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Lifestyle Behaviors and Risk of Metabolic Syndrome: A Case-Control Study among Fishermen and Oil Palm Farmers

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ABSTRACT

Metabolic syndrome (MetS) is a growing health concern in Indonesia, particularly in rural communities with limited healthcare access. Behavioral risk factors such as smoking, coffee consumption, and poor health-seeking behavior (HSB) may increase MetS risk in vulnerable populations. This study aimed to examine the association between lifestyle behaviors—smoking, coffee consumption, and HSB—and the risk of MetS among fishermen and oil palm farmers in Aceh, Indonesia. A case-control study was conducted among 240 adults, comprising 120 couples, recruited from rural fishing and farming communities. Cases met the IDF 2020 MetS criteria, while controls did not. Data on sociodemographics, smoking, coffee intake, and HSB were collected via structured interviews and clinical assessments. Multivariate logistic regression was used to identify independent risk factors, adjusting for age, gender, and education. Smoking among husbands (AOR = 2.89; 95% CI: 1.19–7.02; p = 0.019), coffee consumption (AOR = 2.40; 95% CI: 1.00–5.79; p = 0.049), and low HSB (AOR = 3.10; 95% CI: 1.35–7.11; p = 0.008) were significantly associated with higher odds of MetS. While age and education were not independently significant, they were retained in the model as potential confounders. This study highlights the need for tailored health promotion targeting smoking cessation, improved health service engagement, and dietary awareness in rural Indonesian populations. Interventions should consider sociocultural practices such as sweetened coffee consumption to reduce MetS risk effectively.

Key Messages:

- Smoking and poor health-seeking behavior are strong behavioral predictors of metabolic syndrome among rural fishermen and oil palm farmers.
- Coffee consumption, particularly sweetened coffee, emerged as a significant metabolic risk factor after adjusting for confounding variables.

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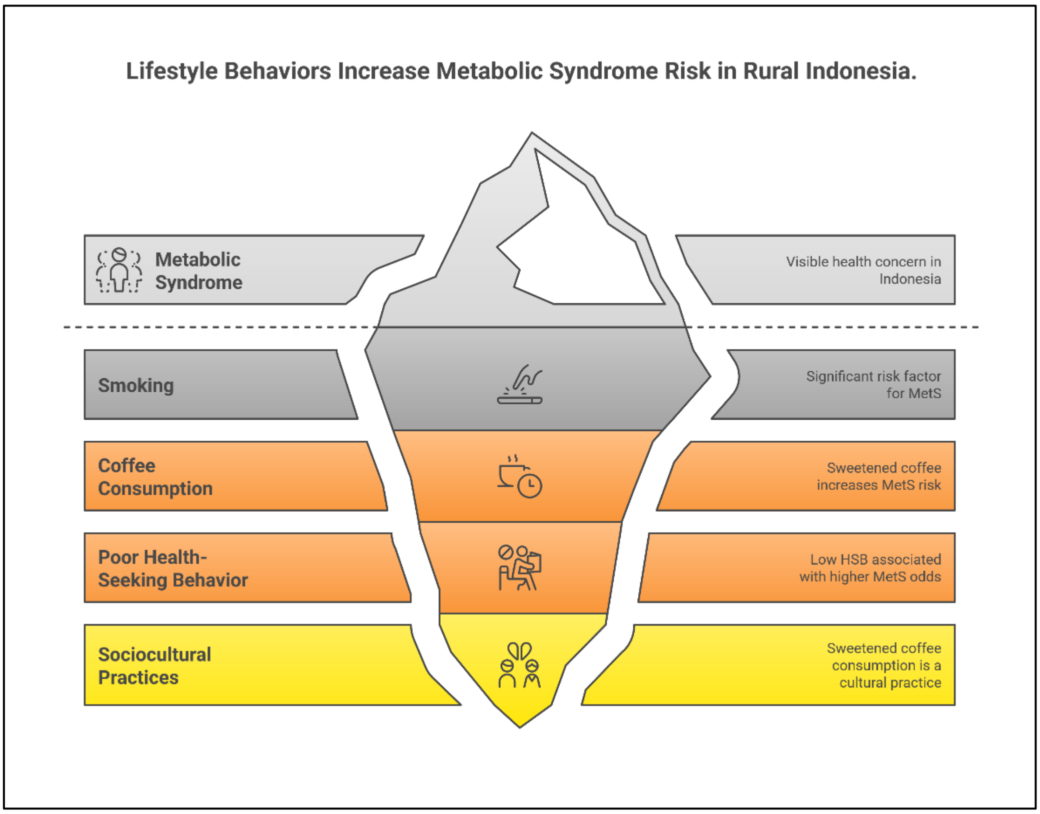
GRAPHICAL ABSTRACT



