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Fasting Glucose Level In Diabetes Mellitus Patients Using Glucometers With And Without Dry Cotton Swabs When Taking Capillary Blood

Lailatul Latifah Dian Kusuma Wardani[1], Juliana Christyaningsih[2*], Wisnu Istanto[3]
Department of Medical Laboratory Technology, Poltekkes Kemenkes Surabaya, Indonesia
Corresponding author: juliana.christy123@gmail.com

ABSTRACT
Errors in using glucometers can lead to inaccuracies in blood glucose measurement, ranging from 90%-97%. This study aims to determine the fasting glucose levels of diabetic patients measured using a glucometer in groups with and without the use of a dry cotton swab. This research used a quasi experimental design. The examination methods for the test materials included a glucometer and the GOD-PAP. The study population consisted of all diabetes mellitus patients undergoing laboratory tests at Wonolangan Probolinggo Hospital. A sample of 30 patients was taken. The mean fasting blood glucose level for the group with capillary blood samples taken with a dry cotton swab was 141.17 mg/dl. For the group with capillary blood samples taken without a dry cotton swab, the mean was 131.93 mg/dl. For venous blood samples with NaF anticoagulant tested using the GOD-PAP method, the mean was 145.63 mg/dl. The statistical test resulted in a significance value of 0.331 > 0.05. The Kruskal-Wallis test showed no significant difference between capillary blood samples with and without the dry cotton swab. However, in terms of health science, there is a difference in the glucose measurement results: the POCT glucose level compared to the gold standard method (GOD-PAP) had a difference of 9.24 mg/dl (for the group with a dry cotton swab) and a mean difference of 13.7 mg/dl (for the group without a dry cotton swab).

Keywords: Fasting glucose, Diabetes mellitus, Glucometer, Capillary blood

INTRODUCTION

Elevated blood glucose levels are a sign of a chronic condition known as diabetes mellitus (DM). DM is caused by a disruption in the metabolic system and the inability of the pancreas to produce insulin in the amounts needed by the body (Hananta and Muhammad, 2011) (Yusransyah, Stiani and Sabilla, 2022). Someone will be categorized as having DM (diabetes mellitus) if the result of a fasting plasma glucose laboratory test is greater than 126 mg/dl (Cosmas and Mbugi, 2024). Fasting in this context refers to a state where a person has not consumed calories for at least eight hours. To monitor the outcomes of diabetes mellitus treatment, it can be done using a glucometer device (PERKENI, 2021b) .

The chronic disease that was the third leading cause of death in Indonesia in 2017 is diabetes mellitus (Hidayat *et al.*, 2022). The Institute for Health Metrics and Evaluation estimated a mortality rate of 57.42 per 100,000 population, and the International Diabetes Federation (IDF) projected that the number of people with diabetes in Indonesia will increase rapidly over the next ten years (starting from 2021) (Ditpui, 2023). To monitor the results of diabetes mellitus treatment, a glucometer can be used. According to Yuniarti et al., glucometers utilize the glucose oxidase biosensor method, which involves an enzymatic reaction that produces electrons. This enzymatic reaction occurs between the glucose oxidase enzyme on the glucometer test strip and the glucose in the blood

sample. The electrons produced are then captured by the electrodes in the glucometer. The number of electrons captured by the electrodes is proportional to the glucose level in the sample (Yuniarti *et al.*, 2018). Measurement with a glucometer can provide faster results, thus reducing Turn Around Time (TAT) (Natsir, 2023) (Hasan, 2019). Additionally, the glucometer can be used independently and use a small amount of blood, approximately ±0.3 to 10 µl (Nirmawati, 2019).

Self monitoring of blood glucose for people with diabetes mellitus can provide information about daily blood glucose variability in people with diabetes, which is useful for reducing morbidity, maintaining blood glucose control, improving achievement, lowering mortality, and potentially saving long-term healthcare costs related to complications, both chronic and acute (Sreelakshmi *et al.*, 2023) (Li *et al.*, 2023). According to Diabcare conducted in 2008 and 2012 found that there was an increase of 16.8% in the use of glucometers in Indonesia (rising from 22.1% to 38.9%) (PERKENI, 2021a).

