AMERICAN UNIVERSITY OF BEIRUT

INTEGRATING E-HEALTH IN DIABETES MANAGEMENT IN MIDDLE EAST AND NORTH AFRICA: A SESTEMATIC REVIEW

by
AHMAD MOHAMMAD WEHBI

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AHMAD MOHAMMAD WEHBI

Approved by:

G. Honein-Abouhaidar

Gladys Honein, Associate Professor
Hariri School of Nursing

First Reader

Lina Younan, Clinical Associate Professor
Hariri School of Nursing

Second Reader

Date of project presentation: January 24, 2023

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ABSTRACT
OF THE PROJECT OF

Ahmad Mohammad Wehbi for Master of Science in Nursing
Major: Community and Public Health Nursing

Title: Integrating E-Health in Diabetes Management in Middle East and North Africa: A Systematic Review

Background: Diabetes is a major healthcare burden in the Middle East and North Africa (MENA) region. E-health tools can contribute to the management of diabetes with improved education, monitoring, and care outcomes.

Objective: The objective of this review is to evaluate the effectiveness of E-health interventions on the improvement of diabetes management and health outcomes in patients with diabetes in the MENA region.

Methods: Peer-reviewed articles from PubMed, Embase, and Medline were identified using various combinations of predefined terms and search criteria. The main inclusion criteria consisted of assessing the utility of e-health tools (mobile apps and communication networks) for the management of type 2 Diabetes Mellitus in any of the MENA countries.

Results: The review included 15 articles evaluating the use of e-health tools in the management of diabetes in the MENA region. The included studies assessed the effect of various interventions (mobile health applications, short messaging system (SMS), and WhatsApp) on three main outcomes (hemoglobin A1c (HbA1c), fasting blood glucose (FBG), and knowledge). Most of the studies reported that interventions were successful in reducing HbA1c and FBG and increasing patients' knowledge. However, the quality of evidence in the majority of the included studies was moderate.

Conclusion: E-Health technologies show potential for managing diabetes in the Arab world, but further research with better design and execution is needed. The nursing sector in Lebanon should play a key role in these studies.

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CHAPTER 1

INTRODUCTION

1.1 Background

Diabetes mellitus (DM), a chronic metabolic disease, is a global healthcare burden. In 2021, the International Diabetes Federation (IDF) reported that 537 million people between the ages of 20 and 79 years had diabetes, and 1.1 billion had impaired glucose tolerance (IDF, 2021). By the year 2045, 700 million people are projected to have diabetes, which is an estimated 10% of the world's population (Cho et al., 2018; IDF, 2021). Moreover, diabetes resulted in 6.7 million deaths in 2021 (IDF, 2021).

Various complications are associated with DM that can lead to significant morbidity and mortality (Papatheodorou, Papanas, Banach, Papazoglou, & Edmonds, 2016). Yet 10% of international health expenditure (US$760 billion) is spent on diabetes (IDF, 2021). It is challenging to deal with DM since one in two adults with diabetes is undiagnosed (IDF, 2021). Therefore, it is crucial to intervene not only to treat but also to control and push for timely detection of diabetes.

In Lebanon, the public health decision-makers remain greatly unaware of the magnitude of the disease and its complications. The national prevalence of DM in Lebanon has not been updated or revised since 2009 (Costanian, Bennett, Hwalla, Assaad, & Sibai, 2014). Moreover, the prevalence at that time did not contain age categories younger than 25 years and included juvenile type one diabetes and maturity type two, hence unable to recognize the prevalence of each (Costanian et al., 2014).

The International Diabetes Federation (IDF, 2021) estimated the overall prevalence of DM in Lebanon in 2015 to be at 122 (100 – 152) per 1,000, where type 2 DM prevalence was estimated to be 110 (100 – 137) per 1000. If we assume that the

total Lebanese population of 4 million, the total number of persons with type 2 DM should accordingly be 440,000 (IDF, 2021), discrepant from the prevalence reported in the literature, and by public health authorities, scientific societies, and healthcare professionals in direct contact with individuals with DM in Lebanon.

1.2 Diabetes management

Maintaining a controlled blood glucose level between (HbA1C 5.7-6.4% or FBG 100-125 mg/dL) is an important indicator for proper management of diabetes (ADA, 2022). Patients capable of controlling their blood glucose level are often those who are adequately monitored by their specialized health care providers, specifically their diabetes nurses (Piatt et al., 2006). Technology can play a role in improving this monitoring.

For the last two decades, technology has improved the management of chronic diseases, including DM (Muegge & Tobin, 2016). Advances in real-time health education and feedback, and new tools to self-monitoring outside the traditional office visit hold great promises to improve the quality and safety of DM care. These tools need to be easy to access and not overburden the provider nor the patient. Eventually, these technologies should also improve patient safety and health outcomes.

During the COVID-19 pandemic, Electronic Health (e-health) has emerged as an essential component of healthcare. E-health services facilitated public health mitigation strategies by increasing social distancing, reducing potential infectious exposures, and increasing access to health services (CDC, 2020).

E-health can eventually be used to deliver DM education, management, and monitoring services. E-health technologies can support diabetes management activities

through various methods such as continuous glucose monitoring (CGM), peer and health professional support systems, and educational support. E-health tools incorporate many opportunities for patients to increase their engagement through focused disease-specific learning, options to receive regular feedback, and frequent reinforcement (Parker et al., 2018). The benefits of e-health services include better health care by improving all aspects of patient care such as safety, effectiveness, patient-centeredness, communication, education, timeliness, efficiency, and equity (Car, Tan, Huang, Sloot, & Franklin, 2017).

