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Master's Program in Public Health, Universitas Sebelas Maret

Meta-Analysis

Meta-Analysis of the Effect of Internet-Based Self-Management on Blood Glucose Control in Type 2 Diabetes Mellitus Patients

Moh Maulana[1)], Didik Tamtomo[2)], Bhisma Murti[1)]

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

ABSTRACT

Background: Diabetes mellitus is a chronic metabolic disorder or disease with numerous etiologies characterized by high blood glucose levels accompanied by lipid, protein, and carbohydrate metabolism disorders. Type 2 diabetes is the most common type of diabetes with about 90% of all diabetes cases. The International Diabetes Federation (IDF) estimates that the number of diabetics in the world can reach 783.7 million people while in Indonesia it is estimated to reach 28.57 million people in 2045. This number is an increase of 46% compared to 536.6 million in 2021. The study aims to discover how much influence internet-based self-management has on blood glucose control in type-2 diabetes mellitus patients.
Subjects and Method: It was a meta-analysis study using PRISMA flowchart guidelines with the PICO formulation. P = type 2 diabetes mellitus patients. I = Internet-based self-management. C= No internet-based self-management. O= HbA1C. This study was conducted by searching for articles obtained from the MEDLINE/PubMed, Google Scholar, ProQuest, Science Direct, and Spinger Link databases with keywords and operators "Boolean electronic health record" OR "computerized" OR "healthcare system information" OR "mobile health" OR "mobile app" OR "Telehealth" AND "self-management" AND "Diabetes" OR "diabetes mellitus" OR " type 2 diabetes mellitus" OR "Type 2 diabetes. Based on the database, 10 articles met the inclusion criteria. The analysis was performed using Revman 5.3 software.
Results: There were 10 articles from Asia, America, and Europe. A meta-analysis using Randomized Controlled Trials indicated that internet-based self-management significantly reduced HbA1c levels by 0.45 units (SMD= -0.45; CI 95%= -0.57 to -0.33= p<0.001).
Conclusion: Internet-based management can reduce HbA1c levels of type 2 diabetes mellitus patients.

Keywords: internet-based self-management, hba1c, type 2 diabetes mellitus

Correspondence:
Moh Maulana. Masters Program in Public Health, Universitas Sebelas Maret. Jalan Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Email: maulana.rosy21@gmail.com. Mobile: +628-851 5667 1759

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BACKGROUND

According to the International Diabetes Federation (IDF) type 2 diabetes is the most common type of diabetes with about 90% of all diabetes cases. Type 2 (two) diabetes is generally characterized by insulin resistance, in which the body does not fully respond to insulin. Since insulin

cannot work properly, blood glucose level continues to rise, releasing more insulin. For some people with type 2 diabetes, it can eventually deplete the pancreas, resulting in the body producing less and less insulin, causing higher blood glucose levels (hyperglycemia). The International Diabetes Federation (IDF) estimates that the number of diabetics in the world can reach 783.7 million people while in Indonesia it is estimated to reach 28.5 7 million people in 2045. This number is an increase of 46% compared to 536.6 million in 2021 (IDF, 2021).

One of the media that can be used is the internet and other digital media that utilize the use of health information technology. The development of technology, especially on the internet, is growing rapidly and can affect activities in all fields, including the health sector. The presence of the use of health information technology can be useful for the treatment or remote monitoring (telemedicine or telemonitoring). The availability of media in the form of the internet and other digital media is one of the efforts to support the implementation of self-management so that it can improve the ability in self-management of patients with type 2 diabetes mellitus (Morrison et al. , 2014)

A study by Maharani et al. (2018) reveals that the development of diabetes in Indonesia is currently ranked fifth as the country with the highest number of diabetics in the world. The smartphone-based mHealth application, which includes self-control of blood glucose, medication, diet, physical activity, weight control, blood pressure control, and education about diabetes self-management, is proven to be effective in improving the self-management of diabetics.

