MHealth Solutions for Type2 Diabetes

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According to WHO (2008), mHealth can be defined as mobile computing, medical sensor, and communication technologies for health care. mHealth employs various features, including SMS text messages, emails, phone calls, and mobile phone apps. Therefore, this technology's potential use is evident, both for the general population and clinical samples, since it is employed to improve healthy behaviors and self-care in many medical conditions.

Keywords: diabetes ; mHealth ; elderly ; adherence ; self-management ; psychological techniques

1. Overview

In diabetes, multiple mHealth solutions were produced and implemented for self-management behaviors. However, little research on the effectiveness of psychological techniques implemented within these mHealth solutions was carried out and even less with the elderly population where technological barriers might exist. Reliable evidence generated through a comprehensive evaluation of mHealth interventions may accelerate its growth for successful long-term implementation and to help to experience mHealth benefits in an enhanced way in all ages. This study aimed to review mHealth solutions for diabetes self-management in older adults (focusing on adherence to treatments and glycemic control) by analyzing the effectiveness of specific psychological techniques implemented. For these purposes, a narrative review was conducted following preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. PubMed (Medline) and American Psychological Association (APA) PsycInfo databases were searched for published papers that addressed eHealth solutions' effectiveness for diabetes self-management. Studies in English, Spanish, and/or German of any design were screened, with no time constraints regarding the year of publication. A qualitative analysis of the selected papers was conducted in several steps. This review found 38 studies setting up and analyzing mHealth solutions for older adults. Most research showed improvements in HbA1c, self-management behaviors, and medication adherence in T2DM patients post-intervention. However, different mid-to-long term effects were found across studies, specifically concerning the maintenance and adherence to healthy behaviors. The most employed psychological framework was CBT, including techniques such as self-monitoring of outcome behaviors (mostly targeting glycemia measurements and healthy habits as physical activity and/or diet), tailored motivational feedback from medical staff, and psychoeducation or health coaches. The most successful mHealth intervention combined the feature of tailored feedback messages, interactive communication with healthcare professionals, and multifaceted functions. To conclude, there is a lack of elaborate and detailed information in the literature regarding the factors considered in the design and development of mHealth solutions used as interventions for T2DM self-management in the elderly. Documentation and inclusion of such vital information will foster a transparent and shared decision-making process that will ultimately lead to the development of useful and user-friendly self-management apps that can enhance the quality of life for diabetes patients. Further research adapting mHealth solutions to older adults' sensory deficits is necessary.

2. mHealth

The term mHealth was introduced in 2003 due to the vast expansion of mobile communication technologies. mHealth is the only Information and Communication Technologies (ICT) solution able to involve the transmission, storage, and receipt of multimedia files in a patient-healthcare provider synchronized manner [1]. The Global Observatory for eHealth (GOe) defined mHealth as "*medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices*" [2]. According to WHO (2008), mHealth can be defined as "*mobile computing, medical sensor, and communications technologies for health care*" [2][3]. mHealth employs various features, including SMS text messages, emails, phone calls, and mobile phone apps. Therefore, this technology's potential use is evident, both for the general population and clinical samples, since it is employed to improve healthy behaviors and self-care in many medical conditions. Hence, mHealth offers interesting opportunities to transform every step of patients' management journey, such as booking appointments, consultation with healthcare professionals, information acquisition, monitoring, and learning about treatments, drugs, and self-management, among other

potentialities. However, the trustworthiness and robustness of mHealth to facilitate safe and cost-efficient care are being questioned because of the lack of strong evidence [4]. This situation may trigger reluctance in investing in and developing mHealth-related policies in organizations and countries.

Type 2 Diabetes (T2D) is a chronic non-communicable disease very prevalent in older adults, caused by a complex interaction of multiple factors, of which unhealthy lifestyles such as sedentary behavior and nutritional habits play a significant role, especially in the elderly [5]. According to the International Diabetes Foundation (IDF), 253.4 million people ≥65 years will be living with diabetes in 2045 [6][7]. Besides, people >65 years old are expected to grow from an estimated 524 million in 2010 to nearly 1.5 billion in 2050, especially in developing countries [8][9][10]. This situation brings a significant economic burden to healthcare, reaching more than 160 billion euros (181 billion USD) in Europe, the second-highest among all IDF regions, since the 60–69 age group the one with the largest expenditure on people with T2D, followed by 70–79 years and 50–59 years, successively [8][9][10].

