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Food Diversity and Diet Quality as Determinants of Metabolic Syndrome in Fishermen Communities

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ABSTRACT

This study aimed to assess the association of food diversity and diet quality with metabolic syndrome (MetS) among fishermen communities in coastal Indonesia. An analytical observational case–control design was conducted among 120 adult fishermen (60 MetS cases and 60 controls) in Lhokseumawe, Aceh. MetS was diagnosed based on International Diabetes Federation criteria. Dietary diversity was measured using the Individual Dietary Diversity Score (IDDS) through two non-consecutive 24-hour recalls, and diet quality was evaluated using the Healthy Diet Indicator (HDI). Bivariate and multivariate logistic regression analyses were performed to determine dietary predictors of MetS, adjusting for age, gender, and physical activity. Fishermen with MetS showed a higher prevalence of low dietary diversity (IDDS $\leqslant$3: 33.3% vs. 20.0%, $p = 0.048$) and poor diet quality (HDI $\leqslant$4: 58.3% vs. 33.3%, $p = 0.010$) compared to controls. Multivariate analysis confirmed that low dietary diversity (AOR = 2.10; 95% CI: 1.05 - 4.50; $p = 0.038$) and poor diet quality (AOR = 2.80; 95% CI: 1.25–6.20; $p = 0.012$) were independently associated with MetS. Socioeconomic factors, including age, household size, education, and income, were not significantly associated with MetS. Low dietary diversity and poor diet quality are significant predictors of MetS among fishermen. Nutrition interventions aimed at improving both dietary variety and overall diet quality may effectively reduce metabolic risks in labor-intensive coastal communities.

Key Messages:

- Low dietary diversity and poor diet quality significantly increase the risk of metabolic syndrome among fishermen, highlighting the importance of nutritional patterns beyond socioeconomic factors.
- Interventions targeting both dietary variety and overall diet quality can be effective strategies to reduce metabolic risks in labor-intensive coastal communities.

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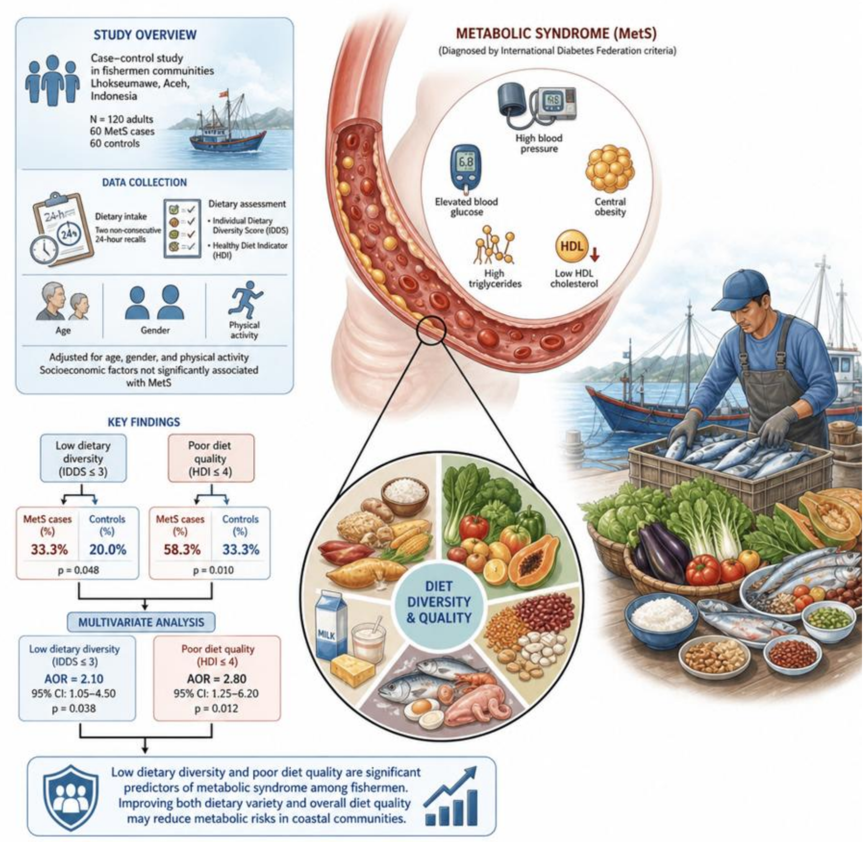
GRAPHICAL ABSTRACT



