels that exceeded the threshold number. A bivariate test revealed that cigarette smoke exposure (0.000) and frequency of seafood consumption (0.040) had a significant impact. Meanwhile, the pregnant woman's age (0.684), the type of seafood consumed (0.163), the use of nail polish (0.979), and the use of hair dye (0.754) had no impact on the cadmium content of her hair. The multivariate test revealed that the factor variables that most affected hair cadmium levels were Exp (B), cigarette smoke exposure (18,059), and frequency of seafood consumption (6,690). In conclusion, cigarette smoking and seafood intake are risk factors for cadmium levels in pregnant women. Exposure to cigarette smoke is the most influential variable, so pregnant women must prevent being exposed to cigarette smoke.

1. Introduction

Cadmium (Cd) is a naturally occurring non-essential metal that has been identified as a danger factor in the workplace and the environment. Cadmium, a heavy metal that occurs naturally as well as a pollutant, serves an essential role in producing concentrated sources of cadmium and releasing it into the environment (Jarup & Akesson, 2009). Cadmium harms the kidneys, bones, and lungs, causing renal tubular injury, osteomalacia, and lung cancer. Cadmium

exposure during pregnancy and after delivery is linked to low birth weight, impaired fetal development, trace element deficiencies, and congenital malformations in children (Al-Saleh et al., 2014).

Pregnancy is a unique physiological state that can affect and change the critical pathways involved in cadmium handling. Some research explain the connection between cadmium levels in pregnant women and seafood consumption, cigarette smoking, and cosmetics such as lipstick, powder,

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eyeshadow, nail polish, and hair dye. Cosmetic dermatitis users with various cosmetic brands were studied, with results ranging from 1.63-2.30 g/g, 0.40-0.76 g/g, 1.05-3.60 g/g, and 1.05-4.53 g/g, respectively, and revealed significantly higher levels of cadmium in blood and hair specimens in cosmetic users (Hassan Imran, 2022).

The smoke produced can affect both the smoker and those around him. Cadmium is one of the components in cigarettes, and it can be absorbed into the body by inhaling the smoke. The impact of cigarette smoke is felt not only by smokers (active smokers) but also by individuals who are exposed to cigarette smoke (passive smokers). Around 65.6 million women and 43 million children in Indonesia are subjected to cigarette smoke or become passive smokers. Many Indonesians are exposed to cigarettes because 91.8% of smokers smoke at home (Shoji, 2019).

People frequently eat fish and shellfish caught in the waters surrounding Makassar. In Wendy McKelvev's research, those who reported eating seafood 20 or more times in the previous 30 days consumed it at 3.7 times the rate of those who did not (95% CI, 3.0 - 4.6). Similarly, a study conducted by Stanford Guan found that consumption of salmon slightly increased cadmium levels compared to other species, most likely due to the higher consumption of salmon in the study population, and it was concluded that the type of fish consumed affected cadmium levels in the body (Standford Guan, 2015).

Human hair can absorb various elements that infiltrate the body, such as cadmium. Hair has long been thought to be a possible repository for all elements that infiltrate the body. Hair mineral analysis identifies the mineral composition of accumulated hair over time, which correlates to trace elements in the body. Hairs record filaments that can represent the metabolic changes of many elements over time (Priya & Geetha, 2010). Therefore, it can be analyzed on hair samples.

This research was conducted to analyze cadmium exposure in pregnant women. Exposure to cadmium can contaminate and enter the human body through polluted air, food media, drinks, and exposure to cigarettes. Cadmium exposure problems occur in the kidneys, bones, and lungs which can cause kidney tubular damage, osteomalacia, and in pregnant women resulting in low birth weight, impaired fetal growth, trace element deficiencies, and congenital malformations. This is the first study that explore cadmium exposure in pregnant woment.

2. Materials and Methods

Data Collection

This was a quantitative research with a cross-sectional research methodology. The sample in this study were 50 pregnant women who visit Andalas, Dahlia, Mamajang, Panambungan, and Tamalanrea Public Health Centers (Puskesmas) and fulfilled the inclusion criteria domiciled in Makassar and had no history of seafood allergies. Pregnant women who agreed to participate in the study were given informed consent and taken his hair 0.5 - 1 cm from the scalp with stainless scissors, then placed in an envelope and labeled. The hair samples were then brought to the Laboratory to be tested for cadmium levels. The sample's characteristics were classified based on education, employment, income, pregnancy age, seafood consumption, cigarette smoke exposure, and cadmium levels.