Errors in using glucometers can lead to inaccuracies in blood glucose measurement, ranging from 90%-97% (PERKENI, 2019). These errors are often encountered in the pre-analytical phase, especially during the capillary blood sampling process. According to Good Laboratry Practice (GLP), the procedure for capillary blood sampling involves pricking the finger with a lancet and using a dry cotton swab to collect the first drop of blood that emerges. The second drop of blood can then be used for testing. Errors occurring in the pre-analytical phase contribute up to 61% of the total errors during laboratory testing (Direktorat Bina Pelayanan Penunjang Medik, 2008). It can result in inaccuracies in judgment and interpreting laboratory test results (Direktorat Bina Pelayanan Penunjang Medik, 2008) (Ogunbosi *et al.*, 2022) . Results from community service activities conducted by Bastian et al., involving 20 laboratory technicians at RS Muhammadiyah Palembang Seberang Ulu I revealed that errors during capillary blood sampling were due to insufficient attention to technique and lack of understanding. For example, using the first drop of blood as the test sample, not paying attention to the depth of the lancet prick, puncturing the skin area still moist with 70% alcohol, and capillary blood samples freezing before testing due to slow processing (Bastian, Hartati and Trianes, 2019).

RESEARCH METHOD

This study employed a quasi-experimental design with a Cross-Sectional research approach aiming to compare fasting blood glucose measurements using a glucometer with and without dry cotton swab during taking capillary blood. As a control, venous blood samples with NaF anticoagulant were collected. Subsequently, glucose levels were measured using a chemistry autoanalyzer with the GOD PAP method at Wonolangan Hospital. The sample for this study consisted of patients diagnosed with diabetes mellitus, who underwent fasting blood glucose tests at Wonolangan Probolinggo Hospital laboratory. A total of 30 patients were sampled from the entire population using purposive sampling technique. The sample criteria included patients diagnosed with diabetes mellitus who underwent fasting blood glucose tests at Wonolangan Probolinggo Hospital laboratory April 2024. Selected respondents who agreed to participate further would fill out an informed consent form and a questionnaire to gather respondent characteristics. Blood samples were then collected via both venous and capillary methods, and their blood glucose levels were measured. The data is presented in table format and processed using SPSS statistics. Etical clearance No.EA/2215/KEPK-Poltekkes_Sby/V/ 2024.

RESULT AND DISCUSSION

Tabel 1. Respondent characteristics

Characteristics	Responden	
	n	%
Gender		
Male	14	46,7%
Female	16	53,3%
Age		
31 – 40	3	10%
41 – 50	3	10%
51 - 60	13	43,3%
>61	11	36.7%
Educational level		
Elementary school	10	33,3%
High school	14	46,7%
Diploma/ bachelor's degree	6	20%
Family history of diabetes mellitus		
Yes	19	63,3%
No	11	36,7%
Duration of diabetes mellitus diagnosis (years)		
0 – 3	9	30,0%
4 – 6	10	33,3%
7 – 10	6	20,0%
>10	5	16,7%

In Table 1, it can be seen that the respondents were predominantly female, totaling 16 (53.3%). Women are 2.77 times more at risk of experiencing type 2 diabetes mellitus compared to men (Nurjannah and Asthiningsih, 2023). The higher prevalence of diabetes in women is attributed to physical factors; women generally have a higher chance of gaining body mass compared to men. Post-menopause and premenstrual syndrome can lead to easier fat accumulation due to hormonal processes in the body (Suryati, 2021). The decrease in progesterone and estrogen hormones will impact an increase in insulin hormone response in the bloodstream. During menopause, women experience decreased insulin hormone response due to low levels of progesterone and estrogen. Additionally, menopause leads to an increase in abdominal fat storage (Arania *et al.*, 2021) (Harraqui *et al.*, 2023). This results in elevated release of free fatty acids, leading to insulin resistance. Women typically have more fat tissue compared to men. Normal fat levels in adult women range from 20-25% of body weight, whereas in adult men, normal fat levels range from 15-20% of body weight. (Arania *et al.*, 2021).

The age group dominating the respondents was 51-60 years old, with 13 (43.3%). It is in line with the research conducted by Rahmasari and Wahyuni , that the majority of respondents, who are type 2 diabetes mellitus patients, fall within the age range of 51 to 60 years, both in the control and treatment groups (Rahmasari and Wahyuni, 2019). Age is closely related to fasting blood glucose levels (Ko, Wai and Tang, 2006). As age increases, blood glucose levels also increase, thus leading to a higher prevalence of diabetes. After the age of 30, physiological, anatomical, and biochemical changes occur in the human body. These changes begin at the cellular level, then progress to tissues, and eventually affect organ function, potentially impacting homeostasis. Parts of the body involved in these changes include pancreatic β-cells (which produce insulin), the nervous system, other hormones affecting blood glucose levels, and target tissue cells (which produce glucose). Hormonal changes can lead to an increase in fasting blood glucose levels of 1 to 2 mg/dl per year and an increase of 5.6 to 13 mg/dl per year after a 2-hour postprandial (Suryati, 2021).

