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RESEARCH ARTICLE

DIGITAL INTERVENTION'S ROLE IN SELF-MANAGEMENT OF DIABETES MELLITUS (DM): A NARRATIVE REVIEW

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Abstract

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Diabetes mellitus (DM) is a chronic illness that raises morbidity and death rates worldwide and substantially negatively influences patients' quality of life. Health authorities now teach patients and their families good behavioral changes and self-management techniques to enhance clinical therapy and lower complications. Diabetes requires a complicated set of everyday habits to manage, such as regular blood glucose testing, eating a balanced diet, exercising, and keeping a healthy weight. Patients now have the tools they need to effectively manage their conditions thanks to the development of e-health and mobile health (mHealth). These technologies help optimize and monitor glucose levels and have been warmly received. A meta-analysis by Captieux M., et al. (2016) found that application users' attitudes toward self-care had improved, and their HbA1c levels had significantly decreased. The efficacy of these technologies varies, though, and obstacles to their broad adoption include low levels of literacy, privacy and security concerns, economic constraints, and the requirement for standardization across various demographics and technical platforms. Notwithstanding these obstacles, digital approaches have demonstrated the potential to enhance diabetic self-management and clinical outcomes. These include telemedicine, mobile health applications, and e-health systems. Applications like BlueStar and OneTouch Reveal, as well as programs like My Diabetes Coach, have been shown to improve glucose management and health-related quality of life. However, more investigation and creation are required to improve the usability and accessibility of these digital health solutions. This narrative review examines the current state of digital health technologies for diabetes self-management and highlights their benefits and drawbacks. It emphasizes the importance of addressing current challenges to fully achieve the potential of digital interventions in controlling type 2 diabetes and type 1 diabetes.

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Introduction:-

Diabetes mellitus (DM) is a chronic illness that is considered a worldwide problem. It affects a patient's quality of life in every aspect, and it raises morbidity and death rates. (1) Health authorities are now focused on educating those affected by diabetes with practical steps to improve self-management and promote positive lifestyle changes to complement clinical treatment, thereby reducing the complications of type 2 diabetes(2)

In addition to regular daily activities, diabetes self-management involves daily behaviors, such as regular blood glucose monitoring, maintaining a healthy weight, exercising, and eating healthfully (3).

Many mobile technologies (m-health) and e-health interventions have been developed in response to patients' demands for greater support with self-management. These applications have been well accepted by the population as a helpful tool in optimizing and monitoring the glucose level. (4)

According to a meta-analysis of 13 trials (Captieux M., et al. 2016), there was a mean reduction of 0.44% in the HbA1c of the intervention compared to the control (4.8 mmol/mol; 95% CI 0.29%, 0.59%) and a higher perception of self-care among app users (5).

Despite such a good response, many limitations are associated with using such technology. This narrative review's primary goal is to examine recent studies on the contribution of digital health technologies to improving diabetes self-management behaviors in people with the disease, emphasizing the effectiveness and drawbacks of these interventions.

Methodology:-

We screened PubMed, Web of Science, and Clinical Key for articles using the search string “Diabetes mellitus AND mHealth OR mobile health” OR “digital interventions AND diabetes mellitus.” It yielded 51492 results. 55 relevant articles were selected for the review. The inclusion criteria were reviews, RCTS, systematic reviews, and Meta-analysis in multiple languages from 2010 till 18 June 2024. The exclusion criteria were non-related studies, studies before 2010, and animal experiments.

Types Of Digital Interventions:

The term "digital health" emerged in 2015 when new technologies to improve healthcare were rising. Digital health refers to using information and communication technologies (ICTs) to assist individuals in managing their health. This is accomplished by providing an opportunity to track, regulate, and enhance health outcomes and customize medical care to meet each patient's needs [12].

Mobile health (mHealth) technologies are one popular application of digital health. "mHealth" describes medical and health-promoting practices compatible with mobile devices, like tablets and smartphones [12,13,14]. For instance, a smartphone can promote health through social networking functions [12,6]. However, it was only a matter of time before smartphone applications became a platform for mHealth solutions, given the introduction of smartphone application stores in 2008 [12,16,17].