1.3 Objective

While there is sufficient evidence from the western world that e-health use can improve the management of DM effectively, there is a paucity of evidence from the Middle East and North Africa (MENA) region on the uptake of the technology and effectiveness, and the role of nurses in this process. Hence, the objectives of this project could be summarized as follows:

Objective: to conduct a systematic review of the literature to review all primary studies conducted in the MENA region to document the use and effectiveness of e-health in the management of diabetes. We will use PubMed Embase, and Medline databases to retrieve relevant articles.

Answering the following research question: How does e-health affect the management of DM patients in the MENA region?

CHAPTER 2

METHODS

2.1 Research design

A systematic review of peer reviewed quantitative primary studies done in the MENA region.

2.2 Search strategy

PubMed, Embase, and Medline were systematically searched using a controlled vocabulary (MeSH and EMTREE) and keywords without date or language restrictions. The last search update was on August 17, 2022. The search strategy was composed of 4 terms to cover Diabetes, e-health, management, and the Arab world according to the following Boolean search strategy (Appendix).

No filters were applied for the type or language of the articles during the search phase of this review to maximize the chance of capturing all articles that might be relevant. Research papers and review articles were hand-searched for any further relevant articles among their references.

2.3 Inclusion and exclusion criteria

Inclusion Criteria

- Studies conducted in MENA countries.
- Studies on using e-health (such as mobile e-health, telehealth tools, mobile messages…)
- Studies on diabetes management approaches using e-health applications
- Quantitative studies

Exclusion Criteria

- Studies on type 1 and gestational diabetes
- Studies from outside MENA countries
- Editorials, letters, secondary analysis, brief discerptions and case reports

All articles assessing the effect of e-health modules on the management of type 2 diabetes in the Arab world were considered.

2.4 Article screening and selection

Screening of the articles started with titles and abstracts being screened by two independent investigators Ahmad Wehbi (AW) and Moustafa Al Hariri, PhD (MAH). All non-relevant articles were excluded. Any discrepancy in the decision of the two investigators on the inclusion of articles in this phase was resolved by meeting and discussing the articles. No discrepancies needed a referral to a third reviewer to be resolved. The articles selected at the title abstract phase were then retrieved and collected for full-text evaluation, which depended on the inclusion-exclusion criteria defined a priori. Any relevant full-text articles were retrieved and analyzed for eligibility using the pre-defined inclusion criteria. The full-text evaluation was independently performed by the same investigators (AW and MAH).

2.5 Data collection

Both investigators (AW and MAH) independently used standardized data collection forms to collect the details of the reviewed articles: Study type, Diabetes type investigated in the article, country of the investigation, the outcome of the article, the primary endpoint of the outcome, number of subjects included in the article, mean age, gender distribution, and intervention assessed. The investigators did not require to

obtain further data from the authors of the included studies. Moreover, details on the biases of the articles were assessed (Selection, study design, accounting for confounders, population, blinding, data collection, and withdrawal and dropouts). The risk of bias for each of these elements was judged as low, moderate, or high using the Quality Assessment Tool for Quantitative Studies (QATQS). Each criterion is rated on a 3-point scale, as strong (3 points), moderate (2 points), or weak (1 point). The mean value of the 6 criteria is the global score. An average score of 2.51-3.00 is strong, 1.51-2.50 moderate, and 1.00-1.50 weak (Thomas, 2004).

CHAPTER 3

RESULTS

3.1 Search strategy

The search strategy identified 2799 articles across the three databases. 472 articles were duplicates and removed. The titles and abstracts of 2328 unique articles were reviewed, and 2253 were excluded based on their titles and abstracts. Among the **75** remaining articles, 60 were excluded for article type, intervention type, participant type, study design, and the purpose of the study. 15 articles were included in the final review (Fig. 1).

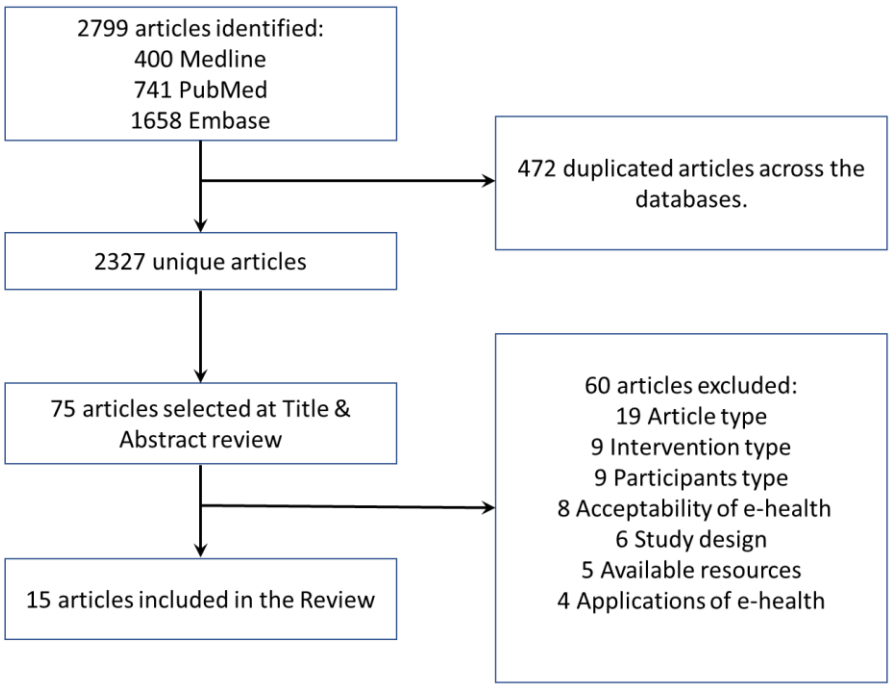


Figure 1: PRIZMA Flow chart of the reviewed and selected articles.

