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# The Relationship between Energy Intake and Blood Glucose Levels with Total Cholesterol Levels in Diabetes Mellitus Patients at the Working Area of Mandala Community Health Center

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## ABSTRACTS

Diabetes mellitus is among the four main priorities in non-communicable diseases. In 2024, Indonesia ranked 5th out of 10 countries with the highest number of diabetes mellitus cases, totaling 20.4 million people. Modifiable risk factors for diabetes mellitus include an unhealthy diet and elevated total cholesterol levels. Data from the 2023 Indonesian Health Survey showed that 11.7% of the population had high total cholesterol levels. This study aims to determine the relationships among energy intake, blood glucose levels, and total cholesterol levels among patients with diabetes mellitus in the working area of Mandala Health Center. This study employed a cross-sectional design and purposive sampling, involving 48 patients with diabetes mellitus. Data collection was conducted through interviews, questionnaires, and capillary blood sampling. Data were analyzed univariately, bivariately using Spearman's Rank test, and multivariately using logistic regression. Bivariate analysis showed a relationship between energy intake and total cholesterol levels in diabetes patients (p=0.001; r=0.459), as well as between blood glucose levels and total cholesterol levels (p=0.003; r=0.422). Multivariate analysis showed that energy intake and blood glucose levels were not associated with total cholesterol levels in patients with diabetes mellitus (very low intake p=0.999; low intake p=0.999; adequate intake p=0.999; excessive intake p=0.558; blood glucose levels p=0.057).



## ARTICLE INFO

***Article History:***

*Received 18 May 2025*

*Revised 05 Jul 2025*

*Accepted 15 Sep 2025*

*Available online 01 Nov 2025*

***Keyword:***

*Blood Glucose Level,*

*Diabetes Mellitus,*

*Energy Intake,*

*Total Cholesterol Level*

## 1. INTRODUCTION

Diabetes mellitus is a chronic disease that occurs when the pancreas does not produce enough insulin or when the body cannot effectively use insulin. Diabetes mellitus is a significant public health problem and is included among the four main priorities of non-communicable diseases that are of global concern. Over the past few decades, the number of cases and the prevalence of diabetes have continued to increase (WHO, 2016).

The global prevalence of diabetes among individuals aged 20–79 years reached 589 million in 2024, with a prevalence rate of 11.1%. Based on data from Southeast Asia, the number of diabetes cases in 2024 reached 107 million, with a prevalence of 10.8%. In 2024, Indonesia ranked 5th among the 10 countries with the highest number of diabetes mellitus cases, totaling 20.4 million people (Atlas, 2015). The 2023 Indonesian Health Survey (SKI) reported that 2.2% of the population aged ≥15 years had been diagnosed with diabetes mellitus by a physician. In North Sumatra Province, the prevalence of diabetes mellitus based on physician diagnosis was recorded at 1.9% (Ministry of Health RI, 2023). According to the Medan Health Office (2023), there were 42,380 patients with diabetes mellitus. Data from Mandala Health Center in 2024 reported 759 patients with diabetes mellitus, accounting for 22.5%.

Modifiable risk factors for diabetes mellitus include overweight, lack of physical activity, hypertension, unhealthy diet, and dyslipidemia (Perkeni, 2021b). Dyslipidemia is a condition characterized by an increase or decrease in plasma lipid fractions. One abnormality in lipid fractions is elevated total cholesterol levels (Perkeni, 2021c). Cholesterol is a type of fat found in the body, produced naturally by the liver, or obtained from food (Anies, 2023). The prevalence of high total cholesterol levels in Indonesia shows that 11.7% of the population has elevated cholesterol (Ministry of Health RI, 2023). A study conducted at Royal Prima Hospital in Medan reported that the average fasting blood glucose level among patients with diabetes mellitus was 230.70 mg/dL, followed by an average total cholesterol level of 219.73 mg/dL (Michille et al., 2022).

High blood glucose levels increase cholesterol levels because insulin resistance prevents cells from effectively using glucose. This condition triggers lipolysis, whereby triglycerides in adipose tissue are broken down into free fatty acids (Pal & Méndez-Sánchez, 2023). Excess free fatty acids enter the liver, are converted back into triglycerides, and are packaged into Very Low-Density Lipoprotein (VLDL) (Pirahanchi et al., 2023). At the same time, reduced insulin activity decreases the function of Lipoprotein Lipase (LPL), thereby inhibiting the breakdown of VLDL and Low-Density Lipoprotein (LDL). As a result, VLDL and LDL accumulate in the blood, increasing cholesterol levels (Van Zwol et al., 2024).

