EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 9
Issue: 6
430-436
Year: 2022

ROLE OF ARTIFICIAL INTELLIGENCE IN MANAGEMENT OF DIABETES

Tanya Chandna[1], Vikram Singh[2] and Girija Kumari[1]*

[1]Department of Clinical Research, Amity Medical School, Amity University Haryana, Amity Education Valley Gurugram, Panchgaon, Manesar-122413, Haryana, India.
[2]Department of Medical Laboratory Technology, Amity Medical School, Amity University Haryana, Amity Education Valley Gurugram, Panchgaon, Manesar-122413, Haryana, India.

***Corresponding Author: Dr. Girija Kumari**
Department of Clinical Research, Amity Medical School, Amity University Haryana, Amity Education Valley Gurugram, Panchgaon, Manesar-122413, Haryana, India.

Article Received on 20/04/2022 **Article Revised on 11/05/2022** **Article Accepted on 01/06/2022**

ABSTRACT
Diabetes is a chronic condition in which body is not able to make enough insulin to keep blood sugar levels steady. Diabetes and its complications are the seventh leading cause of death in today's world. Approximately 537 million adults between the age group of 20-79 years are suffering from diabetes. It is estimated that 643 million people will be suffering from diabetes by 2030 and 783 million by 2045. 6.7 million deaths are caused due to diabetes. Artificial intelligence (AI) could be a fast-growing field and its applications to diabetes, a worldwide pandemic, can reform the approach to diagnosis and management of this chronic condition. Principles of machine learning are accustomed build algorithms to support predictive models for the chance of developing diabetes or its consequent complications. AI is transforming all spheres of life. Patient's symptoms and biomarkers can be continuously monitored in a hassle free manner with advent of AI. Artificial intelligence is a booming and upcoming field and its use in the field of diabetes. Artificial intelligence methods with blend of technical advancements have a power to enable diagnosis and delivery of better management facilities and care delivery systems to deal with chronic diseases like Diabetes. AI has a potential to bring about a paradigm shift in diabetes care from conventional management strategies to obtaining targeted data-driven precision care.

KEYWORDS: Artificial intelligence, Diabetes, virtual system, management system, chronic, genomics.

INTRODUCTION
Diabetes is a long-term chronic illness. According to recently released data from the International Diabetes Federation, the number of people suffering from diabetes worldwide has reached 451 million.[1] After long-term rapid economic growth and lifestyle changes, China is now facing many problems, including aging demographics, urbanization, and the world's largest number of diabetics (approximately 114.4 million).[2]

Diabetes, characterized by insidious onset, numerous complications, and high mortality and disability, imposes immense burden on individuals and society. Therefore, diabetes prevention and management is very important and diabetes education is an integral part. In recent years, more and more AI-based tools for diabetic health have been developed.[3] Patients are supported by more flexible and scientific access to skills and knowledge on various aspects of diabetes self-management, including diabetes prevention, lifestyle and nutrition advice, exercise, insulin injections, and complication monitoring. This white paper describes these advances.[4]

Artificial intelligence (AI) is a broad term defined as the theory and development of virtual systems that can leverage human intelligence such as vision, speech recognition, decision making, and interlingual translation to perform normal tasks.[5] AI is "a field of computer science whose motive is to create a system or method for examining information and permits you to handle a wide range of complex application."[6]

It is possible to apply AI to diabetes. It is desirable for developing tools and devices for efficient data processing and management .Moreover, it offers Safer technology as it has Safe structure, security reserve, procedural guarantee and all uncertainties identified for all potential technologies Systems.[7] The technical progress has given birth to smart phones, wearables and other gadgets which help in continuous tracking and evaluation of patients symptoms and disease status. AI-assisted care should be chosen by patients for successful management of diabetes.[8]

AI can have an impact on and enhance three fundamental spheres of diabetes care: diabetic patients, health care professionals, and health care systems (Figure1). AI has introduced newer dimensions of self-take care of diabetic patients, introduced fast and dependable choice making and flexible follow-ups for health care providers, and optimized resource utilization in health care systems. The US Food and Drug Administration has accredited IDx-DR, a device that makes use of an AI algorithm, to analyze virtual retinal photos and aids the early detection of retinopathy.[9]

