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Meta-Analysis

The Effectiveness of Electronic Health Uptake in Diabetes Mellitus Patients: A Meta-Analysis

Eni Nur Rahmawati[1)], Didik Gunawan Tamtomo[2)], Bhisma Murti[1)]

[1)]Masters Program in Public Health, Universitas Sebelas Maret
[2)]Faculty of Medicine, Universitas Sebelas Maret

ABSTRACT

Background: Diabetes is a chronic disease in the form of a metabolic disorder characterized by blood sugar levels that exceed normal limits. The cause of the increase in blood sugar levels is the basis for grouping the type of Diabetes. This study aims to examine the effectiveness of the use of electronic health in patients with diabetes mellitus.
Subjects and Method: Meta-analysis was carried out using PICO as follows: The population in this study were patients with diabetes mellitus. Intervention in the form of the use of electronic health. Comparison in the form of direct consultation. The outcome is a decrease in HbA1c levels. Meta-analytical studies were applied to this study with electronic data sources: Google Scholar, MEDLINE/PubMed, Science Direct and ProQuest. The article used is a full-text article with a Randomized Control Trial (RCT) study design. There are 9 articles used in this study with a total sample of 1.137 people who were divided into two groups (568 people in the electronic health group and 569 people in the direct consultation group). Articles were analyzed using the Review Manager 5.3 application. The results of this study aim to determine the Standardized Mean difference (SMD) and the heterogeneity of the research sample.
Results: There was a high heterogeneity between one experiment and another (I^2=91%; P<0.001) so the Random Effect Model (REM) was used. The use of Electronic Health help reduces HbA1c levels with Standardized Mean Different (SMD) by 0.39 compared to direct consultation (SMD = -0.39; 95% CI = -0.79 to -0.01; p=0.050).
Conclusion: The use of electronic health help reduces HbA1c levels in diabetes mellitus patients with Standardized Mean Different (SMD) by 0.39 compared to direct consultation.

Keywords: Electronic Health, Diabetes Mellitus, HbA1c

Correspondence:
Eni Nur Rahmawati. Masters Program in Public Health, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Email: eninur_rahma@udb.ac.id. Mobile: +6285743748528.

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BACKGROUND

Diabetes mellitus is a chronic disease in the form of a metabolic disorder characterized by blood sugar levels that exceed normal limits (Kemenkes, 2020). According to the American Diabetes Association (2019), DM disease can be classified into 4 (four) types, namely: type 1 DM, type 2 DM, gestational diabetes, and specific types of diabetes that arise as a result of other diseases (neonatal diabetes, diseases of the exocrine pancreas), such as cystic fibrosis and pancreatitis, and drug or chemical induction or after organ transplantation).

Type 1 diabetes mellitus occurs due to an autoimmune reaction that causes

damage to pancreatic beta cells and results in a decrease in insulin production. While Diabetes Mellitus type 2 insulin production and levels in the body are still normal, but hyperglycemia occurs due to the body's cells being less sensitive to the hormone insulin. Decreased sensitivity of body cells to insulin is known as insulin resistance which chronically causes disturbances in the stimulation of glucose transporters so that blood glucose uptake decreases. Gestational diabetes is a problem in women who experience insulin resistance and occurs for the first time during pregnancy. DM is one of the important public health problems and is one of the four non-communicable diseases that are a priority for the government.

According to the International Diabetes Federation (2019), the prevalence of DM sufferers worldwide reaches 463 million and is expected to continue to increase to 578 million in 2030 to 700 million in 2045. Countries in the Arab-North African and West Pacific region rank first and second with the highest prevalence of diabetes in the population aged 20-79 years among 7 regions in the world, namely 12.2% and 11.4%. The IDF also projects that the number of people with diabetes in the population aged 20-79 years in several countries in the world has identified 10 countries with the highest number of sufferers. China, India and the United States occupy the top three with the number of sufferers 116.4 million, 77 million and 31 million. Indonesia is ranked 7th among 10 countries with the highest number of sufferers, which is 10.7 million. Indonesia is the only country in Southeast Asia on the list, so it can be estimated that Indonesia's contribution to the prevalence of diabetes cases in Southeast Asia can be estimated. Data from Riskesdas (2018) states that the prevalence of DM based on doctor's diagnosis in residents aged 15 years when compared to 2013 increased to 2%. Diabetes caused 1.5 million deaths in 2018 and an additional 2.2 million deaths by increasing the risk of cardiovascular disease. Forty-three percent (43%) of these 3.7 million deaths occurred before the age of 70. The high mortality rate caused by diabetes mellitus is one of the causes of chronic effects that arise as complications of other organs. In an effort to reduce the prevalence of mortality and morbidity due to DM, it can be carried out by controlling blood glucose levels through two types of therapy, namely pharmacological therapy using antidiabetic drugs and non-pharmacological therapy.

