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Risk factors of metabolic syndrome in women of reproductive age at mining area

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ABSTRACT

Lead is one of the four most dangerous heavy metal pollutants, toxic to human health, and linked to metabolic syndrome (MetS). This research aimed to analyze the relationship between respondent characteristics, blood lead level (BLL), nutrition intake, and physical activity to MetS and its components in women of reproductive age at Pemali District Mining Area, Bangka Belitung Regency. This research was conducted with a case-control approach involving 70 women of reproductive age (35 cases and 35 controls). Data was analyzed using chi-square and Mann-Witney tests for bivariate analysis and regression test logistics for multivariate analysis. Based on bivariate analysis, there is a significant relationship between body mass index (BMI) (p=0.000), salt intake (p=0.017), and seasoning intake (p=0.017) to MetS; meanwhile, BLL is not associated with MetS (p=0.473) but are associated with high-density lipoprotein cholesterol (HDLC) (p=0.019). Multivariate test results show that BMI (p=0.000; OR=7.995) and salt intake (p=0.030; OR=6.812) are significant risk factors for MetS. Women of reproductive age must maintain BMI within normal levels and reduce daily salt intake to prevent the occurrence of MetS. BLL must be controlled to prevent decreased HDLC levels in women of reproductive age.

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1. INTRODUCTION

Metabolic syndrome (MetS) is a group of interrelated metabolic disorders, including central obesity, high blood pressure, hyperglycemia, and dyslipidemia, including high triglycerides, high levels of low-density lipoprotein cholesterol (LDLC), and low levels of high-density lipoprotein cholesterol (HDLC) [1]. Based on Indonesian basic health research 2013-2018, the proportion of central obesity in the population aged ≥15 years increased from 26.6% to 31%, the prevalence of hypertension in the population aged ≥18 years increased from 25.8% to 34.11%, and the prevalence of diabetes mellitus based on a doctor's diagnosis in the population aged ≥15 years increased from 1.5% to 2%. The province of Bangka Belitung Islands is one of the regions with a high proportion and prevalence of central obesity, hypertension, and diabetes mellitus, respectively: from 31.8% to 33.8%, from 30.9% to 29.9%, and from 2.1% to 2.5%. The prevalence of central obesity, hypertension, and diabetes mellitus is higher in women than men, with the prevalence of central obesity most in the age group of 35-44 years (46.14%) [2], [3].

The causes of MetS are lifestyle factors, including physical activity and dietary patterns, genetic, and environmental factors. Heavy metal exposure becomes an environmental factor that may be essential in developing MetS [4]. Lead or plumbum (Pb) is one of the four most dangerous heavy metal pollutants, toxic to human health, and linked to MetS. A cross-sectional study on male and female adults stated that blood lead level (BLL) is positively associated with the prevalence of MetS [5]. BLL was significantly associated with systolic pressure, diastolic pressure, waist circumference, triglyceride levels, and fasting blood sugar (FBS) [6], [7].

Lead buildup in the body results in acute and chronic poisoning, including genetic and reproductive problems [8]. Women with BLL of 10 g/dL are at risk for complications such as premature birth, low birth weight, infertility, miscarriage, early childhood neurological defects, and maternal hypertension. Studies in women show that pregnant women tend to experience more complications due to lead accumulation. Fetal growth is directly affected by the bioaccumulation of lead in the blood, ranging from 10-15 ng/dL in women of childbearing age [9]. Related research still needs to be continued to ascertain the association of BLL with MetS, especially with female subjects of reproductive age.

In Indonesia, data or examination of lead levels in humans has not become a service priority, including in areas with high exposure, such as in Pemali District, Bangka Belitung Islands Province. Bangka Belitung Islands Province is Indonesia's largest white tin production area, where exploration has been carried out since the beginning of the XVIII century. The mining area reaches 512,369 hectares on land and off the coast of Bangka, Belitung, and Kundur islands [10]. The potential of tin mineral resources is in all regions, covering six districts and one city: Belitung Regency, Bangka Regency, West Bangka Regency, Central Bangka Regency, South Bangka Regency, East Belitung Regency, and Pangkalpinang City [11]. Bangka Regency is an area of tin exploration and exploitation that has been going on for hundreds of years, including in the Pemali District [12].