Cholesterol levels are influenced not only by blood glucose levels but also by energy intake. In patients with diabetes mellitus, insulin resistance causes the body to switch to fat as an energy source, triggering lipolysis, in which triglycerides in adipose tissue are broken down into free fatty acids and glycerol. Excess free fatty acids then enter the liver, are reconverted into triglycerides, and subsequently into VLDL, which is released into the bloodstream. This process causes lipoproteins containing cholesterol to accumulate in the blood, thereby increasing blood cholesterol levels (Hall & Hall, 2020).

## 2. METHODS

### 2.1. Place and Time of Research

This research was conducted at the Mandala Community Health Center, located on Jalan Cucak Rawa, Tegal Sari Mandala II, Medan Tembung District, Medan City, from July to August 2025.

DOI: http://dx.doi.org/10.17509/xxxx.vxix
p- ISSN 2775-8400 e- ISSN 2775-9857

### 2.2. Population and Sample

The study population comprised 111 patients with diabetes mellitus who visited the Community Health Center in April 2025. Sampling in this study was conducted using purposive sampling, with a total of 48 participants with diabetes mellitus.

### 2.3. Research Design

This research design used a cross-sectional design. Cross-sectional means that each research subject is observed only once, and the measurements of the subject's variables are taken simultaneously.

### 2.4. Data Collection Technique

Respondent characteristics data were collected through interviews using questionnaires, covering age, sex, education, occupation, and income. Energy intake data were obtained through interviews conducted by enumerators using a 2 × 24-hour food recall form, covering both weekends and weekdays, and categorized according to the Ministry of Health of the Republic of Indonesia (2014) as very low intake, low intake, adequate intake, and excessive intake. The average energy intake over two days was divided by each respondent's energy requirement and multiplied by 100%. Respondents' energy requirements were estimated in this study using the formula from Perkeni (2021b).

Blood glucose data were obtained under fasting conditions, with capillary blood sampling using the Easy Touch GCU device by health workers at the Community Health Center (Puskesmas). Blood glucose levels were categorized according to Perkeni (2021a) as low, normal, and high. Total cholesterol data were obtained by health workers at the Community Health Center through capillary blood sampling using the Easy Touch GCU device, and categorized according to Perkeni (2021c) as standard or high.

### 2.5. Data Analysis Techniques

Data analysis used Statistical Product and Service Solutions (SPSS) software version 26. Data on respondent characteristics, energy intake, blood glucose levels, and total cholesterol levels were analyzed univariately through descriptive statistics and frequencies. Data on energy intake and total cholesterol levels, and on blood glucose levels and total cholesterol levels, were analyzed bivariately using crosstabs and Spearman's rank correlation. Data on energy intake, blood glucose levels, and total cholesterol were analyzed multivariately using logistic regression.

## 3. RESULTS

### 3.1. Univariate Analysis

#### 3.1.1. Respondent Characteristics

Respondent characteristics data from **Table 1** are dominated by female gender (68.8%), respondent age is dominated by 55-64 years (37.5%), respondent education level is dominated by college graduates (47.9%), respondent occupation is dominated by homemakers (35.4%), and respondent income level is dominated by no income (35.4%).

**Table 1.** Distribution of Respondent Characteristics.

| No. | Characteristics | n | % |
|---|---|---|---|
| **1.** | **Gender** | | |
| | Male | 15 | 31,2 |
| | Female | 33 | 68,8 |