To face this situation, efforts should be placed to improve diabetes self-management and support. Limited medication adherence and poor compliance with treatment are the main barriers to the successful management of T2D [11]. In this sense, only 50% of patients reach their HbA1c target [12]. It is crucial because poor glycemic control is associated with many diverse complications, such as diabetic retinopathy, nephropathy, neuropathy, cardiovascular disease, other disabilities, and a decrease in quality of life (QoL), therefore increasing the risk of comorbidities and death [13][14]. According to evidence-based guidelines, the seven self-care key behaviors for patients with diabetes are (1) eating healthy, (2) being active, (3) monitoring, (4) taking medications, (5) solving problems, (6) healthy coping, and (7) reducing risks [15][16]. Considering that traditional outpatient consultations cannot provide timely support and feedback regularly, mHealth solutions could be a more ecological and efficient approach to educate and facilitate these actions [17]. Mobile apps can collect, record, monitor, transmit and analyze data anytime and anywhere. Thanks to these potentialities, health apps could foster and reinforce self-management behaviors and medication adherence in diabetic users, even also without in-office training [18]. Additionally, these apps represent a great tool to improve not only self-management but also communication in terms of empowerment and enrichment between elderly patients and healthcare professionals [19], especially at a time when, due to the global COVID-19 pandemic, remote health care became a priority. A systematic review revealed that diabetes apps are one of the most common disease-specific apps developed and commercialized worldwide, probably because they allow for the comprehensive assessment and support of the above referred seven self-care key behaviors [20]. In this sense, these apps could serve insulin, medication and diet recording, data export and communication, and weight management [21][22][23][24].

Recent RCT trials [24][25] found no significant differences in using different apps to improve glycemic control (HbA1c levels). However, these studies do not provide detailed information on whether their designs were based on clinical guidelines and recommendations, including reinforcing educational and supportive aspects [24][25]. Therefore, despite this vast market holding promising beneficial effects for users, 44% of them abandon health apps just one month after being downloaded [26].

Different reasons could explain this lack of engagement. In many cases, no solid theoretical frameworks support the development and implementation of different techniques to engage potential mHealth app users and seem not to be integrated into the ecology of the doctor-patient relationship [27]. Besides, most commercial apps were not evaluated using scientific methods, and these apps tend not to be grounded explicitly in theories of health behavior fostering adherence and motivation among users [28]. When it comes to acceptance and usability requirements for older adults with diabetes, this is especially relevant because, in this sample, several barriers could be found. For instance, the lack of technological skills [29][30][31], availability and access to the internet [32], differences in motivational aspects [33], and also functional and sensory limitations hampering the use of these technologies. A systematic review of all currently available diabetes apps for iOS and Android revealed that the usability of diabetes apps for patients aged ≥50 was moderate to good when applied mainly to apps offering a small range of functions. However, complex multifunctional apps performed considerably worse in terms of usability [29]. Thus, building and maintaining sustained motivation to adhere elderly users to mHealth is still an unresolved problem.

Considering all these reasons, health apps need to be evaluated on (a) their potential to start and/or support healthy lifestyles, (b) their consistency with evidence-based practices and solid psychological theories related to motivation and behavior change, and (c) their effectiveness in improving HbA1c levels (mean HbA1c reduction) as the standard measure of average glycemic control predicting diabetes complications. Therefore, this research aimed to systematically review mHealth solutions for T2D self-management in older adults by analyzing the effectiveness of specific psychological techniques implemented.

3. Implications for policy making and future research

Considering that T2D represents a big burden for both the healthcare system and patients bearing this chronic condition, this review provided evidence that health apps aimed at fostering self-management and promoting behavior change could improve T2D management and reduce the risks of secondary complications, and eventually, mortality.

There is increasing interest in comparing benefits of mHealth approaches. Questions remain to be addressed about the values of diverse mHealth methods and psychological techniques implemented. To promote mHealth interventions of self-management effectively and efficiently, more clinical studies are warranted to detect the relationship between the specific intervention pattern and outcomes. In addition, patients' compliance with self-management interventions should be examined in the future. Finally, particular characteristics of the older adults' population should be carefully considered since different barriers and facilitators were identified and should be incorporated from the initial steps concerning the design of such interventions. Thus, links with the generalizability; it is necessary to determine whether mHealth-based self-management methods should be tailored to age groups, cultural contexts, or need to be extended to include support from health care personnel and more long-term economic evaluation needs to be done.

4. Conclusions

Effective treatment of T2DM requires careful self-management. With the ongoing development of mobile technologies and the scarcity of health care resources, mHealth–based self-management became a useful treatment for T2DM, and its effectiveness was assessed in many trials. However, there is a paucity of comprehensive summaries of the studies carried out with the older adults' population and testing mHealth solutions with a solid psychological framework supporting techniques embedded in the app.