Examples of alternative technology in improving self-management for diabetic patients namely mobile, web, and text messaging (sms) applications. It is inevitable that nowadays everyone owns a smartphone because smartphones are relatively versatile to use and can be an ideal supporting tool for diabetics in improving self-management (Nundy et al., 2014). In addition, the existence of smartphones can provide effective support to patients in rural and remote locations where access to health services is challenging (Heron and Smyth, 2015).

In this article, we synthesized the results of randomized controlled trial (RCT) studies that compared internet-based self-management and no internet-based self-management to control blood glucose in patients with type 2 diabetes mellitus. The study aims to determine how much influence internet-based self-management has on blood glucose control in type-2 diabetes mellitus patients based on the previous primary studies.

SUBJECTS AND METHOD

1. Study Design

This was a meta-analysis study conducted by searching for articles obtained from the MEDLINE/PubMed, Google Scholar, ProQuest, Science Direct, and Spinger Link databases. Article selection was carried out by using the PRISMA flow. The article search strategy used several keywords and operators namely Boolean electronic health record" OR "computerized" OR "healthcare system information" OR "mobile health" OR "mobile app" OR "Telehealth" AND "self-management" AND "Diabetes" OR "diabetes mellitus" OR "diabetes mellitus type 2" OR "Type 2 diabetes.

2. Steps of Meta-Analysis

The meta-analysis was carried out in five steps as follows:

a. Formulate research questions in the PICO format (population, intervention, comparison, outcome).
b. Search for primary study articles from various electronic databases including Google Scholar, PubMed, and Science Direct and non-electronics.
c. Conduct screening and critical appraisal (Critical Appraisal) of primary research articles.
d. Perform data extraction and synthesize effect estimates into RevMan 5.3.
e. Interpret and conclude the results.

3. Inclusion Criteria

The inclusion criteria used in this study were *full-text* articles with randomized controlled trial (RCT) study design, the article was published in English from 2013 to 2022, analysis of perceived benefits until the final results of the study were reported using an adjusted Standardized Mean Difference (SMD).

4. Exclusion Criteria

The exclusion criteria were an article that was meta-analyzed, duplicate articles, and articles with only abstract publications.

5. Operational Definition of Variables

Type 2 Diabetes Mellitus is a metabolic disorder characterized by an increase in blood glucose level above normal due to impaired insulin secretion by pancreatic beta cells or also called insulin resistance. The disease is characterized by the occurrence of hyperglycemia and impaired carbohydrate, fat, and protein metabolism associated with an absolute or relative deficiency of insulin secretion or incidence.

HbA1C is the level or percentage of glucose attached to hemoglobin.

Internet-based Self Management is the utilization of health information technology used to facilitate the implementation of patients' and families' self-management

6. Instrument

The instrument used in this study was articles obtained from several online databases concerning the effect of internet-based self-management on blood glucose control in type 2 diabetes mellitus patients. Data processing of the study was carried out by identifying articles obtained from several databases, followed by screening to obtain qualified articles.

7. Data Analysis

The collected articles were processed by using the *Review Manager* application (RevMan 5.3). Data processing was carried out by calculating the effect size and the value of heterogeneity to determine the mixed model of the study and forming the final results of meta-analysis in the form of forest plots and funnel plots.

The following is a description of the articles used in the meta-analysis related to the effect of internet-based self-management on blood glucose control in type 2 diabetes mellitus patients. There were 10 primary study articles from America, Europe, and Asia, and this analysis came up with a result that internet-based self-management was effective in lowering HbA1C, and was statistically significant (Standardized Mean Difference -0.45, CI 95%= -0.57 to -0.33, $p<0.001$). This meta-analysis did not show the identity of publication bias