Articles reviewed during the screening includes: narrative reviews, commentary, brief papers, protocol, conference abstract, and systematic review. Intervention type

includes: structured e-learning, mobile clinic, and medical health record. Participant type includes: Type 1 Diabetes Mellitus, obese non-diabetic participants, Healthcare workers, Pharmacists, and School personnel. Acceptability of eHealth includes: assessing the willingness, satisfaction, attitudes, barriers, and challenges of using e-Health. Study design includes implementation of programs, databases, and health system. Available resources include review of online apps and software available for patients. Application of e-Health includes utility of e-Health for diagnosis of diabetes complications.

3.2 Characteristics of selected studies:

The characteristics of the included studies in this review are summarized in Table 1. The included studies in this review were published between 2007 and 2022, and they assessed the effect of various interventions on the diabetes management. These interventions included application software on patients' devices (Alanzi, Alanazi, Istepanian, & Philip, 2018; Alotaibi, Istepanian, & Philip, 2016; Farooqi et al., 2022; Istepanian et al., 2014; M Tourkmani et al., 2021; Salzsieder, Augstein, Vogt, Freyse, et al., 2007; Salzsieder, Augstein, Vogt, Kohnert, et al., 2007; Yahia & Bayoumi, 2021), short message systems (SMS) (Abaza & Marschollek, 2017; Abbas, Al Fares, Jabbari, El Dali, & Al Orifi, 2015; Abduelkarem & Sackville, 2008; Haddad et al., 2014) and WhatsApp (Al Omar, Hasan, Palaian, & Mahameed, 2020; Alanzi, Bah, Alzahrani, Alshammari, & Almunsef, 2018; Sani, Makeen, Albasheer, Solan, & Mahfouz, 2018). Table 2 summarizes the general features of the applications used as interventions in the included studies.

As for the counties of the studies, 6 studies were conducted in KSA (Abbas et al., 2015; Alanzi, Alanazi, et al., 2018; Alanzi, Bah, et al., 2018; Alotaibi et al., 2016; M Tourkmani et al., 2021; Sani et al., 2018), 5 in UAE (Abduelkarem & Sackville, 2008; Al Omar et al., 2020; Farooqi et al., 2022; Salzsieder, Augstein, Vogt, Freyse, et al., 2007; Salzsieder, Augstein, Vogt, Kohnert, et al., 2007), 2 in Iraq (Haddad et al., 2014; Istepanian et al., 2014) and 2 in Egypt (Abaza & Marschollek, 2017; Yahia & Bayoumi, 2021).

Eleven studies were interventional (Abaza & Marschollek, 2017; Abduelkarem & Sackville, 2008; Al Omar et al., 2020; Alanzi, Alanazi, et al., 2018; Alanzi, Bah, et al., 2018; Alotaibi et al., 2016; Farooqi et al., 2022; Haddad et al., 2014; Istepanian et al., 2014; Salzsieder, Augstein, Vogt, Freyse, et al., 2007; Sani et al., 2018), 3 were cohort (Abbas et al., 2015; M Tourkmani et al., 2021; Salzsieder, Augstein, Vogt, Kohnert, et al., 2007), and 1 Quasi-experimental in their design (Yahia & Bayoumi, 2021). Twelve studies investigated the effect of the e-health on type two DM (T2DM) (Abaza & Marschollek, 2017; Abbas et al., 2015; Abduelkarem & Sackville, 2008; Alanzi, Alanazi, et al., 2018; Alanzi, Bah, et al., 2018; Alotaibi et al., 2016; Farooqi et al., 2022; Haddad et al., 2014; Istepanian et al., 2014; M Tourkmani et al., 2021; Sani et al., 2018; Yahia & Bayoumi, 2021) whereas 3 studies had a mix of type one DM (T1DM) and T2DM (Al Omar et al., 2020; Salzsieder, Augstein, Vogt, Freyse, et al., 2007; Salzsieder, Augstein, Vogt, Kohnert, et al., 2007) while T2DM patients were more than the half of each study population. As for the outcome of the studies, 13 studies assessed HbA1c levels (Abaza & Marschollek, 2017; Abbas et al., 2015; Al Omar et al., 2020; Alanzi, Alanazi, et al., 2018; Alotaibi et al., 2016; Farooqi et al., 2022; Haddad et al., 2014; Istepanian et al., 2014; M Tourkmani et al., 2021; Salzsieder, Augstein, Vogt,

Freyse, et al., 2007; Salzsieder, Augstein, Vogt, Kohnert, et al., 2007; Sani et al., 2018; Yahia & Bayoumi, 2021), 6 studies assessed patients' knowledge (Al Omar et al., 2020; Alanzi, Alanazi, et al., 2018; Alanzi, Bah, et al., 2018; Alotaibi et al., 2016; Haddad et al., 2014; Sani et al., 2018), 2 studies assessed Fasting blood glucose (FBG) (Farooqi et al., 2022; Salzsieder, Augstein, Vogt, Freyse, et al., 2007), 1 study assessed random blood glucose (RBG), weight, treatment and medication adherence, self-efficacy, and knowledge. (Abaza & Marschollek, 2017), 1 study assessed BMI, activity, and compliance (Yahia & Bayoumi, 2021), and 1 study assessed Summary of Diabetes Self-Care Activities Assessment (SDSCA) as their outcome(s) (Abduelkarem & Sackville, 2008).

