

Effects of digital health for self-management in adult with type 2 diabetes: A systematic literature review

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK

Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

Abstract

Background: Digital health services offer effective solutions to support self-management among adults with T2DM. These tools enable individuals to continuously collect longitudinal data on their daily behaviours and clinical datas, facilitating ongoing health assessments and timely responses to T2DM management.

Methods: A systematic review of English peer-reviewed articles was conducted, involving a comprehensive literature search of PubMed, MEDLINE, CINAHL, Web of Science spanning from 2013 to 2023. Inclusion criteria comprised studies focusing on digital health interventions for self-management of T2DM in adults aged 18 years and above.

Results: Sixteen articles were identified based on the inclusion and exclusion criteria, as well as the quality evaluation standards. The review underscores the transformative potential of digital health technologies, enabling not only the monitoring and management of blood glucose levels, dietary intake, body weight control, medication adherence, and physical activities, but also facilitating personalised health information dissemination, professional education and coaching, and effective two-way communication between adults with T2DM and healthcare professionals, these features empower individuals and enhance their autonomy and engagement in managing their T2DM health.

Conclusion: This review has systematically evaluated the effectiveness and application features of digital health interventions for self-management among adults with T2DM. It identifies self-management behaviours tested in the reviewed literature and assesses the limitations of these studies. Furthermore, this review comprehensively explored the barriers, challenges, facilitators, research gaps, and future policy and practice directions associated with advanced technology-enabled self-care solutions for this population.

Keywords: Digital Health Services; Effects And Barriers; Self-Management; Systematic Literature Review; Type 2 Diabetes.

INTRODUCTION

Self-management is pivotal in the care of adults with type 2 diabetes mellitus (T2DM), (Barlow et al., 2002). This encompasses regular self-monitoring and recording blood glucose, medication management, injection techniques, physical activity, and dietary planning (Diabetes UK, 2009; Hartz, Yingling and Powell-Wiley, 2016).

However, the intricate nature of T2DM management often leads to elevated levels of psychosocial distress, posing significant challenges to consistent adherence to self-care regimens (Carpenter, DiChiacchio and Barker, 2019; Karlsen, Oftedal and Bru, 2012). The integration of digital health technologies has emerged as a promising avenue to support self-management among adults with T2DM (Egede et al., 2017; Ansari et al., 2019; Schwamm, 2014).

There is lack of a comprehensive review to assess the effects of digital health on self-management for this population. This systematic literature review aims to fill this gap by critically

examining previous peer-reviewed articles. The research questions guiding this review address the effectiveness of digital health services, common features of these applications, barriers and facilitators to their adoption, limitations in existing studies, and future directions in this field.

RESEARCH METHOD

This literature search strategy was tailored to align with the objectives and questions of the systematic review (Muka et al., 2020). People with type 1, mixed, or gestational diabetes were excluded from this review. A Librarian from UWS helped to modify the search strategy. The systematic literature search was carried out in September 2023 using the databases of PubMed, MEDLINE, CINAHL, Web of Science from January 2013 to September 2023 in English language. The search key words comprised of "Digital health" OR "e-health" OR "m-health" OR "Telehealth" OR "Telemonitor" OR "Technology enabled care" and "Effectiveness or outcomes or

impact” and “Type 2 diabetes” and “Self-management” OR “self-care” OR “self-regulation” OR “self-monitoring” and “Adults” OR “adult or aged elderly”. In adherence to these criteria, a manual search was incorporated alongside the search terms used in the automated search to ensure the comprehensive identification of relevant studies. Following the identification stage, a total of 835 articles were collected using keywords, with 819 records sourced from digital databases and an additional 16 studies identified through manual searches within cited references. In the screen stage, 432 studies were chosen after removing duplicates, non-English articles, and publications predating 2013. Further screening based on titles and abstracts led to the exclusion of 319 studies, primarily due to focusing on type 1 diabetes, involving patients under 18 years old, lacking outcome records, or lacking relevance to diabetes, or being economic evaluations. Upon conducting a full-text assessment

of the remaining 113 records, 16 articles were chosen based on the inclusion and exclusion criteria, as well as the quality evaluation standards.

The sixteen studies obtained underwent manual synthesis using Microsoft Excel. Before commencing thematic analysis, a data extraction process was conducted to identify study characteristics. Thematic content analysis was then employed to examine differences, similarities, and recurring themes within the findings across all articles (Anderson, 2007). Research objectives and study questions guided theme development, ensuring analytical clarity and enhancing data analysis rigor and acceptability (Vaismoradi et al., 2016). Comparative analysis encompassed identifying primary impacts, barriers, challenges, and facilitators within individual studies, highlighting commonalities and differences across selected studies, and categorizing these findings accordingly.

