Perspective

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Application and prospect of artificial intelligence in diabetes care

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Abstract: Diabetes is one of the fastest-growing non-communicable diseases, becoming an important public health concern worldwide as well as in China. Currently, China has the largest population living with diabetes. Artificial intelligence (AI) is a fast-growing field and its applications to diabetes could enable the delivery of better management services for people with diabetes. This perspective summarized the latest findings of digital technologies and AI use in the following areas of diabetes care, mainly including screening and risk predictions of diabetes and diabetic complications, precise monitoring and intervention combined with new technologies, and mobile health application in self-management support for people with diabetes. Challenges to promote further use of AI in diabetes care included data standardization and integration, performance of AI-based medical devices, motivation of patients, and sensitivity to privacy. In summary, although the AI applications in clinical practice is still at an early stage, we are moving toward a new paradigm for diabetes care with the rapid development and emerging application of AI.

Keywords: diabetes care; digital health; mobile health; self-management support.

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Introduction

Diabetes is one of the fastest-growing non-communicable diseases, becoming an important public health concern worldwide as well as in China. China has the largest population living with diabetes, with the latest prevalence of 11.9% in 2018 [1]. Diabetes is associated with many complications. As suggested by a cross-sectional study including over 173 thousand people with diabetes from China, around half of patients had one or more microvascular and macrovascular complications respectively, while the proportion achieving the composite targets of glycemia, blood pressure and lipids was suboptimal [2]. These findings indicated strong needs for more effective and available tools to enhance diabetes care, especially in primary healthcare. Artificial intelligence (AI) is a fast-growing field and its applications to diabetes could enable the delivery of better management services for people with diabetes.

Screening and risk predictions

Deep-learning approaches might facilitate regular screenings for early detection and prediction of diabetes, especially in resource-limited or remote areas. Based on fundus images alone or in combination with clinical metadata, Zhang et al. developed deep-learning models to identify type 2 diabetes (T2D) with areas under the receiver operating characteristic curve of 0.923 and 0.929 [3]. Through further evaluation on the external test set using smartphone camera-captured images and based on fundus image features from a longitudinal test set, this study potentially provided a non-invasive, high-throughput and low-cost screening tool for early detection of T2D and proved the feasibility of predicting T2D progression through AI. The deployment of a smartphone-based AI fundus detection system could increase access of diabetes screening in primary healthcare.

In terms of diabetic complications screening, deep learning algorithms have been developed to automate the diagnosis of diabetic retinopathy (DR). The AI-based screening of retina has been reported to achieve robust performance in detecting DR [4]. The first AI-based system for screening DR, IDx-DR system, was approved by Food and Drug Administration (FDA) in 2018 [5]. We, at the Shanghai Diabetes Institute, also developed an automated and interpretable system, DeepDR, that was based on a total of 209,322 fundus images and performed real-time image quality feedback, retinal lesion detection, and early- to late-stage DR grading [6]. The DeepDR system could facilitate the screening of DR at the community level, which can detect mild retinopathy and realize early detection and timely intervention. Besides, with the advance of optical coherence tomography (OCT), its angiography have many advantages over fundus photographs. A deep-learning-aided DR classification system based on OCT angiography could provide specialist-level DR classification using only a single imaging modality, which could accurately classify DR while avoiding low diabetic macular edema detection sensitivities and misdiagnoses [7]. It could provide reliable classification of referable and vision threatening DR. Other AI studies have been conducted in prediction and monitoring of diabetic kidney disease and macro-vascular complications such as myocardial infarction and heart failure [8]. Makino et al. [9] constructed a predictive model for diabetic kidney diseases using big data machine learning based on 64,059 patients with diabetes. This AI predictive model could detect progression of diabetic kidney diseases with promising performance and may contribute to more effective and accurate intervention to reduce hemodialysis. The DIABETe project has been developed to predict the risk of decompensation of diabetes and its cardiovascular complications via a telemonitoring platform [8]. Via these approaches, targeted screening and risk prediction could potentially help to deliver stratified interventions to those most likely to develop diabetic complications.

Precise monitoring and intervention

Digital technologies could substantially improve the monitoring and intervention for complex conditions in diabetes care, due to the development of new technologies. Artificial pancreas (AP) treatment, also referred to as closed loop glucose control, is an emerging approach for treating outpatients with type 1 diabetes. Automated algorithms used by the AP to calculate insulin dosage have been intensively investigated, to realize the personalized needs of glucose control [10]. In China, we developed a mobile health (mHealth)-based project named Road to Hierarchical Diabetes Management at Primary Care Settings (ROADMAP), covering both urban and rural areas from 25 provinces, to provide a tiered care team-delivered mHealth-mediated service to patients from primary healthcare [11]. The ROADMAP study showed that digital technologies can help people with diabetes to be managed effectively by remote monitoring and promote health equity, especially in rural areas where access to diabetes care may not be easily accessible. During the pandemic of coronavirus disease 2019 (COVID-19), we used intermittently scanned continuous glucose monitoring (isCGM) for remote glucose monitoring during hospitalization, and found that the use of isCGM was significantly associated with better outcomes of COVID-19 with pre-existing diabetes [12]. The isCGM could provide comprehensive information on glycemic fluctuations, and reduce the risks of biological exposures during hospitalization.

Self-management support

Digital technologies and AI facilitate individuals being empowered to manage diabetes on their own. Digital platform and smartphone apps can support self-management in health education, diet, exercise, and glucose monitoring in daily-life. The BlueStar mobile diabetes coach became the first T2D app available on prescription and a non-prescription version was approved by the FDA in 2017 [13]. In a pilot study combining BlueStar with live peer coaching, it showed that the two were complementary, with participants saying they used the app for routine monitoring and information but the live coach for more complicated thoughts or decisions. Average HbA_{1c} declined from 9.93% to 8.86% [14]. In China, a randomized trial with a total of 276 patients with diabetes with poor glycemic control showed that the use of app to support self-management combined with interactive management can help achieve rapid and sustained glycemic control [15]. In addition, an mHealth technology-based diabetes education program has been implemented in patients with T2D initiating premixed insulin, covering 9,426 patients across 250 hospitals in total [16]. It showed that the 12-week program along with the initiation of insulin significantly decreased HbA_{1c} in patients with T2D, while patient engagement with diabetes education was significantly associated with improvement of glucose control [16]. With digital health, diabetes self-management is becoming more comprehensive and simultaneously more patient-centered.

Discussion

For the application of digital health and AI in diabetes care, challenges still exist. To achieve high-quality AI-based medical devices, data standardization and data integration are vital. The participation and motivation of people with diabetes, ethics, and the cost also influence the application of AI. Good performance is the key to promote the use of AI-based medical devices in healthcare settings. A multicenter real-world validation study of seven automated AI-based DR screening systems summarized that although high negative predictive values (82.72%–93.69%) were observed, sensitivities varied widely (50.98%–85.90%) and the DR screening algorithms showed significant performance differences [17]. Besides, a potential barrier to promote widespread adoption of AI is sensitivity to privacy. Future researches are required to address these challenges.

In summary, AI is full of exciting and important prospects for diabetes care. A wide use of AI techniques in both clinical settings and communities is timely to enhance prevention and management of diabetes. Despite the great potential, the clinical implementation of AI applications is still at an early stage. We are moving toward a new paradigm for diabetes care with the emerging application of AI. Prediction, screening, monitoring and early intervention combined with AI will therefore be major factors in reducing the disease burden of diabetes.

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