The most common educational background was high school, with 14 (46.7%). According to Nugroho and Sari, individuals with lower levels of education are 1.27 times more likely to suffer from diabetes mellitus compared to those with higher education levels. This is because individuals with higher education tend to pay more attention to their lifestyle and dietary patterns, leading to increased awareness of healthy living and greater knowledge about health (Nugroho and Sari, 2020).

A total of 19 (63.3%) respondents had

a family history of diabetes mellitus and 10 (33.3%) respondents had been diagnosed with diabetes mellitus for 4-6 years. Individuals with a family history of diabetes are at a significantly higher risk, between two to six times greater, of developing type 2 diabetes mellitus compared to those without such history (Yusnanda, Rochadi and Maas, 2019) (Tsenkova, Karlamangla and Ryff, 2016). This risk is particularly heightened if a parent or sibling suffers from diabetes mellitus. Genetic factors play a crucial role in increasing the risk of diabetes mellitus. This condition can worsen with unhealthy lifestyle choices (Yusnanda, Rochadi and Maas, 2019). Risk factors can be identified through genetic determinants of diabetes mellitus associated with specific histocompatibility types, such as HLA (Human Leukocyte Antigen) (Nuraisyah, 2018) (Lee and Hwang, 2019).

Tabel 2. Respondent characteristics based on eating habits

Eating habits	Responden	
	n	%
Likes sweet drinks		
Yes	18	60,0%
No	12	40,0%
Frequently consuming high-carbohydrate foods such as white bread, white rice, and foods made from flour		
Yes	27	90,0%
No	3	10,0%

In Table 2, it can be seen that 18 (60%) respondents like sweet drinks, and 27 (90%) respondents frequently consume high-carbohydrate foods such as white bread, white rice, and foods made from flour. Unhealthy eating patterns can lead to an imbalance between carbohydrates and other essential nutrients needed by the body, making it a major risk factor for type 2 diabetes mellitus (Hariawan, Fathoni and Purnamawati, 2019) (Galicia-garcia *et al.*, 2020). In addition, consumption of foods high in simple carbohydrates, sugar, and saturated fats can result in weight gain and insulin resistance, thereby increasing the risk of diabetes mellitus (Harefa and Lingga, 2023). Based on the research conducted by Maimunah *et al.*, (2020), it was found that there is a relationship between the occurrence of type 2 diabetes mellitus and dietary patterns. Individuals with unhealthy eating patterns are at a greater risk, with a 3.8% higher likelihood of developing diabetes mellitus compared to those who maintain a healthy diet (high fiber and low sugar intake). According to, Murtiningsih, Pandelaki, & Sedli, stated that in type 2 diabetes mellitus patients who do not control their food intake and consume carbohydrates in excess of daily requirements, the risk of being unable to control blood glucose levels increases by 12 times compared to those who consume carbohydrates according to their daily needs (Murtiningsih, Pandelaki and Sedli, 2021). Furthermore, cultural attitudes and behaviors towards food play a crucial role in managing the risk of type 2 diabetes mellitus. This includes food choices, food categories consumed, food restrictions, and healthy food choices. Moreover, to reduce the prevalence of type 2 diabetes mellitus, it is important to maintain good nutrition and adhere to a healthy and balanced diet (Murtiningsih, Pandelaki and Sedli, 2021) (Sami *et al.*, 2020).

Tabel 3. Respondent characteristics based on medication adherence

Regularly taking medication or insulin injections as prescribed by the doctor	Responden	
	n	%
Yes	24	80,0%
No	6	20,0%

It can be seen that 24 (80%) regularly take medication or insulin injections as prescribed by the doctor. There is a relationship between blood glucose levels in type 2 diabetes mellitus patients and medication adherence. Patient adherence is crucial for the success of therapy, as it helps stabilize their glucose levels. Patients who adhere to their medication regimen tend to

have normal blood glucose levels, whereas those who are non-adherent may experience higher blood glucose levels (Rismawan, Handayani and Rahayuni, 2023).

Tabel 4. Respondent characteristics based on knowledge about diabetes mellitus

Knowledge about diabetes mellitus	Responden	
	n	%
Ever received education about diabetes mellitus (formal, seminar, or training)		
Yes	3	10,0%
No	27	90,0%
Knowing that to control DM (Diabetes Mellitus), special dietary foods, regular exercise, and taking medication or insulin injections as prescribed by a doctor are required		
Yes	11	36,7%
No	19	63,3%
Knowing that blood glucose testing can be done independently with a glucometer		
Yes	10	33,3%
No	20	66,7%
Have a glucometer		
Yes	5	16,7%
No	25	83,3%
Can use a glucometer		
Yes	5	16,7%
No	25	83,3%
Knowing that capillary blood sampling is done on the middle finger or ring finger. The first drop of blood is wiped with dry cotton, and the subsequent drop is used for blood glucose testing using the glucometer method		
Yes	1	3,3%
No	29	96,7%