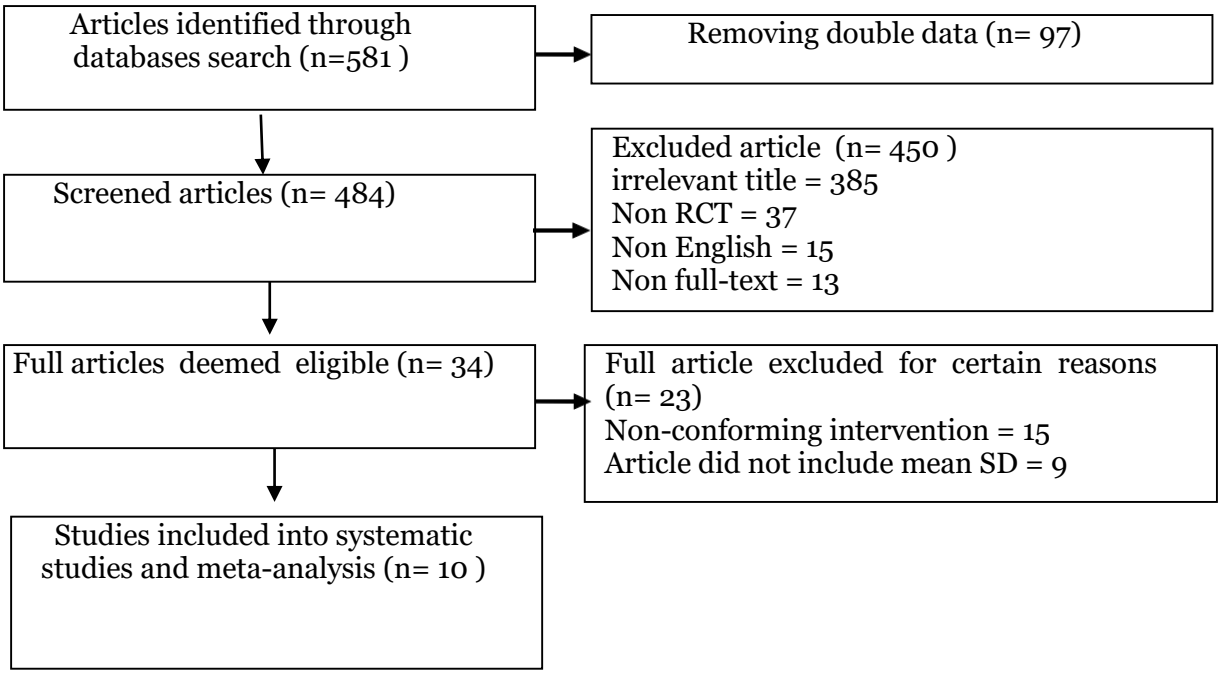

Figure 1. PRISMA flowchart diagram of the Effect of Internet-Based Self-Management on Blood Glucose Control in Type 2 Diabetes Mellitus Patients

Figure 2. Map of the Research Area on the Effect of Internet-Based Self-Management on Blood Glucose Control in Type 2 Diabetes Mellitus Patients

Table 1. Critical appraisal checklist for randomized controlled study in meta-analysis

Primary Studies	Criteria											
	1	2	3	4	5	6	7	8	9	10	11	Total
Agboola et al (2016)	1	1	1	1	1	1	1	1	1	1	1	11
Anzaldo-Campos (2016)	1	1	1	1	1	1	1	1	1	1	1	11
Fortmann et al (2017)	1	1	1	1	1	1	1	1	1	1	1	11
Kleinman et al (2017)	1	1	1	1	1	1	1	1	1	1	1	11
Lim et al (2016)	1	1	1	1	1	1	1	1	1	1	1	11
Mohammed et al (2015)	1	1	1	1	1	1	1	1	1	1	1	11
Orsama et al (2013)	1	1	1	1	1	1	1	1	1	1	1	11
Peimani et al (2016)	1	1	1	1	1	1	1	1	1	1	1	11
Tamban et al (2013)	1	1	1	1	1	1	1	1	1	1	1	11
Torbjørnsen et al (2014)	1	1	1	1	1	1	1	1	1	1	1	11