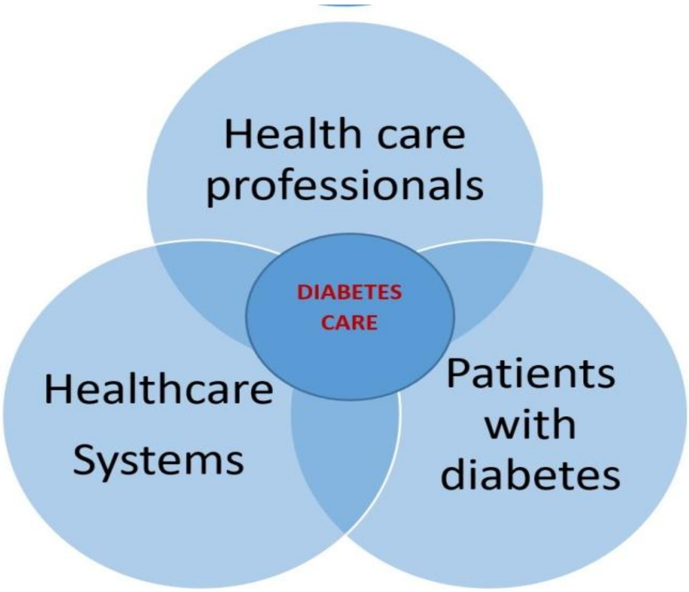

Fig. 1 scope of artificial Intelligence in diabetes Care

The American Diabetes Association (ADA) is assisting the operation of AI in diabetes care. The ADA has acknowledged the use of AI for the diagnosis of diabetic retinopathy and macular edema.[10] AI has enhanced patient influx and patient transfer in the hospital.[11] AI is an umbrella term described as theory and development of virtual systems which are able to take up various tasks like visual perception, speech recognition, decision-making, and translation between languages.[12] It can be rule-based or driven by complex statistical methods.

Artificial intelligence (AI) further has a subdivision called machine learning that provides systems the ability to automatically learn and improve from experience without being explicitly programed.[12,13]

On the basis of genomic data, AI can be used to anticipate the risk of diabetes, detection of diabetes based on EHR Data and anticipate the possibility of complications such as nephropathy and retinopathy. (Table 1)[14]

SNO	AREA	DESCRIPTION
1.	Predicting Diabetes	ML algorithms have been used to discover valuable knowledge from large database for development of risk models of diabetes determine the occurrence of diabetes.
2.	Determining Complications	Complications like neuropathy, nephropathy and retinopathy can be determined using baseline clinical and biochemical data.
3.	Diabetes Management	It is based on Learning algorithms. Information on diet ,exercise ,pharmaceutical use and blood sugar levels is recorded.
4.	Insulin Dose recommendation	CBR is used to calculate individualized insulin dose thereby achieving optimum glucose levels in patients and optimizing insulin treatment.
5.	Hypoglycemia Detection	ES are the desired systems with the ability to capture expert knowledge and facts. Prediction of hypoglycemia can be based on CGM Data. This approach is in commercial use.

Machine learning is being used to create automated screening of variability in blood glucose levels.[15]In India, the prevalence of diabetes is estimated around 8-10% with number of cases being more in urban areas than in rural areas. Thus use of AI would be more beneficial.[16]

However, in CARRS study, prevalence of diabetes in Delhi has been estimated at ~27% and it has been recorded that 46% or more population has prediabetes.[17] Similar estimation has been made about other three metropolitan cities.[17] In another study, the highest incidence of diabetes in age group of 30–34 years were reported.[18] Such a vast and immense occurrence of diabetes creates enormous worries for healthcare system. This huge gap can be removed by utilization of AI in diabetes treatment and management. Another difficulty witnessed by us in Uniformity in care or minimum care standards. Primary health care physicians handle large number of cases and due to lack of any inspection of these practices, average HbA1c of people with diabetes in India stays around 9%.[19]