In Table 4, it can be seen that 27 (90%) respondents have never received education about diabetes mellitus, whether formal education, seminars, or training and 19 (63.3%) respondents know that controlling DM requires a special diet, regular exercise, and medication or insulin injections as prescribed by a doctor. In the management of diabetes to achieve good blood glucose control, there are four pillars of management: physical exercise, pharmacological intervention, medical nutrition therapy, and education (Haskas and Nurbaya, 2019). According to Harahap et al., developing self-care behaviors requires knowledge about diabetes mellitus, which is expected to improve the quality of life for diabetes patients and achieve good metabolic control (Harahap *et al.*, 2021). Education should be conducted periodically, starting from the time of diabetes diagnosis, with education sessions scheduled every month or every six months during laboratory result evaluations, or when patients present with complaints indicating therapy discrepancies leading to uncontrolled blood glucose (Fauziah and Mokondongan, 2023). According to Afriyani, Suriadi, & Righo, educational materials in the form of leaflets are considered more suitable for diabetes patients compared to books and audiovisual (video) resources (Afriyani, Suriadi and Righo, 2020).

20 (66.7%) respondents are aware that blood glucose testing can be done independently with a glucometer. 5 (16.7%) respondents own a glucometer and can use it. However, only 1 (3.3%) respondent knows that capillary blood sampling is done on the middle finger or ring finger. The first drop of blood is wiped with dry cotton, and the subsequent drop is used for blood glucose testing with the glucometer method.

The results of blood glucose testing without and with dry cotton wiping using the glucometer method, and venous blood with NaF anticoagulant measured using an autoanalyzer as the control group in 30 respondents diagnosed with diabetes mellitus can be seen in Table 5 and Table 6.

Table 5. Descriptive data of fasting blood glucose examination results.

Variable	Difference < 10 mg/dl	Difference > 10 mg/dl
With dry	27	3

cotton wiping		
Without dry cotton wiping	11	19

Note: Fasting blood glucose examination using venous blood with NaF anticoagulant, GOD PAP method with an autoanalyzer as the gold method comparison.

Table 6. Descriptive data of fasting blood glucose examination results.

Variabel	N	Mean	SD	Minimun	Maximum	Levene's test of homogeneity	Kolmogorov-Smirnov test of normality	Kruskal-Wallis test
With dry cotton wiping	30	141,17	60,048	78	316	0,949	0,003[c]	0,331
Without dry cotton wiping	30	131,93	57,353	70	295		0,000[c]	
Venous blood with NaF as the control group	30	145,63	61,602	79	323		0,001[c]	

In Table 6, the mean difference between the dry cotton wiped and non-dry cotton wiped variables is 9.24 mg/dl. The mean difference for the non-dry cotton wiped variable compared to the control group is 13.7 mg/dl. The mean difference between the dry cotton wiped variable and the control group is 4.46 mg/dl. According to Laisouw, Anggraini & Ariyadi, fasting blood glucose levels without drying the alcohol swab were lower, ranging from 78 to 127 mg/dL with an average of 91.56 mg/dL, compared to fasting blood glucose levels with drying the alcohol swab, which ranged from 93 to 137 mg/dL with an average of 103.75 mg/dL. The mean difference between glucose levels without and with drying the alcohol swab using a glucometer method was 12.19 mg/dL (Laisouw, Anggraini and Ariyadi, 2017). The lower blood glucose results in the sample group that did not use the alcohol swab during capillary blood collection are likely due to contamination of the capillary blood sample by residual 70% alcohol, which acts as a disinfectant during blood collection, and tissue fluids, leading to falsely low glucose test results. Tissue fluids contain coagulation factors that accelerate blood clotting and can cause blood dilution, thereby influencing test results (Susilowati, 2021). According to Umami SW, Zaetun & Khusuma, body fluids include tissue fluids amounting to 30%, with water serving as the medium (located within the body's cells). The exchange of water and dissolved substances depends on the colloid osmotic pressure of the blood formed by plasma proteins. This osmotic pressure works in conjunction with tissue pressure to draw tissue fluid remnants within cells towards capillary blood (Umami SW, Zaetun and Khusuma, 2019).

In this study, the homogeneity test using Levene's test resulted in a significance value of 0.949. Since the significance value > 0.05, it indicates that

the null hypothesis (H0) is accepted, suggesting that the data is homogeneous. Given the homogeneity of the data, a normality test was conducted to assess whether the distribution of the variables used is normal or not (Herlina, 2019). The normality test using Kolmogorov-Smirnov test showed a significance value < 0.05, indicating that the data is not normally distributed. Therefore, to determine the differences among the three groups, the Kruskal-Wallis test was conducted. The test yielded a significance value of 0.331, which indicates that the significance value > 0.05. Thus, it is concluded that there is no significant difference observed among the groups.