As for the endpoint used to assess the outcomes, 1 study used 2 months (Alanzi, Bah, et al., 2018), 5 used 3 months (Abaza & Marschollek, 2017; Abduelkarem & Sackville, 2008; Farooqi et al., 2022; Salzsieder, Augstein, Vogt, Kohnert, et al., 2007; Yahia & Bayoumi, 2021), 2 used 4 months (Abbas et al., 2015; M Tourkmani et al., 2021), and 7 used 6 months (Al Omar et al., 2020; Alanzi, Alanazi, et al., 2018; Alotaibi et al., 2016; Haddad et al., 2014; Istepanian et al., 2014; Salzsieder, Augstein, Vogt, Freyse, et al., 2007; Sani et al., 2018) as their outcome endpoint.

The number of the enrolled participants in each study ranged from 12 to 200, the average age of the participants in each study ranges from 36 to 57 years, and the percentage of males in each study ranged from none (only females were recruited) to 78%, whereas 3 studies did not report the gender distribution of the participants (Abbas et al., 2015; Alotaibi et al., 2016; M Tourkmani et al., 2021).

Table 1: summary of the studies included in this review.

Author, year	Method	Results	Intervention tested	Citation
R. S. Istepanian, 2014	**Study Type:** Pilot interventional **Diabetes type:** T2DM **Country:** Iraq **Outcome(s):** HbA1c **Primary outcome endpoint:** 6 months	**Number of Subjects:** 12 **Mean age of participants:** 55±11 **Percentage of males:** 50% Outcome indicator: HbA1c reduction of 0.9% vs baseline and 0.65% vs control	Application: DIAR Mobile Health	(Istepanian et al., 2014)
E. Salzsieder, 2007	**Study Type:** Interventional **Diabetes type:** T1DM (33%) & T2DM (67%) **Country:** UAE **Outcome(s):** HbA1c and FBG **Primary outcome endpoint:** 6 months	**Number of Subjects:** 18 **Mean age of participants:** 36±13.1 **Percentage of males:** 33% Outcome indicator: HbA1c reduction of 1.2%, and FBG reduction of 34.2 mg/dL (1.9 mmol/l)	Application: KADIS evidence-based advisory program	(Salzsieder, Augstein, Vogt, Freyse, et al., 2007)
E. Salzsieder, 2007	**Study Type:** Cohort **Diabetes type:** T1DM (44%) & T2DM (56%) **Country:** UAE **Outcome(s):** HbA1c **Primary outcome endpoint:** 3 months	**Number of Subjects:** 34 **Mean age of participants:** 44.6±2.3 **Percentage of males:** 50% Outcome indicator: HbA1c reduction of 0.48%	Application: KADIS evidence-based advisory program	(Salzsieder, Augstein, Vogt, Kohnert, et al., 2007)
M. M. Alotaibi, 2016	**Study Type:** Interventional **Diabetes type:** T2DM **Country:** KSA **Outcome(s):** HbA1c and knowledge **Primary outcome endpoint:** 6 months	**Number of Subjects:** 20 **Mean age of participants:** 45±6.5 **Percentage of males:** Not reported Outcome indicator: HbA1c reduction of 0.91%, and increase in knowledge	Application: SAED	(Alotaibi et al., 2016)
T. Alanzi, 2018	**Study Type:** Interventional **Diabetes type:** T2DM **Country:** KSA **Outcome(s):** HbA1c and knowledge **Primary outcome endpoint:** 6 months	**Number of Subjects:** 19 **Mean age of participants:** <40 **Percentage of males:** 78% Outcome indicator: HbA1c reduction of 0.6%, and increase in knowledge	Application: SANAD	(Alanzi, Alanazi, et al., 2018)

E. A. Yahia, 2021	**Study Type:** Quasi-experimental **Diabetes type:** T2DM **Country:** Egypt **Outcome(s):** HbA1c, BMI, activity, and compliance **Primary outcome endpoint:** 3 months	**Number of Subjects:** 130 **Mean age of participants:** 40.3±10.7 **Percentage of males:** 58% Outcome indicator: HbA1c reduction of 2.69%, BMI reduction of 9.9 units, and increase in activity and compliance	Application: Sokary app	(Yahia & Bayoumi, 2021)
M. Tourkmani A, 2021	**Study Type:** Cohort **Diabetes type:** T2DM **Country:** KSA **Outcome(s):** HbA1c **Primary outcome endpoint:** 4 months	**Number of Subjects:** 130 **Mean age of participants:** 57±12 **Percentage of males:** Not reported Outcome indicator: HbA1c reduction of 1.82%	Application: Telemedicine care model	(M Tourkmani et al., 2021)
M. H. Farooqi, 2022	**Study Type:** Interventional **Diabetes type:** T2DM **Country:** UAE **Outcome(s):** HbA1c and FBG **Primary outcome endpoint:** 3 months	**Number of Subjects:** 38 **Mean age of participants:** 48.2±10.1 **Percentage of males:** 42% Outcome indicator: HbA1c reduction of 2.9%, reduction in FBG of 40.1 mg/dL (2.2mmol/L)	Application: Telemonitoring devices	(Farooqi et al., 2022)
A. Abduelkarem, 2009	**Study Type:** Interventional **Diabetes type:** T2DM **Country:** UAE **Outcome(s):** SDSCA **Primary outcome endpoint:** 3 months	**Number of Subjects:** 59 **Mean age of participants:** 51±11.3 **Percentage of males:** 46% Outcome indicator: increase adherence to diet, exercise, foot care and self-testing behavior.	Messaging: SMS (Education and reminders)	(Abduelkarem & Sackville, 2008)
N. S. Haddad, 2014	**Study Type:** Interventional **Diabetes type:** T2DM **Country:** Iraq **Outcome(s):** HbA1c and knowledge **Primary outcome endpoint:** 6 months	**Number of Subjects:** 42 **Mean age of participants:** 51.4±10.3 **Percentage of males:** 29% Outcome indicator: HbA1c reduction of 0.7%, 1.3 increase in mean knowledge	Messaging: SMS (Education)	(Haddad et al., 2014)
B. B. Abbas, 2015	**Study Type:** Cohort **Diabetes type:** T2DM **Country:** KSA	**Number of Subjects:** 100 **Mean age of participants:** 41±9.5 **Percentage of males:** Not reported	Messaging: SMS (Education and reminders)	(Abbas et al., 2015)