Cadmium Samples and Analysis

Hair samples weighing up to 0.5 grams were placed in the Nessler container, followed by 10 ml of HNO_3 solution. (Merck, Germany). The use of concentrated nitric acid is intended to transform dense hair into liquid. The sample was heated above the Waterbath (Memmert WNB14) at 95o C until it dissolved, and the ensuing steam changed color from brown to white. This heating process required 48 hours to complete. Cadmium reference solution 1000 ppm prepared (Merck, Germany). 10 ppm of cadmium standard solution (diluted in 200 ml and 500 ml) and 1 ppm (diluted in 10 ml, 50 ml, and 100 ml) were used to make 50 ml of cadmium standard. Then working sequence with a blank containing 0.2% nitric acid diluted with aquadest was conducted. After the preparation stage is complete, the sample is diluted with 50 ml of aquadest. The solution was then filtered using Whatman 42 paper with a pore diameter of 2.5 μm. Then the samples were filtered and put into ICP-MS (Inductively Coupled Plasma Mass Spectrometry) (Thermoscientific iCAP RQ)

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for analysis and the process lasted 30 seconds for each sample. Method validation was carried out using a certificate reference material (CRM) from ERA to see the quality assurance of cadmium measurement results (quality control performance acceptance limits 32.2-40.4 µg/L).

Food Frequency Questionary (FFQ)

Data on the consumption frequency of seafood and consumption portions were collected through interviews using a food habit questionnaire with the Semi-Quantitative food frequency questionnaire (SQ-FFQ) to determine the subject's intake history for a month regarding the food model book of the Republic of Indonesia Ministry of Health 2014, which contains the number of servings of seafood consumed according to the type of seafood, and the portion of seafood.

Analysis Statistics

To analyze the effect of the independent variables on cadmium levels in pregnant women, Fisher's bivariate exact test was used, and to see the effect of using multivariate tests, logistic regression with a progressive (wild) method was used.

Ethics

The study was conducted in accordance with the Health Ethics Committee of The Faculthy of Public Health At Hasanuddin University. The approval number is 9068/UN4.14.1/TP.02.02/2022. All paricipants provided written, informed consent.

3. Results and Discussion

Sample Characteristics

The characteristics of respondents were based on age, occupation, education, and family income. There were 43 pregnant women (86%) aged less than 35 years and 7 pregnant women (14%) aged more than 35 years. For the characteristics of family income, 31 pregnant women (62%) had income below the minimum wage and 19 pregnant women (38%) had income above the minimum wage. For job characteristics, 38 pregnant women (76%) did not work, and 12 pregnant women (24%) worked. For educational characteristics, 1 pregnant woman did not attend school, 3 pregnant women graduated from elementary school, 5 pregnant women graduated from junior high school, 28 pregnant women graduated from high school, and 13 pregnant women graduated from university.

Table 1: Characteristics of Respondents (N=50)

Respondent Characteristic Category	n	%
Age		
>35	43	86
<35	7	14
Occupation		
Do not work	38	76
Work	12	24
Family Income		
< RMW*	31	62
> RMW	19	38
Education		
Non-formal school	1	2
Elementary school	3	6
Secondary school	33	66
Graduate	13	26

* RMW (Regional Minimum Wage) IDR:3.513.982

The average cadmium consentration the hair pregnant women is 0,10 µg/g (0,01-0,96 µg/g). This indicates that the cadmium levels exceed the hair concentration threshold. Graph 1 shows From the 50 hair samples of pregnant women examined, there were 32 hair samples pregnant women normal and 18 hair samples of pregnant women who had abnormal hair cadmium values of > 0.10 µg/g (Biolab Medical Unit, 2012)
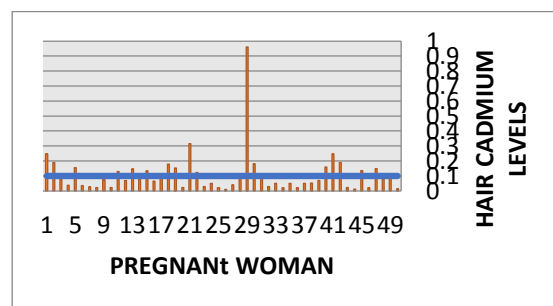