In line with the research conducted by Yap, Sugiarto and Sadeli (2013)which compared capillary and venous blood glucose levels using a glucometer in diabetes mellitus patients, it was concluded from statistical tests that there was no significant difference between the two methods. However, this finding contrasts with the study by Laisouw, Anggraini & Ariyadi (2017), where statistical analysis indicated a significant difference between blood glucose levels with and without drying the alcohol swab using the POCT method. Yap, Sugiarto & Sadeli's study suggests that capillary and venous blood glucose measurements using a glucometer yield similar results, implying that either method could be used interchangeably without significant impact on clinical decisions. On the other hand, Laisouw, Anggraini & Ariyadi's findings highlight the importance of standardizing procedures such as drying alcohol swabs during capillary blood collection to avoid potential inaccuracies in glucose measurements, which could affect clinical management decisions for diabetes patients and not using a control group and technical errors such as shallow needle penetration during blood sampling, necessitating squeezing the fingertip of patients with thick skin. Squeezing during capillary blood sampling does not adhere to the capillary blood collection procedure outlined in good laboratory practice. Insufficient needle penetration followed by squeezing will result in capillary blood samples mixing with tissue fluid, leading to a diluted sample (Direktorat Bina Pelayanan Penunjang Medik, 2008).

The study conducted by Umami SW, Zaetun and Khusuma (2019), found that blood glucose levels in samples treated with massaging during capillary blood collection were lower (mean value 284.4 mg/dl, lowest value 216 mg/dl, highest value 463 mg/dl) compared to the control group without massaging (mean value 303.1 mg/dl, lowest value 227 mg/dl, highest value 496 mg/dl). The difference in glucose levels between the two groups was 18.7 mg/dl.

According to Suryatama, Sebayang, & Hutabarat, when encountering patients with thick fingers during capillary blood sampling, it is necessary to adjust the depth of penetration and use a longer needle so that blood can flow out and an adequate sample can be obtained for testing. Therefore, during the puncture, there is no need for excessive or prolonged pressure on the finger during capillary blood collection (Suryatama, Sebayang and Hutabarat, 2023).

Another factor that causes low results in glucose level examinations is skin puncture that is still wet with alcohol, these errors will cause inaccuracies in the examination (Direktorat Bina Pelayanan Penunjang Medik, 2008). Because incorrect results will lead to improper patient care procedures and can impact service outcomes that are not suitable, potentially leading to fatal consequences. Based on data from the Food and Drug Administration (FDA) of the United States from 1984 to 1992, there were 24 deaths and 984 morbidities due to inaccurate use of glucometers for glucose examination. Handling errors in patients are caused by 50% errors in indications and 32% failures to act due to discrepancies with test results (Hartono, 2011). Specimen collection is the

beginning of determining medical diagnoses, and errors in the pre-analytical stage contribute to 60-70% of overall errors. Common mistakes in capillary blood collection include drawing blood in vasoconstricted or vasodilated areas, puncturing alcohol-wetted skin, shallow punctures, failure to wipe away the first blood drop with dry gauze, and blood drops clotting before examination due to delayed sample testing. Proper capillary blood collection techniques can reduce errors, particularly in phlebotomy, by avoiding repeated blood sampling (Bastian, Hartati and Trianes, 2019). In addition to proper capillary blood collection techniques, attention must be paid to glucometer quality, accuracy, and factors affecting measured blood glucose levels. These factors include glucometer factors, user skill factors, intrinsic factors of diabetes patients, and therapeutic factors (PERKENI, 2021a).

CONCLUSION AND RECOMMENDATION

Based on the results of blood glucose examination, it was found that the average fasting blood glucose level of diabetic patients using the glucometer method with dry cotton swab during capillary blood collection was 141.17 mg/dL. The average fasting blood glucose level of diabetic patients using the glucometer method without using a dry cotton swab during capillary blood collection was 131.93 mg/dL. The difference in average values between the dry cotton swab and non-dry cotton swab methods was 9.24 mg/dL. The difference in average values between the non-dry cotton swab method and the control group was 13.7 mg/dL. The difference in average values between the dry cotton swab method and the control group was 4.46 mg/dL. The Kruskal-Wallis statistical test results indicated no significant difference between capillary blood collection with dry cotton swab and without dry cotton swab. However, from a healthcare perspective, there is a difference in the glucose POCT test compared to the gold method (GOD-PAP) by 9.24 mg/dL (dry cotton swab group) and an average difference of 13.7 mg/dL (non-dry cotton swab group).