RESEARCH RESULTS

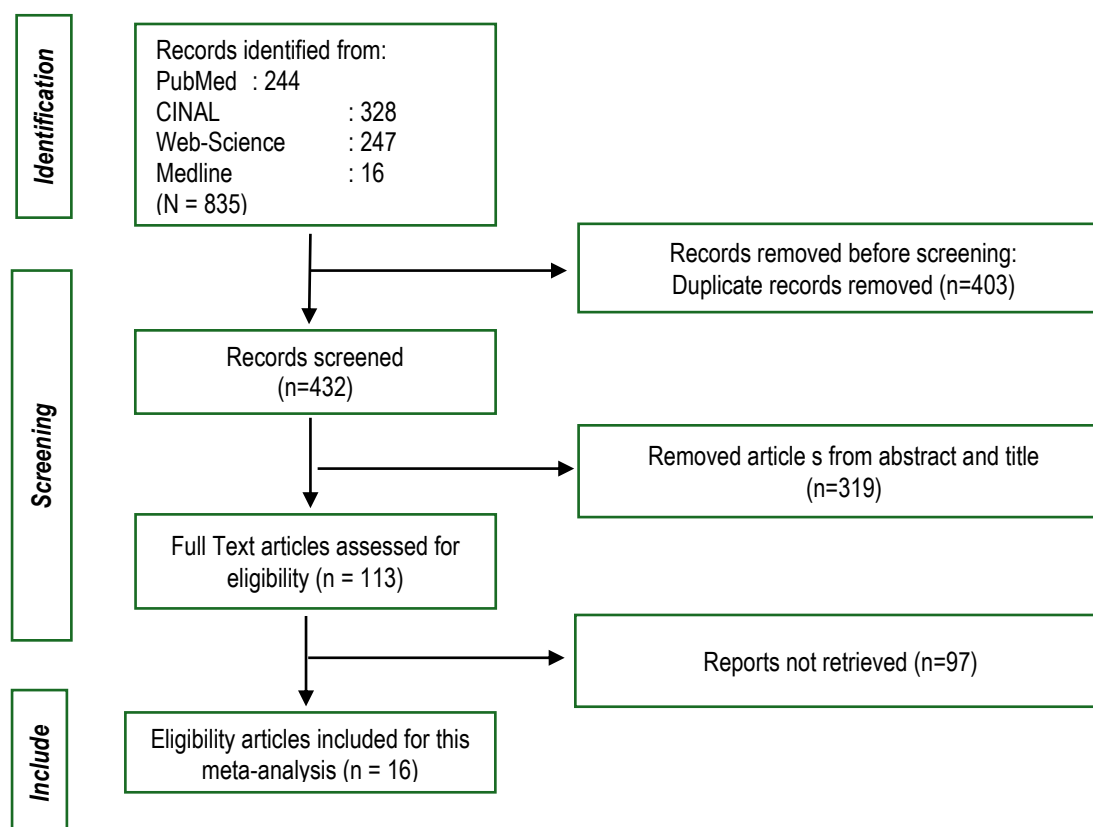


Figure Flow Prism Diagram

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK

Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

Table Summary of Review Articles

(Author, Year) (Country)	Purpose	Method	Results
(Abdel Nasser et al., 2021) (Saudi Arabia)	To identify the use of eHealth among patients with T2DM as well as its association with DSM.	A Cross-Sectional Study	Most Saudi T2DM patients with an average DSM use different eHealth resources and are satisfied with their quality. Dependency to eHealth is significantly associated with lower DSM, especially for health care use and glucose management, a finding that could affect patient outcomes.
(Agarwal et al., 2019) (Canada)	To conduct a pragmatic randomized controlled trial of the BlueStar mobile app to determine if app usage leads to improved HbA _{1c} levels among diverse participants in real-life clinical contexts.	RCT	Hasil analisis kovarians dengan mengendalikan kadar HbA _{1c} awal tidak menunjukkan bukti dampak intervensi terhadap kadar HbA _{1c} pada 3 bulan (selisih rerata [ITG- WLC]- 0,42, IK 95%- 1,05 hingga 0,21; P=0,19).
(Ayre et al., 2019) (Australia)	To explore PCP perspectives on proposed features for a self-management app for patients with diabetes that would link to primary care services.	Interviews qualitative study	This study provided insight into PCP perspectives on a diabetes app integrated with primary care services. This was observed as more than a technological change, PCPs were concerned about changes in workload, their role in self-management, and the nature of consultations.
(Desveaux et al., 2018) (Canada)	To evaluate a Web-based solution for improving self-management in T2DM to identify key combinations of contextual variables and mechanisms of action that explain for whom the solution worked best and in what circumstances.	one-to-one, semi-structured telephonic interviews	Self-efficacy, competing priorities, previous behavior change, and beliefs about Web-based solutions interact to determine engagement and impact on the clinical outcomes. Considering the balance of these patient characteristics is likely to help health care providers identify individuals who are apt to benefit from a Web-based solution to support self-management of T2DM.
(Du Pon et al., 2020) (Netherlands)	To improving patients' self-management skills, was expected to encourage patients to manage their disease through the use of an online platform.	RCT	The added value of self-managing a chronic disease may not be automatically apparent for patients. In addition, platforms may not be suitable for the older adults with lower eHealth literacy. There is a need to invest in developing online skills, particularly for older adults with lower eHealth literacy.
(Guo, 2020) (Taiwan)	To utilize data from the Mobile Self-Monitoring of Blood Glucose System to obtain a picture of	Longitudinal quantative study	Analytical results reveal that short-term usage of the developed system stabilizes the week-by-week glycemic fluctuations. Four categories were