Applications

Automated retinal screening

For the diagnosis of diabetic retinopathy, deep learning algorithms have been developed. AI-based retinal screening is a viable, authentic, and well-accepted method for the detection and monitoring of diabetic retinopathy.[20] For automated retinal screening, a high sensitivity and specificity of 92.3% and 93.7%, respectively have been noted. Patient satisfactory rate is also high with 96% patients being satisfied or very satisfied with automated screening.[21]

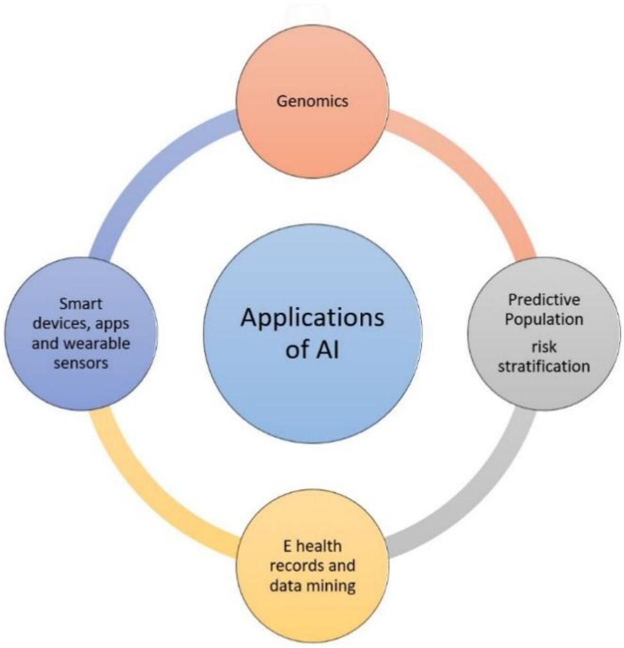

Figure2 shows applications of Artificial Intelligence in diabetes care

Clinical decision support

Clinical decision support tools have been developed based on supervised machine learning to anticipate short- and long-term HbA1c response after insulin initiation in patients with type 2 diabetes mellitus. These tools also help to identification of clinical variables that impact patient's HbA1c response. The elastic net regularization-based generalized linear model supported baseline HbA1c and estimated glomerular filtration rate is reported to reliable to predict the HbA1c response after insulin initiation. Areas under the curve (AUC) of 0.80 (95% confidence interval [CI] 0.78−0.83) and 0.81 (95% CI 0.79−0.84), respectively, are reported for brief and future HbA1c response.[22] An intuitive approach for personalization of interventions in medication adherence and prediction of risk of hospitalization in diabetes has been fulfilled using machine learning. In an exceedingly retrospective cohort study (n = 33,130), machine learning yielded adherence thresholds of 46% to 94% as most discriminating for risk of all-cause hospitalization. This study confirmed the variability of predictive adherence thresholds in line with patient characteristics and complexity of medicines.[23]

Predictive population risk stratification

Machine learning helped the Healthcare recommendation system (HRS) to estimate the risk for a disease, including diabetes, by examining physical health factors, patient's lifestyle, mental health factors, and their social network activities. Data from 68,994 healthy people and diabetic patients have been used as a training data set for applying decision tree, random forest, and neural networks to predict diabetes with high accuracy (accuracy = 0.8084 with all attributes).[24] Predictive models have been built to support big data analytics for building estimates of possibility of occurrence of complications in patients with diabetes. Many such models have been developed to predict the onset of both long-term (retinal, cardiovascular, and renal) and short-term (i.e., hypoglycemia) complications of diabetes.[25] Many mobile apps have been introduced to follow-up with diabetic patients for development of diabetic foot ulcers and apps have been upskilled to interpret the images of feet.[26] Development of decision tree models for prediction of development of type 2 diabetes mellitus in pregnant women with gestational diabetes has been fulfilled by machine learning. The discriminative power of this prediction method was 83.0% in the training set and 76.9% in an independent testing set, stating it to be superior to the conventional monitoring of fasting glucose levels.[27]