To ensure valid results in blood glucose measurement using a glucometer with and without dry cotton swab during capillary blood collection, it is recommended to follow certain practices. It is advised to use a dry cotton swab on the first drop of blood and avoid puncturing areas with vasoconstriction or vasodilation. Additionally, avoid puncturing skin that is still wet from alcohol and ensure the depth of the puncture is appropriate. Insufficient depth in the puncture followed by squeezing can lead to mixing of blood with tissue fluid, resulting in diluted blood and inaccurate test results. Future researchers are encouraged to explore parameters related to glucometer testing and other practices, such as variations in puncture depth, squeezing technique, capillary blood collection before alcohol has dried, glucometer quality control, and other factors that may affect blood glucose measurements obtained using a glucometer.

REFERENCES

Afriyani, Suriadi and Righo, A. (2020) ‘Media Edukasi Yang Tepat Pada Pasien Diabetes Melitus Type 2 Terhadap Kepatuhan Diet : Literature Review’, *Jurnal Ilmiah Universitas Tanjungpura*, 5(2), pp. 1–17. doi: 10.26418/jpn.v5i2.

Arania, R. *et al.* (2021) ‘Hubungan Antara Usia, Jenis Kelamin, Dan Tingkat Pendidikan Dengan Kejadian Diabetes Mellitus Di Klinik Mardi Waluyo Lampung Tengah’, *Hubungan Antara Usia, Jenis Kelamin, Dan Tingkat Pendidikan Dengan Kejadian Diabetes Mellitus Di Klinik Mardi Waluyo Lampung Tengah*, 5(3). doi: 10.1007/s00712-023-00827-w.

Bastian, B., Hartati, D. and Trianes, J. (2019) ‘Edukasi Teknik Pengambilan

Darah Kapiler Pada Petugas Laboratorium RS Muhammadiyah Palembang', *Khidmah Jurnal Pengabmas Masyarakat IKesT Muhammadiyah Palembang*, 1(2), pp. 84–89. doi: 10.52523/khidmah. v1i2.388.

Cosmas, F.N. and Mbugi, E.V. (2024) 'Comparative Performance of Different Glucometers for Random Glucose Measurements in Diabetic Patients', *Research Square*, pp. 1–15. doi: 10.21203/rs. 3.rs-4001063/v1.

Direktorat Bina Pelayanan Penunjang Medik (2008) *Pedoman Praktik Laboratorium Kesehatan Yang Benar (Good Laboratory Practice), Clinical Chemistry and Laboratory Medicine*. Jakarta: Departemen Kesehatan RI.

Ditpui (2023) *Diabetes Penyebab Kematian Tertinggi di Indonesia: Batasi dengan Snack Sehat Rendah Gula*, *Direktorat Pengembangan Usaha Universitas Gadjah Mada*. Retrieved from: https://ditpui.ugm.ac.id/diabetes-penyebab-kematian-tertinggi-di-indonesia-batasi-dengan-snack-sehat-rendah-gula/ (Accessed: 5 November 2023).

Fauziah, S.N. and Mokondongan, R.S. (2023) 'Edukasi Pengenalan, Pencegahan Dan Pengelolaan Diabetes Melitus Pada Peserta Prolanis Di KPRJ Prima Husada Cinere, Depok', *JPM Bakti Parahita : Jurnal Pengabdian Masyarakat Bakti Parahita*, 04, pp. 19–27. doi: 0.54771/jpmbp.v4i02.1199.

Galicia-garcia, U. *et al.* (2020) 'Costus ignus: Insulin plant and it's preparations as remedial approach for diabetes mellitus', *International Journal of Molecular Sciences*, pp. 1–34. doi: 10.3390/ijms 21176275.

Hananta, I.P.Y. and Muhammad, H.F.L. (2011) *Deteksi Dini dan Pencegahan Diabetes Melitus*. Yogyakarta: Media Pressindo.

Harahap, U. *et al.* (2021) 'Edukasi Diabetes Melitus dan pemeriksaan glukosa darah acak serta asam urat sebagai upaya preventif penyakit komorbid Covid-19', *Unri Conference Series: Community Engagement*, 3, pp. 450–456. doi: 10.31258/unricsce.3.450-456.

Harefa, E.M. and Lingga, R.T. (2023) *Monograf Faktor Resiko Kejadian Diabetes Melitus Tipe 2*. Ponorogo: Uwais Inspirasi Indonesia.

Hariawan, H., Fathoni, A. and Purnamawati, D. (2019) 'Hubungan Gaya Hidup (Pola Makan dan Aktivitas Fisik) Dengan Kejadian Diabetes Melitus Di Rumah Sakit Umum Provinsi NTB', *Jurnal Keperawatan Poltekkes Kemenkes Maluku*, 1(1), pp. 1–7. doi: 10.32807/jkt.v1i1.16.