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK

Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

Effects of digital health for self-management in adult with type 2 diabetes: A systematic literature review

the metabolic progression.

established to distinguish different patterns of patients' glycemic variation. If patterns of glycemic control can be recognized or interpreted by newly designed mobile applications, then the collection and analysis of metabolic variation will greatly help both health care providers and patients in effective diabetes management.

(Han et al., 2023)
(China)

To compare telemedicine-assisted structured self-monitoring of blood glucose(SMBG) with a traditional blood glucose meter (BGM) in adults of type 2 diabetes mellitus (T2DM).

RCT

The study demonstrated the superiority of the telemedicine-assisted structured SMBG versus the traditional BGM for improving HbA1c. Additionally, the telemedicine-assisted SMBG reduced the risk of hypoglycemia and enhanced diabetes self-management behaviors, as differences in the LBG1 and the Diabetes Self-Management Questionnaire(DSMQ) results between the groups after 6 months were found to be significant.

(Lewinski et al., 2021)
(USA)

To the use of multiple mobile health (mHealth) devices (Fitbit Alta, fitness tracker, iHealth glucometer, BodyTrace scale) that support self-management behaviors in individuals with type 2 diabetes mellitus (T2DM).

Semi-structured interviews

We identified one theme about visualizations created from data obtained from the mobile devices. Despite some challenges, individuals with T2DM found it feasible to use multiple mobile devices to facilitate engagement in T2DM self-management behaviors.

(McGloin et al., 2015)
(Ireland)

To examine the effectiveness of the use of telephone empowerment-based health coaching as a cost-effective alternative to changing health behaviours of adults with Type 2 diabetes.

A mixed method case study approach

Participants took greater responsibility for health and revealed high self-efficacy scores. Short-term benefits were seen in physiological variables at three months but these deteriorated with the cessation of the intervention indicating the need for continuous support.

(Poppe et al., 2019)
(Belgium)

To test the short-term effect of MyPlan 2.0 in altering levels of PA and SB and in changing personal determinants of behavior in adults with T2DM and in adults aged ≥50 years.

RCT

The SB intervention group displayed an increase in accelerometer-assessed breaks from sedentary time in comparison with the control group ($P=.005$). A total of 14 participants of RCT 1 dropped out. In RCT 2 ($n=63$), the PA intervention group showed an increase for self-reported total PA in comparison with the control group ($P=.003$).

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK

Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

DISCUSSION

In this systematic literature review (SLR), total 835 journal articles were screened, and 16 peer reviewed studies were selected to evaluate the effectiveness and application features of digital health interventions for self-management among adults with T2DM, as well as to identify self-management behaviours tested in the reviewed literature and to assess the limitations of these studies. Additionally, this review systematically explored the barriers, challenges, facilitators, research gaps, and future policy and practice directions associated with advanced technology enabled self-care solutions for this population. Furthermore, JBI critical appraisal tools were utilised to comprehensively evaluate the quality of the sixteen selected studies.

Methodologically, this SLR does not restrict itself to specific sociodemographic characteristics or study locations in the literature selection criteria. As evidenced on this study locations, the studies included in this review were conducted across eleven countries, spanning European, East and Middle Asia regions. This comprehensive approach ensures the inclusion of all relevant studies worldwide and improves the generalisability of the findings (Pita-Barros *et al.*, 2019).