Description of the question criteria:

1 = Did the experiment clearly answer the clinical problem?
2 = Was the provision of interventions to participants randomized?
3 = Were all the patients included in the study properly accounted for in the conclusions? Were all patients analyzed according to randomized study groups?
4 = Was blinding technique for patients, health workers, and researchers applied?
5 = Were the study groups similar at the beginning of the study?
6 = Beyond the interventions studied, were study groups treated equally?
7 = Was the intervention group big enough?
8 = How was the precision of the estimated effect of the intervention?
9 = Did the benefits provided by the intervention outweigh the disadvantages and costs?
10 = Could the results be applied to the context of local practices or populations?
11 = Were all other clinically important outcomes considered in this article?

Description of the answer score:

0 = No
1 = Yes

Table 2. Summary of randomized controlled trial primary study articles in the meta-analysis

No	Authors (Years)	Country	Sample		P	I	C	O
			IG	CG				
1	Agboola et al., (2016)	USA	64	62	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c
2	Anzaldo-Campos et al., (2016)	Mexico	89	92	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c
3	Fortmann et al., (2017)	Mexico	50	59	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c
4	Kleinman et al., (2017)	India	44	45	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c

No	Authors (Years)	Country	Sample		P	I	C	O
			IG	CG				
5	Lim et al., (2016)	Korea	43	42	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c
6	Mohammed et al., (2015)	Bangla-desh	106	94	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c
7	Orsama et al., (2013)	Finland	24	24	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c
8	Peimani et al., (2016)	Europe	50	25	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c
9	Tamban et al., (2013)	Philip-pines	52	52	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c
10	Torbjørnsen et al., (2014)	Norway	39	20	type 2 DM patients	Internet-based self-management	No internet-based self-management	Average Glucose, HbA1c

Based on Table 2, the description of the primary research on the meta-analysis of the effect of internet-based self-management on blood sugar control in patients with type 2 diabetes mellitus was carried out by a meta-analysis of 10 articles with a total sample of 561 study locations from Asia, America, and Europe, where there were 1 article from America, 2 articles from Mexico, 1 article from India, 1 article from Korea, 1 article from Bangladesh, 1 article from Finland, and 1 article from Europe, 1 article from Philippines and 1 article from Norway. Similarities were found in this study, namely, the research design used a randomized controlled trial, the research subjects were type 2 DM patients, and the intervention was given, namely internet-based self-management with no comparison. Internet-based self-management. However, there were differences in the number of intervention and control samples used, namely the intervention sample. the smallest is 24 and the most are 106 while in the control sample, the smallest is 20 and the most are 92.

Table 3. Effect estimates (Mean SD) effect of Internet-Based Self-Management on Blood Glucose Control in Type 2 Diabetes Mellitus Patients

No	Authors (Years)	Mean		SD	
		IG	CG	IG	CG
1	Agboola et al., (2016)	0.43	-0.21	1.29	1.1
2	Anzaldo-Campos et al., (2016)	8.19	9.56	2.17	2.79
3	Fortmann et al., (2017)	8.5	9.4	1.2	2
4	Kleinman et al., (2017)	7.9	8.2	1.1	1.5
5	Lim et al., (2016)	7.3	7.9	0.9	1.2
6	Mohammed et al., (2015)	-0.85	-0.18	1.08	1.11
7	Orsama et al., (2013)	-0.4	0.036	0.66	0.66
8	Peimani et al., (2016)	7.06	7.55	1.31	1.44
9	Tamban et al., (2013)	6.99	7.34	0.86	0.9
10	Torbjørnsen et al., (2014)	7.8	8.2	1.07	1.37

a. Forest plot

Figure 3 presents a forest plot on the effect of internet-based self-management on blood glucose control measured in HbA1C in type 2 diabetes mellitus patients. The forest plot showed that type 2 diabetes mellitus patients who received internet-based self-management had HbA1C levels 0.45 lower than those without internet-based self-management, and the effect was statistically significant (SMD = -0.45; CI 95% = -0.57 to -0.33) the forest plot showed a low variation between the primary studies (I^2= 0%) thus the calculation of the average SMD needs to be conducted with the fixed effect model.