INTRODUCTION

Metabolic syndrome (MetS) is a cluster of interrelated metabolic abnormalities—including central obesity, hypertension, hypertriglyceridemia, low high-density lipoprotein (HDL) cholesterol, and impaired glucose regulation—that substantially increase the risk of type 2 diabetes mellitus and cardiovascular diseases (1–3). Globally, the prevalence of MetS continues to rise alongside increasing trends of obesity and diabetes, with obesity increasing by 82% from 1990 to 2021 and diabetes projected to rise by 68% by 2045 (4,5). In Indonesia, MetS prevalence increased from 23% in 2013 to 24.4% in 2018, with certain occupational groups, including fishermen, disproportionately affected (6,7).

Fishermen communities are particularly vulnerable due to fluctuating income, limited food access, and dietary patterns dominated by inexpensive, carbohydrate-rich, and sodium-dense foods. High rates of smoking and variable physical activity further increase metabolic risks (8,9). Food insecurity, resulting from seasonal fish catch instability and low purchasing power, is highly prevalent, affecting up to 92% of fishermen households and contributing to adverse metabolic outcomes (10,11). The Food Insecurity Experience Scale (FIES) provides a validated tool to assess these constraints (12).

Diet quality and dietary diversity (measured using the Individual Dietary Diversity Score, IDDS) play a crucial role in determining metabolic health outcomes, particularly in resource-limited settings. Coastal fishermen often consume diets with low diversity, lacking adequate fruits, vegetables, legumes, and whole grains, despite high fish consumption. The Healthy Diet Indicator (HDI), based on WHO dietary guidelines, is a widely recognized measure of diet quality and has been linked to lower waist circumference, blood pressure, triglycerides, and MetS risk (13–15).

Although previous studies have examined MetS in Indonesia, limited evidence specifically addresses the role of dietary diversity and diet quality among fishermen. Most research has focused on socioeconomic vulnerability, food insecurity, or general dietary patterns without integrating IDDS or HDI. This study aims to assess dietary diversity, diet quality, and their association with MetS among fishermen communities, providing insights to guide targeted nutrition interventions in high-risk coastal populations.

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METHODS

Study Design and Setting

This study employed an analytical observational case–control design to investigate the role of dietary diversity and diet quality as determinants of metabolic syndrome (MetS) among fishermen communities. The research was conducted in two coastal fishing communities in Lhokseumawe, Aceh, Indonesia, between April and July 2024. These communities represent vulnerable coastal populations with fluctuating income, limited food access, and distinct dietary patterns.

Cases were defined as fishermen diagnosed with MetS based on the International Diabetes Federation (IDF) 2020 criteria, while controls were individuals without MetS from the same community. A non-matched design was used to avoid overmatching and to allow flexibility in modeling behavioral, dietary, and socioeconomic determinants.

Population and Sampling

The study population included adult fishermen aged 35–65 years who had resided in the community for at least one year. Exclusion criteria included pregnancy, chronic infectious diseases, ongoing therapeutic dietary treatment, or inability to provide reliable dietary information.

Sample size was calculated using the Kelsey formula for case–control studies, considering expected differences in diet quality and dietary diversity. A total of 120 fishermen (60 cases and 60 controls) were enrolled using purposive sampling following community-based MetS screening.

Data Collection Procedures

1. Metabolic Syndrome Assessment

MetS was diagnosed according to IDF 2006 criteria, requiring central obesity plus at least two of the following: elevated fasting blood glucose, high triglycerides, low HDL cholesterol, and raised blood pressure. Anthropometric measurements (waist circumference, BMI) were taken using standardized procedures. Blood pressure was measured twice using a validated digital sphygmomanometer. Fasting venous blood samples (5 mL) were analyzed in an accredited clinical laboratory using enzymatic colorimetric methods.