Diabetes mellitus is one of the non-communicable diseases that has been reported to be suffered by some Covid-19 patients. The number of Covid-19 cases in Indonesia as of July 13, 2020 was 76,981, recovered cases were 36,689 and cases died as many as 3,656. Of all the confirmed cases, there were patients who already had comorbidities or comorbidities. So that health services during the Covid-19 pandemic require an updated service strategy so that patients feel safe and comfortable in getting services from doctors.

Diabetes care is strongly influenced by the patient's self-management in performing diabetes care such as proper diet, when to do physical exercise, blood sugar control and insulin use (time of administration and dose) (Cahn *et al.*, 2017). One solution that can be used to overcome the various effects of diabetes mellitus and its complications, both in terms of reducing costs and improving the quality of life of patients, is by utilizing technology that is currently developing rapidly, especially in the health sector. Research shows that the use of the latest health technology can achieve improved metabolic control, quality

of life, and reduce mortality (Giannini *et al.*, 2009).

Efforts to overcome the weakness of DM self care management in controlling blood glucose levels that develop in the community to minimize DM complications can be done by utilizing technological developments. Rapid technological developments, especially computer and communication technology or often referred to as the Information and Communication Technology (ICT) era (Listiyono, 2008). According to Daniel (2012) explains that technology, information, and communication, or ICT is a combination of information technology and communication technology. ICT (Information and Communication Technology) is a tool to get added value in producing fast, complete, accurate, transparent and up-to-date information (Munir, 2009). The era of information and communication technology is used so that the provision of health information is growing.

The development of technology and information is very fast in various fields, one of which is the health sector. This can be applied to patient registration administration systems, patient history information systems, drug information systems, as well as all medical recording activities at health service centers. The use of the right technology can produce fast and accurate information according to the needs of information technology users (Angga, 2015). In other words, the process of recording the patient's medical history can be done by implementing software that helps smooth in improving health services.

One of the technologies in the health sector is mobile health or mHealth. Mobile Health Applications (Apps) are software on smartphones or tablets that can be used in all aspects of human life and their use can help control or control chronic diseases such as diabetes (Brzan *et al.*, 2016). In 2014, 90% of Americans own a mobile phone with 64% of smartphone users. The digital marketing research institute Emarketer estimates that in 2018 the number of active smartphone users in Indonesia is more than 100 million people. With such a large number, Indonesia will become the country with the fourth largest active smartphone user in the world after China, India and America (Rahmayani, 2015).

According to the World Health Organization, electronic health or e-health is the use of cost-effective and safe information and communication technology (ICT) to support various things in the health sector. The scope of technology-based health services is very broad. Not only for online doctor consultations, making consultation appointments, ordering drugs, conducting research, providing health education, processing health data for the benefit of disease control and monitoring public health.

There are several previous systematic review articles that have been published discussing the effectiveness of using electronic health in patients with diabetes mellitus. The author is interested in using meta-analysis techniques in this study to make it easier to obtain evidence-based research results with a large sample size to determine the effectiveness of using electronic health in diabetes mellitus patients compared to direct consultation and can be considered by health workers in its use.

SUBJECTS AND METHOD

A. Study Design

This was a systematic review and meta-analysis involving various databases of appropriate electronic journals including: MEDLINE/PubMed, Science Direct, Google Scholar, and ProQuest. With keywords including: ehealth OR mhealth OR telemedicine OR "electronic health record" AND

diabetes AND "Randomized Controlled Trial".

