Brief Communication

Artificial Intelligence/Machine Learning in Diabetes Care

Rajiv Singla, Ankush Singla[1], Yashdeep Gupta[2], Sanjay Kalra[3]

Departments of Endocrinology and [1]Health Informatics, Kalpavriksh Healthcare, Dwarka, [2] Department of Endocrinology, All India Institute of Medical Sciences, Delhi, [3]Department of Endocrinology, BRIDE, Karnal, Haryana, India

Abstract

Artificial intelligence/Machine learning (AI/ML) is transforming all spheres of our life, including the healthcare system. Application of AI/ML has a potential to vastly enhance the reach of diabetes care thereby making it more efficient. The huge burden of diabetes cases in India represents a unique set of problems, and provides us with a unique opportunity in terms of potential availability of data. Harnessing this data using electronic medical records, by all physicians, can put India at the forefront of research in this area. Application of AI/ML would provide insights to our problems as well as may help us to devise tailor-made solutions for the same.

Keywords: Artificial intelligence, diabetes care, machine learning

Artificial intelligence (AI) is a broad term defined as the theory and development of virtual systems which are able to perform tasks normally by utilizing human intelligence such as visual perception, speech recognition, decision-making, and translation between languages.[1] It can be as simple as rule-based or driven by complex statistical methods. Machine learning is a subset of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programed.[1,2] Machine learning can be supervised, unsupervised, semi-supervised, or reinforcement based. Through deep learning machine tries to emulate human intelligence by simulating structure of human brain using recurrent neural networks.

AI/ML tools are being extensively used in all scientific fields and are responsible for revolutionizing businesses throughout the world. Healthcare systems, on the other hand, have been very slow in adopting these advancements and are lagging far behind in this arena.

AI/ML can be useful in the management of chronic diseases, namely, diabetes. In fact, ML/AI is already being used to predict risk of diabetes based on genomic data, diagnosis of diabetes based on EHR data, to predict risk of complications such as nephropathy and retinopathy, and also in diagnosis of diabetic retinopathy [Table 1].[3] There is a paucity of India specific data on all these aspects of AI in the published literature. Google AI research unit in collaboration with few Indian ophthalmology centers has already made great advances in the field of automated diagnosis and grading of diabetic retinopathy based on fundus photographs.[4] Adoption of these technologies can significantly increase detection and early treatment of diabetic complications.[4]

However, one area of diabetes care, that has seen very few attempts, is management strategies for diabetes. In type 1 diabetes we are witnessing the advancement of closed-loop insulin delivery system with inbuilt AI/ML algorithms to predict both hypoglycemic and hyperglycemic excursions.[5] These systems are still in infancy and yet to show an impact on long-term outcomes and quality of life. Treating type 2 diabetes is even more complicated than type 1 diabetes as there are multiple treatment options that are to be added sequentially and incrementally. Moreover, the choice of medication and its dosage also depends on a lot of individual factors such as BMI, underlying beta-cell function, and insulin resistance among others. There are excellent reviews on compiling studies that have used AI/ML approach in diabetes.

Address for correspondence: Dr. Rajiv Singla, Kalpavriksh Clinic, 66, Sector 12A, Dwarka, Delhi - 110 079, India.
E-mail: docrajivsingla@gmail.com

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Type 2 Diabetes Management

AI/ML application would be even more useful in a country like India where the prevalence of diabetes is estimated at 8–10% with a slightly lower burden on rural areas as compared to urban areas.[6] However, in CARRS study, prevalence of diabetes in the city of Delhi has been determined at ~27% and it has been found that 46% or more population has prediabetes.[7] Similar prevalence has been found in three other metropolitan cities.[7] In another study, authors reported the highest incidence of diabetes in age group of 30–34 years.[8] Such an early and extensive occurrence of diabetes would be a huge burden on the healthcare system. Lack of resources, specially trained doctors, are a roadblock for health allover. The application of AI/ML in diabetes can help in plugging this huge gap. Uniformity of care (or minimum standard care) is another issue witnessed in India. As large number of cases are being handled by primary health care physicians and due to lack of any audit of these practices, average HbA1c of people with diabetes in India stays around 9%.[9] This predicts the potentially ever-increasing burden of complications resulting from poor diabetes control and also presents an opportunity to make things better with the help of AI/ML approach.

An excellent effort by a group from the center for chronic disease control (CCDC) and AIIMS, implemented a decision support system on a mobile platform to help primary care physicians in making better choices for selecting diabetes management strategy.[10,11] However, the intervention failed to show any improvement in glycemic control.[12] There can be few explanations for the same. First, there were logistic restrictions that were applicable for this study for example, only two drugs, viz, metformin and sulfonylureas were made available for titration; Second, drugs were only modified based on fasting blood glucose, postmeal blood glucose values, and HbA1c values. Inclusion of factors such as adherence to diet and exercise, compliance to medications might have increased practical utility of the intervention.