INTRODUCTION

Metabolic syndrome (MetS) refers to a group of interconnected metabolic abnormalities, including central obesity, elevated blood pressure, dyslipidemia—marked by high triglyceride levels and low high-density lipoprotein (HDL) cholesterol—and impaired glucose metabolism. These combined risk factors markedly elevate the risk of developing cardiovascular diseases and type 2 diabetes, both of which continue to rank among the leading contributors to global morbidity and mortality (1,2). In the Indonesian context, the prevalence of MetS has shown an upward trend, increasing from 23% in 2013 to 24.4% in 2018 (Ministry of Health, 2018), mirroring the global rise driven by lifestyle shifts and the effects of urbanization (3).

Communities in rural areas who work in informal sectors—particularly fishermen and oil palm farmers—face an increased risk of developing metabolic disorders. This vulnerability is largely attributed to persistent socioeconomic disadvantages, limited access to healthcare services, and evolving lifestyle behaviors. Several studies have documented that the prevalence of MetS among fishermen ranges between 18.5% and 29.3%, while oil palm farmers show prevalence rates between 12.3% and 16.3%, depending on the diagnostic criteria used(4–6). Nevertheless, these estimates may not fully capture the actual burden, as these populations often experience inadequate health monitoring and suboptimal health-seeking practices.

Fishermen and oil palm farmers were selected due to their contrasting physical work demands—fishing often involves intermittent high-intensity effort, whereas oil palm farming is increasingly mechanized—yet both share common rural lifestyle characteristics, such as limited healthcare access and dietary patterns influenced by local practices. Their shared exposure to rural environmental constraints, despite differing occupational routines, makes them ideal populations for investigating how common lifestyle behaviors may contribute to the risk of MetS. Prior studies in Indonesia have also highlighted how community-level differences in food security, nutrition knowledge, and health behaviors influence nutritional outcomes in rural populations (7–9).

Lifestyle-related factors, including cigarette smoking, coffee intake, and health-seeking behavior (HSB), are widely recognized as modifiable contributors to the development of MetS. Smoking is linked to

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heightened oxidative stress, insulin resistance, and endothelial dysfunction—all of which are mechanisms implicated in the pathogenesis of MetS (10). Similarly, habitual coffee consumption—depending on its type, preparation method, and added ingredients—may impact glucose and lipid metabolism, though findings across various populations remain inconsistent (11). In addition, inadequate health-seeking behavior, such as delayed or infrequent engagement with health services, can impede timely detection and management of metabolic abnormalities, particularly in rural environments (12).

While a substantial body of research has examined the role of individual lifestyle factors in relation to MetS, few studies have specifically investigated the combined influence of smoking, coffee consumption, and health-seeking behavior in the context of fishermen and oil palm farmers in Indonesia. Considering the distinctive occupational and socio-cultural environments of these two rural populations, it is crucial to understand how their daily lifestyle practices contribute to their metabolic health risks. Such understanding is vital for designing targeted, context-specific public health interventions.