B. Inclusion Criteria

1) The article downloaded is full text
2) The article has an appropriate title and is related to the effectiveness of using electronic health in patients with diabetes mellitus
3) Articles published in English and/or Indonesian
4) The article uses a Randomized Controlled Trial (RCT) study design
5) Include the results of the study in the form of the number of respondents, the mean value and the standard deviation (SD) value
7) Intervention on research subjects in the form of electronic health
8) The intervention in the control group did not use electronic health or direct consultation with a doctor

C. Exclusion Criteria

1) Articles are not full-text
2) Articles using a quasi-experimental study design, protocol study, pilot study, cohort, case control and cross-sectional
3) Articles use languages other than English and Indonesian
4) The article does not use multivariate analysis
5) Articles using animal research subjects

D. Variable Operational Definition

Electronic Health is the use of information and communication technology for health services and information, primarily to improve the quality of health services and improve effective and efficient work processes. In general, e-health consists of health informatics and tele-health efforts.

Direct Consultation is a meeting between doctors and patients directly.

HbA1c is an examination that serves to measure the average amount of hemoglobin A1c related to blood sugar (glucose) over the last three months.

E. Instrument

Published articles obtained from various databases of appropriate electronic journals include: Google Scholar, MEDLINE/ Pub-Med, Science Direct and ProQuest. This research was conducted for 30 days (18 October 2021-18 November 2021) by searching and selecting research results from various races, ethnicities and locations in the world.

F. Data Analysis

This research was conducted using secondary data in the form of data from previous research results and data processing was carried out using the Review Manager (RevMan 5.3).

RESULTS

The article selection process is carried out using the Mendeley desktop application. In the initial process of searching the articles obtained a number of 1983.

After the selection process, 985 identical articles were found, so the duplicate articles were deleted. so that a total of 998 articles have been filtered. Of the 998 articles, 940 articles were excluded because they did not meet the inclusion criteria. The 58 articles were screened again, there were 49 articles that were not suitable because they did not meet the inclusion criteria.

There are 9 articles which are the final results of article selection that were included in the systematic review and meta-analysis process, which can be seen in (Figure 1).

