The Relationship Between BMI, Adequacy of Magnesium, Zinc, and Vitamin C with Blood Glucose Levels

Alya Ayu Alvitananda[1], Agus Sartono[2], Purwanti Susantini[3], Salsa Bening[4], Hersanti Sulistyaningrum[5*]

[1,2,3,4,5]Universitas Muhammadiyah Semarang, Semarang, Central Java 50273 Indonesia
hersanti@unimus.ac.id

Abstract. Pre-elderly have a risk of developing degenerative diseases such as hyperglycemia. Several factors that can increase blood glucose levels pre-elderly are obesity adequacy (magnesium, zinc, and vitamin C). An observational analytic study with a cross-sectional approach that aims to determine the relationship between Body Mass Index (BMI), adequacy of magnesium, zinc, and vitamin C with blood glucose levels when carried out on 32 obese pre-elderly as samples taken by simple random sampling technique. Variable relationship test is done by Spearman rank and Pearson correlation test. BMI is measured by BB(Kg)/TB^2(m^2). Magnesium, zinc, and vitamin C adequacy were measured using food recall 2x24 hours non-consecutively compared with the Nutrition Adequacy Rate (RDA)x100—blood glucose levels when measured with a glucometer. The results showed that there was a relationship between BMI and current blood glucose levels (p=0.022), there was no relationship between magnesium adequacy and temporary blood glucose levels (p=0.512), there was no relationship between zinc adequacy and temporary blood glucose levels (p=0.241), and there was relationship between vitamin C adequacy and blood glucose levels (p=0.007).

Keywords: BMI, Magnesium Adequacy, Zinc Adequacy, Vitamin C Adequacy, Blood Glucose Levels, Pre-Elderly.

1. Background

As one progresses toward old age, minor by little, a person will experience physiological, psychological, and social decline, which can increase the risk of developing major degenerative diseases, one of which is DM (Diabetes Mellitus) [26]. DM sufferers in Indonesia are estimated to have reached 8.4 million people in 2000 and will reach 21.3 million people in 2030 [31]. The most significant proportion of diabetes mellitus sufferers is in the age range 55-64 years, including in the pre-elderly category. There are more women (1.8%) than men (1.2%) [25]. Meanwhile, in Central Java, the prevalence of diabetes is

K. Nugraheni et al. (eds.), *Proceedings of the 2nd Lawang Sewu International Symposium on Health Sciences: Nutrition (LSISHSN 2023)*, Advances in Health Sciences Research 80,
https://doi.org/10.2991/978-94-6463-550-8_3

2.1%. In contrast, Semarang City with non-insulin diabetes is included in the highest ranking of non-communicable diseases with a total of 6,153 cases in community health centers, and FKTP (First Level Health Facilities) after hypertension is categorized based on the age of people living with non-insulin diabetes. Most people in Semarang City are in the 45-65 year age range [18].

One of the causes of increased glucose levels in pre-elderly and older people, which triggers DM, is obesity, which can be detected using anthropometric indicators, one of which is Body Mass Index (BMI). The higher a person's degree of obesity, the more adipocytes (fat) cells will increase. These adipocyte cells will produce pro-inflammatory cytokines and stimulate the production of free radicals, which causes insulin resistance and increases blood glucose levels [9]. Several studies also show the influence of micronutrients on blood glucose levels in diabetes mellitus patients. Several studies show low levels of the micronutrients Zinc (Zn) and Magnesium (Mg) are found in people with diabetes mellitus compared to healthy people. The pathogenesis of glucose intolerance and diabetes complications is closely related to zinc and magnesium deficiency [2]. Vitamin C is a vitamin micronutrient that also plays a positive role in regulating blood glucose. One study shows a significant relationship between Vitamin C and blood glucose levels [23].