The present study was designed to examine the relationship between selected lifestyle factors—specifically cigarette smoking, coffee consumption, and health-seeking behavior—and the risk of metabolic syndrome among fishermen and oil palm farmers in Indonesia. Utilizing a case-control study design, this research aims to generate new insights into modifiable behavioral risk factors within these underserved populations, offering evidence-based direction for prevention strategies that are sensitive to the needs of similar rural communities.

METHODS

Study Design and Setting

This research utilized a non-matched case-control design targeting two rural occupational communities: small-scale fishermen in Lhokseumawe and oil palm farmers in Aceh Utara, Indonesia. Participants were assigned to either the case (MetS) or control (non-MetS) group based on screening using the International Diabetes Federation (IDF) 2020 diagnostic criteria (13). Screening was necessary as most participants had never undergone prior metabolic health assessments. The study was conducted from April to July 2024. The non-matched design was chosen to avoid overmatching and to facilitate a more flexible multivariate analysis, particularly when examining behavioral and environmental determinants.

Married couples were specifically recruited to account for shared household-level exposures, including dietary practices, healthcare access, and socioeconomic conditions. This design aimed to reduce intra-household variability and better isolate lifestyle-related risk factors.

Population and Sampling

The study population comprised married couples, with the husbands working as either fishermen or oil palm farmers. In the case group, husbands were required to meet at least three MetS diagnostic components, while wives had to meet a minimum of two. Couples in the control group included those in which neither spouse had MetS, and the wives met fewer than two MetS components. Participants were eligible if they were aged between 35 and 60 years, not pregnant or breastfeeding, free from any acute or chronic infectious diseases, and had provided written informed consent. Individuals with chronic illnesses, undergoing special dietary treatments, or experiencing cognitive impairments were excluded from participation.

Sample size was calculated using the Kelsey formula for unmatched case-control studies, taking into account the odds ratios of primary lifestyle exposures. A total of 240 individuals (120 couples) were included, with 60 couples from each community, divided equally into case and control groups. Participants were recruited using purposive sampling with recommendations from local agricultural and fisheries authorities.

Data Collection

Data collection occurred in two phases: (1) screening for metabolic syndrome and (2) observational data collection. Trained enumerators conducted structured interviews to collect information on sociodemographic characteristics, smoking behavior, coffee consumption, and health-seeking practices.

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Anthropometric measurements included body mass index (BMI), waist circumference, and body fat percentage, while blood pressure was measured using a validated digital device. A venous blood sample (5 mL) was collected after an overnight fast (minimum 10 hours) to assess lipid profiles and fasting blood glucose using enzymatic colorimetric assays with a Selectra-E analyzer

Smoking habits were assessed through smoking status (yes/no), frequency (daily, 4–6 times/week), and the average number of cigarettes smoked per day. Coffee intake was evaluated by status (yes/no), type (sweetened or unsweetened), and frequency (daily, 2–6 times/week, ≤1 time/week). Participants were then categorized based on two criteria: (1) frequency of healthcare visits and (2) reported behavioral changes. Those who visited healthcare services only when sick and reported no lifestyle changes were classified as "Low HSB." Those who visited health services regularly (e.g., annual check-ups or screenings) and reported adopting at least one health-promoting behavior (such as improved diet, physical activity, or medication adherence) were classified as "High HSB." This operational definition was used to ensure clarity and reproducibility in categorization.

Data Analysis

Data were analyzed using IBM SPSS version 27. Descriptive statistics were presented for all study variables. Categorical variables were compared using Chi-square or Fisher's exact tests, as appropriate. For continuous variables, independent t-tests were applied for normally distributed data, while the Mann–Whitney U test was used when data violated the assumption of normality, as assessed by the Shapiro–Wilk test. To examine the association between lifestyle factors and metabolic syndrome (MetS), bivariate logistic regression was first conducted to identify candidate variables ($p < 0.25$). Variables of interest were subsequently included in a multivariate logistic regression model to calculate adjusted odds ratios (AORs) with 95% confidence intervals (CIs).