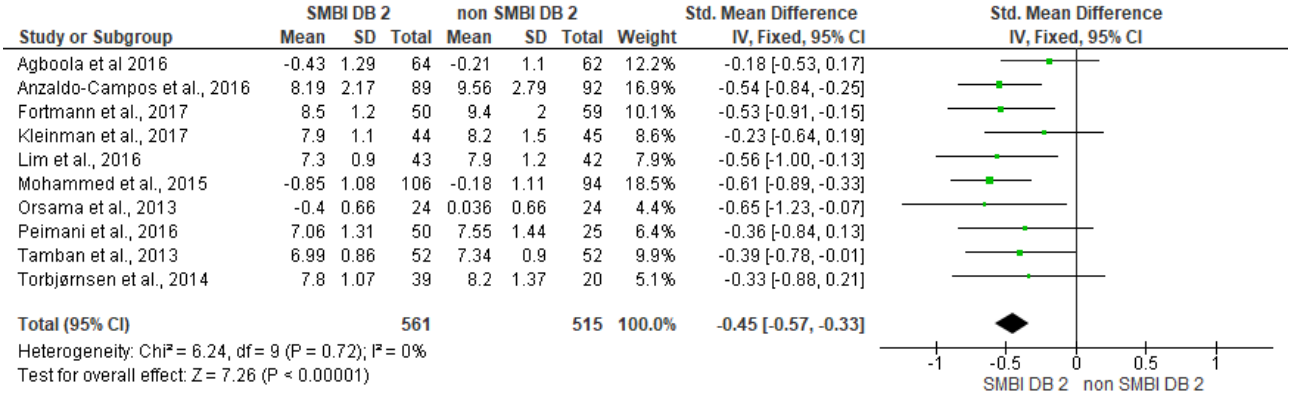

Figure 3. Forest plot of the effect of internet-based self-management to blood glucose control in type 2 diabetes mellitus patients

b. Funnel plot

Figure 4 presents a funnel plot of the effect of internet-based self-management on blood glucose control in type 2 diabetes mellitus patients. The funnel plot showed that the distribution of the estimated effect was symmetrical with the funnel plot which meant it did not identify publication bias.