In the results of the survey and data analysis of the Posyandu for the Elderly Group (POKSILA) Matahari, it was found that 78% of the pre-elderly members were included in the obese category with a certain degree of obesity, where 40 members were included in the obese category out of a total of 52 pre-elderly members. This is thought to be the result of several factors, the main factor being food consumption patterns, which still tend to prioritize macronutrients and ignore food sources of micronutrients. It was also found that 7% of diagnosed diabetes mellitus cases were experienced by obese members. Based on this background, researchers are interested in examining the relationship between Body Mass Index, Adequate Magnesium, Zinc, and Vitamin C with Current Blood Glucose Levels in Pre-Older Obesity Participants in the Posyandu for the Elderly Age Group (POKSILA) Matahari Mijen Permai Housing RW 7, Mijen District, Semarang City.

2. Method

This type of research is observational analytical research with a cross-sectional design. The research was conducted at Posyandu for the Elderly Group (POKSILA) Matahari Mijen Permai Housing RW 7, Mijen District, Semarang City, Central Java Province, in July 2021. The population in this study was all 40 obese pre-elderly people. Sampling using a simple random sampling technique by drawing lots resulted in 32 obese older people who met the inclusion and exclusion criteria. The inclusion criteria in this study were older people willing to voluntarily sign informed consent, while the exclusion criteria were respondents diagnosed with diabetes mellitus and suffering from acute illness. The data collected in this

research consists of primary and secondary data. The primary data in this study is data on the identity of pre-elderly people, height, weight, magnesium adequacy, zinc adequacy, Vitamin C adequacy, and blood glucose levels when pre-elderly people are obese.

In contrast, the secondary data is data on a general description of the research location, number of pre-elderly people, diagnosis of obesity, and DM obtained from the Matahari POKSILA report book. The instruments used were digital scales, microtoise, a 24-hour food recall form, a food photo book, and a glucometer. The method for collecting BMI (Body Mass Index) is by measuring body weight and height and then calculating based on the formula BB(Kg)/$TB^2(m^2)$, adequacy of magnesium, zinc, and Vitamin C obtained from direct interviews with research samples regarding food intake 2x24 Non-consecutive hours are then compared with the Nutritional Adequacy Rate (AKG) x 100. At the same time, blood glucose levels are measured using a glucometer. Data analysis was carried out using the SPSS Statistics Data Editor computer program. Data analysis uses univariate and bivariate tests, and univariate tests include tests used to describe BMI, magnesium adequacy, zinc adequacy, Vitamin C adequacy, and blood glucose levels when using frequency tables, average, median, standard deviation, and minimum-maximum values. Meanwhile, the bivariate test was carried out after the Kolmogorov Smirnov-Z normality test, then continued with the Spearman rank correlation test to see the relationship between Body Mass Index and Vitamin C with blood glucose levels during obesity and the Pearson correlation test to see the relationship between adequate magnesium and zinc and blood glucose levels when the elderly are obese.

3. Result and Discussion

Table 1. Characteristics of the Research Sample.

Respondents Characteristics	N	%
Age		
45-49	6	18,8
50-54	13	40,6
55-59	13	40,6
Sex		
Male	6	18,8
Female	26	81,3
Education		
Elementary graduated	3	3
Junior High School graduated	2	2
Highschool graduated	20	62,5
University graduated	5	15,6

Master Degree	2	6,3
Occupation		
Housewife	9	28,1
Civil Servant	6	18,8
Private Worker	6	18,8
Businessman	10	31,3
Occupation		
Ex-Civil Servant	1	3

Table 1. Shows the characteristics of pre-elderly based on age. Most pre-elderly are in the 50-59 age category, 26 people (81.2%). In Nur Latifah's (2020) research, it was stated that there was a significant relationship between age and fasting blood glucose levels, where the higher the age group of respondents, the greater the number of respondents who experienced hyperglycemia. Increasing a person's age will result in anatomical, physiological, and biochemical changes. Changes at the organ level will affect the decline in homeostatic function, such as insulin-producing pancreatic β cells, the nervous system, target tissue cells that produce glucose, and other hormones that can affect blood glucose levels [18].