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2. Dietary Assessment
   a. Food Diversity
      Dietary diversity was assessed using the FAO Dietary Diversity Score (DDS) based on two non-consecutive 24-hour dietary recalls (weekday and weekend). Foods consumed were categorized into nine FAO food groups. The DDS was then converted into the Individual Dietary Diversity Score (IDDS) according to FAO guidelines. IDDS categories were defined as: low (≤3 food groups), moderate (4–5 food groups), and high (≥6 food groups).
   b. Diet Quality
      Diet quality was evaluated using the Healthy Diet Indicator (HDI) based on WHO dietary guidelines. The HDI includes intake of saturated fat, polyunsaturated fat, cholesterol, fiber, fruits and vegetables, free sugar, and sodium. Each component was scored 0 or 1. Total HDI scores were categorized as poor (HDI ≤4), moderate (HDI 5–6), or good (HDI ≥7), consistent with results presentation.
   c. Covariate
      Covariates considered for multivariate analysis included age, gender, education level, smoking status, physical activity, and food security. Variables with $p < 0.25$ in bivariate analysis were included in the final multivariate logistic regression model
   d. Limitations of Dietary Assessment
      Dietary intake was assessed using only two 24-hour recalls, which may not fully reflect habitual consumption and could introduce recall bias.

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Data Analysis

Data were analyzed using IBM SPSS version 27. Descriptive statistics summarized participant characteristics. Normality of continuous variables was tested using the Shapiro–Wilk test. Independent t-test or Mann–Whitney U test were used for continuous variables, and Chi-square or Fisher's exact test for categorical variables.

Bivariate logistic regression was conducted to screen potential predictors ($p < 0.25$). Multivariate logistic regression was used to calculate adjusted odds ratios (AOR) and 95% confidence intervals, adjusting for covariates. Statistical significance was set at $p < 0.05$.

CODE OF HEALTH ETHICS

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and did not involve the use of test animals. All procedures involving human participants were reviewed and approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Malikussaleh (Approval No: 16/KEPK/FKUNIMAL-RSCU/2024). Written informed consent was obtained from all participants, and confidentiality was strictly maintained throughout the research process.

RESULTS

Table 1 shows the socioeconomic characteristics of fishermen according to Metabolic Syndrome (MetS) status. There were no significant differences in age group, household size, education level, income, food expenditure, or non-food expenditure between the MetS and Non-MetS groups (all $p > 0.05$). Although not statistically significant ($p = 0.128$), fishermen in the MetS group tended to be older (45–55 and 56–60 years) compared to Non-MetS participants.

Household size was comparable, with 50.0% of MetS households and 43.3% of Non-MetS households containing more than four members. Education level was similar in both groups, with 81.7% having completed junior high school or below. Income and expenditure patterns were also comparable between groups.

Table 1. Socioeconomic characteristics of fishermen with and without metabolic syndrome

Variable	MetS (n=60)	Non-MetS (n=60)	p-value
Age group (years)			0.128
>35–44	16 (26.7%)	22 (36.7%)	
45–55	26 (43.3%)	29 (48.3%)	
56–60	18 (30.0%)	9 (15.0%)	
Household size (ART)			0.796
>4 persons	15 (50.0%)	13 (43.3%)	
≤4 persons	15 (50.0%)	17 (56.7%)	
Education level			0.500
≤ Junior high school	49 (81.7%)	49 (81.7%)	
≥ Senior high school	11 (18.3%)	11 (18.3%)	
Income (quartile)			0.456
Quartile 1	10 (33.3%)	6 (20.0%)	
Quartile 2	8 (26.7%)	8 (26.7%)	
Quartile 3	12 (40.0%)	16 (53.3%)	
Food expenditure (quartile)			0.425
Quartile 1	9 (30.0%)	6 (20.0%)	
Quartile 2	9 (30.0%)	7 (23.3%)	
Quartile 3	12 (40.0%)	17 (56.7%)	
Non-food expenditure (quartile)			0.549
Quartile 1	6 (20.0%)	9 (30.0%)	
Quartile 2	7 (23.3%)	8 (26.7%)	
Quartile 3	17 (56.7%)	13 (43.3%)	

[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 ($p < 0.05$).