There is no standard definition for mHealth apps because the market is so diverse and expanding quickly [18,9}. The World Health Organization (WHO) defines mHealth apps as those designed for smartphones and other mobile devices that have the potential to positively impact people's social, mental, and physical health [19]. It is also important to distinguish general mHealth and medical apps, two distinct entities [20.21]. Notably, government and international regulations, including the Medical Device Regulation of the European Union (EU 2017/745), must be considered if a mHealth app is to be categorized as a medical app. This implies that an approval process, including risk analysis, must be completed for a mHealth app to be approved as a medical app [21,22]. Consequently, mHealth apps— especially those classified as medical apps —offer the potential to enhance general healthcare concerns and patient outcomes in diabetes mellitus type 1 (T1DM) and type 2 (T2DM) [13,23,24].

An increasing number of members of the diabetes community have started experimenting with mHealth apps, which present innovative opportunities [25,26]. In 2025, there were about 6.7 million installations of mHealth apps tailored to diabetes mellitus. Since then, there has been a sharp rise in the number of installations, with an estimated 15 million in 2018 [26] and 46.3 million in 2019 [27], representing 11% of patients globally with DM diagnoses in

2019 [27]. 35.8% of the installed mHealth apps were dedicated to T1DM, 47.6% to T2DM, and 32.0% to GDM (gestational diabetes mellitus) [28]. Various Diabetes mellitus-specific mHealth apps with various functionalities are available [27]. Potential features of an app could be the ability to measure blood sugar levels or insulin consumption, calculate insulin dosages, keep track of physical activity, nutrition, and weight, or offer education or information [13,26,27,29].

A rising number of smartphone apps have been developed to help T2DM patients better control their condition [30]. However, not all of them have undergone thorough testing. An app for managing diabetes called BlueStar, which is compatible with smartphones and intended to act as a virtual coach for patients, has been demonstrated to dramatically lower hemoglobin A1c (HbA1c) readings in T2DM patients who are seen by primary care physicians [31]. Because of this, BlueStar is the first app in the US to receive permission from the Food and Drug Administration to be used as a mobile prescription therapy [32]. However, uncertainty exists over the app's effects on the general population in various clinical settings and healthcare systems.[33]

According to a comprehensive analysis conducted by Kamel et al., WhatsApp is another app widely used in the medical and healthcare fields [34]. Additionally, research from Mexico, Indonesia, and London supports WhatsApp's value as a tool for raising diabetes awareness and assisting in managing issues brought on by the illness [35,36].

For patients with T1DM or LADA, the Brazilian Diabetes Society (SBD) suggests 4–8 capillary self-monitoring blood glucose (SMBG) readings per day [37]. OneTouch Reveal (LifeScan, Wayne, PA, USA), a mobile phone application, is one of the many tools that are currently available for SMBG. Patients can enter insulin dosages, carbohydrate intake, and physical activity data with this app, which links to the OneTouch Select Plus Flex (LifeScan) meter. The app also instantly transfers capillary glucose readings from the meter to the patient's data.

Patients can also share the data with their doctors thanks to the meter and app synchronizing. [38]. OneTouch Reveal® (OTR), a web based application, summarizes blood glucose (BG) or insulin data and displays color-coded trends or low or high BG patterns, enabling patients and healthcare professionals to monitor progress and changes in glycemic control to support both self-management and therapeutic decisions. In addition, OTR offers online education, and allows patients to communicate their diabetes information with their HCP between scheduled meetings, or allows patients to use OTR to review progress during in-person consultations.[39]

With review and input from diabetes specialists and primary care teams, a multidisciplinary team comprising public health and mHealth experts, psychologists, diabetes nurse specialists, and a Māori advisory group developed the text messaging program SMS4BG (Self-Management Support for Blood Glucose) for mobile phones.[40] The intervention is based on behavior change theory and aims to improve people's perceptions of their illnesses and their level of self-efficacy [41,42]. It addresses the habits necessary for effective self-management using Behavior Change Techniques (BCTs) [43] and is composed of modules that enable customization for each patient. The Association of American Diabetes Educations highlighted seven main self-management behaviors that the intervention's content is intended to address: (a) healthy eating; (b) being active; (c) monitoring; (d) taking medicine; (e) problem-solving; (f) reducing risks; and (g) good coping. [44]

According to the American Telemedicine Association and the World Health Organization (WHO), telemedicine is defined as the distant exchange of medical services and/or information between a doctor and patient via electronic information communication technology. [45,46,47] Potential telemedicine options are multiplying, reflecting the continuously changing nature of technology. A few examples of these electronic resources are websites, email, mobile phones, Bluetooth, and other telecommunications devices; they have also featured real-time video conferencing. Telemedicine can potentially improve access for marginalized communities and reduce healthcare expenses, all while enabling more efficient management of chronic illnesses.[48]