Characteristics of pre-elderly people based on gender show that the number of pre-elderly women is five times more, namely 26 people (81.3%) than pre-elderly men. This is because women have a higher risk of obesity than men. According to Adriani (2012), women have a three times greater risk of becoming obese. Pre-elderly women generally have lower activity levels and lower metabolic processes during postmenopause. Women's metabolic rate at rest is 10% lower compared to men. Therefore, women tend to convert more fat after eating, while men convert more food into energy and muscle reserves.

The characteristics of pre-elderly education based on education show that the level of pre-elderly education is quite good because 27 people (84.3%) have a high school education or above. Highly educated people will more readily accept the information or message conveyed. This situation reflects that people's behavior towards DM disease is at risk of suffering from DM disease. This is per research results that show a relationship between the respondents' education level and the risk of DM [32].

The characteristics of pre-elderly people based on employment show that the types of work for pre-elderly people are pretty diverse, with the most common type of work being self-employed with ten people (31.3%). The type of work can influence a person's level of physical activity and income. Adequate physical activity in an individual can help improve blood circulation, control or reduce weight, and improve insulin sensitivity so that it can improve blood glucose levels [27]. A person's type of work can also determine or influence an individual's income and economic level, which also influences a person's food consumption patterns, which can be a factor in the occurrence of health problems. This is in line with research by Nugroho and Musdalifah [17], which states a relationship between economic level and the incidence of diabetes mellitus.

3.1. Univariat Test

Table 2. Distribution of Pre-Elderly based on Degree of Obesity (BMI Category).

Obesity Category	N	%
Pre Obesitas (BMI : 23-24,9 Kg/m^2)	5	21,9
Obesitas I (BMI : 25-29,9 Kg/m^2)	18	68,8
Obesitas II (BMI: ≥ 30 Kg/m^2)	9	9,4

Table 2 shows that the majority (56.3%) of obese pre-elderly people are in the first degree of obesity, 18 people. This could be due to the consumption patterns of pre-elderly people. Based on the results of the analysis of 2x24 hour non-consecutive food recall interviews, it is known that most pre-elderly people like to consume food, especially snacks that are high in calories, fat, and high in sugar. At the same time, pre-elderly people also drink drinks quite often. Sweet drinks such as tea, coffee, and syrup can increase weight. Other factors can also be influenced by the pre- elderly's exercise patterns, which are rarely done because they consider daily activities at home or work to be part of the exercise so they may be at high risk of obesity.

A person who is obese and genetically combined can result in insulin resistance and impaired glucose tolerance, which in turn can cause lipotoxicity, hyperinsulinemia, and glucotoxicity in pancreatic β cells, which fails insulin to maintain a sufficient balance of insulin levels to compensate for the effects of insulin resistance resulting in insulin levels blood glucose can increase and be diagnosed as diabetes mellitus [12].

Table 3. Distribution of Pre-Elderly Based on Magnesium Adequacy

Magnesium Sufficiency		
Lack (< 77 %)	24	75
Fit (≥ 77%)	8	25

Table 3 shows that most older people have insufficient magnesium, 24 people (75%). The average value of magnesium adequacy in the elderly is 63%, with a minimum adequacy of 24% and a maximum of 147%. Magnesium adequacy is lacking because the research sample mostly consumed magnesium food sources, especially vegetables and fruit, in portions that were less or still below the portion recommended by the World Health Organization (WHO), consisting of 250 grams of vegetables and 150 grams of fruit [21]. Several other factors that can influence magnesium adequacy include an individual's diet, which includes several things such as the type, source, and amount of food consumed daily (Persagi, 2009). This eating pattern can influence an individual's nutritional adequacy, which has a significant relationship with controlling a person's blood sugar levels [5].

Table 4. Distribution of Pre-Elderly Based on Zinc Adequacy.

