

COST-EFFECTIVENESS ANALYSIS OF USING METFORMIN AND GLIMEPIRIDE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS IN YOGYAKARTA, INDONESIA

Ingenida Hadning¹, Dhiya Putri Zalfa¹, Dio Fahlevi Yokka Rajasa¹
and Azizah Khoiriyati²

¹School of Pharmacy, ²School of Nursing, Faculty of Medicine and Health Science,
Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia

Abstract. Cost-effectiveness analysis (CEA) is a pharmacoeconomic method that assists in decision-making about the selection of benefit-effective and cost-effective therapies. The average cost-effectiveness ratio (ACER) is expressed as the dollar amount generated for each specific clinical outcome, regardless of comparison. The incremental cost-effectiveness ratio (ICER) reveals the costs to obtain one outcome unit relative to its comparison. Metformin is an oral antidiabetic for people with type 2 diabetes mellitus. Glimepiride can effectively improve glucose control in people with type 2 diabetes mellitus who possess a good health profile. This research aimed to determine the effectiveness of therapy, average cost, and cost-effectiveness of using metformin and glimepiride in people with type 2 diabetes mellitus. This research employed an observational study. Data collection was carried out retrospectively using total sampling at the community health centers in Yogyakarta. Data were analyzed using ACER or ICER to determine a more cost-effective therapy for lowering blood glucose levels. The cost-effectiveness analysis involving a total of 192 patients, 133 patients receiving metformin and 59 patients receiving glimepiride, disclosed that glimepiride was more cost-effective than metformin. The clinical results also unveiled the higher effectiveness of glimepiride therapy over metformin in reducing blood glucose levels. The average cost of glimepiride was IDR 6,101, exhibiting an effectiveness of 77.96% and an ACER value of IDR 78. The ICER calculation was omitted due to the low average cost, high effectiveness, and low ACER value of glimepiride in comparison to metformin. Therefore, glimepiride demonstrated more cost-effectiveness than metformin in people with type 2 diabetes mellitus at the community health centers in Yogyakarta.

Keywords: cost-effectiveness analysis, type 2 diabetes mellitus, glimepiride, metformin

Correspondence: Ingenida Hadning, School of Pharmacy, Faculty of Medicine and Health Science, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia
Tel: +62 8562177937 E-mail: ingenida.hadning@umy.ac.id

INTRODUCTION

Diabetes mellitus is a chronic condition when the pancreas fails to produce enough insulin or when the body cannot effectively utilize the insulin produced. Insulin is a hormone that regulates blood glucose levels. Hyperglycemia, or increased blood glucose, is a common result of uncontrolled diabetes, causing severe damage to the body's systems, especially the nerves and blood vessels (WHO, 2021). According to the Indonesian Endocrinology Association (PERKENI), diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia due to abnormalities in insulin secretion, insulin action, or both (Indonesian Endocrinology Association, 2021). Diabetes mellitus is a disease caused by a relative or absolute deficiency of insulin. Insulin deficiency can arise through three mechanisms (Fatimah, 2015): damage to pancreatic β cells due to external influences (viruses, chemicals, *etc*), decrease glucose receptors in the pancreas, and damage to insulin receptors in peripheral tissues. The etiology of diabetes mellitus includes a combination of genetic and environmental factors. Other etiologies of this disease are insulin secretion or insulin action. These metabolic abnormalities interfere with insulin secretion, mitochondrial abnormalities, and a group of different conditions interfering with glucose tolerance. Hormones that work as insulin antagonists can also cause diabetes mellitus (Putra and Berawi, 2015). Diabetes mellitus can be classified as follows (Soltis-Herrera *et al*, 2018): type 1, type 2, gestational diabetes, and other types resulting

from metabolic disorders. Diabetes mellitus is generally divided into types 1 and 2.