This review demonstrated that despite promising results in terms of self-management and adherence to treatment and healthy lifestyle recommendations, theory-driven interventions are still scarce despite being the most claimed and recommended in evidence-based guidelines. Some psychological techniques were proved to be effective in the self-management of chronic illness [34][35][36] (although there are still several gaps in the applied knowledge concerning their specific implementation and effects in older adults' samples). Only 14 out of 38 articles were explicit in terms of which theoretical framework and psychological techniques were employed to design the mHealth intervention and to implement it. This research was mainly based on CBT alone or combined with SDT, ACT, or gamification principles proving consistency with evidence-based practices related to behavior change.

As mHealth technologies grow, emerging applications of the technologies will enable life-changing uses for the elderly population. The application of mHealth has the potential to improve health outcomes and change the course of healthcare as it is provided today, potentially reducing socioeconomic and human costs. However, more in-depth studies in the older adults' population with T2DM are required to validate these potentialities and provide more conclusive evidence.

References

1. Istepanian, R.; Laxminarayan, S.; Pattichis, C.S. M-Health: Emerging Mobile Health Systems; Springer Science & Business Media: Berlin, Germany, 2007; ISBN 9780387265599.
2. Kay, M.; Santos, J. Report on the world health organization global observatory for ehealth strategic planning workshop, April 2008. Methods Inf. Med. 2008, 47, 381–387.
3. Sloninsky, D. Towards the Development of an MHealth Strategy: A Literature Review; 2008; WHO: Geneva, Switzerland, 2008.
4. Car, J.; Tan, W.S.; Huang, Z.; Sloot, P.; Franklin, B.D. eHealth in the future of medications management: Personalisation, monitoring and adherence. BMC Med. 2017, 15, 73.
5. Wong, R.; Ofstedal, M.B.; Yount, K.; Agree, E.M. Unhealthy lifestyles among older adults: Exploring transitions in Mexico and the US. Eur. J. Ageing 2008, 5, 311–326.
6. Global burden of diabetes. International Diabetes federation. Diabetic atlas 8th edition 2017, Brussels. Available online: (accessed on 7 March 2019).
7. 8940_IDF_Atlas_2017_Spanish_Interactive. Available online: (accessed on 25 April 2019).
8. Shaw, J.E.; Sicree, R.A.; Zimmet, P.Z. Global Estimates of the Prevalence of Diabetes for 2010 and 2030. Diabetes Res. Clin. Pract. 2010, 87, 4–14.