Based on the findings of the selected studies, this SLR revealed that digital health features are associated with a variety of functionalities and applications. These functionalities align with previous studies, offering various health information resources and services such as health coaching, education, and self-management support for adults with T2DM (Leonardsen *et al.*, 2020; Aranha *et al.*, 2021; Ashrafzadeh and Hamdy, 2019). This evidence also noted that digital health devices enable the utilisation of healthcare services and the exchange of professional information, thereby improving health recording and promoting interaction and communication between patients and professional healthcare teams (Tsai *et al.*, 2020). As highlighted by Ashrafzadeh and Hamdy (2019), telemedicine presents opportunities for improved access to health care and more convenient interactions, particularly important with clinicians' time and resource limitations and patients' extensive diabetes self-management responsibilities. The increasing popularity of virtual appointments suggests that the diabetes clinic of the future may go beyond physical boundaries (Ashrafzadeh and Hamdy, 2019). Of particular significance is the role of digital health services as virtual coaches and reminders, delivering evidence-based information and real-time

messages to enhance individual motivation and engagement, foster sustained behavioural changes, and educate individuals to improve T2DM self-management and diabetes control (Maglalang *et al.*, 2017; Bassi *et al.*, 2022; Ashrafzadeh and Hamdy, 2019).

Furthermore, evidence suggests that digital health apps facilitate accurate data recording, transmission, analysis, and evaluation of exercise activities, body weight, food intake, and blood glucose levels. With technological advancements, these apps have developed more personalised, culturally adapted, feasible, helpful, and accessible, enabling real-time recording, accurate monitoring, and comprehensive analysis of daily behaviours (Bassi *et al.*, 2022). For example, culturally tailoring mHealth programs has been reported to improve site accessibility and enhance patient engagement (Georgsson and Staggers, 2017). Additionally, digital health services enable the review of patients' goals, care plans, potential problems, and their solutions, along with the administration of related health tests (Solomon and Rudin, 2020; Sharma *et al.*, 2018).

Thus, the key functionalities of digital health devices for managing type2 diabetes encompass blood glucose monitoring, medication tracking, exercise monitoring, body weight checking and dietary management, complemented by tailored messaging and information. Simultaneously, digital health services, serving as tools for self-management and decision support for adults with T2DM, have the potential in improving health outcomes by promoting engagement in self-care, bridging communication gaps, and customising services to individual needs (Sharma *et al.*, 2018). Support applications empower adults with T2DM to extend diabetes self-management beyond clinical settings, allowing them to optimise their health conditions.

Overall, by analysing and synthesising the findings of the selected studies, this review has comprehensively explored the functionalities of digital health services in self-management for adults with T2DM, as presented in Figure 5. However, the success of these tools hinges on their user-friendliness and complexity, which can influence adoption and engagement among adults with T2DM (Greenwood *et al.*, 2017). Notably, it's important to address that only a few studies in this review clearly demonstrated and critically explained the enhancements and satisfactions derived from digital

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK

Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

health interventions among adults self-managing T2DM. More important, in this systematic literature review, there is limited evidence concerning digital health functionalities related to daily emotional changes and monitoring, as well as the comprehensive analysis of psychosocial records. Finally, the rapid evolution of digital health tools has also attracted increased regulatory attention and scrutiny (Grundy, 2022).

This review presents compelling evidence of the diverse utilisation of digital health services across the studies. While some studies reported high engagement and usage rates of digital health services, resulting in positive outcomes in self-management, others observed low levels of usage and engagement, which showed no significant effects on self-management for adults with T2DM. These findings align with other studies, indicating that the provision of triage and technical support services alongside the digital health services were also important catalysts of engagement (Doyle *et al.*, 2021; Kaveh, Kaveh and Faradonbeh, 2023; Adu *et al.*, 2020). A systematic review also provides a strong evidence of empowering patients and increasing awareness of their symptoms and treatment through use of digital health services (Leonardsen *et al.*, 2020). For example, the evidence presented in this review, along with other reports, addressed the notable impact of wearing trackers integrated with e-health recording on engaging adults in diabetes self-management. These trackers offer immediate feedback on behaviours, including step count per day and sleeping status, along with the ability to provide alerts and reminders, such as reminders to reduce sedentary time. However, a challenge lies in the limited information available on these digital devices, which often require pairing with smartphones or computers (Rollo *et al.*, 2016; Keogh *et al.*, 2024). Additionally, this review discovered that person-centered digital health services, equipped with features such as automated prompts, reminders, data entry capabilities, health educational materials, and two-way feedback for both patients and professionals, can enhance accountability for self-management behaviours, complement face-to-face consultations, and facilitate self-monitoring for adults with T2DM (Kebede, 2019; Parmar *et al.*, 2022; Iqbal *et al.*, 2023). A recent study has provided additional evidence supporting the effectiveness of automated motivational interviewing (MI) techniques, driven by artificial intelligence on mobile devices, in offering

effective motivational support for patients with T2DM. The findings also emphasise the importance of adopting a hybrid intervention model that combines app-based automated MI with health professional coaching (Yoon *et al.*, 2024).