The global prevalence of diabetes mellitus reaches 5-10% for type 1 and 90-95% for type 2 (ADA, 2020). The countries with the largest increases, ranging 15-22 percentage points was in a belt of countries north of the equator extending from southeast Asia. In 2022, age-standardized diabetes prevalence in the world was 13.9% for women and 14.3% for men (NCD-RisC, 2024). An estimated 828 million adults had diabetes, a substantial increase of 630 million from 1990 (NCD-RisC, 2024). Of these, 420 million were women and 408 million were men. India and China accounted for the largest proportion of this number, followed by the USA, Pakistan, Indonesia, and Brazil. Indonesia also one of the countries with the largest number untreated diabetes (NCD-RisC, 2024). In Indonesia, especially in the Special Region of Yogyakarta Province, disease patterns are monitored by the integrated disease surveillance system. The prevalence of diabetes mellitus is 4.9% in Yogyakarta City, 3.3% in both Sleman and Bantul Regencies, 2.8% in Kulon Progo Regency, and 2.4% in Gunung Kidul Regency (Ministry of Health Republic Indonesia, 2020).

Diabetes mellitus has several disadvantages in the health economy, such as increased treatment costs and loss of labor productivity (IDF, 2011). In 2011, the cost of treating diabetes mellitus reached USD 465 billion and this cost will continue to rise to USD 595 billion in 2030 (Finkelstein *et al*, 2014). Diabetes mellitus is estimated to escalate the cost burden that the Indonesian government must bear for its treatment to reach USD 1.27 billion by 2030 (Finkelstein *et al*, 2014). Following the estimated costs, it is necessary to carry out a pharmacoeconomic analysis to determine the economic impact of alternative drug therapy or other health interventions (Andayani, 2013). Cost-effectiveness analysis (CEA) is a widely applied method in cost analysis. It examines the costs and health outcomes of one or more interventions (CDC, 2021).

Metformin is an oral anti-diabetic drug from the biguanide class for people with type 2 diabetes mellitus. PERKENI has asserted that metformin has relatively good effectiveness and low hypoglycemia side effects, suggesting safety in its use (Indonesian Endocrinology Association, 2021). However, when metformin cannot be given, sulfonylurea drugs can be administered as an alternative therapy for patients allergic to metformin or unable to tolerate its gastrointestinal side effects (Indonesian Endocrinology Association, 2021). Glimpiride is one of the widely employed sulfonylurea drugs as it can effectively improve glucose control in type 2 diabetes mellitus patients with a good health profile (Guo *et al*, 2013).

This research aimed to determine cost-effective treatments for type 2 diabetes mellitus in patients at community health centers in Yogyakarta, especially when using oral antidiabetics metformin and glimepiride. With the results of this research, community health centers in Yogyakarta can consider and provide recommendations for effective treatment to patients both clinically and cost.

MATERIALS AND METHODS

Study design and setting

This research adopted an observational design with the retrospective method. Data were collected from medical records of patients receiving metformin or glimepiride therapy at Umbulharjo I Health Center and Bantul 2 Health Center in 2021. This research was conducted for seven months, from August 2022 to February 2023. Total sampling was utilized, generating a sample of 192 patients meeting both inclusion and exclusion criteria (Masturoh and Anggita, 2018). The inclusion criteria were patients with type 2 diabetes mellitus receiving metformin or glimepiride therapy,

patients who had previously received metformin or glimepiride therapy, patients aged 18 years or older, and patients who regularly checked their blood glucose after three months of treatment.

Data collection procedure

Data were gathered from patients' medical records, focusing on those required for the analysis, encompassing gender, age, diabetes medication consumed, blood glucose before treatment, blood glucose after treatment, and the price of the drug per tablet. This study was approved by the Health Research Ethics Committee of Universitas 'Aisyiyah Yogyakarta (Approval No. 221/KEP-UNISA/VII/2022).

Data analysis

Analysis of the effectiveness of therapy

The average effectiveness of antidiabetic drugs in patients with type 2 diabetes mellitus was collected from their medical records. These data unveiled the most effective antidiabetic therapy for lowering blood glucose. The following formula was employed to run the analysis.

$$\text{Therapeutic effectiveness} = \frac{\text{Number of patients reaching therapy targets}}{\text{Total patients}} \times 100\%$$

Analysis of the average cost of drugs

Drug cost analysis was carried out by taking data on patient treatment costs listed in their medical records. It determined the average treatment costs between the antidiabetic metformin and glimepiride.