DOI: http://dx.doi.org/10. 17509/xxxxt.vxix
p- ISSN 2085-9783 e- ISSN 2549-6123

| | | | |
|---|---|---|---|
| | **Total** | **48** | **100** |
| **2.** | **Age** | | |
| | 35-44 years | 8 | 16,7 |
| | 45-54 years | 10 | 20,8 |
| | 55-64 years | 18 | 37,5 |
| | ≥65 years | 12 | 25 |
| | **Total** | **48** | **100** |
| **3.** | **Last Education Level** | | |
| | Elementary school/equivalent | 2 | 4,2 |
| | Junior high school/equivalent | 4 | 8,3 |
| | Senior high school/equivalent | 19 | 39,6 |
| | College/University/Equivalent | 23 | 47,9 |
| | **Total** | **48** | **100** |
| **4.** | **Occupation** | | |
| | Unemployed/Housewife | 17 | 35,4 |
| | Retired | 13 | 27,1 |
| | Civil Servant/Police/Army/State-Owned Enterprises | 3 | 6,3 |
| | Private Employee | 3 | 6,3 |
| | Entrepreneur/Self-employed | 12 | 25,0 |
| | **Total** | **48** | **100** |
| **5.** | **Income** | | |
| | No Income | 17 | 35,4 |
| | Low (<Rp. 1.500.000) | 5 | 10,4 |
| | Medium (Rp. 1.500.000-3.500.000) | 13 | 27,1 |
| | High (>Rp. 3.500.000) | 13 | 27,1 |
| | **Total** | **48** | **100** |

### 3.1.2. Respondent Characteristics

Based on the research results in **Table 2**, the highest energy intake category was very low, at 29.2%. The minimum energy sufficiency was 55%, and the maximum was 163%, with an average of 96.75%.

**Table 2.** Distribution of Respondents' Energy Intake.

| No. | Category | N | % |
|---|---|---|---|
| 1. | Very Low | 14 | 29,2 |
| 2. | Low | 13 | 27,1 |
| 3. | Adequate | 10 | 20,8 |
| 4. | High | 11 | 22,9 |
| | **Total** | **48** | **100** |
| | **Min-Max** | **55-163** | |
| | **Mean ± SD** | **96,75±29,502** | |

### 3.1.3. Blood Glucose Levels

Based on the research results in **Table 3**, the highest glucose level category was high, at 54.2%. The minimum fasting blood glucose level was 90 mg/dL, the maximum was 421 mg/dL, and the average was 152.44 mg/dL.

**Table 3.** Distribution of Respondents' Glucose Levels.

| No. | Category | n | % |
|---|---|---|---|
| 1. | Low | 0 | 0 |

DOI: http://dx.doi.org/10.17509/xxxx.vxix
p- ISSN 2775-8400 e- ISSN 2775-9857

| | | | |
|---|---|---|---|
| 2. | Normal | 22 | 45,8 |
| 3. | High | 26 | 54,2 |
| **Total** | | **48** | **100** |
| **Min-Max** | | **90-421** | |
| **Mean ± SD** | | **152,44±60,499** | |

### 3.1.3. Total Cholesterol Level

Based on the research results in **Table 4**, the highest cholesterol level was 70.8%. The minimum total cholesterol level was 152 mg/dL, the maximum was 332 mg/dL, and the average was 223.15 mg/dL.

**Table 4.** Distribution of Respondents' Total Cholesterol Levels.

| No. | Category | n | % |
|---|---|---|---|
| 1. | Normal | 14 | 29,2 |
| 2. | High | 34 | 70,8 |
| **Total** | | **48** | **100** |
| **Min-Max** | | **152-332** | |
| **Mean ± SD** | | **223,15±44,892** | |

### 3.2. Bivariate Analysis

### 3.2.1. The Relationship Between Energy Intake and Total Cholesterol Levels in Diabetes Patients

The results of the study, as seen in **Table 5**, indicate that 22.9% of respondents with high total cholesterol levels had higher energy intake. The Rank-Spearman correlation analysis yielded a p-value of 0.001 and an r-value of 0.459.

**Table 5.** The Relationship Between Energy Intake and Total Cholesterol Levels.

| No. | Energy Intake | Total Cholesterol Levels | | | | | |
|---|---|---|---|---|---|---|---|
| | | Normal | | High | | Total | |
| | | n | % | n | % | n | % |
| 1. | Very Low | 8 | 16,7 | 6 | 12,5 | 14 | 29,2 |
| 2. | Low | 4 | 8,3 | 9 | 18,8 | 13 | 27,1 |
| 3. | Adequate | 2 | 4,2 | 8 | 16,7 | 10 | 20,8 |
| 4. | High | 0 | 0,0 | 11 | 22,9 | 11 | 22,9 |
| **Total** | | **14** | **29,2** | **34** | **70,8** | **48** | **100** |
| ***Spearman Rank Correlation*** | | **R** | | | | **0,459** | |
| | | ***P-value*** | | | | **0,001** | |

### 3.2.2. The Relationship Between Glucose Levels and Total Cholesterol Levels in Diabetes Patients

The study results, shown in **Table 6**, indicate that 47.9% of respondents with high cholesterol also had high blood glucose levels. Based on Spearman's rank correlation analysis, the p-value was 0.003, and the r-value was 0.422.