The prevalence of central obesity, hypertension, and diabetes mellitus in Bangka Regency is 35.33%, 28.34%, and 2.67%, respectively. In 2020, Pemali District became the region with the highest percentage of obesity, the 2nd highest for hypertension, and the third highest for diabetes mellitus [13]. Therefore, this research aims to analyze the relationship between respondent characteristics, BLL, nutrition intake, and physical activity to MetS and its components in women of reproductive age at Pemali District Mining Area, Bangka Belitung Regency.

2. METHOD

2.1. Study design

This type of research is observational analytics with a case-control approach to determine the relationship between independent (respondent characteristics, BLL, nutrition intake, and physical activity) and dependent variables (MetS and its components). This approach was chosen because measurements of independent and dependent variables are not performed simultaneously. The research was conducted in the Pemali Health Center area, Bangka Regency, Bangka Belitung Islands Province, from June 2022 to December 2022.

2.2. Sample size and sampling technique

The respondents were selected by purposive sampling, where the researcher selected respondents for the case and control groups based on the screening process of the affordable population. The sample consisted of 35 women of reproductive age with MetS as the case group and 35 without MetS as the control group. Determination of MetS diagnosis using the national cholesterol education program-adult treatment panel III (NCEP-ATP III) standard, namely respondents with symptoms of central obesity and accompanied by two other symptoms of high blood pressure, high blood sugar levels, high triglyceride levels, and or low HDLC levels. The criteria for inclusion of respondents are living in the research location area or other areas in Bangka Belitung Province with the same exposure for ≥20 years and willing to be a research sample. The respondent’s exclusion criteria were active or passive smokers, through a diet program, pregnant or breastfeeding, and having one or both parents suffering from MetS. Data was collected by measuring each symptom of MetS on data on women's participation in activities managed by Pemali Health Center in 2021 so that respondents were obtained for the case and control groups. After confirming that respondents entered each group, measurements of independent variables were carried out. The sample selection flow is listed in Figure 1.

2.3. Data analyses

Blood sampling was taken from respondents according to the schedule agreed by the researcher and respondents. All respondents received one blood draw schedule. Blood samples are taken by competent laboratory staff with a syringe or vacutainer and inserted into a 3 ml red vacuum tube. The respondents' blood samples were stored in a portable cooling box and then delivered to the laboratory of Depati Bahrin Hospital, Bangka Regency (plenary accreditation). The laboratory processes blood samples to check FBS, HDLC, and cholesterol levels. The researcher receives the examination results 3-4 days after the blood sample is deposited.

The Chi-square statistical test was conducted to analyze the relationship between age, occupation, income, BLL, and nutrition intake with MetS. The Mann-Whitney statistical test analyzed the relationship between body mass index (BMI) and physical activity with MetS. Bivariate relationships are expressed as significant if p values <0.05. Multivariate tests were performed using logistic regression tests with backward methods. Multivariate analysis is used in logistic regression to analyze the results of bivariate analysis that have statistical significance p≤0.25. Next, the odds ratio (OR) is calculated to estimate the magnitude of the risk of the independent variable against the dependent variable.

2.4. Ethical standard disclosure

This research has been approved by the Health Ethics Commission, Faculty of Public Health, University of Jember. The registration number is 245/KEPK/FKM-UNEJ/VIII/2022. Informed consent was obtained from each respondent before the interview.