9. Global Health and Aging. Available online: (accessed on 25 April 2019).
10. Wild, S.; Roglic, G.; Green, A.; Sicree, R.; King, H. Global Prevalence of Diabetes: Estimates for the Year 2000 and Projections for 2030. Diabetes Care 2004, 27, 1047–1053.
11. García-Pérez, L.-E.; Álvarez, M.; Dilla, T.; Gil-Guillén, V.; Orozco-Beltrán, D. Adherence to therapies in patients with type 2 diabetes. Diabetes Ther. 2013, 4, 175–194.
12. McGovern, A.; Tippu, Z.; Hinton, W.; Munro, N.; Whyte, M.; De Lusignan, S. Comparison of medication adherence and persistence in type 2 diabetes: A systematic review and meta-analysis. Diabetes Obes. Metab. 2018, 20, 1040–1043.
13. Del Cañizo-Gómez, F.J.; Del Cañizo-Gómez, F.J.; Moreira-Andrés, M.N. Cardiovascular risk factors in patients with type 2 diabetes. Diabetes Res. Clin. Pract. 2004, 65, 125–133.
14. Marín-Peñalver, J.J.; Martín-Timón, I.; Sevillano-Collantes, C.; Del Cañizo-Gómez, F.J. Update on the treatment of type 2 diabetes mellitus. World J. Diabetes 2016, 7, 354–395.
15. American Diabetes Association 6. Glycemic targets: Standards of medical care in diabetes—2018. Diabetes Care 2018, 41, S55–S64.
16. Beck, J.; Greenwood, D.A.; Blanton, L.; Bollinger, S.T.; Butcher, M.K.; Condon, J.E.; Cypress, M.; Faulkner, P.; Fischl, A.H.; Francis, T.; et al. 2017 national standards for diabetes self-management education and support. Diabetes Care 2017, 40, 1409–1419.
17. American Diabetes Association 4. Lifestyle Management: Standards of medical care in diabetes—2018 Diabetes Care 2018, 41, S38–S50.
18. Bergenstal, R.M.; Layne, J.E.; Zisser, H.; Gabbay, R.A.; Barleen, N.A.; Lee, A.A.; Majithia, A.R.; Parkin, C.G.; Dixon, R.F. Remote application and use of real-time continuous glucose monitoring by adults with type 2 diabetes in a virtual diabetes clinic. Diabetes Technol. Ther. 2021, 23, 128–132.
19. Triberti, S.; Bigi, S.; Rossi, M.G.; Caretto, A.; Laurenzi, A.; Dozio, N.; Scavini, M.; Pergolizzi, E.; Ozzello, A.; Serino, S.; et al. The activeageing mobile app for diabetes self-management: First adherence data and analysis of patients' in-app notes. Lect. Notes Inst. Comput. Sci. Soc. Inform. Telecommun. Eng. 2018, 253, 129–138.
20. Martínez-Pérez, B.; De la Torre-Díez, I.; López-Coronado, M. Mobile health applications for the most prevalent conditions by the world health organization: Review and analysis. J. Med. Internet Res. 2013, 15, e120.
21. Årsand, E.; Frøisland, D.H.; Skrøvseth, S.O.; Chomutare, T.; Tatara, N.; Hartvigsen, G.; Tufano, J.T. Mobile health applications to assist patients with diabetes: Lessons learned and design implications. J. Diabetes Sci. Technol. 2012, 6, 1197–1206.
22. Bovbjerg, M.L.; Lee, J.; Wolff, R.; Bangs, B.; May, M.A. Pilot study for managing complex chronic care medicaid patients with diabetes using a mobile health application achieves "triple aim" improvement in a primary care setting. Clin. Diabetes 2017, 35, 227–231.
23. Whitehead, L.; Seaton, P. The effectiveness of self-management mobile phone and tablet apps in long-term condition management: A systematic review. J. Med. Internet Res. 2016, 18, e97.
24. Chomutare, T.; Fernandez-Luque, L.; Årsand, E.; Hartvigsen, G. Features of mobile diabetes applications: Review of the literature and analysis of current applications compared against evidence-based guidelines. J. Med. Internet Res. 2011, 13, e65.
25. Goyal, S.; Nunn, C.A.; Rotondi, M.; Couperthwaite, A.B.; Reiser, S.; Simone, A.; Katzman, D.K.; Cafazzo, J.A.; Palmert, M.R. A mobile app for the self-management of type 1 diabetes among adolescents: A randomized controlled trial. JMIR Mhealth Uhealth 2017, 5, e82.
26. Lee, K.; Kwon, H.; Lee, B.; Lee, G.; Lee, J.H.; Park, Y.R.; Shin, S.-Y. Effect of self-monitoring on long-term patient Engagement with mobile health applications. PLoS ONE 2018, 13, e0201166.
27. Rossi, M.G.; Bigi, S. mHealth for diabetes support: A systematic review of apps available on the italian market. Mhealth 2017, 3, 16.
28. Mercer, K.; Li, M.; Giangregorio, L.; Burns, C.; Grindrod, K. Behavior change techniques present in wearable activity trackers: A critical analysis. JMIR Mhealth Uhealth 2016, 4, e40.
29. Arnhold, M.; Quade, M.; Kirch, W. Mobile applications for diabetics: A systematic review and expert-based usability evaluation considering the special requirements of diabetes patients age 50 years or older. J. Med. Internet Res. 2014, 16, e104.
30. Priesterroth, L.; Grammes, J.; Holtz, K.; Reinwarth, A.; Kubiak, T. Gamification and behavior change techniques in diabetes self-management apps. J. Diabetes Sci. Technol. 2019, 13, 954–958.

31. Hoppe, C.D.; Cade, J.E.; Carter, M. An evaluation of diabetes targeted apps for android smartphone in relation to behaviour change techniques. J. Hum. Nutr. Diet. 2017, 30, 326–338.
32. Silva, B.M.C.; Rodrigues, J.J.P.C.; De la Torre Díez, I.; López-Coronado, M.; Saleem, K. Mobile-health: A review of current state in 2015. J. Biomed. Inform. 2015, 56, 265–272.
33. Kim, B.Y.; Lee, J. Smart devices for older adults managing chronic disease: A scoping review. JMIR Mhealth Uhealth 2017, 5, e69.
34. Fredrix, M.; McSharry, J.; Flannery, C.; Dinneen, S.; Byrne, M. Goal-setting in diabetes self-management: A systematic review and meta-analysis examining content and effectiveness of goal-setting interventions. Psychol. Health 2018, 33, 955–977.
35. O'Brien, N.; McDonald, S.; Araújo-Soares, V.; Lara, J.; Errington, L.; Godfrey, A.; Meyer, T.D.; Rochester, L.; Mathers, J.C.; White, M.; et al. The features of interventions associated with long-term effectiveness of physical activity interventions in adults aged 55-70 years: A systematic review and meta-analysis. Health Psychol. Rev. 2015, 9, 417–433.
36. Castellano-Tejedor, C.; Moreno, J.; Knittle, K.; Nurmi, J.; Ginchev, T.; Parramón, G.; Ciudin, A.; Ramos-Quiroga, J.A.; Lusilla-Palacios, P. Assessing the user experience and usability of the PRECIOUS system: A randomized controlled trial in obese patients. Inform. Health Soc. Care 2020, 45, 410–427.