**Table 6.** Relationship between Glucose Levels and Total Cholesterol Levels.

| No. | Glucose Levels | Total Cholesterol Levels | | | | | |
|---|---|---|---|---|---|---|---|
| | | Normal | | High | | Total | |
| | | n | % | n | % | n | % |
| 1. | Low | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. | Normal | 11 | 22,9 | 11 | 22,9 | 22 | 45,8 |

DOI: http://dx.doi.org/10. 17509/xxxxt.vxix
p- ISSN 2085-9783 e- ISSN 2549-6123

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3. | High | 3 | 6,3 | 23 | 47,9 | 26 | 54,2 |
| **Total** | | **14** | **29,2** | **34** | **70,8** | **48** | **100** |
| ***Spearman Rank Correlation*** | | | | **R** | | | **0,422** |
| | | | | ***P-value*** | | | **0,003** |

### 3.3. Multivariate Analysis

Based on the results of the logistic regression test in **Table 7**, it was found that energy intake and blood glucose levels were not related to total cholesterol levels in diabetes sufferers (very low energy intake p=0.999; low energy intake p=0.999; appropriate energy intake p=0.999; excess energy intake p=0.558; blood glucose levels p=0.057).

**Table 7.** Multivariate Analysis Results.

| No. | Variable | *P-value* | *Odds Ratio* | 95% CI | *Negelkerke R-Square* |
|---|---|---|---|---|---|
| 1. | Energy Intake (Very Low) | 0,999 | | | |
| 2. | Energy Intake (Low) | 0,999 | | | |
| 3. | Energy Intake (Adequate) | 0,999 | | | 0,420 |
| 4. | Energy Intake (High) | 0,558 | | | |
| 5. | Glucose Levels | 0,057 | 4,642 | 0,958– 22,497 | |

## 4. DISCUSSION

### 4.1. Respondent Characteristics

The gender distribution of diabetes patients in this study showed that females (68.8%) were more prevalent than males (31.3%). In this study, the number of diabetes and high cholesterol cases was higher among females, which was influenced by the unequal sample composition, as female patients visited the Community Health Center (Puskesmas) more frequently than males. Beyond respondent composition factors, in women, the transition from the reproductive phase to menopause is marked by a decline in estrogen production, which increases hepatic lipase activity (Ariadi et al., 2019).

The age distribution in this study was dominated by the elderly (55–64 years), accounting for 37.5%. Data from the 2023 Indonesian Health Survey (SKI) showed that the highest prevalence of high cholesterol levels occurred in the 55–64 age group, at 21.2%. Increasing age leads to a decline in estrogen and testosterone levels, thereby reducing hormonal regulation of body fat distribution (Michille et al., 2022).

Respondents' educational background was dominated by university graduates, accounting for 47.9%. Data from the 2023 Indonesian Health Survey (SKI) indicated that the highest prevalence of diabetes was found among individuals with D1/D2/D3/University education (2.9%), while the highest prevalence of high cholesterol levels was observed among those with D1/D2/D3 education (15.4%) and university graduates (15.1%). Education level may influence physical activity due to occupational demands. Individuals with higher education generally work in jobs requiring less physical activity compared to those with lower education (Arania et al., 2021; Rosadi et al., 2024).

The most significant proportion of respondents' occupations fell into the unemployed/housewife category (35.4%). Household routines are mainly carried out indoors, which allows for more rest time. Individuals with limited physical activity may develop abnormal lipid profiles, particularly among patients with diabetes (Michille et al., 2022; Yang et al., 2024).

DOI: http://dx.doi.org/10.17509/xxxx.vxix
p- ISSN 2775-8400 e- ISSN 2775-9857

Respondents' income was predominantly in the non-income category (35.4%), as the majority were unemployed or homemakers. Those who were unemployed had limited income, relying solely on family members' earnings, resulting in restricted food choices and simple meals. Income is associated with one's ability to access health check-ups, food provision, and medical treatment (Faizal et al., 2024).