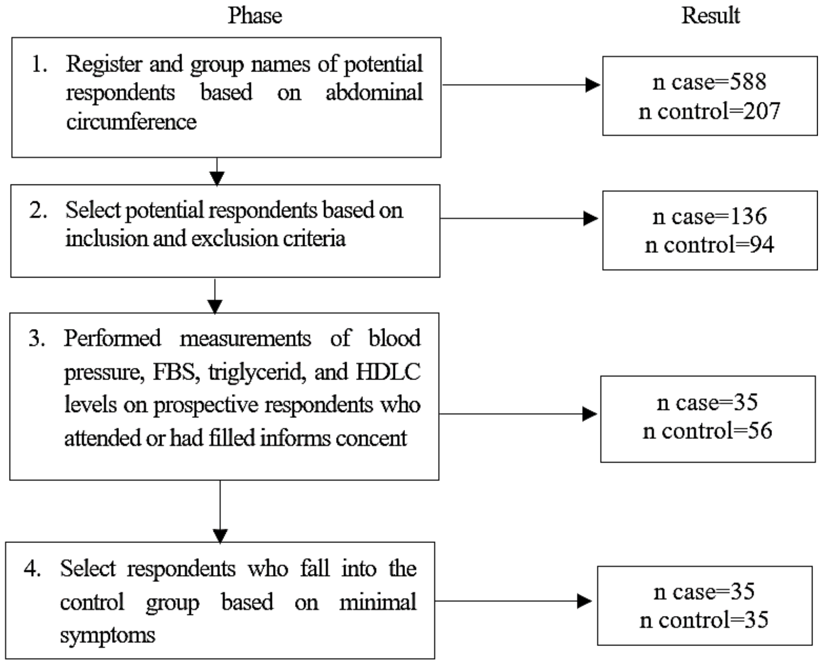

Figure 1. Sample selection flow

3. RESULTS AND DISCUSSION

3.1. Association of independent variables and MetS

The categorization of age, BLL, protein, fat, carbohydrate, sugar, salt, and seasoning intake is based on median values because the data is abnormally distributed. Calorie intake is categorized based on mean values because the data is normally distributed. The income variable is grouped based on the value of the Bangka Belitung Provincial Minimum Salary. The categorization of occupation is determined based on the majority of respondents, education based on the level of education in Indonesia, BMI based on the World Health Organization (WHO) category, and physical activity based on measurements of the International Physical Activity Questionnaire (IPAQ).

Table 1 showed that most respondents were aged 30-38 in the case group (54.3%) and control group (62.9%). The respondent characteristics based on occupation showed that most respondents had employment status as housewives (88.6%) in each case and control group. The respondent characteristics based on education showed that most respondents had the last education at the high school level in the case group (62.9%) and control group (57.1%). The respondent characteristics based on income showed that most respondents had an income of <Rp. 3,264,884 in the case group (65.7%) and control group (74.3%). The

respondent characteristics based on BMI showed that most respondents in the case group were in obesity I status (40%), and most in the control group were in normal status (51.4%). Most case group respondents had BLL in the high category (54.3%), while control group respondents were mainly in the low category (57.1%).

Table 1. Association of independent variables and MetS

Variable		MetS				Asymp. sig. (2-tailed)	OR
		Case		Control			
		n	%	n	%		
Respondent characteristics	Age (years)						
	30-38	19	54.3	22	62.9	0.627	1.425
	39-49	16	45.7	13	37.1		
	Occupation						
	Housewives	31	88.6	31	88.6	1.000	1.000
	In addition to housewives	4	11.4	4	11.4		
	Education						
	Elementary school	4	11.4	4	11.4	0.289	1.284
	Junior high school	8	22.9	4	11.4		
	High school	20	57.1	22	62.9		
	Diploma	2	5.7	3	8.6		
	Bachelor	1	2.9	2	5.7		
	Income (rupiah)						
	<3,264,884	23	65.7	26	74.3	0.428	0.364
	≥3,264,884	12	34.3	9	25.7		
	BMI						
	Underweight	0	0	5	13.3	0.000	4.428
	Normal	3	8.6	18	51.4		
	Overweight	7	20	7	20		
	Obesity I	14	40	4	11.4		
	Obesity II	11	31.4	1	2.9		
	BLL (μg/dl)						
	Low	16	45.7	20	57.1	0.473	6.273
	High	19	54.3	15	42.9		
Nutrition intake	Calorie intake (KKal)						
	Low	19	54.3	20	57.1	1.000	1.123
	High	16	45.7	15	42.9		
	Protein intake (g)						
	Low	16	45.7	19	54.3	0.633	1.410
	High	19	54.3	16	45.7		
	Fat intake (g)						
	Low	18	51.4	17	48.6	1.000	0.892
	High	17	48.8	18	51.4		
	Carbohydrate intake (g)						
	Low	20	57.1	15	42.9	0.339	0.563
	High	15	42.9	20	57.1		
	Sugar intake (g)						
	Low	20	57.1	18	51.4	0.810	6.812
	High	15	42.9	17	48.6		
	Salt intake (g)						
	Low	12	34.3	23	65.7	0.017	3.674
	High	23	65.7	12	34.3		
	Seasoning intake (g)						
	Low	12	34.3	23	65.7	0.017	3.674
	High	23	65.7	12	34.3		
	Physical activity						
	Low	23	65.7	22	62.9	0.917	1.000
	Moderate	4	11.4	6	17.1		
	High	8	22.9	7	20.0		