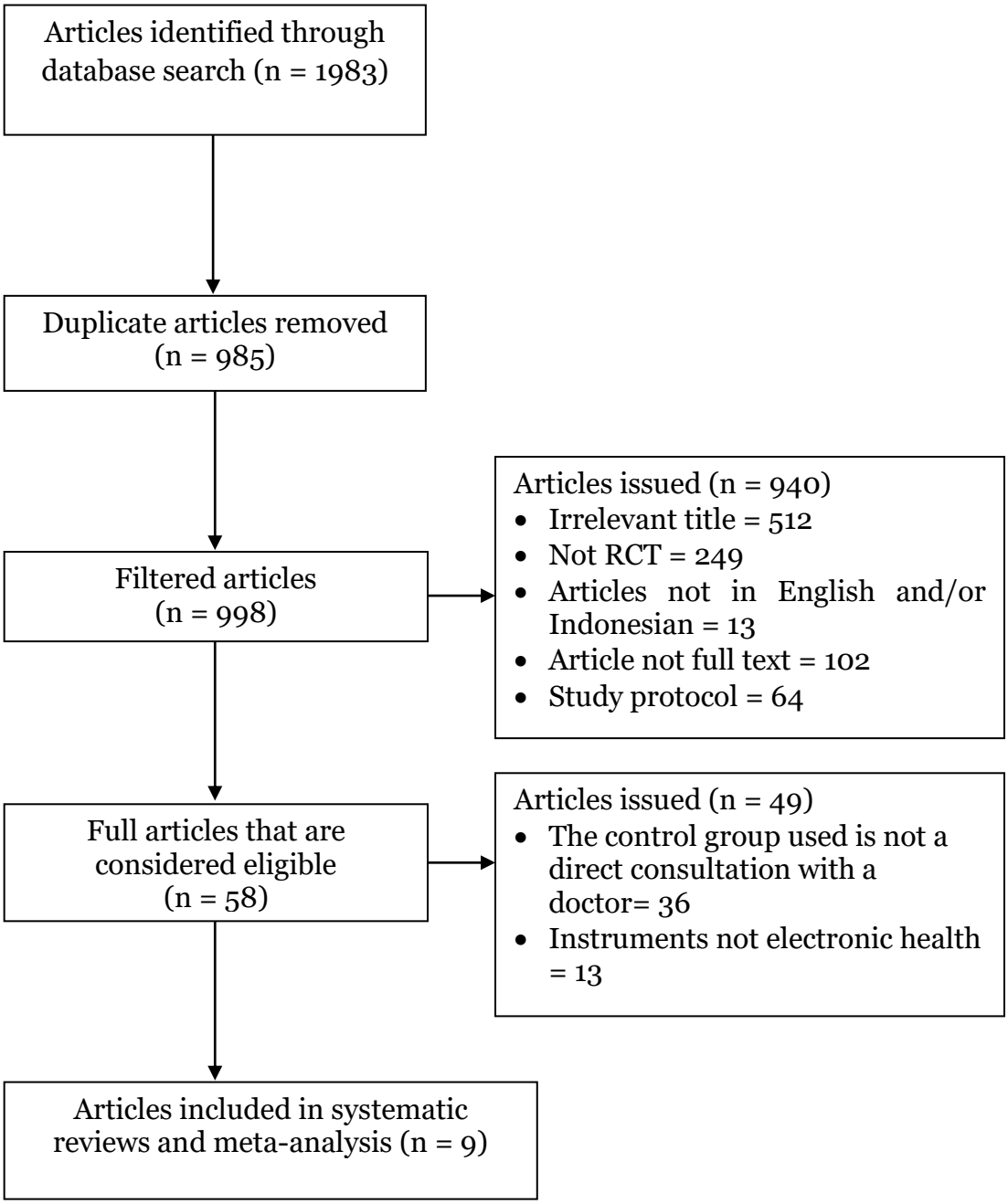

Figure 1. Flow chart of article review process

The interpretation of the results of the meta-analysis of 9 primary research articles in this study can be seen in the forest plot image of the effectiveness of using electronic health in patients with diabetes mellitus to reduce HbA1c levels (Figure 2). Based on the results of the analysis using RevMan 5.3 software, it is known that there is a high heterogeneity between one experiment and another (I^2=91%; P<0.001) so the Random Effect Model (REM) was used. The use of electronic health was able to reduce HbA1c levels with Standardized Mean Different (SMD) by 0.39 compared to direct consultation (SMD = -0.39; 95% CI = -0.79 to -0.01; p=0.05).