Vitamin C Sufficiency		
Lack (< 77 %)	19	59,4
Fit (≥ 77%)	13	40,6

Table 4 shows that the majority of pre-elderly people have insufficient zinc, 24 people (75%). The average value of zinc adequacy in the elderly is 64%, with a minimum adequacy of 32% and a maximum of 148%. The insufficient zinc adequacy was due to the sample consuming food sources of zinc, especially protein, in portions and frequencies that were less than recommended. The guidelines for the contents of my plate (Ministry of Health of the Republic of Indonesia) recommend that food sources of protein (side dishes) that contain sufficient zinc content are 1/3 of ½ plate for each main meal, three times a day. The status of zinc adequacy in the body, apart from being directly influenced by food intake, can also be influenced by several other factors, including age, gender, pregnancy, the presence of acute infections and inflammation, diurnal variations, fasting status, hemolysis, mal-absorption syndrome, chronic disease status, and rate of tissue synthesis during growth. Insufficient zinc adequacy can also result from the inhibition of zinc absorption due to high levels of phytic acid in the food consumed, especially food from plant sources such as wheat, nuts, cereals, or foods that have high fiber content [4].

Table 5. Distribution of Pre-Elderly Based on Vitamin C Adequacy

Vitamin C Sufficiency		
Lack (< 77 %)	19	59,4
Fit (≥ 77%)	13	40,6

Table 5 shows that most pre-elderly people have insufficient Vitamin C sufficiency, namely 19 people (59.38%). The average value of Vitamin C adequacy for the elderly is 102%, with a minimum adequacy of 12% and a maximum of 410.33%. Insufficient Vitamin C adequacy is caused by the majority of respondents not consuming enough vegetables and fruit and not having a variety of types of food sources of Vitamin C consumed. Insufficient Vitamin C adequacy, apart from being influenced by sample consumption patterns, can also be influenced by the processing of food sources of Vitamin C using high temperatures, oxidization, dissolving in water, or being exposed directly to sunlight. This is because Vitamin C is not resistant to high temperatures, so the Vitamin C content in vegetables and fruit can be damaged or degraded, so the body does not get enough Vitamin C when consuming these foods [1].

Table 6. Distribution of Pre-Elderly Based on Current Blood Glucose Levels.

Temporary Blood Glucose Levels	n	%
Normal (<110 mg/ dL)	7	21,9
Pre Diabetic (110 -199 mg/dL)	22	68,8
Diabetic(≥200 mg/dL)	3	9,4

Table 6 shows that the majority of pre-elderly people are included in the pre-diabetes category, namely 22 people (68.75%). The average value of blood glucose levels during the research sample was 138.75 mg/dL, with a minimum value of 95 mg/dL and a maximum value of 235 mg/dL. This shows that the research sample can still limit glucose through food consumption patterns, but this has a risk of leading to diabetes. Temporary blood glucose levels can be influenced by several factors, including diet and physical activity, which have a significant relationship with instantaneous blood glucose levels [6]. Kurniyanianingsih's [13] research states a significant relationship between age, stress, and a high-carbohydrate diet on temporary blood glucose. There is also a significant relationship between BMI (p-value 0.001) and instantaneous blood glucose levels [15].

3.2. Bivariate Test

Relationship between Body Mass Index and Temporary Blood Glucose Levels

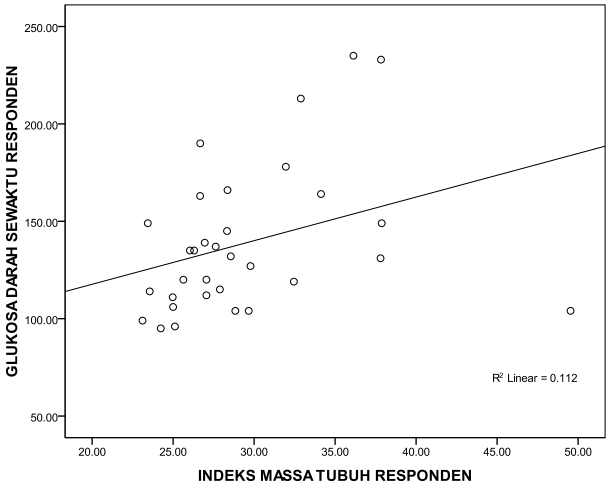

Fig. 1. Relationship between Body Mass Index and Temporary Blood Glucose Levels.

