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Masters Program in Public Health, Universitas Sebelas Maret

Meta-analysis

Meta Analysis of the Effect of Telemonitoring on Blood Sugar Levels and Quality of Life in Diabetes Patients

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ABSTRACT

Background: Type 2 diabetes mellitus (DM) is a chronic disease that requires continous monitoring and treatment so that it can produce a better quality of life. Telemonitoring is a medium that can help in monitoring patients with type 2 DM. This study aims to analyze the effect of using telemonitoring on blood sugar levels and quality of life of patients with type 2 DM with a meta-analysis study.

Subjects and Method: This was a systematic review and meta-analysis conducted with PRISMA flow diagram. The searching of articles was done through journal databases including PubMed, Google Scholar, Science Direct and ProQuest by selecting articles published in 2000-2021. The keywords used were ("telemedicine" OR "telemonitoring" OR "tele-monitoring") AND ("diabetes" OR "diabetes mellitus" OR "diabetes mellitus type 2") AND ("glucose level") AND ("quality of life"). The searching of articles used the PICO model. Population: people with type 2 diabetes mellitus, Intervention: telemonitoring, Comparison: not using telemonitoring, Outcome: blood sugar level and quality of life. Inclusion criteria were full text articles with RCTR Randomized Controlled Trial (RCT) study design, articles were in English, with the relationship size study method used using Mean SD. Eligible articles were analyzed using the Revman 5.3.

Results: A meta-analysis of 11 primary studies on the use of telemonitoring of blood sugar level showed a decrease in blood sugar (HbA1c) levels in patients with type 2 diabetes by 0.20 times compared to not using telemonitoring (SMD= -0.20; 95% CI= -0.39 to -0.01; p= 0.040) and from 6 primary studies on the use of telemonitoring on quality of life showed an increase in quality of life in type 2 diabetes patients by 0.16 times compared to not using telemonitoring (SMD= -0.16; 95% CI= -0.29 to -0.03; p= 0.020).

Conclusion: The use of telemonitoring can improve blood sugar levels and improve the quality of life of patientswith type 2 diabetes.

Keywords: telemonitoring, type 2 diabetes mellitus, quality of life, meta-analysis

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BACKGROUND

Non-communicable diseases caused mortality by 41 million people per year, equivalent to 71% of deaths globally. There are five most non-communicable diseases in the world, namely heart disease, stroke, cancer, diabetes mellitus (DM), and chronic lung disease. Diabetes mellitus is one of the fourth non-communicable diseases (NCDs) after heart, cancer and respiratory diseases, which have caused 1.6 million people to die (WHO, 2020). Diabetes mellitus is a

general term for a group of metabolic disorders characterized by chronic hyperglycemia, which originates from impaired insulin secretion, or impaired insulin effectiveness or can occur due to both (Petersmann et al., 2018). The prevalence of diabetes mellitus in the world is 8.3%. The Middle East and North Africa region had the highest prevalence of diabetes in adults by 12.2%. Indonesia is in 7th place with the highest number of diabetics in the world by 10.7%(IDF, 2019).

Based on the results of Basic Health Research in 2018, the prevalence of DM based on a doctor's diagnosis in all population aged 15 years old according to Province was 2%, an increase from Basic Health Research's data in 2013 which was 1.5% (Basic Health Research, 2018). The prevalence of diabetes mellitus is progressively increases annually. Therefore, patients with diabetes need continuous monitoring and treatment. Hyperglycemia or elevated blood sugar is a common effect of uncontrolled diabetes mellitus which over time can cause serious damage to many body systems, especially nerves and blood vessels(WHO, 2020). People with diabetes have low quality of life and may have increased symptoms of depression than individuals who do not have diabetes, which may have a negative effect on their quality of life (Kopp et al., 2012).