Published literature on studies trying to optimize/automate therapy using machine learning algorithms at the patient level, on their routine visit is scant at the global level and is nonexistent at the national level. At the global level, there are few studies from China and western world.[13-15] Studies on type 2 diabetes management strategies have been summarized in Table 2.

A few caveats in these studies need to be noted while planning further research. First, these studies use data generated by multiple practitioners in routine diabetes care. While this may be the best way to get big data for analysis, it would not lead to an improvement in the standards of care. Moreover, at its best, system created from this data would match the outcomes of current practices. Second, due to multiple sources of data, noise level is likely to be very high making it difficult to delineate the most efficient path forward. Third, unless data has records

Table 1: Aspects of diabetes care using AI/ML

Area	Description
Prediction of diabetes	Based on genetic as well as clinical data, algorithms have been used to ascertain risk of occurrence of diabetes. Based on electronic health record data, certain algorithms can alert physicians towards possibility of diagnosis of diabetes being missed
Glycemic control	Largely pertains to artificial pancreas system. A large number of studies using different AI approaches have tried to automate insulin infusion rates based on continuous glucose monitoring (CGM) data and also to suggest insulin bolus dose
Prediction of glycemic events	Prediction of impending hypoglycemia or hyperglycemia can be predicted based on CGM data. This approach is already in commercial use
Prediction of complications	Prediction of risk of retinopathy, nephropathy, neuropathy or cardiovascular event by using baseline clinical and biochemical data
Diagnosis of complications	AI/ML approach is revolutionizing detection of retinopathy in clinics of diabetologists by directly recognizing and classifying stages based on images obtained by fundus cameras

Table 2: Summary of studies using AI/ML in diabetes management

Authors, Year of publication	Institute	Aim	Data Source	AI/ML approach	Result
Jing Mei *et al*.[13] 2017, China	IBM Research China	To provide personalized hypoglycemic medication prediction for diabetic patients	21,796 patients from an EHR repository of a level 2 city in China	Hierarchical recurrent neural network (HRNN)	Successful use of HRNN but no clinical benefits elaborated.
Aileen P. Wright *et al*.[14] 2014, USA	Yale School of Medicine, New Haven, CT, United States	Identifying temporal relation- ships between medications and accurately predicting the next medication likely to be prescribed for a patient	Inpatient claims data from insurance	Constrained Sequential Pattern Discovery using Equivalence classes	Authors were able to predict the medication prescribed for 90.0% of patients when making predictions by drug class, and for 64.1% when making predictions at the generic drug level with three attempts
Adem Karahoca *et al*.[15] 2012. Turkey	Bahçeßsehir University, Turkey	To manage the drug dosage planning process for three anitdiabetes drugs namely Metformin, Gliclazide and Pioglitazones	Data set of T2DM patients were collected from Sinop State Hospital in Turkey. Diabetic data set had 142 diabetes assays from 45 T2DM patients	Indexing High Dimensional Model Representation (HDMR)	Indexing HDMR method worked well in modeling drug dosages

of adherence to lifestyle measures (diet and exercise) and of compliance towards medication, the real-world utility of this AI/ML approach would be limited. Selecting specialist practices with glycemic control better than average would be the first step towards overcoming these problems. Careful prospective data collection by these practices should include records of compliance levels. Using supervised machine learning initially and gradually switching over to unsupervised machine learning would make this data relevant in the real world.

Type 1 Diabetes Management

There is a huge amount of literature on AI/ML approach being used in type 1 diabetes. There are algorithms that have been used to detect composition of food based on images of food thereby helping in carb counting.[16] Prediction of future blood glucose values and anticipating impending hypoglycemic or hyperglycemic event has been the focus of research in numerous publications.[17] Major work is also being done on developing bolus calculators to automate the process of calculating premeal insulin dose prediction.[18]

From the perspective of the applicability of these approaches in India, there are two major lacunae. Firstly, most of this research is carried out among people using the insulin pumps and CGMs. As use of these modalities in India is limited due to economic issues, usability of this research in India is also limited. Secondly, different researchers have focused on individual areas of type 1 diabetes management and there is still no single application/technology available that can solve management of type 1 diabetes including carbohydrate counting, calculating insulin-carbohydrate ratios, and also predicting insulin dose for each meal for each patient, especially on multiple subcutaneous daily injections.

Limitations and the way forward

AI/ML is as good as the data used to generate this intelligence. Our country is sometimes called as "country with no records", however, this may not be exactly true but it does underline the general scenario of lack of record-keeping as an essential part of medical practice in India. A huge burden of disease can be transformed into an opportunity, if entire data is harnessed in a usable form and AI/ML is used to generate insights and solutions specific to our population. A concerted and collective effort is needed by the government and large associations, like, endocrine society of India to initiate data collections and research.

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Conflicts of interest

There are no conflicts of interest.

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