Figure 1 shows that there is a tendency that the higher the body mass index, the higher the blood glucose level will be, with a correlation coefficient (r) of 0.403. Based on the Spearman rank correlation test, the value of $p = 0.022$ ($p<0.05$) was obtained, so it can be concluded that there is a relationship between body mass index and temporary blood glucose levels. A person with a high BMI shows a higher degree of obesity, where they will have more fat tissue, which will cause body tissue and muscles to become increasingly resistant to insulin, mainly if the fat in a person's body is concentrated in the stomach (central obesity). This fat can block insulin's action by inhibiting sugar's transport into cells so that it collects in the blood circulation [29]. Fat works in the peripheral and central systems to inhibit the phosphorylation of insulin receptor substrate-1 (IRS-1), which results in inhibited glucose uptake and increased blood sugar levels [3]. These fat cells will also produce pro-inflammatory cytokines such as Interleukin I (IL-I) and tumor necrosis factor (TNF) and stimulate the production of free radicals such as ROS (reactive oxygen species), which cause insulin resistance, which causes an increase in blood glucose levels [9].

Harahap's research [10] shows a significant relationship between Body Mass Index (BMI) and blood glucose levels in people with diabetes mellitus. Excessive body mass index is a risk factor for high blood glucose levels in DM sufferers in Sisumut Village, Kotapinang District. Research on type 2 diabetes mellitus sufferers at the Gamping I Community Health Center concluded that there was a relationship between BMI and blood glucose levels in type 2 DM sufferers where the higher the BMI category (underweight, normal, overweight, and obese), the higher or worse the blood sugar levels in the body [11].

Relationship between Magnesium Adequacy and Temporary Blood Glucose Levels

Based on the Pearson correlation test, the value of $p = 0.512$ ($p>0.05$) was obtained, so it can be stated that there is no relationship between magnesium adequacy and temporary blood glucose levels. The absence of a relationship between magnesium adequacy and blood glucose could be due to the magnesium adequacy of most samples still being deficient. This can be analyzed from the non-consecutive 2x24-hour recalls where the research sample did not consume enough foods high in magnesium, especially vegetables. Lack of magnesium intake can affect its role in maintaining blood glucose homeostasis and activation factors involved in insulin sensitivity [16].

Magnesium is needed in the chemical reaction that allows insulin to deliver glucose into cells, pushing it into pathways that produce energy for the body. If there is insufficient magnesium to carry out the chemical reaction, insulin and glucose will increase in the bloodstream outside the cells [7]. This research is in line with research conducted by Wulandari [13], which stated that there was no relationship between magnesium intake and blood sugar levels in Type II Diabetes Mellitus Patients in the Inpatient Room at Tugurejo Regional Hospital, Semarang.

Relationship between Zinc Adequacy and Temporary Blood Glucose Levels

The p-value = 0.241 (p>0.05) is based on the Pearson test. The results of this study show no relationship between zinc adequacy and temporary blood glucose levels. This is due to the sample's consumption pattern of food sources of zinc, which is still relatively low in portion and frequency, so it can affect zinc's role in stimulating glucose absorption by free adipose cells. Low zinc will result in a high risk of DM because zinc is essential in insulin synthesis, storage, and secretion [28]. Zinc imbalance with decreased plasma can determine the deficiency of pancreatic beta cells to produce and secrete insulin. This cation deficit can affect the phosphorylation or dephosphorylation of one or more steps in insulin cell signaling. Zinc is also involved in antioxidants that can protect insulin from free radical attacks on cells. This can happen if the zinc in the body is in sufficient condition according to needs [20]. Research [24] also states no relationship between dietary compliance and zinc intake with GDP and GD2PP levels in patients with type 2 diabetes mellitus.