The high cost of professional care, so that patients need to be encouraged to do the best possible health management to reduce complications and dependence on the health care system, scientific studies show the beneficial effects of monitoring and educating the patients (Bujnowska-Fedak et al., 2011). Information and communication technology is one of the solutions that can reduce several problems related to chronic disease rates, an aging population, a lack of professional health personnels and health care facilities. Proper use of telemedicine can facilitate services in remote areas and reduce the impact of the lack of health personnels (Paré et al., 2010).

Telemonitoring is part of telemedicine in the form of technology that can collect and transmit patient's data that is useful to help health monitor and patients diagnose (Rudel and Fisk, 2011). The use of telemedicine system can help to optimize patient management processes and possible prognoses, especially by preventing emergencies (Andrès et al., 2019). Study on the benefits of using telemonitoring and managing this condition has been widely used in patients with asthma, diabetes mellitus, heart disease and hypertension (Pecina et al., 2013). In a study conducted in 4 regions of the UK, it was found that telemonitoring has an impact on clinical improvements in glycemic control in type 2 diabetes patients in family practice (Wild et al., 2016). A study by Valdivieso et al., (2018) in 6 primary care centers in the city of Valencia, Spain shows that there is a relationship between Telehealth and better quality of life in chronic patients who are at high risk but not in mortality (González-Molero et al., 2012).

Based on this background, it can be seen that if the telemonitoring intervention gave positive results on blood sugar levels and quality of life, the researchers are interested in studying further. The data obtained would be analyzed using meta-analysis by synthesizing study results to reduce bias.

SUBJECTS AND METHOD

1. Study Design

The study design used in this study was a systematic review and meta-analysis, using the PRISMA diagram flow guidelines. Article searches were conducted by using journal databases including: PubMed,

Google Scholar, Science Direct, ProQuest. The keywords used were ("telemedicine" OR "telemonitoring" OR "tele-monitoring") AND ("diabetes" OR "diabetes mellitus" OR "diabetes mellitus type 2") AND ("level glucose") AND ("quality of life").

2. Inclusion Criteria

In this study, the inclusion criteria were full text articles in 2000-2021 using a randomized controlled trial (RCT) study design, articles were in English, the relationship measure used was Mean SD, the study subjects were type 2 diabetics, the intervention was the use of telemonitoring, the and outcomes were blood sugar level and quality of life.

3. Exclusion Criteria

Exclusion criteria in this study included articles with an observational study design, diabetics who had comorbidities and complications.

4. Operational Definition

In formulating study problems, the researchers used PICO. Population is people with type 2 diabetes mellitus. Intervention is the use of telemonitoring, comparison is not using telemonitoring, and outcomes are blood sugar level and quality of life.

Telemonitoring is the use of communication technology in the form of audio, video and other telecommunications in health services to monitor patients from a distance.

Blood sugar level is the level of blood sugar in the body**.**

Quality of life is an individual's perception of his/her life situation which includes aspects of culture, and the values in which the individual lives in relation to the purpose of life, and their standards and benefits.

5. Study Instrument

An assessment of the quality of study articles was carried out using theCritical Appraisal Skills Programme (CASP) for RCT.

6. Data Analysis

The Review Manager application (RevMen 5.3) was used in analyzing the data in this study. The results of data analysis are in the form of effect size values and study heterogeneity which later the results of the data that have been analyzed are interpreted in the form of forest plots and funnel plots.

RESULTS

Research from the primary study is related to the effect of using telemonitoringon blood sugar levels and quality of life consists of 17 articles from 4 continents, namely Asia, Europe, Australia, and America. Furthermore, the researchers conducted an assessment of the quality of the articles and there were 17 articles using RCT studies, showing the results that the use of telemonitoring had an effect on blood sugar levels and quality of life.

The search for articles was carried out using a database based on PRISMA flow diagrams, which can be seen in Figure 1.

1. The Effect of Telemonitoring Use on Low Blood Sugar Level

Research related to the effect of using telemonitoring on low blood sugar came from the continents of Asia and Europe, consisting of China, South Korea, Japan, Slovenia, Poland, Italy, Greece and Indonesia, which can be seen in Table 1.