Figure 1. Hair Cadmium Levels of Pregnant Women in Makassar City

Table 2 shows variable cigarette exposure has a p-value 0,00, seafood consumption has a p-value 0,04, fish type has a p-value 0,16, consumption portion has a p-value 0,30, education has a p-value 0,49, age has a p-

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vallue 0,68, and family income has a p-vallue 0,92. that after conducting Fisher's exact test for the cigarette smoke exposure variable, seafood consumption had a significant effect on hair cadmium levels because the p-value was <0.05. While other variables did not affect cadmium levels because the p-value was > 0.05, namely the type of fish

Table 2. Correlation between Cigarette Smoke Exposure and Seafood Consumption with Hair Cadmium Levels

| Ç | Hair Cadmium Levels | | | | Total | | p vallue |
| | normal | | Abnormal | | | | |
	n	%	n	%	n	%	
Cigarette Exposure							
No	26	83,9	5	16,1	31	100	0,00
Yes	6	31,6	13	68,4	19	100	
Seafood consumption							
< 3x week	22	75,9	7	24,1	29	100	0,04
> 3x week	10	47,6	11	52,4	21	100	
Seafood type							
Fish	23	59,0	16	41,0	39	100	0,16
Shell, Mollusca, Crustacea	9	81,8	2	18,2	11	100	
Consumption portion							
<12 ons	24	75	11	61,1	35	100	0,30
>12 ons	8	25	7	38,9	15	100	
Education							
<12 year	24	61,5	15	38,5	39	100	0,49
>12 year	8	72,7	3	27,3	11	100	
Age							
<35 year	28	65,1%	15	34,9%	43	100	0,68
>35 year	4	57,1%	3	42,9%	7	100	
Family income							
<RMW	20	64,5	11	35,5	31	100	0,92
>RMW	12	63,2	7	36,8	19	100	

Table 3. Multivariate Analysis of the Effect of Seafood Consumption and Exposure to Cigarette Smoke on Hair Cadmium Levels of Pregnant Women.

| Variable independent | Sig. | Exp (B) | 95 % C.I.for EXP (B) | |
			lower	upper
Cigarette Exposure	0.001	18.059	3.380	96.492
Frequency seafood consumption	0.026	6.690	1.252	35.747
Seafood type	0.285	0.372	0.061	2.278

Variables that can be tested are multivariate that has a p value <0,25 in the bivariate test. The variables included are smoking exposure, frequency of seafood consumption, and types of seafood. while the variables that excluded the portion of consumption, education, age, and family income. In the logistic regression test using the forward stepwise (wald) method, there were 2 influential variables, namely exposure to cigarette smoke and frequency of seafood consumption with a p-value <0.05. The most influential variable was exposure to cigarette smoke exp (b) 18.059, which means that 18.059 tends to be more at risk of affecting hair cadmium levels.

Cadmium is heavy metal found as an environmental contaminant, Prenatal exposure to cadmium has an important role in the development of the individual human and its impact on public health. The route of exposure has an impact on the absorption of cadmium through inhalation, especially through cigarette smoke, while the oral route is through contaminated water and food (offal and seafood). The factor is the high levels of hair cadmium that enter the body through respiratory and digestive mechanisms and accumulates in the blood. Hair follicles are densely packed with blood vessels, through which blood flows, providing a transport medium for an essential and possibly toxic element. (cadmium). When the elements reach the hair follicle, they are incorporated into the proteins that are developing in the hair. Hair is a metabolic byproduct that incorporates elements into its structure as it develops. As it approaches the skin structure, the hair hardens and the elements accumulated during formation are sealed into the protein structure of the hair. Because the follicle receives a constant blood supply during development, the concentration of hair elements can mirror the concentration in other body tissues (Pradita, 2023).

There were 43 (86%) pregnant women aged < 35 years and 7 (%) pregnant women aged > 35 years. It is where age does not affect cadmium levels in pregnant women, this is because pregnant women aged >35 years are rarely found in puskesmas, due to socialization for the use of family planning at age >35 years. Exposure to cadmium can also be affected by activity. The results of the study showed that 38 (76%) pregnant women did not work and 12 (24%) pregnant women worked where work did not affect the cadmium levels of pregnant women. This is because exposure to cadmium could also occur when pregnant women are at home. The family income factor could also affect cadmium levels. The results showed that 31 pregnant women have family income <RMW and 19 > RMW. However, the family income did not affect cadmium exposure, this is because pregnant women do not buy goods that are a source of cadmium. While education also did not affect cadmium levels because exposure to cadmium could occur accidentally through surrounding environmental factors.