The absence of a relationship between the adequacy of magnesium and zinc with blood glucose levels sometimes shows that other factors can also influence blood glucose levels. Among these factors is the existence of several research samples with high blood glucose levels, such as (235 mg/dL) and sufficient magnesium adequacy (147%). Some pre-elderly people have pre-diabetic blood glucose levels (149 mg/dL) despite sufficient zinc adequacy (148.13%). In contrast, pre-elderly people have pre-diabetic blood glucose levels (149 mg/dL). People tend to consume higher levels of zinc and magnesium in food sources such as rice, which also contributes to the nutrient magnesium, and coffee and tea, which also contain the nutrient magnesium and zinc.

The intake of macronutrients consumed by the elderly is also influences because the body needs them in larger quantities. Among the intake of macronutrients are carbohydrates and fiber, which influence insulin's work in controlling blood glucose levels. Carbohydrate intake is the primary energy supplier in the form of glucose, which is converted in the body with the help of insulin. High-fat intake can also affect insulin sensitivity because it will reduce adiponectin, which is responsible for controlling insulin sensitivity, in the blood. Besides intake factors, current blood glucose levels can also be influenced by pre-elderly individual factors such as age, gender, obesity, food consumption patterns, stress levels, physical activity, education, and work.

Relationship between Vitamin C Adequacy and Temporary Blood Glucose Levels

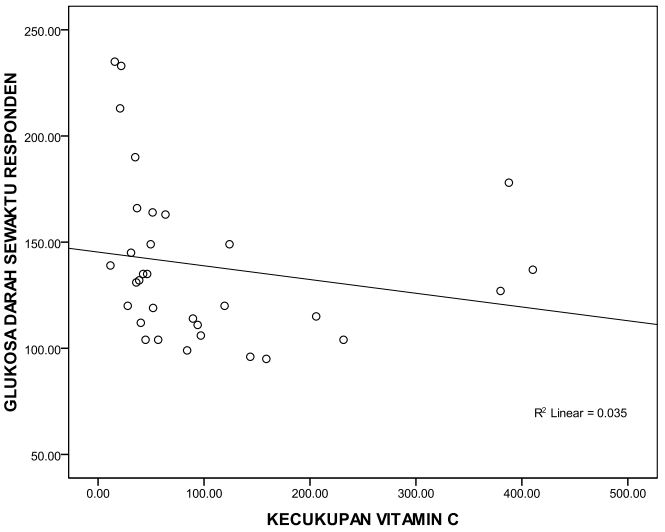

Fig. 2. Relationship between Vitamin C Adequacy and Temporary Blood Glucose Levels.

Figure 4 shows that there is a tendency that the higher the adequacy of Vitamin C, the lower the blood glucose level will be, with a correlation coefficient (r) of -0.469. Based on the Spearman rank correlation test, the value of $p = 0.007$ ($p<0.05$) was obtained, so it can be concluded that there is a relationship between Vitamin C adequacy and temporary blood glucose levels. Vitamin C, as a cofactor, can act as an antioxidant, which can be used to ward off free radicals in the body [22]. One of the pathologies of hyperglycemia is oxidative stress, which is caused by the number of free radicals in the body exceeding its capacity and causing fat peroxidation. Free radicals that cause damage to pancreatic β cells can be overcome with Vitamin C, which can overcome the risk of insulin resistance [14]. Vitamin C will donate its electricity to overcome the chain reaction in fat peroxidation [19]. Research [30] states that there is a relationship between Vitamin C intake and fasting blood sugar levels in diabetes mellitus patients at the Internal Medicine Polyclinic at RAA Soewondo Pati Hospital. Research [23] also states that there is a relationship between Vitamin C and blood glucose levels in patients treated for type 2 DM

4. Conclusion

The study results showed that most of the blood glucose levels in the pre-elderly population (68.75%) were pre-diabetic. Most pre-elderly BMIs (56.3%) are included in the category I

obesity. Most pre-elderly Magnesium Adequacies (75%) are in the deficient category. Most pre-elderly zinc adequacy (75%) is in the deficient category. Most of the pre-elderly's Vitamin C adequacy (59.38%) is deficient. There is a relationship between Body Mass Index and temporary blood glucose levels, no relationship between adequate magnesium and temporary blood glucose levels, no relationship between sufficient zinc and temporary blood glucose levels, and a relationship between sufficient vitamin C and temporary blood glucose levels.