Genomics

New advancements like Advanced molecular phenotyping, genomics, epigenetic alterations, and development of digital biomarkers have been made for the diagnosis and management of disease conditions.[28] These can be applied to diabetes[having a heterogeneous nature and chronic course] so huge data sets are generated. A repository of microbial marker genes have been built using microbiome data which can be used to predict the possibility of development of diabetes and assist in the treatment of patients with confirmed diabetes.[29] More than 400 signals have been recognized by Genome-wide association that could potentially signify the genetic susceptibility to diabetes. [30]Training of Convolutional neural networks models on multiple genome wide mapping and regulatory epigenomic annotations is made available for pancreatic islets to forecast regulatory variants for refining the signals associated with diabetes.[31]

Patient self-management tools

Self-management leads to good outcomes in the treatment of diabetes. With the emergence of AI, patients are empowered to manage their own diabetes, generate data for their own parameters, and be their own experts for health.

Increased awareness

Digital platforms permit the education of patients with diabetes. Awareness and knowledge about eating habits and activity patterns are now accessible through web-based programs and mobile and smartphone apps.[32] This has been particularly beneficial for the management of diabetes in pregnant women. A web-based intervention was reported to extend the knowledge of gestational diabetes and proved to be a decent adjunct to the management of diabetes in 21 women.[33]

Self-treatment

AI allows diabetic patients to take daily decisions regarding the diet and activity. Apps have been developed which allow patients to assess the quality and calorie value of food intake. Patients have the feature to capture a picture of their own food and assess what they eat which strengthens the accountability for diabetes care.[34]

Digital therapeutics has been assessed in the management of diabetes. To manage diabetes, a digital intervention was introduced to demonstrate the effects, an example for the same is further explained. Farewell, a digital application, incorporating artificial human assistance was assigned as the intervention for the study. 118 adult individuals were enrolled. The inclusion criteria for the study was that the patients must present with type II diabetes mellitus. The details for the intervention are as follows- The application provided support in the form of watching after every 14 days through phone. The main focus of this intervention was to counsel the patients to adopt using plant based items in their daily diet along with consistent physical Activity. The variable to be checked was the value of HbA1C. Prior to the intervention, all the patients are presented with more than 6.5% of HbA1C. When assessed after the study reports, about 30% of the subjects reflected that the value of HbA1C lies below 6.5%. After the third month, more than 80% of the individuals continued using the digital application and more than 55% of the subjects reflected significant reduction in HbA1C, minimizing the administration of oral hypoglycemics or both. The subject constructively welcomed the app and more than 90% of them showed trust in modulating the diabetes as compare to the times before they were enrolled in the study.[35]

The One Drop Mobile app was created to set medication reminders, view statistics, set goals, track health outcomes, and get data-driven insights in patients with type 1 and type 2 diabetes. 1.07% to 1.27% absolute reduction in HbA1c during a median 4 months of using the app was reported by total of 1288 patients. The use of One Drop Mobile app for tracking self-care was associated with improved HbA1c in patients with diabetes.[36]

Other applications

The management of diabetes has been transformed by apps like Tele health. Digital follow ups with patient have reduced the time spent in in person OPD visits and allows to keep track off more real time monitoring of glycemic status and overall health of patients. In fact AI can replace 50% to 70% of routine clinical consultation visits with virtual engagements and remote monitoring .[37] SMS Messaging is being tested in randomized controlled trial in over 800 diabetic patients living in Sub Saharan Africa for improvement in medical adherence.[38]

Other devices

Diet and exercise are the early and powerful approaches to prevent type 2 diabetes mellitus in high-risk individuals. [39] Customized diets and alterations in food intake to suit an individual's lifestyle are provided by various apps. Wearables are used to track the Daily activity levels, record step counts and time and intensity of other activities.[40] Wearable devices are effective facilitators of changes in behavior toward health.[41] These devices enable tracking of daily activity and can motivate an individual to include a targeted activity into routine to prevent chronic diseases, including type 2 diabetes mellitus. Several apps are also designed to examine the images of food and provide details of the nutrient and calorie value of food. These apps can help to keep a check on body weight and prevent obesity, an established precursor to type 2 diabetes mellitus.[40] Web-based programs provide information about diet and physical activity and patients can log in their daily intake and activity data and acquire continuous feedback.[32]