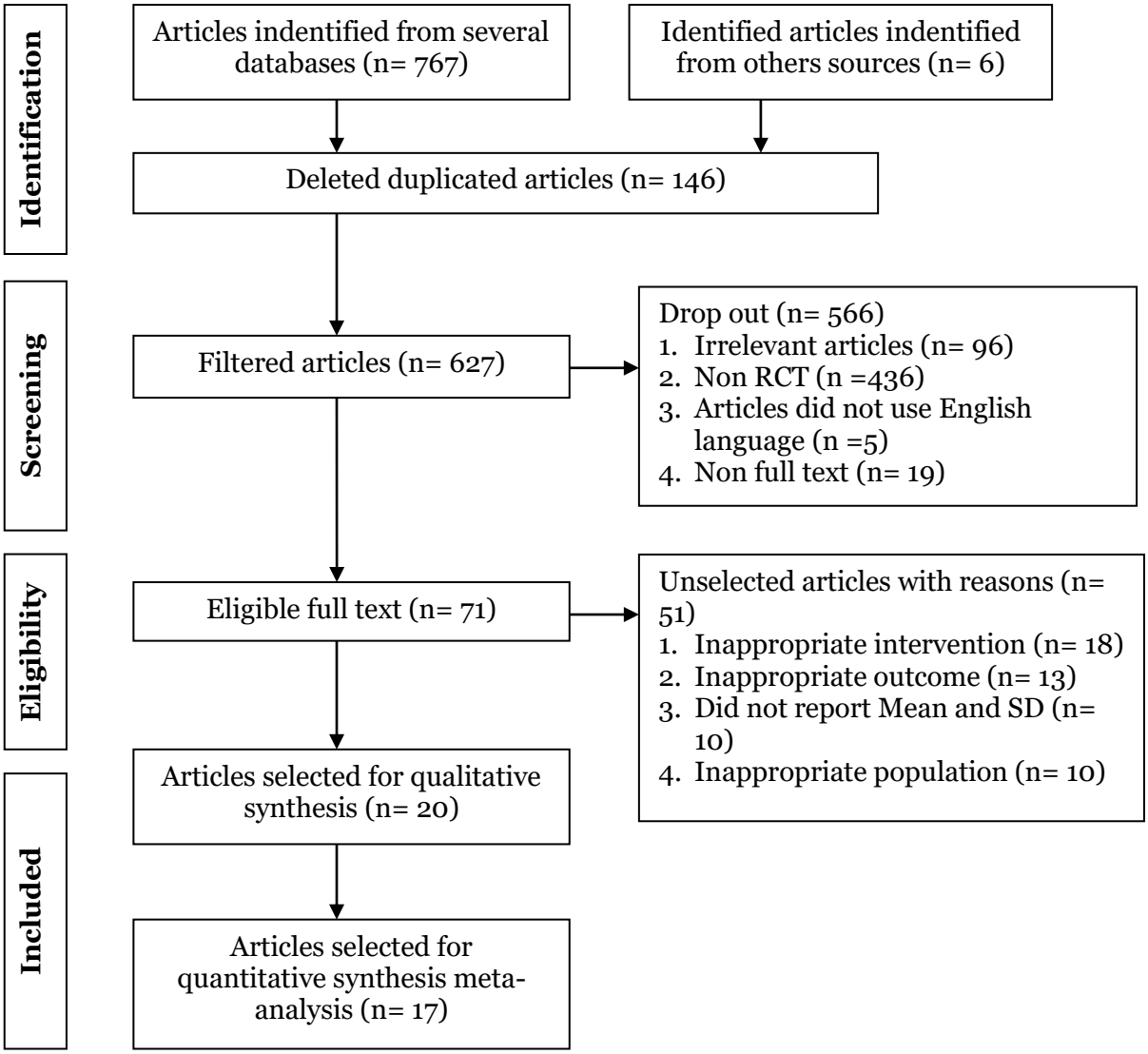

Figure 1. PRISMA flow chart

a. Forest Plot

The forest plot provides a summary of the data entered and gives weights for each study, effect sizes, methods and models used to perform the meta-analysis, confidence intervals used, impact estimates for each study, overall effect estimates, and statistical significance of the analysis. Interpretation of the results of the meta-analysis process can be seen through the forest plot.