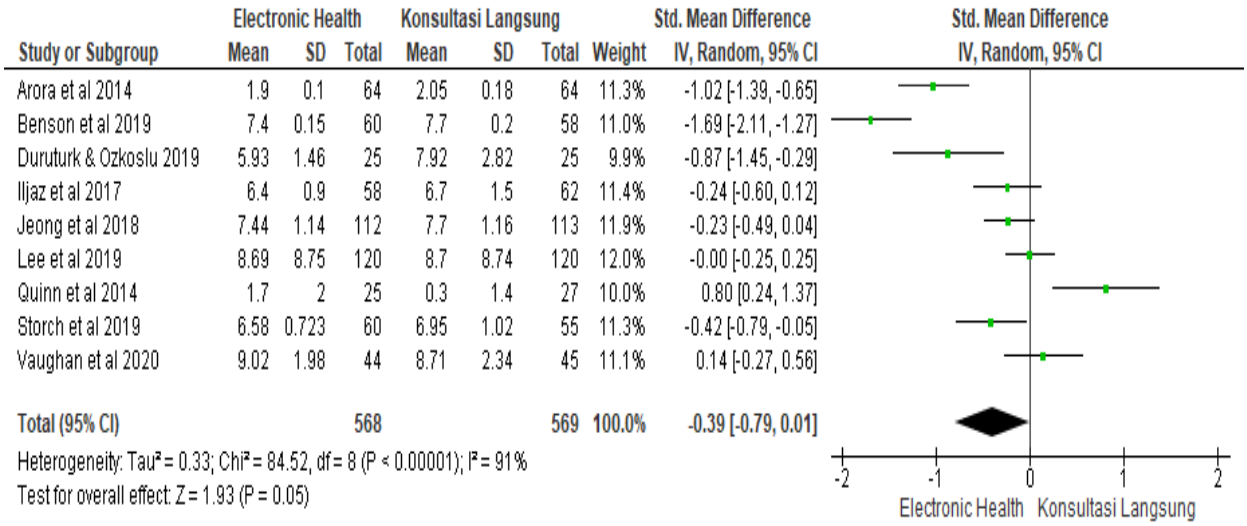

Figure 2. Forest Plot on the effectiveness of using electronic health in patients with diabetes mellitus to reduce HbA1c levels

Funnel plot is a plot that depicts the effect size of each study on an estimate of its accuracy which is usually the standard error. The interpretation of the funnel plot results shows that there is no publication bias as indicated by: 1. The plot is symmetrical on the right and left sides, 2. The distance between plots is balanced, 3. SE value < 0.5. The funnel plot description in this study can be seen in the funnel plot image about the effectiveness of using electronic health in patients with diabetes mellitus to reduce HbA1c levels (Figure 3). The funnel plot images in this study do not indicate that there is publication bias. This is indicated by a more or less symmetrical distribution of effect estimates on the right and left sides of the plot.

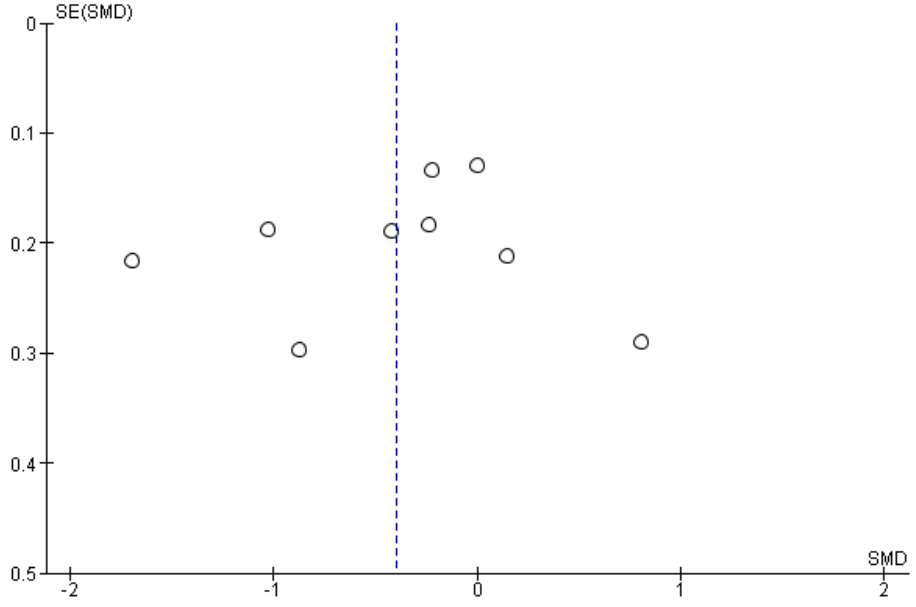

Figure 3. Funnel Plot on the effectiveness of using electronic health in patients with diabetes mellitus to reduce HbA1c levels

DISCUSSION

E-health is the use of information and communication technology for health services and information, primarily to improve the quality of health services and improve work processes that are effective and efficient. In general, e-health consists of health informatics and tele-health efforts (Peraturan Menteri Kesehatan RI No. 46 Tahun 2017 Tentang Strategi e-Kesehatan Nasional., 2017). E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology (Vijay, 2016).