In addition, age, sex, and education level were included in the multivariate model as potential confounding variables, regardless of statistical significance in the bivariate analysis. This approach ensured that observed associations between behavioral factors (e.g., smoking, coffee consumption, and health-seeking behavior) and MetS were independent of these background characteristics. The analysis was performed for the combined dataset, with stratified interpretation provided for each community (fishermen and farmers) to acknowledge contextual differences in occupational patterns and lifestyle exposures.

Ethical Considerations

This study on food security, diet quality, and the risk of metabolic syndrome among fishermen and oil palm farmers was approved by the Health Research Ethics Committee (HREC) of the Faculty of Medicine, Universitas Malikussaleh (Approval No: 16/KEPK/FKUNIMAL-RSCU/2024). Written informed consent was obtained from all participants prior to data collection

RESULTS

Table 1 shows the characteristics of the participants according to Metabolic Syndrome (MetS) status. There was no significant difference in sex and education level between the MetS and Non-MetS groups ($p = 1.000$ and $p = 0.396$, respectively). Although the mean age did not differ significantly ($p = 0.086$), participants in the MetS group were more likely to be in the older age categories (45–60 years) compared to the Non-MetS group.

Smoking habits showed notable differences. Husbands in the MetS group had a significantly higher mean cigarette consumption per day (19.6 ± 6.3 vs. 12.3 ± 4.6; $p = 0.002$), highlighting the importance of smoking intensity in relation to MetS. They also smoked daily more frequently (73.3% vs. 61.7%). Wives' smoking prevalence was low in both groups. Health-seeking behavior was significantly lower in the MetS group (66.7%) than in the Non-MetS group (35.0%) ($p = 0.001$). Coffee consumption did not differ significantly between the groups in the descriptive analysis.

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Table 1. Characteristics of Participants According to Metabolic Syndrome Status

Variables	MetS (n = 120)	Non-MetS (n = 120)	p-value
Sex, n (%)			1.000
Male	60 (50%)	60 (50%)	
Female,	60 (50%)	60 (50%)	
Age, n (%)			0.086
35-44 years	41 (34.2%)	54 (45.0%)	
45-55 years	50 (41.7%)	49 (40.8%)	
56-60 years	29 (24.2%)	17 (14.2%)	
Education Level, n (%)			
≤ Junior High School	102 (85.0%)	96 (80.0%)	0.396
≥ Senior High School	18 (15.0%)	24 (20.0%)	
Household Income, n (%) (n=60)			
Quartile 1	20 (33.3%)	12 (20.0%)	0.187
Quartile 2	14 (23.3%)	17 (28.3%)	
Quartile 3	26 (43.3%)	31 (51.7%)	
Smoking, n (%)			
Smoking Status (Husband) (n=60)			0.144
Smoker	48 (80.0%)	39 (65.0%)	
Non-smoker	12 (20.0%)	21 (35.0%)	
Smoking Status (Wife) (n=60)			0.234
Smoker	4 (6.7%)	1 (0.8%)	
Non-smoker	116 (96.7%)	119 (99.2%)	
Smoking Frequency (Husband)			0.019[a]
Does not smoke	12 (20.0%)	21 (35.0%)	
Daily	44 (73.3%)	37 (61.7%)	
4–6 times/week	4 (6.7%)	2 (3.3%)	
Smoking Frequency (Wife)			0.323
Does not smoke	116 (96.7%)	119 (99.2%)	
Daily	2 (1.7%)	0 (0.0%)	
4–6 times/week	2 (1.7%)	1 (0.8%)	
Cigarettes/day (Mean ± SD)			
Husband	19.6 ± 6.3	12.3 ± 4.6	0.002[b]
Wife	1.6 ± 0.5	0.8 ± 0.4	0.021[b]
Coffee Consumption			
Yes	84 (70.0%)	81 (67.5%)	0.781
No	36 (30.0%)	39 (32.5%)	
Type of Coffee			
Not drinking	36 (30.0%)	39 (32.5%)	0.803
Black (no sugar)	14 (11.7%)	16 (13.3%)	
Sweet	70 (58.3%)	65 (54.2%)	
Health Seeking Behavior, n (%)			
Low	80 (66.7%)	42 (35.%)	0.001[a]
High	40 (33.3%)	39 (65%)	