Figure 2 showed that the use of telemonitoring can reduce blood sugar (HbA1c) levels in type 2 diabetes patients. Thus, the provision of telemonitoring interventions can reduce blood sugar levels (Hba1c) in type 2 diabetes patients by 0.20 times compared to not using telemonitoring (SMD= -0.20; 95% CI= -0.39 to -0.01; p= 0.040). Based on the analysis above, there was a high heterogeneity between experiments (I^2= 60%; p<0.001) so the Random Effect Model (REM) was used.

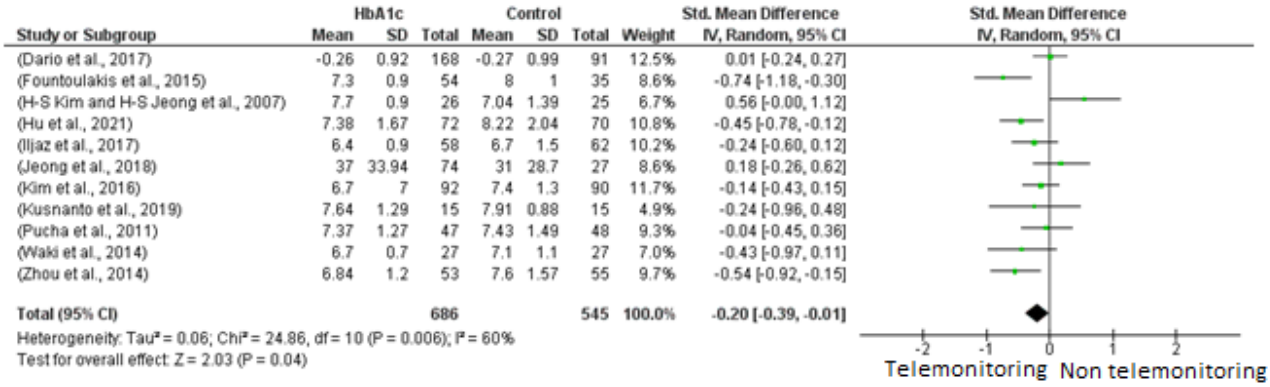

Figure 2. Forest plot of the effect of using telemonitoring on blood sugar levels

b. Funnel Plot

A funnel plot is a plot that depicts the approximate size of the effect of each study on the estimate of its accuracy which is usually the standard error.

Based on Figure 3, it showed that there was no publication bias which was indicated by the symmetry of the right and left plots.