Ahmed's research (2013) was conducted to make the use of electronic health applications effective in helping improve diabetes self-management which requires discipline in monitoring and care. This study found that 91% of participants said the application was easy to use and had the potential to improve self-management, while 90% of online reviews indicated that the application was easy to use and changes to diabetes control could be seen. 15 years ago, technological innovations related to prevention and intervention

against diabetes is done through short message services (SMS) and internet portals. SMS is used as a reminder of appointments with doctors, medication adherence and as a medium to send motivational messages to patients. The provision of internet-based interventions is considered more sophisticated in terms of data transmission between patients and health workers, distribution of health education and lifestyle changes (Hartz *et al.*, 2016). With the advent and wide reach of smartphones, wearables, and mobile applications, there are increasing opportunities for health data storage, feedback from healthcare professionals, motivation and guidance that can improve diabetes management both at home and in hospitals with ease. Until now, thousands of applications related to diabetes can be found, both prevention and management (Hartz *et al.*, 2016). Research on Welltang A Smart Phone Based Diabetes Management Application Improves Blood Glucose Control in Chinese People with Diabetes results that the Welltang application is effective for diabetes management, especially in reducing HbA1c levels and improving clinical conditions, behavior and patient knowledge. As many as 84% of patients in this study said the application could be used easily and were satisfied with the use of the Welltang application (Zhou *et al.*, 2016).

Diabetes is a chronic (chronic) disease in the form of a metabolic disorder characterized by blood sugar levels that exceed normal limits. The cause of the increase in blood sugar levels is the basis for grouping the type of diabetes (Kemenkes, 2020). According to the National Institute of Diabetes and Digestive and Kidney Diseases (2014), Diabetes mellitus (DM) is a disorder of carbohydrate, lipid, and protein metabolism with various causes and is a chronic disease. A person with diabetes has high blood glucose levels, also known as hyperglycemia. Diabetes mellitus (DM) is a heterogeneous group of metabolic disorders characterized by hyperglycemia. It is associated with abnormalities of carbohydrate, fat, and protein metabolism and can lead to chronic complications including microvascular, macrovascular, and neuro-

pathic disorders (Dipiro *et al.*, 2015). The term "diabetes" comes from the Greek meaning "siphon", when the body becomes a channel for excreting excess fluid, and "mellitus" from the Greek and Latin words meaning honey. Abnormalities that are the underlying cause of diabetes mellitus is a relative or absolute deficiency of insulin.

This study takes the topic of the effectiveness of using electronic health in patients with diabetes mellitus, where the independent variable in this study is electronic health and the dependent variable in this study is HbA1c levels in patients with diabetes mellitus. Confounding factors are things that cannot be avoided in a study, but can be controlled. Confounding factors affect the relationship or effect of exposure to disease events estimated (estimated) by studies that are not the same as the relationship or effect that actually occurs in the target population, aka the study results are invalid (incorrect) (Murti, 2018).

This study uses research that controls confounding factors, this can be seen from the inclusion and exclusion requirements required in this study, so that they can control confounding factors that can make the research invalid. There are 9 articles that have passed the inclusion and exclusion requirements of a number of primary studies that were included in this systematic review and meta-analysis. Then the number of respondents, the mean and standard deviation (SD) values were combined and processed using the RevMan 5.3 application. The mean and standard deviation (SD) values were obtained from the measurement scale for HbA1c levels in patients with diabetes mellitus, namely diabetes 6.5%, prediabetes 5.7 to 6.4% and normal < 5.7%.

HbA1c is a substance formed from the chemical reaction between glucose and hemoglobin (part of red blood cells). HbA1c examination is used as an indicator in monitoring long-term blood sugar control, diagnosis, determination of prognosis, management of DM patients. By measuring glycohemoglobin, it can be seen how big the percentage of hemoglobin that contains sugar. If blood sugar levels are high for several weeks, then HbA1c levels will also be high. The HbA1c bond formed is stable which can last up to 2-3 months. HbA1c levels will reflect the average levels in the period 2-3 months before the examination. By measuring HbA1c levels, it can be seen the quality of DM disease control in the long term, so that the patient's obedience in undergoing meal planning and treatment is known (Sirait, 2018). Hemoglobin in normal conditions does not contain glucose when the erythrocytes first leave the bone marrow, but after a life span of 120 days, the hemoglobin will be bound to glucose. Glycate hemoglobin or HbA1c is the fraction of hemoglobin that is directly bound to glucose which indicates blood sugar levels for 8-12 weeks. HbA1c examination is a standard examination to assess long-term glycemic status and is effective in all types of people with Diabetes Mellitus (Tompira *et al.*, 2016). The HbA1c test has so far been successful in providing control over diabetes. The test shows the average amount of blood sugar in 2-3 months, therefore diabetics are recommended to routinely control at least 2 times a year (Russel, 2011).