End Users

Health care professionals in clinics and hospitals, diabetes management centers, and scientific research institutes are the end users of technical advances in diabetes care. Compatible and homogenous data capture and increased access to data is granted by EHR. EHRs are being utilized as data repositories to train and develop algorithms for the prediction, detection, and management of diabetes.[42] Patients represent a remarkable end user of AI-based advances for the management of diabetes and have supported technical advances with avidity. The management of diabetes has been made convenient by technical advances and enabled patients to effectively operate and execute the required management strategies. The use of mobile apps have enabled patients to keep a check on glycemic index which in turn helps in the management of type 2 diabetes mellitus. In a systematic review of 14 studies (n = 1360), It was found that there was a mean reduction in HbA1c of 0.49% (95% Cl 0.30, 0.68; I2 = 10%) with the use of digital apps when compared with controls.[43] In another recent meta-analysis of 21 studies (n = 1550), mean HbA1c reductions were found to be 0.49% (95% CI, 0.04-0.94; I2 = 84%) and 0.57% (95% CI, 0.32-0.82; I 2 = 77%) for type 1 and type 2 diabetes, respectively.[44]

Exactness dosing in Diabetes- With the help of Smart phone apps, patients can now get reminders for their scheduled medicines, so that taking medicines doesn't escape their mind.[45]

Limitations of Artificial Intelligence

Cons of application of AI in diabetes care are-

Human factors

Analysis of Factors influencing the implementation of AI in diabetes care have been done in some studies like in a meta-analysis of 14 randomized control trials, it was revealed that younger patients procured greater advantages from mobile apps for diabetes care and the effect size was enhanced with constructive feedbacks by health care profession=nals.[43] AI can pose a danger of deskilling physicians by introducing dependence. This might lead to a vicious cycle of inaccuracy because AI in itself requires timely refinements by experts.[8]

Technical factors:

Price, access, and implementation are main hurdles in application of AI in diabetes. With a growing range of devices and apps, interoperability has come out to be a common potential barrier in diabetes management.[37]

Limitations of data

Developing logical and accurate algorithms with shortage of supporting data is a common challenge in diabetes care. Data sets should be more mature and organized so that digital applications can create more impactful solutions. Issues regarding the safety, data protection and regulatory concerns are also restraining the seamless adoption of technology in diabetes care.

Limitations of design

Use of retrospective data sets has been made for validation of current models and applications of AI in diabetes in care. The digital biomarkers, data from apps and activity trackers should be included, so end points should be redefined.

CONCLUSION

AI is fascinating the digital industry for its use in diagnosis and treatment of diseases like diabetes. With technical advancement and the development of mobile based apps, patients have been able to add an aspect of personal care in the management of diabetes. Patients are being entitled to manage their health through technical platforms. AI based methods are being established for being employed in daily clinical practices for management of diabetes. These advances have saved the time and cost by reducing the routine follow-up visits to clinic and collecting data through online platforms. These methods are dynamic tools for improvising the quality of life of people. The subtle conclusion drawn out from this paper is that there is more need of research in fields such as the implementation of AI in all age groups, interoperability, and data safety of remotely collected data. AI has brought about a known change in the field of disease management and care and is continuously evolving