References

1. Al-Baari, A.N., Pratiwi, A.B., Hasdar, M., Nurrahman, Nurhidajah, Rohadi, Sumardi: Pangan Untuk Sistem Imun. Edisi 1, Semarang: SCU Knowledge Media (2021)
2. Albertus, J.: Status mineral Seng (Zn) dan Magnesium (Mg) pada Penderita DM Tipe 2 dengan regulasi darah baik dan jelek Endokrin-Metabolik Penyakit Dalam. Tesis. Semarang: Universitas Diponegoro (2000)
3. Adnan, M., Mulyati, T., Isworo, J.K.: Hubungan Indeks Massa Tubuh (MT) Dengan Kadar Gula Darah Penderita Diabetes Mellitus (Dm) Tipe 2 Rawat Jalan Di Rs Tugurejo Semarang. Jurnal Gizi Universitas Muhammadiyah Semarang. 2 (1) : pp.18-24 (2013)
4. Adriani, M., Wirjatmadi, B.: Gizi & Kesehatan Balita: Peranan Mikro Zinc. Edisi 1, Jakarta : Kencana (2014)
5. Alianatasya, N., Khoiroh, S.: Hubungan Pola Makan dengan terkendalinya Kadar Gula Darah pada Penderita Diabtes Mellitus Tipe II di RSUD Abdul Wahab Sjahranie Samarinda. Borneo Student Research. 1 (3) : pp.1784 – 1790 (2020)
6. Amelia, R., Taiyeb, M., Idris, I.S.: Hubunngan Pola Makan dan Aktivitas Fisik terhadap Kadar Glukosa Darah Penderita Diabetes Mellitus di Wilayah Kera Puskesmas Sabbangparu Kabupaten Wajo. Prosiding Seminar Nasioal Biologi VI. Makassar, Indonesia. Hal. 620 – 630 (2019)
7. Dean, C.: The Magnesium Miracle. 2th ed, Amerika : Random House Publishing Group (2017)
8. Dinkes Kota Semarang.: Profil Kesehatan Kota Semarang Tahun 2016. Semarang : Dinas Kesehatan Kota Semarang (2016)
9. Gommers, L. M. M., Hoenderop, J. G. J., Bindels, R. J. M. & De Baaij, J. H. F.: Hypomagnesemia in Type 2 Diabetes : A Vicious Circle ? Diabetes. National Center for Biothecnolology Information. 65(1) : 3–13 (2016)
10. Harahap, A.P., Ariati, A., Siregar, Z.A.: Hubungan Indeks Massa Tubuh dengan Kadar Gula Darah Pada Penderita Diabetes Mellitus di Desa Sisimut, Kecamatan Kota Pinang. Ibnu Sina; Jurnal Kedokteran dan Kesehatan-Fakultas Kedokteran Universitas Islam Sumatera Utara. 19 (2): 81 – 86 (2020)