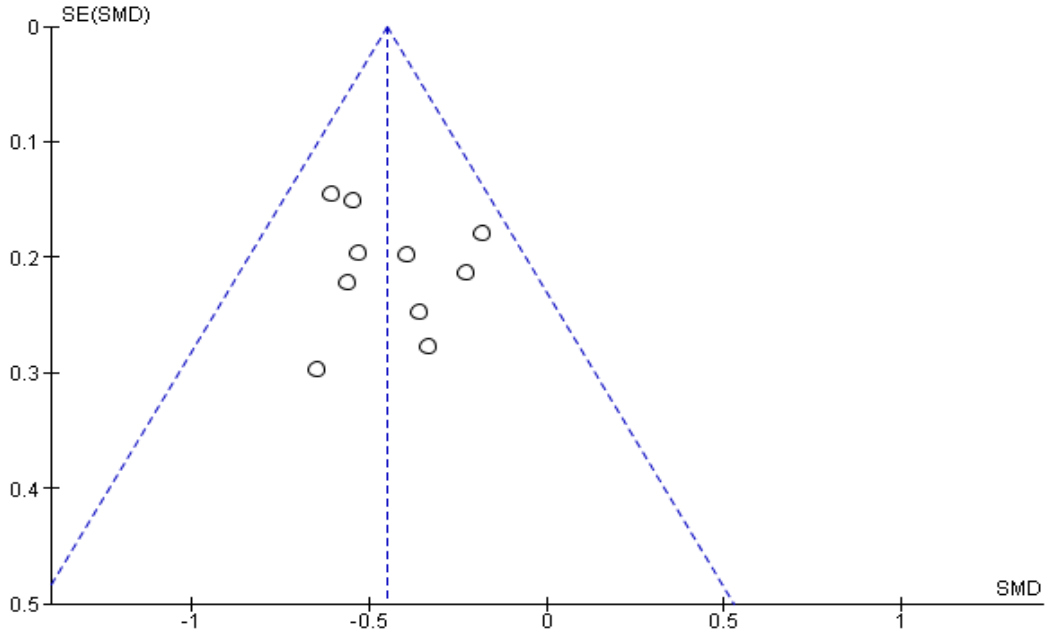

Figure 4. Funnel plot of the effect of internet based self management on blood glucose control in type 2 diabetes mellitus patients

DISCUSSION

This meta-analysis study raised the theme of the effect of internet-based self-management on blood sugar control in type 2 diabetes mellitus patients. The dependent variable in this study was blood sugar control in type 2 diabetes mellitus patients. The independent variable in this study was internet-based self-management.

Meta-analysis synthesizes 10 primary studies from the Americas, Europe, and Asia with 1 article from America, 2 articles from Mexico, 1 article from India, 1 article from Korea, 1 article from Bangladesh, 1 article from Finland, and 1 article from Europe, 1 article from the Philippines and 1 article from Norway. This meta-analysis concluded that Internet-based self-management was effective in lowering HbA1C, and was statistically significant (Standardized Mean Difference -0.45, 95% CI -0.57 to -0.33, p<0.001). This meta-analysis does not reveal the identity of publication bias.

The results of this study are by the research of Torbjørnsen et al (2014) which states that internet-based self-management has a positive impact on glycemic control in type 2 diabetes mellitus patients regardless of several potential disturbing factors such as psychological stress, mental stress, and depression during self-management. Modest but significant improvement in glycemic control which most likely reflects more regular daily activities and reduced work-related distress is the impact of Internet-based self-management in type 2 diabetes mellitus patients.

The results of this study are in line with Shahid et al. (2015), which showed that patients in the intervention group showed an increase (p < 0.001) in following the diet plan from 17.3% at baseline to 43.6% at the end, but the control group showed a non-significant increase (p= 0.522) from 13.6% at baseline to 15.9% at the end. The intervention group (RR= 2.71, 95% CI= 1.18 – 6.40) showed a significant positive relationship with the normalization of HbA1c levels.

A study by Chan et al. (2014) investigated whether continuous control through telephone-based peer support programs can reduce HbA1c. His study suggested that telephone-based peer support substantially improves glycemic control and diabetes knowledge in high-risk patients in medical units.

Steventon et al (2014) this study aimed to determine whether telehealth causes changes in glycosylated hemoglobin (HbA1c) among patients with type 2 diabetes. Effects on HbA1c were assessed using a repeated measurement model that included all HbA1c readings recorded over a 12-month trial period, and adjusted for differences in HbA1c readings noted before recruitment. In the results of the study, 513 out of 3,230 participants were identified as having type 2 diabetes so these participants or patients were included in the criteria. Telehealth can lower HbA1c than usual care

The meta-analysis in this study shows that internet-based self-management can reduce HbA1c levels in type 2 diabetes mellitus patients compared to those without internet-based self-management. This is because internet-based self-management provides positive lifestyle changes, such as physical activity, diet, physical-mental health, and the availability of uninterrupted access so that internet-based self-management can be used as part of the healing process for type 2 diabetes mellitus.

AUTHOR CONTRIBUTION

Moh Maulana is the main researcher who chose the topic, searched for data and collected study data. Didik Gunawan Tamtomo and Bhisma Murti contributed as supervisors in data analysis and publication preparation.

CONFLICT OF INTEREST

There was no conflict of interest in the study.

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