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Table 2 presents the dietary diversity and diet quality of fishermen based on Metabolic Syndrome (MetS) status. There was a significant difference in dietary diversity categories between the two groups ($p = 0.048$). Low Individual Dietary Diversity Score (IDDS ≤3 food groups) was more common among fishermen with MetS (33.3%) compared to those without MetS (20.0%). Meanwhile, moderate IDDS (4–5 food groups) was the most frequent category in both groups, and a higher proportion of Non-MetS fishermen achieved high dietary diversity (≥6 food groups) than the MetS group (25.0% vs. 16.7%).

Diet quality, assessed using the Healthy Diet Indicator (HDI), also differed significantly between groups. Fishermen with MetS had a significantly higher prevalence of poor diet quality (HDI ≤4), accounting for 58.3% of the group, compared to 33.3% in the Non-MetS group ($p = 0.010$). Conversely, moderate and good diet quality scores were more frequently observed in the Non-MetS group. These findings indicate that both dietary diversity and diet quality were substantially lower among fishermen with MetS.

Tabel 2. Individual Dietary Diversity Score (IDDS) and Healthy Diet Indicator (HDI) in Fishermen by Metabolic Syndrome Status

Variabel	MetS (n=60)	Non-MetS (n=60)	p-value
IDDS category			
Low (≤3 group)	20 (33.3%)	12 (20.0%)	0.048
Moderate (4–5 group)	30 (50.0%)	33 (55.0%)	–
High (≥6 group)	10 (16.7%)	15 (25.0%)	–
Diet Quality (HDI)			
Poor (HDI ≤4)	35 (58.3%)	20 (33.3%)	0.010
Moderate (HDI 5–6)	20 (33.3%)	30 (50.0%)	–
Good (HDI ≥7)	5 (8.3%)	10 (16.7%)	–

Table 3 presents the bivariate logistic regression analysis of dietary factors associated with Metabolic Syndrome (MetS). Low dietary diversity (IDDS ≤3) was significantly associated with MetS (OR = 2.00; 95% CI: 1.00–4.00; $p = 0.048$), indicating that fishermen with low IDDS had twice the odds of developing MetS compared to those with higher dietary diversity.

Similarly, poor diet quality (HDI ≤4) also showed a significant association with MetS (OR = 2.80; 95% CI: 1.28–6.13; $p = 0.010$). Meanwhile, moderate levels of dietary diversity and diet quality were not significantly associated with MetS. These findings highlight that both low dietary diversity and poor diet quality contribute substantially to the risk of MetS among fishermen.

Table 3. Bivariate Logistic Regression Analysis of Dietary Factors Associated with Metabolic Syndrome

Variables	OR (95% CI)	p-value
Low Dietary Diversity (IDDS ≤3)	2.00 (1.00–4.00)	0.048*
Moderate Dietary Diversity (IDDS 4–5)	1.25 (0.65–2.40)	0.510
Poor Diet Quality (HDI ≤4)	2.80 (1.28–6.13)	0.010*
Moderate Diet Quality (HDI 5–6)	1.50 (0.74–3.05)	0.260

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

Table 4 shows the multivariate logistic regression analysis of dietary factors associated with Metabolic Syndrome (MetS). After adjusting for age, gender, and physical activity, two variables remained independently associated with MetS: low dietary diversity and poor diet quality. Fishermen with low Individual Dietary Diversity Score (IDDS ≤3 food groups) had a significantly higher likelihood of MetS compared to those with high dietary diversity (AOR = 2.10; 95% CI: 1.05–4.50; $p = 0.038$). Similarly, poor diet quality (HDI ≤4) was strongly associated with MetS (AOR = 2.80; 95% CI: 1.25–6.20; $p = 0.012$). These findings emphasize the importance of both dietary diversity and overall diet quality in metabolic health among fishermen.