	Outcome(s): HbA1c, FBG, and knowledge **Primary outcome endpoint:** 4 months	Outcome indicator: HbA1c reduction of 0.4%, FBG reduction of 15.1 mg/dL (0.83 mmol/l), and increase in knowledge		
H. Abaza, 2017	**Study Type:** Interventional **Diabetes type:** T2DM **Country:** Egypt **Outcome(s):** HbA1c, random blood glucose (RBG), weight, treatment and medication adherence, self-efficacy, and knowledge. **Primary outcome endpoint:** 3 months	**Number of Subjects:** 73 **Mean age of participants:** 51.5±9 **Percentage of males:** 44% Outcome indicator: HbA1c reduction of 1.05%, RBG reduction of 61 mg/dl (3.38mmol/l), weight reduction of 1.3 kg, and increase in treatment and medication adherence, self-efficacy, and knowledge	Messaging: SMS (Education and reminders)	(Abaza & Marschollek, 2017)
T. Alanzi, 2018	**Study Type:** Interventional **Diabetes type:** T2DM **Country:** KSA **Outcome(s):** Knowledge and self-efficacy **Primary outcome endpoint:** 2 months	**Number of Subjects:** 84 **Mean age of participants:** > 40 **Percentage of males:** Mainly females Outcome indicator: increase in knowledge and self-efficacy.	Messaging: WhatsApp messaging (Education)	(Alanzi, Bah, et al., 2018)
M. Sani, 2018	**Study Type:** Interventional **Diabetes type:** T2DM **Country:** KSA **Outcome(s):** HbA1c, FBG and knowledge **Primary outcome endpoint:** 6 months	**Number of Subjects:** 200 **Mean age of participants:** Categorical **Percentage of males:** 50% Outcome indicator: HbA1c reduction of 0.35%, FBG reduction of 30 mg/dL (1.6 mmol/L), and increase in knowledge.	Messaging: WhatsApp messaging (Peer group interaction)	(Sani et al., 2018)
M. Al Omar, 2020	**Study Type:** Interventional **Diabetes type:** T1DM (40%) & T2DM (60%) **Country:** UAE **Outcome(s):** HbA1c **Primary outcome endpoint:** 6 months	**Number of Subjects:** 164 **Mean age of participants:** 42±15 **Percentage of males:** 42% Outcome indicator: HbA1c reduction of 0.7%	Messaging: WhatsApp messaging (Education)	(Al Omar et al., 2020)

Table 2: Brief description and general features of the applications used in the included studies.

Application name		Application description and feature
DIAR	Diabetes Intelligent Assistant and Remote monitoring	DIAR is a mobile app and wearable device that uses AI and remote monitoring technology to help people with diabetes manage their condition by monitoring glucose levels, tracking food intake and exercise, and providing personalized feedback and recommendations.
KADIS®	Karlsburger Diabetes Management System	KADIS is a software system designed to support the management of diabetes patients. It is typically used by healthcare professionals, such as diabetes educators, endocrinologists, and general practitioners, to collect and analyze data on patients' blood glucose levels, insulin therapy, and other diabetes-related parameters.
SAED	Intelligent mobile diabetes management system	SAED is a system that uses artificial intelligence (AI) and mobile technology to help people with diabetes manage their condition. It includes a mobile app and a wearable device that continuously monitors blood glucose levels, and allows patients to track food intake, exercise, and insulin doses.
SANAD	Saudi Arabia Networking for Aiding Diabetes	SANAD is a healthcare initiative in Saudi Arabia that aims to improve the management and treatment of diabetes in the country. The system is designed to promote smart social behavioral change intervention and mobile management tailored to Saudi diabetic patient. The system consists of three principal modules: a smart mobile diabetes management module, a social networking module, and a cognitive behavioral therapy module. The system collects blood glucose data wirelessly from Smartphone using Bluetooth technologies from the glucose sensors. The SANAD system is a part of the Saudi Ministry of Health's efforts to improve the overall quality of healthcare in the country.
SOKARY	Android mobile application سكري	SOKARY is an Android mobile application that has the advantage of Arabic interface, free to use, and allows users to record their blood glucose level, nutrition, and physical activity, then provide the user with statistics for those readings. Other features as receiving notifications about medication reminders and healthy lifestyle advice.