11. Hasanah, R.: Hubungan antara Status Gizi dengan Kadar Glukosa Darah pada Penderita Diabetes Mellitus Tipe II di Puskesmas Gamping I. Skripsi. Yogyakarta: Universitas Aisyiyah Yogyakarta (2018)
12. Hastuti, P.: Genetika Obesitas.Edisi 1, Yogyakarta: Universitas Gadjah Mada Press (2019)
13. Kurnianingsih, W.: Pengaruh Usia, Stres, Dan Diet Tinggi Karbohidrat Terhadap Kadar Glukosa Darah. Jurnal Ilmiah Rekam Medis Dan Informatika Kesehatan. 8 (1): 16-25 (2018)
14. Meerza, D., Iqbal S., Zaheer S., Naseem I.: Retinoids have therapeutic in type 2 diabetes. Nutrition. 3-11 (2016)
15. Megawati, Entianopa, Listiawaty R.: Hubungan IMT, Shift Kerja, dan Stress Kerja dengan Kadar Glukosa Darah Sewaktu Pada Karyawan di PT Persada Harapan Kahuripan Kabupaten Tebo Tahun 2020. Journal PDm Bengkulu (2020)
16. Multasih, E.S.: Hubungan Asupan Magnesium dengan Kadar Glukosa Darah pada Penderita Diabetes Mellitus Tipe Ii di Puskesmas Tawangsari Sukoharjo. Skripsi. Surakarta: Universitas Muhammadiyah Surakarta (2020)
17. Musdalifah dan Nugroho, P.S.: Hubungan Jenis Kelamin Dan Tingkat Ekonomi Dengan Kejadian Diabetes Melitus Di Wilayah Kerja Puskesmas Palaran Kota Samarinda Tahun 2019. Borneo Student Rsearch. 1(2) : 1238 – 1242 (2020)
18. Nadrati, B., Supriatna L.D.: Buerger Allen Exercise Dan Ankle Brachial Indeks (Abi) Pada Penyandang Diabetes Melitus. Edisi 1, Pekalongan : Penerbit NEM (2021)
19. Nimse, S.B., Pal D.: Free radicals, natural antioxidants, and their reaction mechanisms. Royal Society of Chemistry. 5 : 27986-28006 (2015)
20. Oguntibeju, O.: Diabetes Mellitus: Insights and Perspectives. Croatia: InTech (2013)
21. Permenkes RI No.41 Tahun 2014.: Pedoman Gizi Seimbang. Jakarta: Kementrian Kesehatan RI (2014)
22. Prihanto, A.A.: Reaksi Fisiko Kimia Produk Perikanan Tradisional. Edisi 1, Malang: UB Press (2017)
23. Purwaningtyastuti, R., Nurwanti, E., Huda, N.: Asupan Vitamin C Berhubungan dengan Kadar Glukosa Darah pada Pasien Rawat Jalan DM tipe 2. Jurnal Gizi dan Dietetik Indonesia. 5 (1): 44-49 (2017)
24. Ridwanto, M., Kusumawati, D., Kartika Sari, F.Y.: Hubungan Asupan Zinc dan Stres Psikologis dengan Kadar Glukosa Darah 2 Jam Pasca Puasa pada Pasien Diabetes Melitus Tipe 2. Jurnal Medika Indonesia. 1 (2): 10-16 (2020)
25. Riset Kesehatan Dasar (Riskesdas).: Badan Penelitian dan Pengembangan Kesehatan Kementerian RI tahun 2018. Jakarta: Kementrian Kesehatan RI (2018)
26. Riset Kesehatan Dasar (Riskesdas).: Badan Penelitian dan Pengembangan Kesehatan Kementerian RI tahun 2013. Jakarta: Kementrian Kesehatan RI (2013)

27. Supriyadi.: Panduan Praktis Skrining Kaki Diabetes Melitus. Edisi 1, Yogyakarta: Deepublish (2017)
28. T. Davis, I.J.: The Clinical Significance of the Essential Biological Metals. 1th ed, London: Butterworth-Heinemann (2013)
29. Tandra, H.: Segala Sesuatu yang Harus Anda Ketahui tentang DIABETES. Edisi 2, Jakarta: PT Gramedia Pustaka Utama (2017)
30. Wardani, N.K. Hubungan Asupan Vitamin C, Vitamin E dan Selenium dengan Kadar Gula Darah Puasa Pasien Diabetes Mellitus di Poliklinik Penyakit Dalam RSUD RAA Soewondo Pati. Skripsi. Semarang: Universitas Muhammadiyah Semarang (2018)
31. WHO.: Global report on diabetes. (http://apps.who.int/iris/bitstream/10665/). Diakses Juli 2021 (2016)
32. Widyasari, N.: Hubungan Karakteristik Responden dengan Risiko Diabetes Melitus dan Dislipidemia Kelurahan Tanah Kalikedinding. Jurnal Berkala Epidemiologi. 5 (1): 130 – 141 (2017)