[a] Significant differences between MetS and Non-MetS groups based on the Chi-square test ($p < 0.05$).
[b] Significant differences between MetS and Non-MetS groups based on the Independent *t*-test ($p < 0.05$).

Table 2 presents the bivariate logistic regression analysis. Variables significantly associated with MetS were husband's smoking (OR = 2.33; 95% CI: 1.23–4.40; p = 0.009), daily smoking frequency (OR = 2.14; 95% CI: 1.17–3.93; p = 0.014), indicating that frequency/intensity of smoking is more critical than mere smoking status. Low health-seeking behavior (OR = 3.81; 95% CI: 2.20–6.61; p < 0.001), and age (OR

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= 1.05; 95% CI: 1.01–1.10; p = 0.019) were also significant. Coffee consumption and sweet coffee preference were not significantly associated with MetS in the bivariate model.

Table 2. Bivariate Logistic Regression Analysis of Factors Associated with Metabolic Syndrome (MetS)

Variables	OR (95% CI)	p-value
Smoking (Husband)	2.33 (1.23–4.40)	0.009 *
Smoking Frequency (Daily)	2.14 (1.17–3.93)	0.014 *
Coffee Consumption (Yes)	1.13 (0.65–1.97)	0.664
Sweet Coffee	1.16 (0.68–2.00)	0.585
Low Health-Seeking Behavior	3.81 (2.20–6.61)	<0.001 *
Age (per year)	1.05 (1.01–1.10)	0.019 *
Gender (Male)	1.00 (0.61–1.64)	1.000
Low Education	1.33 (0.73–2.43)	0.351

*Bivariate logistic regression; OR: Odds Ratio; CI: Confidence Interval.
*Significant at p < 0.05.

Table 3 shows the multivariate logistic regression analysis. After adjusting for potential confounders (age, gender, education), three factors remained independently associated with MetS: husband's smoking (AOR = 2.89; 95% CI: 1.19–7.02; p = 0.019), coffee consumption (AOR = 2.40; 95% CI: 1.00–5.79; p = 0.049), and low health-seeking behavior (AOR = 3.10; 95% CI: 1.35–7.11; p = 0.008). Notably, coffee consumption emerged as a risk factor for MetS only after adjustment, suggesting the influence of confounding variables.

Table 3. Multivariate Logistic Regression Analysis of Factors Associated with Metabolic Syndrome (MetS).

Variables	**Adjusted OR (95% CI)**	**p-value**
Smoking (Husband) (Yes)	2.89 (1.19–7.02)	0.019*
Coffee Consumption (Yes)	2.40 (1.00–5.79)	0.049*
Low Health Seeking Behavior	3.10 (1.35–7.11)	0.008*

* Multivariate logistic regression analysis, adjusted for age, gender, and education level.
OR: Odds Ratio; CI: Confidence Interval.
* Statistically significant at $p < 0.05$.

DISCUSSION

This study identified several behavioral factors significantly associated with metabolic syndrome (MetS) among adults in rural fishing and farming communities. The results revealed that husbands' smoking, low health-seeking behavior (HSB), and coffee consumption were independently associated with increased odds of MetS. These findings provide important insights for public health interventions targeting metabolic risk in low-resource rural populations.