The following formula was utilized to perform the analysis.

$$\text{Average Cost} = \frac{\text{Effective therapeutic cost}}{\text{Number of patients reaching therapy targets}}$$

Pharmacoeconomic analysis

The cost-effectiveness of metformin and glimepiride antidiabetic therapy for type 2 diabetes mellitus patients at the Umbulharjo I Community Health Center was analyzed by calculating treatment costs. The cost of antidiabetics was calculated until the patients reached the therapy target of lowering blood glucose after the administration of antidiabetics for three months. The cost-effectiveness of therapy was examined using ACER with the following formula.

$$\text{ACER} = \frac{\text{Average cost of each drug}}{\text{Therapeutic of effectiveness}}$$

The ACER calculation disclosed antidiabetic therapy with the smallest cost for each outcome obtained. Cost-effectiveness is obtained if antidiabetic therapy has higher or the same effectiveness at a lower price. Meanwhile, ICER can be employed when antidiabetic therapy has higher effectiveness at a higher cost or has lower effectiveness at a lower price. The ICER could be performed using the following formula.

$$\text{ICER} = \frac{\text{Cost of therapy A}-\text{Cost of therapy B}}{\text{Effectiveness of therapy A}-\text{Effectiveness of therapy B}}$$

RESULTS

A total of 192 patient data were analyzed in this study. As displayed in Table 1, 133 (69.27%) patients received metformin, and the rest 59 (30.73%) received glimepiride. Women (65.10%) dominated type 2 diabetes mellitus patients, with the largest age group (91.15%) of sufferers being over 45 years old.

Table 2 exhibits that, out of 133 type 2 diabetes mellitus patients treated with metformin, 95 (71.43%) were successful. In comparison, out of 59 patients treated with glimepiride, 46 (77.97%) demonstrated effectiveness. As listed in Table 3, the average cost was IDR 7,382 ± 3,038.77 for metformin and IDR 6,101 ± 3,270.81 for glimepiride.

A pharmacoeconomic analysis was carried out by calculating the

Table 1
Characteristics of respondents (N = 192)

Characteristic	Frequency <i>n</i> (%)
Gender	
Female	67 (34.90)
Male	125 (65.10)
Age	
<45 years old	17 (8.85)
≥45 years old	175 (91.15)
Therapy	
Metformin 500 mg	133 (69.27)
Glimepiride 2 mg	59 (30.73)

mg: milligrams

Table 2
Effectiveness of using metformin and glimepiride

Therapy	Number of participants receiving the drug	Number (percentage) of participants that show the drug is effective
Metformin 500 mg	133	95 (71.43)
Glimepiride 2 mg	59	46 (77.97)

mg: milligrams

Table 3
Cost of using metformin and glimepiride

Therapy	Number of participants receiving the drug	Number of participants that shows the drug is effective	Average cost mean \pm SD (IDR)
Metformin 500 mg	133	95	7,382 \pm 3,038
Glimepiride 2 mg	59	46	6,101 \pm 3,270

IDR: Indonesian Rupiah; mg: milligrams; SD: standard deviation

ACER value, calculated from the average drug cost and the percentage of drug effectiveness using Microsoft Excel. As depicted in Table 4, the calculation revealed an ACER value of IDR 103 for metformin and IDR 78 for glimepiride.

DISCUSSION

This research compared the effectiveness of metformin and glimepiride, in terms of cost and therapy, in reducing blood glucose in

Table 4
Average cost-effectiveness ratio

Therapy	Cost (IDR)	Effectiveness (%)	ACER (IDR)
Metformin 500 mg	7,382 ± 3,038	71.43	103.34 ± 42.53
Glimepiride 2 mg	6,101 ± 3,270	77.97	78.24 ± 41.94

ACER: average cost-effectiveness ratio; IDR: Indonesian Rupiah; mg: milligrams

patients with type 2 diabetes mellitus. A total of 125 (65.10%) female patients and 67 (34.90%) male patients participated in this study. It illustrates that woman outnumbered men among type 2 diabetes mellitus patients. Women have a greater chance of developing diabetes mellitus compared to men because, physically, they have a greater rise in body mass index. The hormonal process during post-menopause facilitates the accumulation of body fat distribution, causing women to be at risk of suffering from diabetes mellitus (Komariah and Rahayu, 2020).

Most diabetes mellitus patients were aged 45 years old or older. Of the patients, 175 (91.15%) were diagnosed with diabetes mellitus at the age of 45 years or older, and 17 (8.85%) were diagnosed at the age below 45 years. According to Basic Health Research 2018, those aged 45 years or older are the most affected by diabetes mellitus (Ministry of Health Republic Indonesia, 2019). At this age, the functionality of the body's systems, including the immune, metabolic, endocrine, gastrointestinal, muscle, and nervous systems, begins to decline. Degenerative diseases are increasingly being diagnosed, resulting in reduced activities and quality of life due to physical and psychological disabilities (Arania *et al*, 2021).