In the clinic, it might be challenging to address the factors that contribute to PPDM (persistently poorly controlled diabetes), such as depression, inadequate nutrition and exercise, medication nonadherence, inaccessible blood glucose data, and complex prescription regimens [49,50]. Telehealth can potentially enhance PPDM outcomes by enabling communication beyond the clinic setting. Compared to clinic-based care, telehealth techniques that address the specific causes contributing to poor T2D control lower HbA1c levels by 0.3% to 0.6%. [51,52]

Summary of Key Digital Interventions in Diabetes Mellitus Self-Management:			
Type Of Digital Interventions	Features	Impact	Relevant Key Studies
mHealth Apps	Offer the potential to enhance general health care concerns and, in particular, concerns pertaining to diabetes mellitus type 1 (T1DM) and type 2 (T2DM). Potential features of an app could be the ability to measure blood sugar levels or insulin consumption, calculate insulin dosages, keep track of physical activity, nutrition, and weight, or offer education or information.	Widespread adoption;46.3 million installations in 2019, representing 11% of patients globally with DM diagnoses in 2019	[13,23,24,27]
BlueStar App	Act as a virtual coach for patients;lower haemoglobin A1c (HbA1c) readings in T2DM patients.	BlueStar is the first app in the US to receive permission from the Food and Drug Administration to be used as a mobile prescription therapy.	[31,32]
Whatsapp	Used for raising diabetes awareness	Research from Mexico, Indonesia, and London supports the value of WhatsApp as a tool for raising diabetes awareness and assisting in the management of issues brought on by the illness.	[34,35,36]
OneTouch Reveal App	Used for self-monitoring blood glucose (SMBG) readings. Allows patients to enter insulin dosages, carbohydrate intake, and physical activity	Patients can share the data with their doctors thanks to the metre and app synchronising.	[38,39]

	data with this app linked to the OneTouch Select Plus Flex (LifeScan) metre,enabling patients and healthcare professionals to monitor progress and changes in glycemic control to support both self-management and therapeutic decisions.		
SMS4BG (Self-Management Support for Blood Glucose)	A text messaging program developed to aid blood glucose self-management.	Customizable; addresses seven key self-management behaviors; developed by The Association of American Diabetes Educations.	[40,41,42,43,44]
Telemedicine	The distant exchange of medical services and/or information between a doctor and patient via electronic information communication technology e.g., websites, email, mobile phones, Bluetooth, and other telecommunications devices; they have also featured real-time video conferencing, reducing healthcare expenses, all while enabling more efficient management of chronic illnesses like Diabetes.	Improved T2D control and lower HbA1c levels can be achieved with telehealth techniques, particularly when cu to meet individual patient needs.	[45,46,47,48,49,50,51,52]

Efficacy of Digital Interventions:

Intervention Type	Outcome	Study Reference
Mobile Apps (mHealth)-BlueStar App	The findings showed that, after three months, there was no significant change in the intervention and control groups' HbA1c levels (p=0.19).	[53]
Teleconsultation	The HbA1c levels of type 1 diabetes patients decreased from 7.7% to 7.5%, while type 2 diabetes patients' levels remained stable at 6.6%. The results indicated stable or improved glycemic management.	[54]
Social Media (I-ACE Program)	I-ACE group showed faster improvement in lifestyle knowledge (P=.02). Significant reduction in HbA1c in both groups (P <.001).	[55]

Mobile apps and other mobile health (mHealth) technologies have been created to help with type 2 diabetes mellitus (T2DM) self-management. These devices provide several features, such as medication reminders, diet and activity tracking, and blood glucose monitoring, all aimed at helping patients take better care of their conditions.

An FDA-approved study on the BlueStar app used a multicenter pragmatic randomized controlled trial to evaluate the app's effect on HbA1c levels in a varied group of individuals in real-world clinical settings. There were 223 participants in the study; 110 were assigned to the immediate treatment group (ITG) and 113 to the wait-list control group (WLC). The main outcome assessed was the degree of glucose control, as demonstrated by the three-month HbA1c readings. The findings showed that, after three months, there was no discernible change in the intervention and control groups' HbA1c levels (mean difference -0.42, 95% CI -1.05 to 0.21; P=.19). But according to exploratory analysis, using apps for an extra day was linked to a 0.016-point drop in HbA1c levels (95% CI -0.03 to -0.003), emphasizing the significance of app engagement [53].