Nonetheless, there is limited evidence regarding the impact of digital health services on health outcomes among adults with T2DM, which is consistent with findings from other reviews (Morton *et al.*, 2017; Choi *et al.*, 2020). In the seven RCTs included in this review, only two statistically demonstrated significant improvements in health outcomes (Tan *et al.*, 2023; Han *et al.*, 2023). The remaining five RCTs did not find significant effects of digital interventions on health outcomes for adults with T2DM. Based on the sixteen selected papers, this review identified positive health outcomes strongly associated with medication adherence and enhanced self-care behaviour through digital health services among adults with T2DM. Similarly, the evidence also indicates that poor adherence to medication and self-care behaviours contributes to an increase in complications related to T2DM (da Rocha, Silva and Cardoso, 2020).

Furthermore, this review highlights the crucial role of effective communication between adults and clinical practitioners facilitated by digital technologies. The integration of professional coaching and education with robust communication has been demonstrated to significantly impact patients' satisfaction and engagement with digital services and their self-management of T2DM. Importantly, the low usage and retention of digital services, along with poor patient engagement, are closely associated with inadequate communication between health providers and patients (Abdel Nasser *et al.*, 2021; Agarwal *et al.*, 2019; Ayre *et al.*, 2019; Yamaguchi *et al.*, 2019; Van Het Schip *et al.*, 2020; Young *et al.*, 2020). At the same point, a previous systematic review provided substantial evidence of the impact of digital health services on reducing HBA1c level which was achieved through the integration of four key elements including two-way communication between patients and professional teams, education, feedback, and patient-generated health data (Greenwood *et al.*, 2017).

While the selected studies have demonstrated positive health outcomes, there remains a lack of insights into the long-term sustainability and effectiveness of digital health services in self-management for adults with T2DM. This gap is

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK

Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

consistent with findings from existing systematic literature reviews, which suggest that while diabetes self-management technologies can lead to significant weight reduction in the short term, most interventions do not meet the benchmarks necessary for clinical significance over the long term (Alsayed *et al.*, 2023).

When examining the utilisation of digital health services for self-management among adults with T2DM, various barriers emerge from this literature review. Notably, the issues related to low digital literacy level among adults with T2DM can hinder the widespread adoption of digital health services (Han *et al.*, 2023). One of the RCT studies analysed in this literature review found that patients with a higher self-perceived eHealth literacy tend to use digital health platforms more frequently compared to those with lower self-perceived eHealth literacy (Du Pon *et al.*, 2020). Additionally, evidence indicates that adults with limited digital literacy often encounter difficulties in navigating interfaces and unintentionally disclosing irrelevant information. These challenges raise concerns about the adoption of digital health services (Pywell *et al.*, 2020). While the level of digital literacy and technological skills impact on the adoption of digital health services, scholars argue that the use of digital health tools may be limited by internet access, and the availability of the necessary devices (Alsayed *et al.*, 2023). This is particularly pertinent for adults in lower socio-economic or remote environments, who may encounter digital disparities that hinder their ability to access these tools without adequate social support (Mannoubi *et al.*, 2024).

Furthermore, individuals with T2DM display diverse levels of self-efficacy, internal motivation, and beliefs about the usefulness of virtual solutions, influencing their perception of digital health tools (Desveaux *et al.*, 2018; Poppe *et al.*, 2019; McGloin *et al.*, 2015; Young *et al.*, 2020). The previous study shows that adults with low self-efficacy fear their limited digital proficiency may compromise clinical care effectiveness (Pywell *et al.*, 2020). Importantly, the findings from one of selected studies highlight that use of digital health tools for self-management is person specific and relies on individual perceptions and abilities (Lewinski *et al.*, 2021). Aranha and colleagues also emphasise attitudes toward technology, social influences, and the usability features of digital health devices as significant barriers, particularly for older adults (Aranha *et al.*, 2021).

Challenges in clinical integration and personalisation arise, as seamlessly integrating these digital tools into existing clinical workflows and tailoring them to individual patient needs remains a complex task (Ayre *et al.*, 2019). Achieving seamless integration mandates interoperability among electronic health records, medical devices, and other healthcare technologies. This entails the combination of standardisation endeavours and collaborative efforts among stakeholders (Cellina *et al.*, 2023). Moreover, the low engagement and retention rates among adult patients with T2DM, coupled with the technological training requirements for both healthcare providers and patients, also contribute to the barriers (Abdel Nasser *et al.*, 2021). Although smartphone training programs show promise in enhancing mobile device competency among older adults further research is needed to assess their efficacy (Zhao *et al.*, 2020).