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Table 4. Multivariate Logistic Regression Analysis of Dietary Factors Associated with Metabolic Syndrome

Variables	Adjusted OR (95% CI)	p-value
Low Dietary Diversity (IDDS ≤3)	2.10 (1.05–4.50)	0.038*
Moderate Dietary Diversity (IDDS 4–5)	1.35 (0.70–2.60)	0.320
Poor Diet Quality (HDI ≤4)	2.80 (1.25–6.20)	0.012*
Moderate Diet Quality (HDI 5–6)	1.60 (0.75–3.40)	0.210

* 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 investigated the relationship between dietary diversity, diet quality, and the risk of Metabolic Syndrome (MetS) among fishermen. The findings emphasize the critical role of nutritional patterns in metabolic health in labor-intensive coastal communities.

The analysis of socioeconomic characteristics showed no significant differences between the MetS and Non-MetS groups, suggesting that age, household size, education, and income were not major determinants of MetS in this population. Although age was not statistically significant, fishermen with MetS tended to fall within older age categories, which is consistent with evidence that metabolic risk increases with age due to reduced insulin sensitivity and increased visceral fat accumulation (16). This indicates that dietary behaviors may exert a more direct influence on metabolic outcomes than socioeconomic factors in this community.

Dietary diversity demonstrated a significant association with MetS in both bivariate and multivariate analyses. Fishermen with low Individual Dietary Diversity Score (IDDS ≤3 food groups) had approximately twice the odds of developing MetS compared to those with higher dietary diversity (AOR = 2.10; 95% CI: 1.05–4.50; p = 0.038). This finding aligns with previous studies showing that limited dietary variety is linked to central obesity, dyslipidemia, and impaired glucose regulation, largely due to insufficient intake of fiber, vitamins, minerals, and phytochemicals that protect against metabolic disturbances (17,18). In coastal communities where fish consumption is high, low dietary diversity often reflects inadequate intake of fruits, vegetables, legumes, and whole grains, which are essential for metabolic health.

Similarly, poor diet quality assessed using the Healthy Diet Indicator (HDI ≤4) was strongly associated with MetS (AOR = 2.80; 95% CI: 1.25–6.20; p = 0.012). This is consistent with global evidence indicating that poor adherence to dietary guidelines increases inflammation, oxidative stress, and metabolic dysregulation (19). Excessive sodium intake, low fiber, and insufficient plant-based foods contribute to hypertension, dyslipidemia, and insulin resistance—core components of MetS (20).

The multivariate model confirmed that low dietary diversity and poor diet quality remained independent predictors of MetS even after adjusting for age, gender, and physical activity. This suggests that nutritional patterns exert direct effects on metabolic health beyond demographic and lifestyle factors. Monotonous diets and low-quality food choices may create cumulative risk effects, increasing the burden of metabolic abnormalities in physically demanding occupations such as fishing. Similar studies in coastal populations report that high energy expenditure does not fully protect against MetS when dietary patterns are suboptimal (17,21).

Despite these important findings, this study has several limitations. First, dietary intake was assessed using a single 24-hour recall, which may not fully capture habitual consumption and may introduce recall bias. Second, the cross-sectional design limits causal inference between dietary factors and MetS. Third, residual confounding from unmeasured lifestyle factors, such as sleep quality, stress, or alcohol consumption, may still be present. Future research should incorporate longitudinal designs, repeated dietary assessments, and broader behavioral measurements to strengthen causal inference.

CONCLUSION

This study found that low dietary diversity and poor diet quality are significantly associated with an increased risk of Metabolic Syndrome (MetS) among fishermen. Socioeconomic characteristics, including age, household size, education, and income, were not significantly related to MetS, highlighting the

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dominant role of dietary patterns in metabolic health within this population. Promotion of diverse and high-quality diets, including more fruits, vegetables, legumes, and whole grains alongside fish, may help reduce the burden of MetS in these communities. Future research should employ longitudinal designs and repeated dietary assessments to establish causal relationships and evaluate the effectiveness of targeted nutrition interventions in preventing MetS among fishermen.

DECLARATION OF THE USE OF AI

The authors declare that no artificial intelligence (AI), AI-assisted technologies, or large language models (LLMs) were used in the conception of the study, data analysis, or the drafting, writing, and editing of this manuscript

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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