Harraqui, K. *et al.* (2023) 'Association between Physical Activity, Body Composition, and Metabolic Disorders in Middle-Aged Women of Ksar el Kebir (Morocco)', *International Journal of Environmental Research and Public Health*, 20(3). doi: 10.3390/ijerph20031739.

Hartono, K. (2011) 'Keuntungan Dan Kerugian Penjaminan Mutu Berdasarkan Uji Memastikan Kecermatan (POCT)', *Indonesian Journal of Clinical Pathology and Medical Laboratory*, 13(1), pp. 1–6. doi: 0.24293/ijcpml.v13i1.898.

Hasan, D. (2019) 'Error Estimation In Glucose Testing Among Private And Public Medical Laboratories In Kalar District', *Journal of Garmian University*, 6(SCAPAS Conferance), pp. 84–88. doi: 10.24271/garmian.scpas11.

Haskas, Y. and Nurbaya, S. (2019) 'Upaya Peningkatan Kualitas Hidup Penderita DM dengan Memberikan Pelatihan Senam Diabetes', *Indonesian Journal of Community Dedication*, 1(1), pp. 14–18. doi: 10.35892/community.v1i1.15.

Herlina, V. (2019) *Panduan Praktis Mengolah Data Kuesioner Menggunakan SPSS*. Jakarta: PT Elex Media Komputindo.

Hidayat, B. *et al.* (2022) 'Direct Medical Cost of Type 2 Diabetes Mellitus and Its Associated Complications in Indonesia', *Value in Health Regional Issues*, 28, pp. 82–89. doi: 10.1016/j.vhri.2021.04.006.

Ko, G.T.C., Wai, H.P.S. and Tang, J.S.F. (2006) 'Effects of age on plasma glucose levels in non-diabetic Hong Kong Chinese', *Croatian Medical Journal*, 47(5), pp. 709–713.

Laisouw, A.J., Anggraini, H. and Ariyadi, T. (2017) 'Perbedaan Kadar Glukosa Darah Tanpa dan Dengan Hapusan Kapas Kering Metode POCT (Point-Of-Care-Testing)', *Jurnal Universitas Muhammadiyah Semarang*, (September), 661-665.

Lee, H.S. and Hwang, J.S. (2019) 'Genetic aspects of type 1 diabetes', *Annals of Pediatric Endocrinology and Metabolism*, 24(3), pp. 143–148. doi: 10.6065/apem.2019.24.3.143.

Li, A. *et al.* (2023) 'Evaluating the Clinical Accuracy of a Non-invasive Single-Fasting-Calibration Glucometer in Patients with Diabetes: A Multicentre Study', *Diabetes Therapy*, 14(6), pp. 989–1004. doi: 10.1007/s13300-023-01402-8.

Maimunah, S. *et al.* (2020) 'TERHADAP KEJADIAN DIABETES MILITUS TYPE II DI RSUD DR . H . MOCH ANSARI SALEH BANJARMASIN TAHUN 2020', *International Journal Of Science And Society (IJSOC)*, 5(3). doi: 10.54783/ijsoc.v5i3.750.

Murtiningsih, M.K., Pandelaki, K. and Sedli, B.P. (2021) 'Gaya Hidup sebagai Faktor Risiko Diabetes Melitus Tipe 2', *e-CliniC*, 9(2), p. 328. doi: 10.35790/ecl.v9i2.32852.

Natsir, R.M. (2023) *Buku Ajar Kimia Klinik 1*. Yogyakarta: Selat Media Patners.

Nirmawati, A. (2019) *Undur - Undur (Myrmelon sp.) Sebagai Antidiabetik*. Ponorogo: Uwais Inspirasi Indonesia.

Nugroho, P.S. and Sari, Y. (2020) 'HubunganTingkat Pendidikandan Usiadengan Kejadian HipertensidiWilayah Kerja Puskesmas Palaran Tahun 2019', *Jurnal Dunia Kesmas*, 8(4), pp. 1–5. doi: 10.33024/jdk.v8i4.2261.

Nuraisyah, F. (2018) 'Faktor Risiko Diabetes Mellitus Tipe 2', *Jurnal Kebidanan dan Keperawatan Aisyiyah*, 13(2), pp. 120–127. doi: 10.31101/jkk.395.

Nurjannah, M. and Asthiningsih, N.W.W. (2023) *Hipoglikemi Pada Penderita Diabetes Mellitus Tipe 2*. Banyumas: CV. Pena Persada.

Ogunbosi, B.O. *et al.* (2022) 'Comparison of point-of-care glucometers and laboratory based glucose oxidase test in determining blood glucose levels', *Nigerian Journal of Paediatrics*, 49(3), pp. 266–271. doi: 10.4314/njp.v49i3.7.