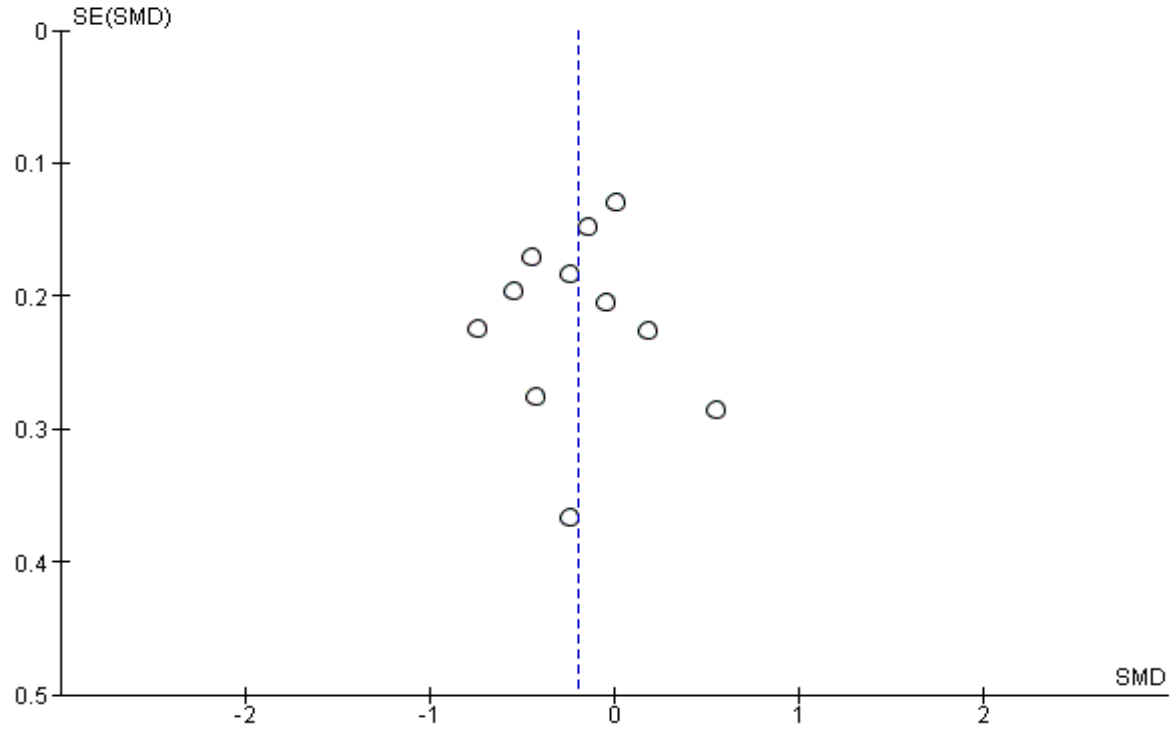

Figure 3. Funnel plot of the effect of using telemonitoring on blood sugar level

Table 1. Description of the primary study of the effect of telemonitoring on blood sugar levels

Author, Year	Location	Sample size	Population (P)	Intervention (I)	Comparison (C)	Outcome (O)
Kim et al., 2016	Chinese	92	Male and female patients with type 2 diabetes, aged <40 to 60 years old.	Internet-based glucose monitoring system (IBGMS)	Conventional treatment	HbA1c levels
Waki et al., 2014	Japan	27	Male and female patients with type 2 diabetes	DialBetics	Non-DialBetics	HbA1c levels
Jeong et al., 2018b	South Korea	74	Male patients with type 2 diabetes, aged 20 to 60 years old.	Telemonitoring	Conventional care	HbA1c levels
Iljaz et al., 2017	Slovenia	58	Male and female patients with type 2 diabetes.	e-Diabetes care	Conventional care	HbA1c levels
Pucha et al., 2011	Poland	47	Male and female patients with type 2 diabetes, aged 18 to 70 years old.	In-home wireless glucose monitor and transmitter	Conventional care	HbA1c levels
Dario et al., 2017b	Italy	168	Male patient with type 2 diabetes.	Telemonitoring	usual care	HbA1c levels
Hu et al., 2021	China	72	Male and female patients with type 2 diabetes, aged 18 to 70 years old.	Telemedicine	Conventional care	HbA1c levels
Zhou et al., 2014)	China	53	Male and female patients with type 2 diabetes, aged 18 to 75 years old.	Telemedicine	Conventional care	HbA1c levels
Fountoulakis et al., 2015	Greece	54	Male and female patients with type 2 diabetes, aged 18 to 86 years old.	Telemonitoring	Usual care	HbA1c levels
Kim and Jeong et al., 2007	South Korea	26	Male and female patients with type 2 diabetes.	Nurse short message service (SMS)	Usual care	HbA1c levels
Kusnanto et al., 2019	Indonesia	15	Male and female patients with type 2 diabetes, aged 36 to 65 years old.	DM-calendar apps	media leaflets	HbA1c levels

2. The effect of telemonitoring use on quality of life improvement

Research related to the effect of using telemonitoring on lowering blood sugar comes from the continents of Asia, America and Australia, which consist of England, Australia, South Korea, America, India and Singapore, which can be seen in Table 4.

a. Forest plot

The forest plot provides a summary of the data entered and gives weights for each study, effect sizes, methods and models used to perform the meta-analysis, confidence intervals used, impact estimates from each study, overall effect estimates, and statistically significant. Interpretation of the results of the meta-analysis process can be seen through the forest plot. Figure 4 showed that the use of telemonitoring can improve the quality of life in type 2 diabetes patients.