The results of data processing using the RevMan 5.3 application on 9 articles from Southern California, Maryland, Minnesota, Texas, South Korea, Malaysia, Slovenia, Turkey and Germany, resulted in the following conclusions: the use of electronic health help reduce HbA1c levels with Standardized Mean Different (SMD) was 0.39 compared with direct consultation

(SMD = -0.39; 95% CI = -0.79 to -0.01; p=0.05).

This is in line with a previous study by Quinn *et al*., (2014) which stated that there was a decrease in HbA1c levels after 12 months of using a mobile phone, compared to usual care, for patients in both age groups (p<0.001). Among older patients, HbA1c changed by 1.8% (95% CI= −2.4 to 1.1) in the intervention group and by 0.3% (95% CI= −0.9 to 0.3) in the control group. Among younger patients, HbA1c changed by 2.0% (95% CI= −2.5 to 1.5) in the intervention group and by 1.0% (95%). The results of this study indicate that mobile phones can be an alternative to help treat diabetes mellitus patients.

The results of the study of Iljaz *et al*., (2017) using the eDiabetes App were confirmed as an innovative approach for better self-management of type 2 DM patients that can significantly reduce HbA1c values and a significant correlation between self-measured mean blood pressure and final HbA1c values in the intervention group.

Results from the study of Jeong *et al*., (2018) reduced HbA1c concentrations after 24 weeks in the conventional treatment, telemonitoring, and telemedicine groups (-0.66% – 1.03% vs. -0.66% – 1.09% vs. -0.81% – 1.05%; p > 0.05 for each pairwise comparison). Fasting glucose concentrations were lower in the telemonitoring and telemedicine groups than in the conventional group. Hypoglycemia rates were lower in the telemedicine group than in the other two groups, and adherence to treatment was better in telemonitoring and telemedicine compared to the conventional group. Telehealthcare is as effective as conventional treatments for improving glycemia in patients with type 2 diabetes.

The results of the Duruturk & Ozkoslu study (2019) that HbA1c levels changed significantly (p = 0.00) in the tele-rehabilitation group (TR). There was no significant improvement in the control group (p > 0.05). This study demonstrates that tele-rehabilitation (TR) interventions are found to be safe and effective, and may be an alternative treatment model for the management of type 2 diabetes mellitus (DM) using tele-rehabilitation (TR).

The results of the study of Storch *et al*., (2019) The intervention group resulted in a significantly greater decrease in HbA1c compared to the control group. In addition, the tele-assisted participants showed significant improvements in the Diabetes Self-Management scale score and body mass index compared to the regular care participants. Patients with T2DM may benefit from telemedicine-assisted self-management programs, which may offer new options for the treatment and prevention of disease progression.

Based on Vaughan *et al*., (2020) research on the application of A Telehealth-supported, Integrated care with CHWs, and Medication-access (TIME) found that participants who used the TIME application compared to control participants had a significant decrease in HbA1c (9.02 to 7.59% (1.43%) vs. 8.71 to 8.26% (−0.45%), respectively, p = 0.002), change in blood pressure (systolic: 6.89 mmHg vs. 0.03 mmHg, p = 0.023; diastolic: 3.36 mmHg vs. 0.2 mmHg, respectively, p = 0.046), and adherence to ADA guidelines (p<0.001) from baseline to 6 months.

AUTHORS CONTRIBUTION

Eni Nur Rahmawati as the main researcher who chooses the topic, implements the research, collects research data, formulates research articles, and processes data. Didik Gunawan Tamtomo helped formulate a frame of mind and analyze research data. Bhisma Murti played a role in formulating

the background and discussion of the research.

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This study is self-funded.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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