PERKENI (2019) *Pedoman Pemantauan Glukosa Darah Mandiri 2019*, *Perkumpulan Endokrinologi Indonesia*.

PERKENI (2021a) *Pedoman Pemantauan Glukosa Darah Mandiri 2021*. Jakarta: PB PERKENI.

PERKENI (2021b) *Pedoman Pengelolaan dan Pencegahan Diabetes Mellitus Tipe 2 Dewasa di Indonesia 2021*. Jakarta: PB PERKENI.

Rahmasari, I. and Wahyuni, E.S. (2019) 'Efektivitas Memordoca carantia (Pare) terhadap Penurunan Kadar Glukosa Darah', *Infokes*, 9(1), pp. 57–64. doi: 10.47701/infokes.v9i1.720

Rismawan, M., Handayani, N.M.T. and Rahayuni, I.G.A.R. (2023) 'Hubungan Kepatuhan Minum Obat Terhadap Kadar Gula Darah Sewaktu Pada Penderita Diabetes Mellitus Tipe 2', *Jurnal Riset Media Keperawatan*, 6(1), pp. 23–30. doi: 10.51851/jrmk.v6i1.373.

Sami, W. *et al.* (2020) 'Dietary attitude of adults with type 2 diabetes mellitus in

the Kingdom of Saudi Arabia: A cross-sectional study', *Medicina (Lithuania)*, 56(2). doi:10.3390/medicina56020091.

Sreelakshmi, R. *et al.* (2023) 'Common but Missed Errors in Blood Glucose Monitoring', *International Journal of Diabetes and Technology*, 2(4), pp. 137–140. doi: 10.4103/ijdt.ijdt_ 15_24.

Suryatama, F.D., Sebayang, R. and Hutabarat, M.S.H. (2023) 'Perbandingan Kadar Trombosit pada Darah Vena dan Kapiler menggunakan Antikoagulan K3EDTA', *Jurnal Ilmu Kesehatan dan Gizi (JIG)*, 1(1), pp. 121–128. doi: 10.55606/jikg.v1i1.853.

Suryati, I. (2021) *Buku Keperawatan Latihan Efektif Untuk Pasien Diabetes Mellitus Berbasis Hasil Penelitian*. Yogyakarta: Deepublish Publisher.

Susilowati, A.T. (2021) *Buku Ajar Untuk Mahasiswa D4 Analis Kesehatan (Ahli Tehnologi Laboratorium Medik / ATLM)*. Semarang: Academia Publication.

Tsenkova, V.K., Karlamangla, A.S. and Ryff, C.D. (2016) 'Parental History of Diabetes, Positive Affect, and Diabetes Risk in Adults: Findings from MIDUS', *Annals of Behavioral Medicine*, 50(6), pp. 836–843. doi: 0.1007/s12160-016-9810-z.

Umami SW, W.N., Zaetun, S. and Khusuma, A. (2019) 'Pengaruh Cara Pengambilan Darah Kapiler Terhadap Kadar Glukosa Darah Sewaktu Pada Penderita Diabetes Melitus', *Jurnal Analis Medika Biosains (JAMBS)*, 6(1), p. 31. doi: 10.32807/jambs.v6i1.122.

Yap, A., Sugiarto, C. and Sadeli, L. (2013) 'Perbandingan Kadar Glukosa Darah Kapiler Dengan Kadar Glukosa Darah VenaMenggunakan Glukometer Pada Penderita Diabetes Melitus'. Retrieved from: http://repository.maranatha.edu/id/eprint/12265.

Yuniarti, E. *et al.* (2018) 'Correlation of Fasting Blood Glucose With IL-6 Levels in Type-2 Diabetes Mellitus Ethnic Minangkabau', *Bioscience*, 2(1), p. 11. doi: 10.24036/02018219 858-0-00.

Yusnanda, F., Rochadi, R.K. and Maas, L.T. (2019) 'Pengaruh Riwayat Keturunan terhadap Kejadian Diabetes Mellitus pada Pra Lansia di BLUD RSUD Meuraxa Kota Banda Aceh Tahun 2017', *Journal of Healthcare Technology and Medicine*, 4(1), p. 18. doi: 10.33143/jh tm.v4i1.163.

Yusransyah, Y., Stiani, S.N. and Sabilla, A.N. (2022) 'Hubungan Antara Kepatuhan Minum Obat Pasien Diabetes Mellitus dan Support yang Diberikan Keluarga', *Jurnal Ilmiah Kesehatan Delima*, 4(2), pp. 74–77. doi: 10.60010/jikd.v4i2.79.