3.2.1 Effect of software applications on T2DM management

All the studies that investigated the effect of developed software applications on the devices of the participants assessed HbA1C level as an outcome, as well as

knowledge and FBG level. However, the outcome endpoints varied among these studies and ranged from 3 to 6 months.

All the studies that assessed the effect of application software on HbA1c level of the patients showed a reduction in HbA1c. The reduction of HbA1c was reported to be statistically significant to the control group and ranged from 0.48% to 2.9% (Alanzi, Alanazi, et al., 2018; Alotaibi et al., 2016; Farooqi et al., 2022; M Tourkmani et al., 2021; Salzsieder, Augstein, Vogt, Freyse, et al., 2007; Salzsieder, Augstein, Vogt, Kohnert, et al., 2007; Yahia & Bayoumi, 2021). However, one report failed to reach statistical significance when compared to either patients baseline or to the control group (0.9% vs. baseline and 0.65% vs. control group) (Istepanian et al., 2014).

As for the studies that assessed the effect of application software on the knowledge of patients, 2 studies reported a significant increase in patients' knowledge post-intervention compared to baseline (Alanzi, Alanazi, et al., 2018; Alotaibi et al., 2016).

On another note, two studies reported that application software significantly reduced the FBG level of participants (Farooqi et al., 2022; Salzsieder, Augstein, Vogt, Freyse, et al., 2007). The FBG level reduction was reported to be 28.8 mg/dL (1.6 mmol/L) (Salzsieder, Augstein, Vogt, Freyse, et al., 2007) and 40.1 mg/dL (2.2mmol/L) (Farooqi et al., 2022).

3.2.2 Effect of messaging system(s) on T2DM management

Majority of the studies (5 out of 7) that investigated the effect of messaging systems (SMS or WhatsApp) on T2DM management assessed HbA1c level as an outcome, as well as knowledge, effectiveness, and FBG level. However, the outcome endpoints varied among these studies and ranged from 2 to 6 months.

Three studies (2 using SMS and 1 using WhatsApp) reported that messaging systems significantly reduced HbA1c of participants and the reduction ranged from 0.4% to 0.7% (Abbas et al., 2015; Al Omar et al., 2020; Haddad et al., 2014). Two other studies reported a reduction in HbA1c levels, however, failed to reach statistical significance (Abaza & Marschollek, 2017; Sani et al., 2018).

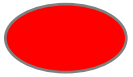
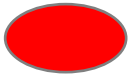
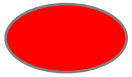
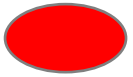
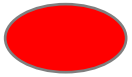
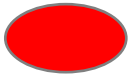
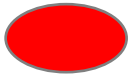
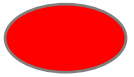
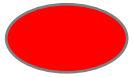
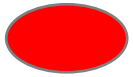
On another note, four studies reported that messaging system increased the knowledge of participants' post-intervention (Abaza & Marschollek, 2017; Abbas et al., 2015; Alanzi, Bah, et al., 2018; Haddad et al., 2014). Moreover, two studies reported reduction in FBG level post intervention and the level of reduction ranged between 15.1 mg/dL (0.84 mmol/l, statistically significant) (Abbas et al., 2015) and 30 mg/dL (0.2 mmol/L, failed to achieve statistical significance) (Sani et al., 2018). Furthermore, one study that assessed the effectiveness of SMS messaging and reported that participants expressed an increase adherence to diet, exercise, foot care and self-testing behavior. (Abduelkarem & Sackville, 2008).

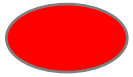
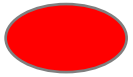
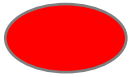
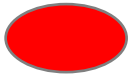
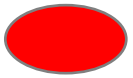
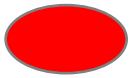
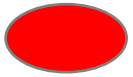
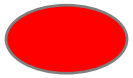
3.2.3 Quality of included studies

The quality of the included studies is summarized in Table 3. Two studies were considered of "Weak" evidence (Istepanian et al., 2014; Salzsieder, Augstein, Vogt, Freyse, et al., 2007), and the rest of the studies were considered of "Moderate" evidence (Abaza & Marschollek, 2017; Abbas et al., 2015; Abduelkarem & Sackville, 2008; Al Omar et al., 2020; Alanzi, Alanazi, et al., 2018; Alanzi, Bah, et al., 2018; Alotaibi et al., 2016; Alyami et al., 2022; Farooqi et al., 2022; Haddad et al., 2014; M Tourkmani et al., 2021; Salzsieder, Augstein, Vogt, Kohnert, et al., 2007; Sani et al., 2018; Yahia & Bayoumi, 2021). None of the studies was considered to have "Strong" evidence. Among the significant limitations of some of the included studies were the population size studied, blinding of the research team, and consideration to assess the

effect of confounding variables on the effect of the intervention on the outcome. The nature of the intervention assessed in the included studies makes it impracticable to achieve blindness in the studies, however, Abaza et al. attempted to mitigate the blindness issue by blinding some of the research members on the allocation of the participants (Abaza & Marschollek, 2017). On another note, only 4 Arab countries out of the 22 were reported to have e-health assessment on T2DM patients.

Table 3: Assessment of the quality of the included studies in this review. Green oval represents a “Strong” quality, yellow oval represents a “Moderate” quality, and red oval represents a “Weak” quality.