Based on Table 1, the respondent's calorie intake was mainly in the low category in the case group (54.3%) and control group (57.1%). The protein intake of respondents in the case group was mainly high (54.3%), while the control group was primarily low (54.3%). The fat intake of respondents in the case group was primarily low (51.4%), while in the control group, it was mainly high (51.4%). The respondent's carbohydrate intake in the case group was primarily low (57.1%), while in the control group, it was mostly high (57.1%). Respondent's sugar intake was mainly low in the case group (57.1%) and control group (51.4%). The intake of salt and seasoning in the case group respondents was mainly high (65.7%), while in the control group, it was primarily low (65.7%). Most respondents in the case group (65.7%) and control groups engaged in physical activity in the low category (62.9%).

A significant association is found in the BMI (p=0.000), salt intake (p=0.017), and seasoning intake (p=0.017) variables, which means a significant association exists between BMI, salt intake, and seasoning intake with MetS incidence. The significant value of age, occupation, education, income, BLL, physical activity, and calorie, protein, fat, carbohydrate, and sugar intake are >0.05, meaning there is no significant relationship between them with MetS incidence.

Variables that qualify for admission to multivariate tests are variables with significant results p≤0.25. Based on Table 2, the appropriate variables for multivariate tests in this study were BMI, salt intake, and seasoning intake. Multivariate test results showed that the main variable factors in MetS are BMI (p=0.000; OR=7.995) and salt intake (0.030; OR=6.812). Women of reproductive age with higher BMI levels have a 7,995 times greater risk of MetS after controlling for another variable. Women of reproductive age in the high salt intake category have a 6,812 times greater risk of MetS after controlling for another variable.

The results revealed that the respondent's BMI was 20.1–38.9 kg/m^2 and was categorized into five levels, namely underweight, normal, overweight, obesity I, and obesity II [14]. The BMI as a single survey measurement of obesity offers a high predictor for MetS and can be used by physicians and patients for this purpose [15]. This study shows a relationship between BMI and MetS in women of reproductive age in Pemali District, Bangka Regency (p=0.000; OR=7.995). These results were reinforced by a study among 3,227 people aged 18 years or older in the Northwestern Ethiopian City of Gondar, showing that BMI was significantly associated with MetS [16].

Adult women with a high BMI have a much higher prevalence of MetS [17]. BMI modifies the relationship between parity with MetS and its four components: abdominal obesity, blood pressure, increased fasting glucose levels, and elevated triglyceride levels. These conclusions suggest that it is essential for women to control their weight to avoid the risk of MetS [18].

Salt intakes in the respondents of this study were in the range of 0–7.5 g. This study shows a relationship between salt intake with MetS in women of reproductive age in Pemali District, Bangka Regency (p=0.017; OR=6.812). The results of this study strengthen other research that states a significant relationship between food consumption in salted foods and MetS [19], [20]. Salt intake increased in individuals with MetS compared to those without [21]. Another meta-analysis revealed that higher sodium input into the body is directly associated with the likelihood of MetS [22]. High salt intake in MetS participants was observed with increased waist circumference and blood pressure, so it is closely linked to hypertension through several well-studied mechanisms [23], [24].