Thus, the provision of telemonitoring interventions can improve the quality of life in type 2 diabetes patients by -0.16 times higher compared to not using telemonitoring (SMD= -0.16; 95% CI= -0.29 to -0.03; p= 0.020). Based on the above analysis, there is low heterogeneity between experiments (I^2= 17%; p<0.30), so that Fixed Effect Model was used.

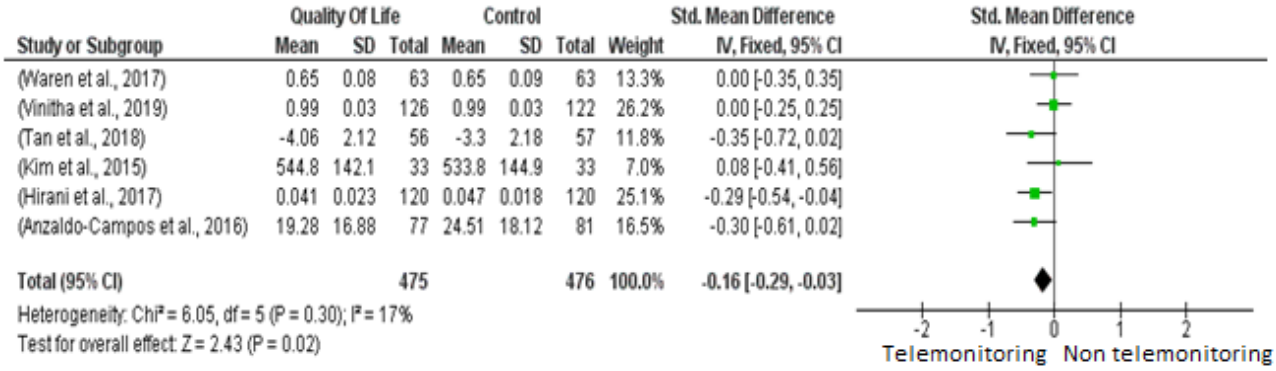

Figure 4. Forest plot of the effect of using telemonitoring on improving the quality of life

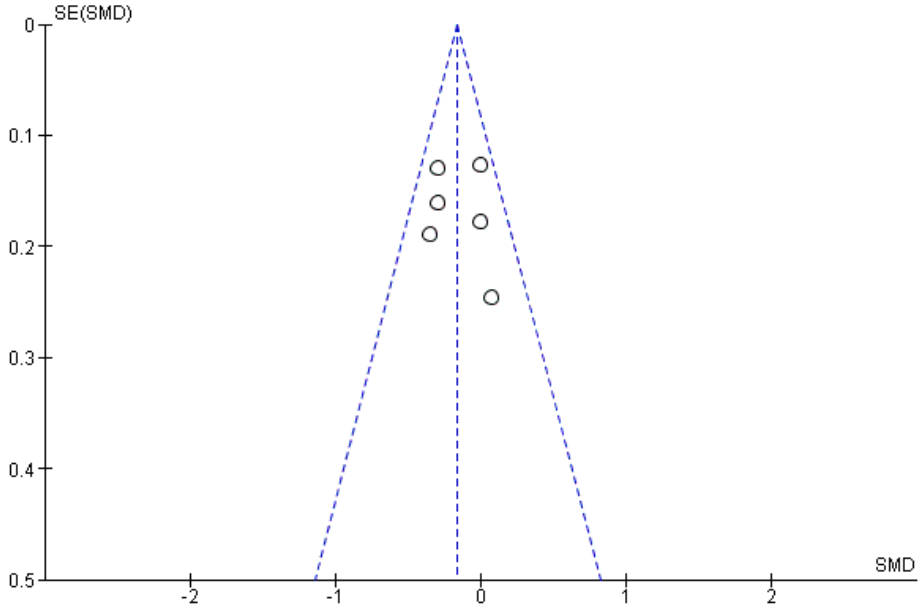

Figure 5. Funnel plot of the effect of using telemonitoring on improving the quality of life

b. Forest plot

A funnel plot is a plot that depicts the approximate size of the effect of each study on the estimate of its accuracy which is usually the standard error.