The effectiveness of teleconsultation in managing type 1 and type 2 diabetes mellitus during the COVID-19 pandemic was evaluated in a retrospective cohort study (et al. 2015). Without the need for in-person visits, the program enabled thorough patient assessments, including health status, medication adherence, and glucose monitoring, through the use of synchronous video conversations. The HbA1c levels of type 1 diabetes patients decreased from 7.7% to 7.5%, while type 2 diabetes patients' levels remained stable at 6.6%. The results indicated stable or improved glycemic management. Over extended follow-up periods, statistical analyses employing the Wilcoxon test showed substantial reductions in triglyceride levels among individuals with type 2 diabetes. The study also showed a low rate of serious diabetes-related complications, demonstrating how well teleconsultation enhances patient care and distance management amid pandemic-related constraints [54].

Social media sites have also been investigated as diabetes management tools, offering chances for peer support, patient education, and involvement. The Interactive Lifestyle Assessment, Counseling, and Education (I-ACE) program was created to support dietitian-delivered lifestyle counseling for low-socioeconomic level ethnic minority patients with type 2 diabetes. This was done in a pilot randomized controlled study. Fifty people participated in the study; they were split into two groups: one that used the I-ACE tool as an experimental group and the other that received standard lifestyle advice (SLA). The findings showed that the I-ACE group's DM-related lifestyle knowledge increased more quickly than that of the SLA group (P=.02). Furthermore, over time, both groups' HbA1c levels significantly decreased (P <.001). These results imply that customized digital treatments can improve diabetes management and awareness in various demographics [55].

Patient Engagement and Adherence

A.Strategies to Increase User Engagement

Educating/ Familiarizing patients about the basics of diabetics and how this digital intervention is benefiting them[56][58] . Providing a clear benefit to the patient's health using mHealth technology can increase their motivation [56]. Emphasising the importance that the intervention is an integral part of the total care package, not an optional add-on [58]. Using a simple interface, non monotonous , less steps and error prone, interactive web surface and apps that are easy to understand and use[56]. Setting the app/ device / website according to patient's language[56].Gauging patient's technology illiteracy before starting the intervention[56]. The feedback information has to be short, precise and interesting so that the patient does not lose interest[56][58]. Encouragement from family and social groups.[56], hearing or reading about other people's experiences and responses to similar challenges (e.g. the diagnosis) could be useful in managing their adherence [57]. Engagement was also encouraged through regular emails and/or texts[58]. step-by-step booklet for easily navigating the intervention without prior experience. In addition a user activity booklet with some details of where to find commonly requested information and activities to do using the interactive tools [58]. Mobile device supported app rather than clinic provided specific medical device[56]

B. Challenges in Sustaining Long-term Adherence

Frustration technology is one of the main obstacles of sustaining long term adherence [60]. Multiple reporting requirements, electronic record system ,complicated process, multiple steps, technical errors, complicated solution to technical error makes patients lose interest over time[59][60]. Cost and duration of the designed device is a problem in long term adherence [56].People tend to use it rigorously if its an mobile app rather than a separate app or web based.[60] Perceiving the content and / or feedback irrelevant ,Incomprehensible and not tailored to personal goal is a major reason of discontinuation[59]. Lack of face to face human interaction demotivates people.[59]

C. Role of Personalization and Customization in Digital Tools

Individual tailored automated message , reminder, notification helps patient feel connected.[58] A large percentage are elder that use non smart mobile phone and do not have technology literacy; having personally tailored automated text messages reach a wider population.[58]Giving options of voice interactive interface along with written form increases adherence and interaction .[56]Digital tools having different versions like simple text message, web app, mobile app and wearable offers a wide array of options catering to different individual preference and age groups .[6][56]

Challenges and limitations

Various digital interventions have been developed and are crucial in managing and self-care for type 2 diabetes in certain populations. However, many challenges and limitations prevent digital technology from reaching its full potential in the self-management of Type 2 Diabetes. We will go over the most important challenges and limitations that need attention.