REFERENCES

1. Cho NH, Shaw JE, Karuranga S, Huang Y, Da Rocha Fernandes JD, Ohlrogge AW, et al. IDF diabetes atlas: global estimates of diabetes prevalence for 2017 and projections for 2045. Diabetes Res Clin Pract, 2018; 138: 271–81.
2. Xu Y, Wang L, He J, Bi Y, Li M, Wang T, et al. Prevalence and control of diabetes in Chinese adults. JAMA, 2013; 310: 948–59.
3. Contreras I, Vehi J. Artificial intelligence for diabetes management and decision support: literature review. J Med Internet Res, 2018; 20: e10775.
4. Russell SJ, Norvig P. Artificial Intelligence: A Modern Approach; Pearson Education Limited: 2016.
5. Definition of artificial intelligence in English by Oxford Dictionaries, https://en.oxforddictionaries.com/definition/artificial_intelligence
6. Contreras I, Vehi J. Artificial intelligence for diabetes management

7. and decision support: literature review. J Med Internet Res, 2018; 20(5): e10775.
8. Ellahham S, Ellahham N, Simsekler MCE. Application of artificial intelligence in the health care safety context: opportunities and challenges. Am J Med Qual, 2019; 35(4): 341-348.
9. Buch V, Varughese G, Maruthappu M. Artificial intelligence in diabetes care. Diabet Med, 2018; 35: 495–7.
10. FDA permits marketing of artificial intelligence-based device to detect certain diabetes-related eye problems. https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm604357.htm.
11. Microvascular complications and foot care: standards of medical care in diabetes. Diabetes Care, 2020; 43(1): S135–51.
12. Ellahham S, Ellahham N. Use of artificial intelligence for improving patient flow and healthcare. J Comput Sci Syst Biol, 2019; 12(3): 1–6.
13. Definition of artificial intelligence in English by Oxford Dictionaries, https://en.oxforddictionaries.com/definition/artificial_intelligence .
14. What is Machine Learning? A definition – Expert System, https://www.expertsystem.com/machine-learning-definition/
15. Kavakiotis I, Tsave O, Salifoglou A, Maglaveras N, Vlahavas I, Chouvarda I. Machine learning and data mining methods in diabetes research. Comput Struct Biotechnol J, 2017; 15: 104–16.
16. Marling C, Wiley M, Bunescu R, Shubrook J, Schwartz F. Emerging applications for intelligent diabetes management. AI Mag, 2012; 33(2): 67.
17. IDF SEA Members, https://www.idf.org/our-network/regions-members/south-east-asia/members/94-india.html.
18. Deepa M, Grace M, Binukumar B, Pradeepa R, Roopa S, Khan HM, et al. High burden of prediabetes and diabetes in three large cities in South Asia: The center for cardio-metabolic risk reduction in South Asia (CARRS) study. Diabetes Res Clin Pract, 2015; 110:172–82.
19. Singla R, Garg A, Singla S, Gupta Y. Temporal change in profile of association between diabetes, obesity, and age of onset in Urban India: A brief report and review of literature. Indian J Endocrinol Metab, 2018; 22: 429–32.
20. Mohan V, Shah SN, Joshi SR, Seshiah V, Sahay BK, Banerjee S, et al. Current status of management, control, complications and psychosocial aspects of patients with diabetes in India. Indian J Endocrinol Metab, 2014; 18: 370–8.
21. Grzybowski A, Brona P, Lim G, et al. Artificial intelligence for diabetic retinopathy screening: a review. Eye (Lond), 2020; 34(3): 451–60.
22. Keel S, Lee PY, Scheetz J, et al. Feasibility and patient acceptability of a novel artificial intelligence-based screening model for diabetic retinopathy at endocrinology outpatient services: a pilot study. Sci Rep, 2018; 8: 4330.
23. Nagaraj SB, Sidorenkov G, van Boven JFM, Denig P. Predicting short- and long-term glycated haemoglobin response after insulin initiation in patients with type 2 diabetes mellitus using machine-learning algorithms. Diabetes Obes Metab, 2019; 21(12): 2704–11.
24. Lo-Ciganic WH, Donohue JM, Thorpe JM, et al. Using machine learning to examine medication adherence thresholds and risk of hospitalization. Med Care, 2015; 53: 720–8.
25. Zou Q, Qu K, Luo Y, Yin D, Ju Y, Tang H. Predicting diabetes mellitus with machine learning techniques. Front Genet, 2018; 9: 515.
26. Cichosz SL, Johansen MD, Hejlesen O. Toward big data analytics: review of predictive models in management of diabetes and its complications. J Diabetes Sci Technol, 2016; 10(1): 27–34.
27. Yap MH, Chatwin KE, Ng CC, et al. A new mobile application for standardizing diabetic foot images. J Diabetes Sci Technol, 2018; 12: 169–73.
28. Allalou A, Nalla A, Prentice KJ, et al. A predictive metabolic signature for the transition from gestational diabetes mellitus to type 2 diabetes. Diabetes, 2016; 65(9): 2529–39.
29. Seyhan AA, Carini C. Are innovation and new technologies in precision medicine paving a new era in patients centric care? J Transl Med, 2019; 17(1):114.
30. Han W, Ye Y. A repository of microbial marker genes related to human health and diseases for host phenotype prediction using microbiome data. Pac Symp Biocomput, 2019; 24: 236–47.
31. Mahajan A, Taliun D, Thurner M, et al. Fine-mapping type 2 diabetes loci to single-variant resolution using high-density imputation and islet-specific epigenome maps. Nature Genetics, 2018; 50: 1505–13.
32. Wesolowska-Andersen A, Zhuo Yu G, Nylander V, et al. Deep learning models predict regulatory variants in pancreatic islets and refine type 2 diabetes association signals. Elife, 2020; 9: e51503.
33. Rollo ME, Aguiar EJ, Williams RL, et al. eHealth technologies to support nutrition and physical activity behaviors in diabetes self-management. Diabetes Metab Syndr Obes, 2016; 9: 381–90.
34. Carolan-Olah M, Steele C, Krenzin G. Development and initial testing of a GDM information website for multi-ethnic women with GDM. BMC Pregnancy Childbirth, 2015; 15: 145.
35. Frøisland DH, Arsand E. Integrating visual dietary documentation in mobile-phone-based self-management application for adolescents with type 1 diabetes. J Diabetes Sci Technol, 2015; 9(3): 541–8.
36. Berman MA, Guthrie NL, Edwards KL, et al. Change in glycemic control with use of a digital therapeutic in adults with type 2 diabetes: cohort study. JMIR Diabetes, 2018; 3(1): e4.