### 4.2. Energy Intake

Based on the study results, the most common energy intake category was very low intake, accounting for 29.2%. The minimum adequacy of energy intake was 55%, the maximum was 163%, and the average was 96.75%. The findings showed that only a small proportion of respondents had adequate energy intake (20.8%). Energy requirements in patients with diabetes mellitus are influenced by ideal body weight derived from height, age, sex, stress factors, physical activity, and nutritional status (Perkeni, 2021b). These factors determine the amount of energy to be consumed. When energy intake exceeds requirements, it is stored as body fat; insufficient intake may lead to energy deficits (National Academies, 2023).

### 4.3. Blood Glucose Levels

Based on the study results, the most common blood glucose level category was high, accounting for 54.2%. The minimum fasting blood glucose level was 90 mg/dL, the maximum was 421 mg/dL, and the average was 152.44 mg/dL. In patients with diabetes, fasting blood glucose levels are elevated due to insulin resistance, which is the most common cause of impaired glucose tolerance (Pant et al., 2019). The increase in fasting blood glucose levels may be influenced by diet, age, body fat concentration, glucose metabolism, medication use, lifestyle, and physical activity (Budiamal et al., 2020).

### 4.4. Total Cholesterol Level

Based on the study results, the most common cholesterol level category was high, accounting for 70.8%. The minimum total cholesterol level was 152 mg/dL, the maximum was 332 mg/dL, and the average was 223.15 mg/dL. Interviews with respondents who had high cholesterol levels revealed that they consumed cholesterol-rich foods such as coconut milk, fried foods, eggs, beef, and butter. Foods high in cholesterol include fast food, fatty meats, offal, egg yolks, ice cream, dried meat, and fried foods (Budianto & Akbar, 2022; Sulayfiyah et al., 2024). Respondents also reported rarely checking their cholesterol levels because cholesterol testing services at the Community Health Center (Puskesmas) were not always available, and testing outside the Puskesmas was considered expensive, making it difficult for respondents to monitor their cholesterol levels regularly.

### 4.5. The Relationship Between Energy Intake and Total Cholesterol Levels in Diabetes Patients

The study results showed that 22.9% of respondents with high total cholesterol levels had excessive energy intake. The findings also indicated that respondents with very low (12.5%), low (18.8%), and adequate (16.7%) energy intake also had high total cholesterol levels. This condition may occur because respondents' energy intake was calculated over only 2 days using the 2 × 24-hour food recall form, which does not reflect long-term dietary intake accumulation. Additionally, fasting conditions during cholesterol testing may have influenced total cholesterol levels.

When a person fasts, especially with insufficient energy intake, the body draws energy from fat, triggering lipolysis that breaks triglycerides into free fatty acids and glycerol (Nielsen et al., 2014; Lala et al., 2025). Excess free fatty acids enter the liver, are reconverted into

DOI: http://dx.doi.org/10. 17509/xxxxt.vxix
p- ISSN 2085-9783 e- ISSN 2549-6123

triglycerides, and incorporated into Very Low-Density Lipoprotein (VLDL), which contains high cholesterol levels. This process leads to elevated blood cholesterol levels (Malhotra et al., 2020; Chen et al., 2024). On the other hand, cholesterol is continuously synthesized in the liver, with approximately 70% of blood cholesterol produced endogenously, while the remainder comes from dietary sources (Anies, 2023).

Based on the Spearman Rank analysis, a p-value of 0.001 with an r-value of 0.459 was obtained, indicating a significant relationship between energy intake and total cholesterol levels among diabetes mellitus patients in the working area of Mandala Health Center. The correlation coefficient indicated a moderate positive association, meaning that higher energy intake was associated with higher total cholesterol levels. These findings are consistent with previous research, which also reported a relationship between energy intake and total cholesterol levels (p=0.016), with a moderate correlation strength (r=0.434) (Sugini, 2019).

In patients with diabetes mellitus, hyperglycemia and insulin resistance cause the body to switch to fat as an energy source, triggering lipolysis, in which triglycerides in adipose tissue are broken down into free fatty acids and glycerol. Excess free fatty acids then enter the liver, are reconverted into triglycerides, and subsequently into VLDL, which is released into the bloodstream. Low insulin levels also reduce lipoprotein lipase activity, an enzyme required to break down VLDL and LDL (Hirano, 2018). This condition leads to the accumulation of both cholesterol-containing lipoproteins in the blood, thereby increasing blood cholesterol levels (Hall & Hall, 2020).