Previous studies revealed that the prevalence of lifestyle-related diseases increased with higher salt intake. Blood glucose and hemoglobin A1c (HbA1c) increase with increased salt intake and the prevalence of diabetes [25]. A diet with a high fat content and an increased intake of fructose and salt accelerates the development of MetS [26]. Long-term high salt intake impacts the development of metabolic disorders by inducing fructose overproduction, leptin resistance, ghrelin overproduction, and insulin resistance, thereby altering natriuretic peptides and other metabolism-related hormones [23].

BLL in this study's respondents were 11–94 μg/dl. Blood lead concentration with no negative effects on health has not been identified; blood lead concentrations as low as 5 µg/dL and 10 µg/dL are associated with various effects, including cardiovascular disease in adults [27]. This study showed no relationship between BLL and MetS (p=0.473). These results reinforce previous research suggesting no significant association between BLL and MetS in United States (US) adults aged 20 [28]. Other studies also state that there are no significant differences in BLL pre-MetS and control groups and between pre-MetS and MetS groups, so it cannot be stated that lead exposure is an environmental risk factor for MetS [29].

In another study, BLL was not correlated with MetS components such as hypertension, dyslipidemia, and dysglycemia. However, further research proved the combined toxicity of heavy metals (lead, mercury, and cadmium) even if they are below toxic levels. This study showed that the accumulation of each heavy metal that impairs the functioning of the endocrine system may have an additive or synergic effect on the development of particular metabolic disorders, even if this heavy metal alone does not show such an effect [30].

Table 2. Multivariate analysis results

Variable	B	Sig.	OR	95% C.I for EXP (B)	
				Lower	Upper
BMI	2.079	0.000	7.995	2.819	22.678
Salt intake	1.919	0.030	6.812	1.198	38.733

3.2. Association of BLL and MetS components

The components of MetS include abdominal circumference, hypertension, FBS levels, HDLC, and triglyceride levels. Based on Table 3, respondents with hypertension mostly had low BLL (53.85%). Most respondents with abdominal circumference >80 cm (52.78%), GDP >100 mg/dL (60%), HDLC <50 mg/dL (60.61%), and triglycerides ≥150 mg/dL (53.33%) had high BLL. The results of the chi-square test analysis stated a significant relationship between BLL and HDLC (p=0.019; OR=2.527). Respondents with high BLL are at risk of 2,527 times lower HDLC levels than respondents who have low BLL. Other components of MetS, such as hypertension, abdominal circumference, FBS levels, and triglyceride levels, were not associated with BLL (p>0.05).

Table 3. Association of BLL and MetS components

MetS components	Blood lead level				Asymp. sig. (2-tailed)	OR
	Low		High			
	n	%	n	%		
Abdominal circumference						
≤80 cm	19	55.88	17	47.22	0.564	1.416
>80 cm	15	44.12	19	52.78		
Hypertension						
Yes	21	53.85	18	46.15	0.831	0.804
No	15	48.39	16	51.61		
Fasting blood sugar levels						
≤100 mg/dL	32	53.33	4	40	0.605	1.714
>100 mg/dL	28	46.67	6	60		
HDLC						
≥50 mg/dL	23	62.16	13	39.39	0.019	2.527
>50 mg/dL	14	37.84	20	60.61		
Triglyceride levels						
<150 mg/dL	29	52.73	7	46.67	0.262	1.275
≥150 mg/dL	26	47.27	8	53.33		

Although some studies state no relationship between BLL and HDLC [6], a study states that most respondents with higher BLL had low HDLC levels [29]. Lead-exposed persons have altered lipid profiles, increased total cholesterol, and decreased HDL [31]. Higher lead concentrations were significantly associated with decreased HDLC levels [32]. In another study, respondents with high lead levels have a 22% chance of having high LDLC levels/low HDLC [33]. Further research found that there is a strong association between lead exposure and dyslipidemia, a disease with low HDLC [34].

4. CONCLUSION

This study concluded that the risk factors variable for MetS incidence are BMI and salt intake. BLL is not a risk factor for the incidence of MetS but is associated with HDLC in women of reproductive age in Pemali District, Bangka Belitung Regency. Women of reproductive age must maintain BMI within normal levels and reduce daily salt intake to prevent the occurrence of MetS. BLL must be controlled to prevent decreased HDLC levels in women of reproductive age.

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