Author, year	Selection Bias	Study Design	Confounders	Population size	Blinding	Data collection	Withdrawal & dropouts	Overall rating	Citation
R. S. Istepanian, 2014									(Istepanian et al., 2014)
E. Salzsieder, 2007									(Salzsieder, Augstein, Vogt, Freyse, et al., 2007)
E. Salzsieder, 2007									(Salzsieder, Augstein, Vogt, Kohnert, et al., 2007)
M. M. Alotaibi, 2016									(Alotaibi et al., 2016)
T. Alanzi, 2018									(Alanzi, Alanazi, et al., 2018)
E. A. Yahia, 2021									(Yahia & Bayoumi, 2021)

M. Tourkmani A, 2021									(M Tourkmani et al., 2021)
M. H. Farooqi, 2022									(Farooqi et al., 2022)
A. Abduelkarem, 2009									(Abduelkarem & Sackville, 2008)
N. S. Haddad, 2014									(Haddad et al., 2014)
B. B. Abbas, 2015									(Abbas et al., 2015)
H. Abaza, 2017									(Abaza & Marschollek, 2017)
T. Alanzi, 2018									(Alanzi, Bah, et al., 2018)
M. Sani, 2018									(Sani et al., 2018)
M. Al Omar, 2020									(Al Omar et al., 2020)

CHAPTER 4

DISCUSSION

DM continues to burden the public health sectors globally, with magnified impact on the sectors of developing countries. MENA countries have the highest reported prevalence of DM globally (Cho et al., 2018; IDF, 2021). Patients' self-management is a well-established method to mitigate the complications of DM (Thorpe et al., 2013).

The reported decrease in the HbA1c levels using e-health in the included studies in this review was comparable to a systematic reviews and meta-analyses of studies conducted in western (or developed) countries (Bassi et al., 2021; Riazi, Larijani, Langarizadeh, & Shahmoradi, 2015). Interestingly, Farooqi et al. reported a decrease in HbA1c of 2.9% over a 3-months follow up period using a tele-monitoring phone application among participants in UAE (Farooqi et al., 2022). This level of HbA1c is higher than many reports in the literature and we could not find any published reports that show a comparable decrease in HbA1c in T2DM patients to be achieved in 3 months period following a monitoring application. Moreover, Farooqi et al. did not report the confounding effects of other variables on the outcome. Therefore, a re-assessment of the participants included in this study is warranted to decipher the contributing factors for this level of reduction in addition to the intervention.

As for the effect of the e-health interventions on the knowledge participants, all studies showed an increase in knowledge. We were not able to have a quantitative summary of the knowledge modification since the included studies used various knowledge assessment tools and there was no consensus on a single tool. Therefore, we reported the knowledge modification relying on the assessment of the authors.

Many reports confirmed the improvement of T2DM patients' knowledge following an e-health intervention, which is in line with the finding in the Arab world (Alaslawi, Berrou, Al Hamid, Alhuwail, & Aslanpour, 2022; Moussa, Sherrod, & Choi, 2013; Pacaud, Kelley, Downey, & Chiasson, 2012).

As for the reduction of participants' FBG post intervention, it is worth mentioning that the reviewed studies were heterogeneous due to their endpoint period and type of intervention. For instance, one study reported the highest reduction 3-month post intervention, one study 4-month post intervention, and two studies 6-month post intervention. Moreover, for this outcome, two studies assessed the effect of messaging intervention and the other two assessed the effect of device applications on FBG. On another note, the level of FBG reduction in the included studies was comparable to the levels reported by repots in the literature (Harno, Kauppinen-Mäkelin, & Syrjäläinen, 2006; Zhang et al., 2022). It is noteworthy that Farooqi et al. reported the highest level of FBG reduction (40.1 mg/dL or 2.2 mmol/L) 3-month post intervention (Farooqi et al., 2022). Previous reports on Hispanic and USA T2DM patients showed similar FBG levels compared to Farooqi et al (Fortmann et al., 2017; Xu et al., 2020). HbA1c and FBG are among the only clinical parameters affected by e-health as reported by Kim et al. The latter reported that e-health interventions failed to show effects on other clinical factors of T2DM patients such as blood pressure, lipid profile, and BMI (Kim, Park, & Kim, 2022).

The review has shown that all the studies it included had significant outcomes in decreasing HbA1c and FBG levels and improving the patients' knowledge. Previous systematic reviews have established that telemonitoring is a successful approach for enhancing glycemic control and other relevant outcomes for diabetes patients (Bassi et al., 2021; Riazi, Larijani, Langarizadeh, & Shahmoradi, 2015).

Telemonitoring offers various benefits for diabetes patients, such as remote monitoring, increased patient involvement and adherence, and improved communication and coordination.

Taking the Lebanese context as an interest for this review, it is crucial to assess the feasibility of implementing e-Health technologies in the country. Ballout et al. reported in their study that implementing SMS reminders for Palestinian refugees residing in Lebanon increased the attendance and disease screening rates of the patients (Ballout et al., 2021). Additionally, two studied reported that more than 70% of the Lebanese healthcare providers assessed in these studies indicated their willingness to utilize Telemedicine technologies to provide healthcare services for their patients (Honein-AbouHaidar, Antoun, Badr, Hlais, & Nazaretian, 2020; Shaarani et al., 2022).

On another note, the current economic crises hitting Lebanon since late 2019 burden the whole societal sectors and burden the fragile healthcare sector. The Lebanese currency lost more than 97% of its worth compared to foreign currencies. Although the Lebanese officials attempted to impose corrections for the devaluation situation, many of Lebanon's residents still receive their salaries in the Lebanese currencies, which lost almost all its purchasing values (Al Hariri et al., 2022). Additionally, many of the residents of Lebanon report that their salaries are not sufficient to meet the live expenses.