37. Osborn CY, van Ginkel JR, Rodbard D, et al. One drop | mobile: an evaluation of hemoglobin a1c improvement linked to app engagement. JMIR Diabetes, 2017; 2(2): e21.
38. Fagherazzi G, Ravaud P. Digital diabetes: perspectives for diabetes prevention, management and research. Diabetes Metab, 2019; 45 (4): 322–9.
39. Cafazzo JA, Casselman M, Hamming N, Katzman DK, Palmert MR. Design of an mHealth app for the self-management of adolescent type 1 diabetes: a pilot study. J Med Internet Res, 2012; 14(3): e70.
40. Zheng Y, Ley S, Hu F. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. Nat Rev Endocrinol, 2018; 14: 88–98.
41. Shah VN, Garg SK. Managing diabetes in the digital age. Clin Diabetes Endocrinol, 2015; 1:16.
42. Patel MS, Asch DA, Volpp KG. Wearable devices as facilitators, not drivers, of health behavior change. JAMA, 2015; 313(5): 459–60.
43. Singla R, Singla A, Gupta Y, Kalra S. Artificial intelligence/machine learning in diabetes care. Indian J Endocr Metab, 2019; 23: 495–7.
44. Hou C, Carter B, Hewitt J, Francisa T, Mayor S. Do Mobile Phone Applications Improve Glycemic Control (HbA1c) in the Self-management of Diabetes? A systematic review, meta-analysis, and GRADE of 14 randomized trials. Diabetes Care, 2016; 39(11): 2089–95.
45. Hou C, Xu Q, Diao S, Hewitt J, Li J, Carter B. Mobile phone applications and self-management of diabetes: A systematic review with meta-analysis, meta-regression of 21 randomized trials and GRADE. Diabetes Obes Metab, 2018; 20(8): 2009–13.