Oral antidiabetics are given to type 2 diabetes mellitus patients whose blood glucose cannot be controlled with diet, exercise, and weight loss. The antidiabetic frequently administered to diabetes mellitus

patients at community health centers in Yogyakarta was a single oral antidiabetic drug. The oral diabetes drugs provided in this study were metformin and glimepiride. In addition, the treatment for patients with type 2 diabetes mellitus involved giving oral diabetes medication of metformin or glimepiride because of their long-standing and most widely used (Hardianto, 2020). Metformin was administered to 69.27% of the patients, while the rest, 30.72%, received glimepiride. Therefore, metformin, an oral anti-diabetic, was the drug most prescribed to patients with type 2 diabetes mellitus. It is a widely used drug that provides benefits in glucose metabolism and diabetes complications (Rena *et al*, 2017). Metformin can also reduce the risk of death and cardiovascular events compared to other drugs (Maruthur *et al*, 2016). Glimepiride belongs to the sulfonylurea class of drugs. It is the first drug for type 2 diabetes mellitus, especially for elderly patients. The mechanism of action of glimepiride involves reducing blood glucose by declining glucose absorption in the gastrointestinal tract, lowering hepatic gluconeogenesis, and raising insulin sensitivity (Syarifuddin *et al*, 2021). Glimepiride also demonstrates lower hypoglycemic events than other sulfonylurea groups (Ghanem, 2018).

The effectiveness of therapy was assessed based on the achievement of the blood glucose target of patients, which was classified into two categories: effective and ineffective. The effective category comprises patients whose blood glucose levels reach the instantaneous blood glucose target of below 200 mg/dl for three months; the ineffective category includes patients whose blood glucose levels fail to reach the target within three months. The effectiveness of the glimepiride therapy group was 77.96%, surpassing that of metformin, which was 71.42%, indicating that the glimepiride therapy group was more effective in reducing blood glucose levels. This discovery is supported by a review conducted by Arini and Kurnianta (2019) who disclosed that the use of glimepiride was

more effective for lowering blood glucose levels than metformin, with an effectiveness of 83.78% for glimepiride and 75.67% for metformin. Based on clinical studies, glimepiride can significantly reduce fasting blood glucose, instant blood glucose, and HbA1C (Malihah and Emelia, 2022). The South Asian Federation of Endocrine Societies statement emphasizes that modern sulfonylureas (glimepiride) should be more extensively utilized because of their low hypoglycemia and weight gain results (Devarajan *et al*, 2017).

A cost analysis from the perspective of the health centers was performed in this study, including only the cost of oral antidiabetics as the components. The cost of oral antidiabetics was based on the price of the drug from the pharmacy installation of the community health centers. Costs were calculated by multiplying the unit price of oral diabetes medication by the number of daily medicines administered during treatment. It was calculated from the first time the patients received the drug until they reached the therapeutic target. The average cost for using oral antidiabetics in the glimepiride group was lower than in the metformin group. The average cost was IDR 6,101 for glimepiride and IDR 7,382 for metformin. Similarly, a study conducted by Ramadhan and Dharma (2020) revealed that the costs for glimepiride therapy were lower than metformin: IDR 23,334,083 for glimepiride and IDR 162,750,079 for metformin. The difference in total therapy costs was influenced by the frequency of drug administration, duration of drug use, and the price of oral antidiabetics between the two therapy groups. The total average cost is a component required in this research to calculate cost-effectiveness.

CEA refers to an analysis of the effectiveness of therapy and its costs. The effectiveness of treatment could be determined by comparing the costs incurred by the patient to the percentage of success of antidiabetics in reducing the patient's blood glucose levels. Cost-effectiveness was determined by calculating the ACER value, by comparing the average

total cost with the treatment effectiveness of the group. A therapy group can be cost-effective if it has a lower ACER value than other groups. The glimepiride therapy group had a lower ACER value compared to the metformin therapy group, which was IDR 78. It aligns with the research conducted by Jannah *et al* (2021) disclosing that the ACER value in the glimepiride therapy group had a lower value than metformin, which was IDR 4,523 for glimepiride and IDR 5,042 for metformin. A therapy group with the lowest ACER is the most cost-effective. In this study, the metformin therapy group exhibited higher expensive costs and low effectiveness, while the glimepiride therapy group demonstrated lower costs and high effectiveness.