### 4.6. The Relationship Between Glucose Levels and Total Cholesterol Levels in Diabetes Patients

The study found that 47.9% of respondents with high cholesterol also had high blood glucose levels. The findings further indicated that 22.9% of respondents with high cholesterol levels had elevated blood glucose. Among respondents with normal blood glucose levels but high cholesterol, they consumed cholesterol-rich foods such as offal, egg yolks, butter, coconut milk, fried foods, beef, and duck meat.

The study revealed that respondents had an average blood glucose level of 152.44 mg/dL and an average total cholesterol level of 223.15 mg/dL. In patients with diabetes, high fasting blood glucose levels are often accompanied by elevated cholesterol levels (Ramdhani et al., 2020; Oktaviana et al., 2022). The Spearman Rank analysis yielded a p-value of 0.003 with an r-value of 0.422, indicating a significant relationship between blood glucose levels and total cholesterol levels among diabetes mellitus patients in the working area of Mandala Health Center. The correlation coefficient demonstrated a moderate positive correlation, meaning that the higher the fasting blood glucose level, the higher the total cholesterol level of respondents (Puspitorini, 2017; Ramdhani et al., 2020). Consistent with this study, previous research also reported a p-value of 0.026, confirming a correlation between blood glucose levels and total cholesterol in patients with diabetes mellitus (Rakhmawati, 2024).

In patients with diabetes, blood glucose levels influence cholesterol levels through insulin resistance, which triggers lipolysis in adipose tissue to maintain energy supply, thereby breaking down triglycerides into free fatty acids and glycerol (Pal & Méndez-Sánchez, 2023). Excess free fatty acids enter the liver, are reconverted into triglycerides, and incorporated into Very Low-Density Lipoprotein (VLDL) (Pirahanchi et al., 2023). At the same time, low insulin levels reduce the activity of Lipoprotein Lipase (LPL), an enzyme required to break down VLDL and LDL, both of which contain high cholesterol levels (Shang & Rodrigues, 2024). This condition leads to elevated blood cholesterol levels (Van Zwol et al., 2024).

DOI: http://dx.doi.org/10.17509/xxxx.vxix
p- ISSN 2775-8400 e- ISSN 2775-9857

### 4.7. The Relationship Between Energy Intake and Blood Glucose Levels with Total Cholesterol Levels in Diabetes Patients

Based on the results of logistic regression analysis, energy intake and blood glucose levels were not associated with total cholesterol levels in diabetes patients (very low energy intake p=0.999; low energy intake p=0.999; adequate energy intake p=0.999; excessive energy intake p=0.558; blood glucose level p=0.057). This finding is consistent with previous research, which reported that energy intake was not significantly associated with cholesterol levels (p=0.404), as most respondents consumed energy below their requirements (Dewi & Sugiyanto, 2020).

The study findings also indicated no relationship between blood glucose levels and total cholesterol in patients with diabetes (p=0.307), which was attributed to the limited sample size at the hospital (Langitan et al., 2025). Similar research also reported no association between blood glucose levels and total cholesterol in patients with diabetes (p=0.728), which may be influenced by limited sample size, physical activity, and diabetes duration (Rahayu, 2020).

The analysis yielded a Nagelkerke R-square of 0.420, indicating that the independent variables explained 42% of the variation. In comparison, the remaining 58% was influenced by other variables not examined in this study, such as waist circumference, fiber intake, and physical activity.

## 5. CONCLUSION

In this study, bivariate analysis revealed relationships between energy intake and total cholesterol levels, and between blood glucose levels and total cholesterol levels, in patients with diabetes mellitus. The majority of respondents had high fasting blood glucose levels (54.2%), and high total cholesterol levels (70.8%), and only 20.8% met adequate energy intake. However, multivariate analysis showed that neither energy intake nor blood glucose levels was associated with total cholesterol levels. This may be due to the small sample size, which was limited to patients with diabetes mellitus visiting the Community Health Center (Puskesmas).

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DOI: http://dx.doi.org/10.17509/xxxx.vxix
p- ISSN 2775-8400 e- ISSN 2775-9857

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DOI: http://dx.doi.org/10. 17509/xxxxt.vxix
p- ISSN 2085-9783 e- ISSN 2549-6123