Smoking was associated with more than twice the odds of MetS in the multivariate model, consistent with prior evidence that cigarette smoking contributes to insulin resistance, dyslipidemia, and central obesity through oxidative stress and chronic inflammation(14–16). Importantly, this study emphasized smoking intensity rather than smoking status alone, as daily cigarette consumption was notably higher among MetS participants. Similar associations have been reported in Indonesian and other Southeast Asian populations, where smoking prevalence among adult males remains high (17).

Low health-seeking behavior emerged as the strongest predictor of MetS in this study (AOR = 3.10), underscoring the critical role of healthcare engagement in early diagnosis and prevention. Participants with poor engagement in healthcare services were more likely to miss early diagnosis or management of MetS components such as hypertension, hyperglycemia, and dyslipidemia. This finding aligns with studies in rural Indonesia and other LMICs, where barriers such as low health literacy, financial constraints, and geographical inaccessibility limit utilization of preventive care (18,19). Our findings

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reinforce the need to strengthen HSB by improving rural health infrastructure and promoting early screening and prevention programs that are culturally sensitive and community-based.

Interestingly, coffee consumption particularly the culturally embedded practice of consuming sweetened coffee was not significant in bivariate analysis but became a risk factor after adjustment (AOR = 2.40). This suggests that coffee drinking may interact with other dietary and behavioral variables. While many epidemiological studies have linked moderate coffee intake with reduced cardiometabolic risk due to antioxidant and anti-inflammatory properties (20), the benefits may be attenuated in settings where coffee is commonly consumed with sugar or sweetened condensed milk. A study in Malaysia also reported increased MetS risk associated with sugar-sweetened beverages, including sweet coffee (21,22). Thus, it is crucial to consider preparation methods and cultural consumption patterns when evaluating coffee's health impact in specific populations.

Although age was associated with MetS in the bivariate model, this association diminished after adjusting for behavioral variables, likely due to collinearity or confounding. Likewise, gender and education level were included in the multivariate model as potential confounders based on theoretical and empirical relevance, even though they were not statistically significant. Including these sociodemographic variables ensured a more robust model that reflects the complexity of health behavior and disease risk across different population subgroups..

This case-control study has several limitations. First, due to its observational and retrospective design, it cannot establish causal relationships between behavioral factors and metabolic syndrome. Second, the reliance on self-reported information for lifestyle variables such as smoking and coffee intake may have introduced recall bias. Third, although we controlled for several potential confounders, residual confounding cannot be ruled out. Additionally, dietary assessments did not capture total energy intake or quantify sugar content in beverages, which may have affected the estimation of nutritional risks.

Future research should adopt prospective cohort or interventional designs to confirm these findings and explore causal mechanisms. In addition, more detailed dietary assessments and the inclusion of biochemical markers (e.g., blood glucose, lipid profiles, and inflammatory markers) could help elucidate the pathways linking nutrition, lifestyle, and metabolic risk in rural populations.

CONCLUSION

This study underscores a significant association between smoking, inadequate health-seeking behavior, and an increased risk of metabolic syndrome (MetS) among individuals residing in coastal and agricultural communities. These findings emphasize the critical role of modifiable behavioral factors particularly smoking intensity and limited engagement with healthcare services in the development of MetS. Interestingly, while coffee consumption did not show a significant association in bivariate analysis, it emerged as a predictor in the multivariate model, possibly due to synergistic interactions with other lifestyle factors or the frequent addition of sugar to coffee in these populations.

In light of these findings, public health strategies should prioritize behavior-focused interventions, including smoking cessation initiatives and programs to enhance healthcare access and utilization in rural areas. Nutrition education efforts targeting reduced sugar intake, particularly from sweetened beverages like coffee, could also support MetS prevention. Future research employing longitudinal or interventional designs is recommended to confirm these associations and unravel causal pathways. Moreover, integrating biochemical indicators and comprehensive assessments of dietary intake and physical activity may enrich the evidence base and inform more effective policy and community-level interventions for MetS prevention in vulnerable populations.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest on this research.

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