Critically, communication barriers due to lack of online access to healthcare providers add layers of complexity (Abdel Nasser *et al.*, 2021). This highlights the importance of establishing clear and effective communication channels between patients and health professionals by technology developers (Mannoubi *et al.*, 2024).

The methodology issues and limitations in this study stem from both internal and external factors. Internal factors related to the narrow database search in this study, and external factors associated with the limitations of the included studies demonstrated above section. The search in this study was confined to just four primary databases, and while these methodology issues were initially assessed the potential impact on the search results, no apparent differences were noticed (Kebede, 2019). Considering the extensive workload required for a more robust methodology, including obtaining missing data from authors and imputing values, this study only focus on these four fundamental databases. The thematic content analyses utilised in this study were additionally impacted by limitations inherent in the included studies. The process of identifying components and key terms of complex interventions in systematic reviews heavily relies on the quality and specificity of the intervention descriptions provided.

The studies selected to assess the impact of digital technologies on glycaemic control and self-management behaviours in T2DM reveal limitations related to their settings, designs, and analyses.

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK

Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

While the studies included in this review covered various regions, there is limited evidence from underdeveloped countries, impacting the generalisability of the findings. Furthermore, the applicability of the findings may be constrained to the specific study context and may not directly translate to other cultural or healthcare settings (Van Zyl *et al.*, 2021). Data collection via online platforms may also exclude individuals without digital literacy or access to such platforms (Du Pon *et al.*, 2020). Moreover, the quality of online health information and its reliability remain significant concerns. To accurately assess the dynamics of glycaemic control, future studies should incorporate multiple measurements. It is also important to continue research efforts to address these limitations and improve our comprehension of digital health interventions for adults with T2DM in self-management.

CONCLUSION

In summary, this review systematically examines the effectiveness of digital health services in aiding self-management for adults with T2DM. The key findings are presented through a comprehensive exploration of five research questions aligned with the study's aims and objectives. The review emphasises the transformative potential of digital health technologies, encompassing mobile health applications, telemedicine, web-based platforms, and wearable tracking and monitoring devices, in supporting individuals in managing T2DM. These technologies not only facilitate the monitoring and management of blood glucose levels, dietary intake, body weight control, medication adherence, and physical activity, but also provide a platform for personalised health information, professional education and coaching, and effective two-way communication between adults with T2DM and healthcare professionals, thereby empowering individuals and enhancing their autonomy and engagement in managing their health, furthermore, the review reveals a high acceptance and satisfaction rate of digital health services among users with high self-efficacy and digital literacy, attributed to their convenience, accessibility, and potential to offer personalised support and real-time feedback. However, the effectiveness of these interventions varies, with some studies reporting significant improvements in clinical outcomes and self-management behaviours, while others observe minimal or no changes.

Nevertheless, the adoption and effective utilisation of digital health services are influenced by various factors, including barriers such as digital literacy and technology access issues, integration into existing

healthcare practices, and facilitating factors such as technology usability, personalised design, and motivation and support provision through digital interventions and interactions with healthcare professionals. Despite the positive outcomes associated with digital health interventions, challenges such as sustaining long-term user engagement, addressing privacy and data security concerns, and ensuring the seamless integration of digital tools into clinical workflows persist. Moreover, the variability in the effectiveness of these interventions across different populations underscores the necessity for personalised approaches that consider the unique needs, preferences, and contexts of individuals with T2DM.

REFERENCES

- Adu, M. D., Malabu, U. H., Malau-Aduli, A. E., Drovandi, A. and Malau-Aduli, B. S. (2020) 'User retention and engagement with a mobile app intervention to support self-management in Australians with type 1 or type 2 diabetes (My Care Hub): mixed methods study', *JMIR mHealth and uHealth*, 8(6), pp. e17802.
- Anderson, R. (2007) 'Thematic content analysis (TCA)', *Descriptive presentation of qualitative data*, 3, pp. 1-4.
- Ansari, R. M., Hosseinzadeh, H., Harris, M. and Zwar, N. (2019) 'Self-management experiences among middle-aged population of rural area of Pakistan with type 2 diabetes: a qualitative analysis', *Clinical Epidemiology and Global Health*, 7(2), pp. 177-183.
- Aranha, M., James, K., Deasy, C. and Heavin, C. (2021) 'Exploring the barriers and facilitators which influence mHealth adoption among older adults: A literature review', *Gerontechnology*, 20(2).
- Ashrafzadeh, S. and Hamdy, O. (2019) 'Patient-driven diabetes care of the future in the technology era', *Cell metabolism*, 29(3), pp. 564-575.
- Barlow, J., Wright, C., Sheasby, J., Turner, A. and Hainsworth, J. (2002) 'Self-management approaches for people with chronic conditions: a review', *Patient education and counseling*, 48(2), pp. 177-187.