Looking at the cost-effective plane, glimepiride fell into quadrant II, signifying its superiority. Hence, the ICER calculation was unnecessary. It is only performed when the therapy group with high effectiveness costs more or when the therapy group with low effectiveness costs less (Andayani, 2013).

In conclusion, glimepiride therapy for type 2 diabetes mellitus patients was more effective, judging from the cost and the treatment, in reducing blood glucose levels than metformin.

ACKNOWLEDGMENTS

We would like to thank Universitas Muhammadiyah Yogyakarta for facilitating and funding this research.

CONFLICT OF INTEREST DISCLOSURE

All authors declare no conflict of interest.

REFERENCES

- American Diabetes Association (ADA). 2. Classification and diagnosis of diabetes: standards of medical care in diabetes - 2020. *Diabetes Care* 2020; 43(Suppl 1): S14-31.
- Andayani TM. Pharmacoeconomic principles and methodologies. Yogyakarta, Indonesia: Bursa Ilmu; 2013. [in Indonesian]
- Arania R, Triwahyuni T, Esfandiari F, Nugraha FR. Relationship between age, gender and education level with diabetes mellitus at the Clinic Mardi Waluyo Lampung Tengah, 2021 [cited 2023 May 12]. Available from: URL: <https://ejournalmalahayati.ac.id/index.php/medika/article/view/4200/pdf> [in Indonesian]
- Arini HD, Kurnianta PDM. Comparative review of studies on the cost-effectiveness of oral antidiabetic drugs in type 2 diabetes mellitus in Indonesia, 2019 [cited 2023 May 11]. Available from: URL: <https://ojs.farmasimahagesha.ac.id/index.php/AHP/article/view/13/14> [in Indonesian]
- Center for Disease Control and Prevention (CDC). Cost-effectiveness analysis, 2021 [cited 2023 May 10]. Available from: URL: [https://www.cdc.gov/polaris/php/economics/cost-effectiveness.html#:~:text=Cost%2Deffectiveness%20analysis%20\(CEA\),gained%20or%20a%20death%20prevented](https://www.cdc.gov/polaris/php/economics/cost-effectiveness.html#:~:text=Cost%2Deffectiveness%20analysis%20(CEA),gained%20or%20a%20death%20prevented)
- Devarajan TV, Venkataraman S, Kandasamy N, *et al.* Comparative evaluation of safety and efficacy of glimepiride and sitagliptin in combination with metformin in patients with type 2 diabetes mellitus: Indian multicentric randomized trial-START Study. *Indian J Endocrinol Metab* 2017; 21(5): 745-50.
- Fatimah RN. Type 2 diabetes mellitus, 2015 [cited 2023 May 15]. Available from: URL: <https://www.scribd.com/document/340995330/>

Diabetes-Melitus-Tipe-2-Restyana-Noor-Fatimah [in Indonesian]

Finkelstein EA, Chay J, Bajpai S. The economic burden of self-reported and undiagnosed cardiovascular diseases and diabetes on Indonesian households. *PLoS One* 2014; 9(6): e99572.

Ghanem Y. Glimpiride as add-on therapy in type 2 diabetic patients with metformin monotherapy: a real-life study from Egypt. *Med J Cairo Univ* 2018; 86(6): 4699-704.

Guo X H, Lv XF, Han P, *et al.* Efficacy and safety of glimepiride as initial treatment in Chinese patients with type 2 diabetes mellitus. *Curr Med Res Opin* 2013; 29(3): 169-74.