Based on Figure 5, it shows that there is no publication bias which is indicated by the symmetry of the right and left plots.

Table 2. Description of primary study of the effect of telemonitoring use on quality of life

Author, Year	Location	Sample size	Population (P)	Intervention (I)	Comparison (C)	Outcome (O)
Hirani et al., 2017	England	246	Male and female patients with type 2 diabetes.	Telehealth	Usual care	EQ-5D
Warenet al., 2017	Australia	63	Male patients with type 2 diabetes aged 18 years old or older.	Tele-monitoring	Usual care	SF-6D
Kim et al., 2015	South Korea	33	Patients with type 2 diabetes, aged 60 to 85 years old.	U-Health care System	Standar care	SF- 36
Anzaldo-Compos et al., 2016	America	77	Male and female patients with type 2 diabetes, aged 18 to 75 years old.	PD-TE (MyGluco Health)	Usual care	HRQoL
Vinitha et al., 2019	India	126	Male and female patients with type 2 diabetes, aged 20 to 60 years old.	Message	Usual care	EQ-5D
Tan et al., 2018	Singapore	56	Patients with type 2 diabetes, aged 50 years old and over.	Diabetes self-efficacy enhancing program (DSEEP)	Usual care	ADDQoL

DISCUSSION

This systematic study and meta-analysis discusses the effect of using telemonitoring on improving blood sugar levels and improving quality of life. The independent variable in this study was telemonitoring and the dependent variables in this study were blood sugar level and quality of life.

Diabetes is a chronic disease that requires rapid treatment and periodic treatment where metabolic control can reduce complications and death González-Molero et al., (2012). Regular glucose monitoring provides an advantage over irregular glucose monitoring.

Information about the direction, magnitude, duration, frequency and causes of fluctuations in blood glucose that can be obtained with continuous blood monitoring (Klonoff et al., 2017). In the long term, diabetes can cause microvascular complications (renopathy and neuropathy) and macrovascular complications (myocardial infarction, angina, pectoris and stroke). Complications in diabetes other than hypoglycemic episodes, fear of hypoglycemia, lifestyle changes, can lead to fear of long-term consequences that can affect low health-related quality of life (HRQoL) (Solli, Stavem and Kristiansen, 2010). Diabetes affects the functional ability and quality of the individual which significantly causes morbidity and early death (Abdul et al., 2020). HRQoL refers to the patient's perception of their health status and well-being in terms of physical, psychological and social interaction processes(Dario et al., 2017).

Telemedicine is one of the intervenetions that meet the criteria in the provision of health services in minimizing the workload and increasing patient's comfort (Waki et al., 2014). Telehealth interventions (including telemonitoring) have shown consistent positive effects on the management of type 2 DM in glycemic control, as well as the effects of diabetes risk factors such as blood pressure, lipids and weight/body

mass index. In addition, quality of life and care satisfaction also improved as a result of the telemonitoring intervention (Warren et al., 2017). European governments have recently recognized the benefits of telemonitoring in the management of chronic diseases, particularly diabetes, in terms of improving health-related quality of life (HRQoL), quality of health care, resource use(Dario et al., 2017).

The primary studies involved in this study were research conducted in various countries and races, so that general conclusions were obtained and it can be applied. The results of the systematic study and meta-analysis were presented in the form of forest plot and funnel plot diagrams. Forest plots showed the magnitude of variation (heterogeneity) visually. The funnel plot showed the relationship between the effect size of the study and the sample size of the various studies studied, which can be measured in different ways (Murti, 2018). Estimates of the combined relationship of the use of telemonitoring to improve blood sugar levels and improve quality life was processed using the RevMan 5.3 application.