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK

Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

Effects of digital health for self-management in adult with type 2 diabetes: A systematic literature review

- Bassi, G., Giuliano, C., Perinelli, A., Forti, S., Gabrielli, S. and Salcuni, S. (2022) 'A virtual coach (Motibot) for supporting healthy coping strategies among adults with diabetes: proof-of-concept study', *JMIR Human Factors*, 9(1), pp. e32211.
- Carpenter, R., DiChiacchio, T. and Barker, K. (2019) 'Interventions for self-management of type 2 diabetes: an integrative review', *International journal of nursing sciences*, 6(1), pp. 70-91.
- Cellina, M., Cè, M., Ali, M., Irmici, G., Ibba, S., Caloro, E., Fazzini, D., Oliva, G. and Papa, S. (2023) 'Digital Twins: The New Frontier for Personalized Medicine?', *Applied Sciences*, 13(13), pp. 7940.
- Choi, W., Wang, S., Lee, Y., Oh, H. and Zheng, Z. (2020) 'A systematic review of mobile health technologies to support self-management of concurrent diabetes and hypertension', *Journal of the American Medical Informatics Association*, 27(6), pp. 939-945.
- da Rocha, R. B., Silva, C. S. and Cardoso, V. S. (2020) 'Self-care in adults with type 2 diabetes mellitus: A systematic review', *Current diabetes reviews*, 16(6), pp. 598-607.
- Diabetes UK (2009) *Improving supported self-management for people with diabetes*. Available at: <https://www.diabetes.org.uk/resources-s3/2017-09/Supported-self-management.pdf>.
- Doyle, J., Murphy, E., Gavin, S., Pascale, A., Deparis, S., Tommasi, P., Smith, S., Hannigan, C., Sillevs Smitt, M. and Van Leeuwen, C. (2021) 'A digital platform to support self-management of multiple chronic conditions (ProACT): findings in relation to engagement during a one-year proof-of-concept trial', *Journal of medical Internet research*, 23(12), pp. e22672.
- Egede, L. E., Williams, J. S., Voronca, D. C., Knapp, R. G. and Fernandes, J. K. (2017) 'Randomized controlled trial of technology-assisted case management in low-income adults with type 2 diabetes', *Diabetes technology & therapeutics*, 19(8), pp. 476-482.
- Georgsson, M. and Staggers, N. (2017) 'Patients' perceptions and experiences of a mHealth diabetes self-management system', *CIN: Computers, Informatics, Nursing*, 35(3), pp. 122-130.
- Greenwood, D. A., Gee, P. M., Fatkin, K. J. and Peebles, M. (2017) 'A systematic review of reviews evaluating technology-enabled diabetes self-management education and support', *Journal of diabetes science and technology*, 11(5), pp. 1015-1027.
- Grundy, Q. (2022) 'A review of the quality and impact of mobile health apps', *Annual review of public health*, 43, pp. 117-134.
- Hartz, J., Yingling, L. and Powell-Wiley, T. M. (2016) 'Use of mobile health technology in the prevention and management of diabetes mellitus', *Current cardiology reports*, 18, pp. 1-11.
- Iqbal, M. P., Newman, B., Ellis, L., Mears, S. and Harrison, R. (2023) 'Characterising consumer engagement in virtual models of care: A systematic review and narrative synthesis', *Patient Education and Counseling*, pp. 107922.
- Karlsen, B., Oftedal, B. and Bru, E. (2012) 'The relationship between clinical indicators, coping styles, perceived support and diabetes-related distress among adults with type 2 diabetes', *Journal of advanced nursing*, 68(2), pp. 391-401.
- Kaveh, M. H., Kaveh, S. and Faradonbeh, M. R. (2023) 'Mobile health-based interventions in self-care and treatment adherence in older people: a review study', *International Journal of Aging*, 1(1), pp. e6-e6.
- Kebede, M. M. (2019) *Augmenting Diabetes Care & Self-Management: What Can Digital Health Offer?*, Universität Bremen.
- Keogh, A., Brennan, C., Johnston, W., Dickson, J., Leslie, S. J., Burke, D., Megyesi, P. and Caulfield, B. (2024) 'Six-Month Pilot Testing of a Digital Health Tool to Support Effective Self-Care in People With Heart Failure: Mixed Methods Study', *JMIR Formative Research*, 8(1), pp. e52442.