Hardianto D. A comprehensive review of diabetes mellitus: classification, symptoms, diagnosis, prevention and treatment, 2020 [cited 2023 Jul 05]. Available from: URL: <https://ejournal.brin.go.id/JBBI/article/view/1961/1208> [in Indonesian]

Indonesian Endocrinology Association. Guidelines for management and prevention of diabetes mellitus type 2 in adults in Indonesia, 2021 [cited 2023 Jun 10]. Available from: URL: <https://pbperkeni.or.id/wp-content/uploads/2021/11/22-10-21-Website-Pedoman-Pengelolaan-dan-Pencegahan-DMT2-Ebook.pdf> [in Indonesian]

International Diabetes Federation (IDF). Global Diabetes Plan 2011-2021, 2011 [cited 2023 Jun 10]. Available from: URL: https://ncdalliance.org/sites/default/files/rfiles/Global_Diabetes_Plan_Final%5B1%5D.pdf

Jannah EN, Ismunandar A, Maulana LH. Cost-effectiveness analysis of the use of oral antidiabetics in type 2 diabetes mellitus patients BPJS participants at Bumiayu Hospital, 2021 [cited 2022 Jun 21]. Available from: URL: <https://media.neliti.com/media/publications/348557-analisis-efektivitas-biaya-penggunaan-an-1f01f40f.pdf> [in Indonesian]

- Komariah, Rahayu S. Relationship between age, gender and body mass index with fasting blood sugar levels in type 2 diabetes mellitus patients at the Proklamasi Outpatient Primary Clinic, Depok, West Java, 2020 [cited 2023 Jul 20]. Available from: URL: <https://jurnal.ukh.ac.id/index.php/JK/article/view/412/320> [in Indonesian]
- Malihah D, Emelia R. Pattern of antidiabetic treatment of diabetes mellitus type 2 outpatient in dr. M. Salamun Hospital, 2022 [cited 2023 May 27]. Available from: URL: <https://jurnal.akbidharapanmulya.com/index.php/delima/article/download/161/124/> [in Indonesian]
- Maruthur NM, Tseng E, Hutfless S, *et al.* Diabetes medications as monotherapy or metformin-based combination therapy for type 2 diabetes. *Ann Intern Med* 2016; 164(11): 740-51.
- Masturoh I, Anggita N, editors. Health Research Methodology, 2018 [cited 2022 Jul 21]. Available from: URL: <https://elibrary.stikesghsby.ac.id/index.php?p=fstream&fid=232&bid=2006> [in Indonesian]
- Ministry of Health Republic Indonesia. Stay productive, prevent and overcome diabetes mellitus, 2020 [cited 2022 Jul 25]. Available from: URL: <https://fliphtml5.com/toqez/xfxq/Infodatin-2020-Diabetes-Melitus/> [in Indonesian]
- Ministry of Health Republic Indonesia. Basic Health Research Data Report 2018, 2019 [cited 2022 May 05]. Available from : URL : <https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/1/Laporan%20Risesdas%202018%20Nasional.pdf> [in Indonesian]
- NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in diabetes prevalence and treatment from 1990 to 2022: a pooled analysis of 1108 population-representative studies with 141 million participants. *Lancet* 2024; 404(10467): 2077-93.
- Putra IWA, Berawi KN. Four pillars of management of type 2 diabetes mellitus patients, 2015 [cited 2022 May 05]. Available from: URL:

<http://repository.lppm.unila.ac.id/235/1/khairunnisa%20berawi3.pdf> [in Indonesian]

Ramadhan IR, Dharma WST. Analysis of the effectiveness of monotherapy antidiabetic medicine and combination in diabetes mellitus patient type 2 participants of BPJS patients in hospital in Islamic Cempaka Putih Jakarta patient Period 2018, 2020 [cited 2022 Jul 25]. Available from: URL: <https://journal.uta45jakarta.ac.id/index.php/SCPIJ/article/view/1864/1771> [in Indonesian]

Rena G, Hardie DG, Pearson ER. The mechanisms of action of metformin. *Diabetologia* 2017; 60(9): 1577-85.

Soltis-Herrera C, Triplitt C, Reasner C, DeFronzo RA, Cercosimo E. Classification of diabetes mellitus, 2018 [cited 2023 Jul 11]. Available from: URL: <https://www.ncbi.nlm.nih.gov/books/NBK279119/>

Syarifuddin S, Marpaung RF, Hotria P. Use of antidiabetic drugs in hospitalization at Harapan Pematangsiantar, 2021 [cited 2023 Aug 15]. Available from: URL: <https://jurnal.univrab.ac.id/index.php/klinikal/article/view/1869/1006> [in Indonesian]

World Health Organization (WHO). Diabetes, 2021 [cited 2023 May 10]. Available from: URL: <https://www.who.int/news-room/fact-sheets/detail/diabetes>