Privacy and Security:

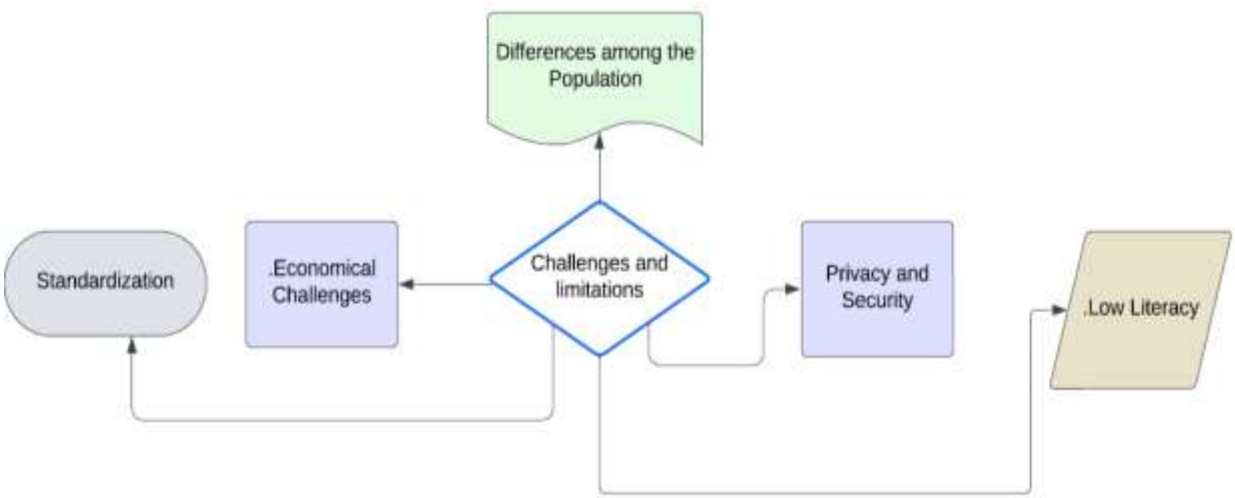
Diabetes applications help users monitor their data and communicate with healthcare providers, but data privacy and security are a major problem, and cyber security needs to be guaranteed. Despite advancements in technology, diabetes apps raise concerns about privacy and security (7).

Low Literacy:
An RCT was carried out during the COVID-19 pandemic regarding social media-delivery patient education to enhance the self-management and attitudes of patients with type 2 Diabetes. It was found that low literacy had a significant impact on the baseline knowledge score in the intervention (8).

Economic Challenges:
According to a study, one of the main reasons people reject and stop using mobile applications is cost (9). The cost is broken down further into the price of buying a mobile device and the cost of keeping an internet connection open so that mobile applications can be used. According to another study, cost is a barrier because users will choose free mobile applications over those that require a subscription (10).

Differences among the Population:
Mobile applications targeting older adults with diabetes need to be created with consideration for their anticipated degree of technological competence. It is also possible that the diabetes management applications that are now on the market are only available in English and are not accessible to those who have specific physical or mental impairments (such as colour blindness, blindness or hearing impairment). Moreover, people who live in isolated locations or severely impoverished socioeconomic areas do not have access to smartphone technology. In addition to the premium pricing paid for these branded diabetic medications, the expense of acquiring and activating a smartphone and the cost of any apps that cannot be downloaded for free may be a significant barrier (10).

Standardization:
Customers use a wide range of mobile operating systems, such as Apple iOS and Android. In the US market, the two most popular systems are Android and Apple iOS. In the United States, about 75 %of doctors use Apple iOS devices as of 2012 (10).On the other hand, app developers should ensure that these apps work consistently and to the same level whether they are offered for less widely used platforms. Additionally, it's important that information stored in health apps can be quickly transferred from smartphones to other platforms, such as electronic health records that may be shared with healthcare professionals. As an illustration, consider Apple Health, a mobile app for health informatics that serves as a central database for medical data. Apple Health may record and share health data and be incorporated with a variety of mobile health and fitness applications for Apple devices (11). Tidepool Mobile is one app that has been connected with Apple Health. (11)



Conclusion:-
The effectiveness of social media based education and mobile health technology in the management and prevention of type 2 diabetes demonstrates encouraging but inconsistent outcomes. Even while overall HbA1c level improvements are not always statistically significant across trials, the use of these digital instruments is essential to their efficacy. Moreover, the effectiveness of these mediums is hindered by data privacy, economic barriers, low health literacy, and variability in population needs and technology standards. Addressing these limitations, particularly in terms of accessibility and security, is essential to maximize the potential of digital technologies in

diabetes management.Prospective investigations ought to concentrate on pinpointing elements that augment user involvement and customizing interventions to cater to the distinct requirements of heterogeneous patient cohorts. This strategy may help manage type 2 diabetes to the fullest extent possible by utilizing social media and mHealth technology.

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