1. The effect of telemonitoring on blood sugar improvement

Based on the results of a meta-analysis of 11 articles, it was reported that there was an effect of using telemonitoring on blood sugar (HbA1c) levels in type 2 DM patients. The forest plot in Figure 2 showed that telemonitoring intervention can reduce blood sugar (Hba1c) levels in type 2 diabetes patients by 0.20 times higher compared to not using telemonitoring (SMD= -0.20; 95% CI= -0.39 to -0.01; p= 0.040).

The results of this study were in line with Cho et al., (2011), which showed that the mean value of HbA1c decreased significantly in the PDA-type and the Internet intervention group conducted in health services in type 2 diabetes patients. Frequency of glucose measurement in patients given PDA-type and the Internet intervention is higher than the control group, thus the system can motivate nurses and patients.

A study by Wakiet al., (2014) showed that the use of remote health monitoring using data added with communication with patients to support diabetes management itself resulted in an increase in HbA1c within 3 months. In addition, users of the Dialbetics intervention felt that the intervention was easy to use and not time consuming. Williams et al., (2012) in their study in Australia using TLC Diabetes (interactive telephone) showed improvement in diabetes management after 6 months of intervention. The Diabetes TLC intervention also showed a significant increase in HbA1c compared to the routine care that has already available for diabetics in Brisbane Australia, this step can provide significant results if it was maintained in the long term. A multicenter pragmatic trial conducted by Wild et al., (2016) in family practice in the UK, showed that there was a greater improvement in glycemic control performed in diabetics using a telemonitoring intervention for 9 months compared to diabetics who use regular care.

Based on a systematic review conducted by Paré et al. (2007), telemonitoring in the treatment of chronic diseases can be a promising approach to patient management, besides telemonitoring can also provide accurate and reliable results, which can empower and influence attitudes and behavior so as to improve the patient's medical condition.

2. The effect of using telemonitoring on improving quality of life

Based on the results of a meta-analysis in 6 articles, it was reported that there was an

effect of using telemonitoring on the quality of life in type 2 diabetes patients. Forrest plot in Figure 4 showed that the provision of telemonitoring intervention can improve the quality of life in type 2 diabetes patients by -0.16 times higher compared to not using telemonitoring (SMD= -0.16; 95% CI= -0.29 to -0.03; p= 0.020).

The results of this study were in line with research conducted by Bujnowska-Fedak et al., (2011) in Poland in patients with type 2 diabetes which showed that the telehomecare group had high scores on measures of quality of life (personal interpretation of illness, satisfaction, independence, and feelings of freedom) compared to the control group.

Nicolucci et al., (2015) obtained the results from his study on telecare programs helping in optimizing insulin in type 2 diabetes patients showed results if there was a change in quality of life and satisfaction scores in 1 month after telecare. A study by Boaz et al., (2009) on patients with type 1 and 2 diabetes who were given telemedicine interventions showed that telemedicine improves quality of life and improves control over the feeling of the disease. These results coincide with the satisfaction that results from telemedicine monitoring, which suggests that patient care can be improved through the use of telemedicine. This suggests that it is inappropriate to conclude that the use of telemedicine has no impact on clinical outcomes.

Carr et al. (2001) stated that there are two factors that drive changes in the way of thinking about health and care, namely knowledge of the importance of social views on a disease and medical action that aims to increase the duration and quality of survival. Therefore, the quality, effectiveness and efficiency of health care must be assessed for its impact on the patient's quality of life.

AUTHOR CONTRIBUTION

Anisa Asri Sholihahis the main researcher who chose the topic and conducted a search for data collection in this study. Didik Tamtomo and Hanung Prasetya conducted data analysis and reviewed study documents.

FUNDING AND SPONSORSHIP

This study used personal funds from the main researcher.

CONFLICT OF INTEREST

There was no conflict of interest.

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