Based on the graph, there are 18 out of 50 pregnant women with cadmium levels that exceed the threshold value. This is the same as Arzu's (2016) research (9) where cadmium in pregnant women was detected in 24 (19.8%) of 121 samples of pregnant women. It demonstrated the significance of prenatal cadmium exposure in human development and its effect on public health. Birth outcomes associated with cadmium exposure have been proven in populations all over the globe, including associations with poorer cognition and epigenetic changes (Frank, 2017).

The results showed that 19 (38%) mothers were subjected to cigarette smoke, while 31 (62%) mothers were not. The Odds Ratio value in the risk estimate was 0.089 (95% CI 0.023 - 0.346), which means that mothers exposed to cigarette smoke had a 0.089 times greater chance of influencing cadmium levels than mothers who are not exposed to cigarette smoke. This is because pregnant women in this research were passive smokers whose family members smoked inside the house and were also exposed to cigarettes from locations other than the home, such as workplaces and public facilities. This exposure occurred because pregnant women and active smokers did not avoid each other during periods of smoking activity. It is like a spouse who continues to smoke at home while his pregnant wife is in another room. Pregnant women were the ones who did not prevent cigarette smoke from active smokers in their workplace. This is what may have an impact on cadmium levels in expectant women. Passive cigarette smoke exposure may impact the cadmium levels in pregnant women's hair. This is consistent with the results of research conducted by Faizah et al. (2018) who discovered that pregnant women subjected to cigarettes had three times the hair cadmium levels as pregnant women who were not exposed to cigarettes, with a p-value of 0.047. Yibing zhu (2018) et al. conducted research. With a p-value of 0.01, it was also stated that long-term exposure to second-hand smoke has the potential to raise cadmium levels, which are harmful to pregnant women and the unborn fetus.

The results showed that the frequency of seafood consumption in the frequent category was 21 (42%), while in the rare category, it

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was 29 (58%) pregnant women. and the risk estimate obtained the Odds Ratio value = 0.289 (95% CI 0.087 – 0.967) which means that frequent seafood consumption has a risk of affecting cadmium levels by 0.289 times pregnant women than pregnant women who rarely eat seafood. It is because pregnant women frequently consume seafood more than three times per week, according to this research. Similarly, the study results showed that the portion of seafood consumption had no significant impact with a p-value 0.204, indicating that there was no effect of the portion of seafood consumption on cadmium levels in pregnant women.

One of the most common ways of cadmium exposure in humans is through seafood consumption. Cadmium could accumulate in seafood through food and waterborne exposure, posing a health danger. Due to the high consumption of seafood by pregnant women in the city of Makassar, the frequency of seafood consumption could influence hair cadmium levels in this research. This contradicts the findings of Ram B Jan (2010) who found that consumption of fish/shellfish was not associated with elevated levels of cadmium in pregnant women aged 17-39 years.

The results indicated that the consumption of fish species was 39 (78%), while non-fish consumption was 11 (22%) in pregnant women. The risk estimate obtained the Odds Ratio value = 0.319 (95% CI 0.061-1.680), which means that the consumption of seafood has a risk of affecting cadmium levels by 0.319 times. Due to the various types of fish consumption in this study, it is not known what type of fish the source of cadmium exposure came from. Many types of fish are rich in cadmium, but the bioavailability and potential toxicity after consumption are still unclear.

Consumption of different types of fish had no effect on pregnant women's hair cadmium levels, which is consistent with the research of Stanford Guan, who discovered that no type of seafood fish meal was significantly associated with blood cadmium. However, it was discovered in this research that salmon cadmium levels were not higher than in many other marine species, and the association with salmon intake is most likely due to this

population's high salmon consumption. As in this study, flying catfish is the most consumed fish by the research sample group, suggesting that flying fish could be a source of cadmium intake in pregnant women in Makassar.

4. Conclusion

The research concluded that there was a relationship between cigarette smoke exposure and seafood consumption and cadmium levels in pregnant women's hair. Furthermore, exposure to cigarette smoke was the most important variable. It is recomended of into the waters must be monitored or controlled by the Health Department because it can pollute the waters and have an effect on marine biota that will be consumed by the public. One of them is preventing exposure to cigarette smoke when pregnant women are around active smokers. Future researchers must conduct a study on cadmium levels in infants and mothers' milk to determine whether there is a connection between cadmium levels in pregnant women and the health of the baby.

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