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK
Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com

Effects of digital health for self-management in adult with type 2 diabetes: A systematic literature review

- Leonardsen, A.-C. L., Hardeland, C., Helgesen, A. K. and Grøndahl, V. A. (2020) 'Patient experiences with technology enabled care across healthcare settings-a systematic review', *BMC health services research*, 20, pp. 1-17.
- Lewinski, A. A., Vaughn, J., Diane, A., Barnes, A., Crowley, M. J., Steinberg, D., Stevenson, J., Yang, Q., Vorderstrasse, A. A., Hatch, D., Jiang, M. and Shaw, R. J. (2021) 'Perceptions of Using Multiple Mobile Health Devices to Support Self-Management Among Adults With Type 2 Diabetes: A Qualitative Descriptive Study', *Journal of Nursing Scholarship*, 53(5), pp. 643-652.
- Maglalang, D. D., Yoo, G. J., Ursua, R. A., Villanueva, C., Chesla, C. A. and Bender, M. S. (2017) "'I don't have to explain, people understand": Acceptability and Cultural Relevance of a Mobile Health Lifestyle Intervention for Filipinos with Type 2 Diabetes', *Ethn Dis*, 27(2), pp. 143-154.
- Mannoubi, C., Kairy, D., Menezes, K. V., Desroches, S., Layani, G. and Vachon, B. (2024) 'The Key Digital Tool Features of Complex Telehealth Interventions Used for Type 2 Diabetes Self-Management and Monitoring With Health Professional Involvement: Scoping Review', *JMIR Medical Informatics*, 12, pp. e46699.
- Morton, K., Dennison, L., May, C., Murray, E., Little, P., McManus, R. J. and Yardley, L. (2017) 'Using digital interventions for self-management of chronic physical health conditions: a meta-ethnography review of published studies', *Patient education and counseling*, 100(4), pp. 616-635.
- Muka, T., Glisic, M., Milic, J., Verhoog, S., Bohlius, J., Bramer, W., Chowdhury, R. and Franco, O. H. (2020) 'A 24-step guide on how to design, conduct, and successfully publish a systematic review and meta-analysis in medical research', *European journal of epidemiology*, 35, pp. 49-60.
- Parmar, P., Ryu, J., Pandya, S., Sedoc, J. and Agarwal, S. (2022) 'Health-focused conversational agents in person-centered care: a review of apps', *NPJ digital medicine*, 5(1), pp. 21.
- Pita-Barros, P., Bourek, A., Brouwer, W. and Lehtonen, L. (2019) 'Assessing the impact of digital transformation of health services. Report of the EXPH (Expert Panel on effective ways of investing in Health)'.
- Rollo, M. E., Aguiar, E. J., Williams, R. L., Wynne, K., Kriss, M., Callister, R. and Collins, C. E. (2016) 'eHealth technologies to support nutrition and physical activity behaviors in diabetes self-management', *Diabetes, metabolic syndrome and obesity: targets and therapy*, pp. 381-390.
- Schwamm, L. H. (2014) 'Telehealth: seven strategies to successfully implement disruptive technology and transform health care', *Health Affairs*, 33(2), pp. 200-206.
- Solomon, D. H. and Rudin, R. S. (2020) 'Digital health technologies: opportunities and challenges in rheumatology', *Nature Reviews Rheumatology*, 16(9), pp. 525-535.
- Tsai, T.-H., Lin, W.-Y., Chang, Y.-S., Chang, P.-C. and Lee, M.-Y. (2020) 'Technology anxiety and resistance to change behavioral study of a wearable cardiac warming system using an extended TAM for older adults', *PloS one*, 15(1), pp. e0227270.
- Vaismoradi, M., Jones, J., Turunen, H. and Snelgrove, S. (2016) 'Theme development in qualitative content analysis and thematic analysis'.
- Van Zyl, C., Badenhorst, M., Hanekom, S. and Heine, M. (2021) 'Unravelling 'low-resource settings': a systematic scoping review with qualitative content analysis', *BMJ global health*, 6(6), pp. e005190.
- Yoon, S., Tang, H., Tan, C. M., Phang, J. K., Kwan, Y. H. and Low, L. L. (2024) 'Acceptability of Mobile App-Based Motivational Interviewing and Preferences for App Features to Support Self-Management in Patients With Type 2 Diabetes: Qualitative Study', *JMIR diabetes*, 9(1), pp. e48310.
- Zhao, X., Wang, L., Ge, C., Zhen, X., Chen, Z., Wang, J. and Zhou, Y. (2020) 'Smartphone application training program improves smartphone usage competency and quality of life among the elderly in an elder university in China: A randomized controlled trial', *International journal of medical informatics*, 133, pp. 104010.

Ziying Shuai*, Martin Murray

Robert Gordon University, Aberdeen, UK
Corresponding author: Ziying Shuai.*Email: shuaiziying@yahoo.com