Nevertheless, the American University of Beirut Medical Center (AUBMC) transformed its medical health record system into EPIC in November 2018. This system is widely used in the US and proved to be powerful in centralizing the medical records of the patients. Additionally, MyChart feature of EPIC system proved to be a robust tool for patients to have access to their medical charts and communicate with

their healthcare providers (nurses and physicians). Moreover, MyChart's push notification replaces the need for SMS system to remind the patients of any future medical encounter or any instruction from their physician. These built-in features of EPIC system make it suitable to be used for any telemedicine intervention on the patients who utilize the services of AUBMC. Although it is a powerful tool, yet it is not meaningfully used. There are gaps in utilization of patient portals.

Further, AUBMC is considered non accessible for most of the patients residing in Lebanon for its geographical location (especially for the rural areas) and medical services expenses. Therefore, a cheaper and more accessible e-Health solutions are needed to implement national studies in Lebanon.

WhatsApp tool is widely used in Lebanon for its free-of-charge services and its connection features (voice and video call). Among the included studies, three assessed the effectiveness of WhatsApp on T2DM management (Al Omar et al., 2020; Alanzi, Bah, et al., 2018; Sani et al., 2018). The results of these studies were positive in reducing HbA1c and/or FBG and enhancing the knowledge of the patients post the intervention. Based on these studies, we should expect the success of a study adopting this intervention on the Lebanese population. Such an intervention could utilize a peer-support groups, sending reminders, and delivering educational and medical messages to the patients.

The main limitation of this review is that none of the included studies were conducted in Lebanon, and none assessed the role of nurses in improving patient outcomes. On another note, most of the studies were of moderate quality, 2 were low quality, and none was strong, and specifically on the design and selection of participants phases of the included study. The quality of included studies weakened the evidence generated from this review.

To improve the quality of future studies, the use of rigorous study designs such as randomized controlled trials, proper sample sizes calculation, long-term follow-up, and conducting multi-center studies are suggested. By incorporating these recommendations, future studies can be improved, leading to the production of more solid and trustworthy evidence regarding their effectiveness.

Also, the potential benefits of allowing nurses to use e-health for diabetes management are numerous. To effectively use e-health, nurses should be designated diabetes nurses in clinics and well-trained in educating patients, monitoring self-care practices, and ensuring compliance with both pharmaceutical and non-pharmaceutical treatments. Additionally, nurses need to be well-versed in remotely monitoring patients' situations, which can lead to early detection of complications and prompt interventions, resulting in improved outcomes for patients and reduced healthcare costs. Also, nurses can empower patients to use e-health technology, this will enable them to take a more active role in managing their diabetes, leading to better compliance with treatment plans. E-health can also serve as a valuable tool for nurses providing care to patients in remote or underserved areas where access to healthcare may be limited.

Consequently, it is crucial for nurses to receive education on how to effectively utilize e-health tools. This will guarantee that nurses are equipped to deliver high-quality care to patients who are utilizing these technologies. Incorporating e-health into nursing education will also help prepare nurses for the future of healthcare, which is likely to become increasingly reliant on technology.

4.1 Conclusion

E-Health technologies are relatively new to the Arab world and not well assessed in many of all of the Arab countries. The evidence of the included studies was moderate for the majority of the studies which warrants a better design and execution of studies. Nursing sector in Lebanon should proactively contribute to studies on the management of chronic diseases for the pivotal role that nurses play within the realms of healthcare facilities.

APPENDIX

1. [(exp diabetes mellitus/ or exp diabetes mellitus, type 2/) **OR** (((diabet* or prediabet*) adj3 (mody or (onset* adj2 (maturit* or slow or adult*)) or (niddm or (depend?nt adj2 non?insulin)) or (resist?nt adj2 ketosis) or stable or (type and (two or ii))))).mp.] **AND**
2. [(exp informatics/ or consumer health informatics/ or exp medical informatics/ or exp health information exchange/ or exp medical informatics applications/ or medical informatics computing/ or nursing informatics/ or exp public health informatics/ or infodemiology/) **OR** (((informati* or computer or science* or technolog* or digital* or mobile*) adj3 (clinic* or medic* or health or e?health or nurs*)).mp.)] **AND**
3. [(glycemic control/ or exp patient care/ or exp nursing care/ or primary care nursing/ or patient care bundles/ or exp self care/) **OR** ((care* or control* or manag*) adj3 (nurs* or self or patient* or informal or glycem* or diabet*)).mp.)] **AND**
4. [africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or tunisia/ or south sudan/ or sudan/ or middle east/ or bahrain/ or iraq/ or jordan/ or kuwait/ or lebanon/ or oman/ or qatar/ or saudi arabia/ or syria/ or united arab emirates/ or yemen/ or somalia/ or mauritania/ or djibouti/ or arabs/ or comoros/ or (algeria* or bahrain* or comoros* or egypt* or iraq* or jordan* or kuwait* or kuweit* or leban* or liban* or lubnan* or lobnan* or yemen* or aden or sanaa or UAE or Emirat* or (abu adj dhabi) or dubai or libya* or morocco or moroccan* or oman* or muscat or palestin* or ghazza or ghaza or gaza or (west* adj2 bank) or q?atar* or katar* or saudi* or KSA or Syria* or tunis* or ((east* or north*) adj2 africa*) or sudan* or djibouti* or somali* or mauritania* or ifni or (trucial adj state*) or MENA or EMRO or ((middle or near) adj2 east*) or (east* adj2 mediterranean) or orient or arabs or arab or arabia or levant).mp.]

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