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Artificial Intelligence for Predicting and Diagnosing Complications of Diabetes

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ABSTRACT
Artificial intelligence can build models with the ability to diagnose diabetes and its consequences medically by using data from the actual world. This commentary article's goals are to give a broad overview and highlight current developments on the use of artificial intelligence to enhance the identification and prognosis of six major diabetic complications, such as (1) gestational diabetes, (2) hospitalized hypoglycemia,(3) diabetic retinopathy, (4) diabetic foot ulcers,(5) diabetic peripheral neuropathy and (6) diabetic kidney disease.

Keywords
1. Diabetes,
2. Complications,
3. Artificial intelligence,
4. Machine learning algorithm,
5. Risk factors,
6. Prediction

I. INTRODUCTION

A significant amount of data is produced by the treatment of diabetics from gadgets, mobile apps, medical interactions, and diagnostic research. With the proliferation of these technologies and their increasing accessibility to patients and providers, interest in utilizing sophisticated.The application of analytics and data science techniques to generated data has grown. Usingsynthetic Over the past 15 years, there has been an exponential growth in intelligence (AI). The word "intelligent" is a general phrase that covers a range of methods that allow computers torepresent human intellect and encompass a number of subdomains (such as deep learning andmachine learning). learning) and methods (such random forests and logistic regressions). A form of artificial intelligence called machine learning (ML) focuses on algorithms that become better with time, whereas deep learning (DL) is a subset of ML that employs artificialneural networks and big data sets to handle computationally difficult issues, Depending on the model's final objective, various different ML algorithm types, including reinforcement learning, semi-supervised learning, and supervised learning, as well as unsupervised learning, can be applied to get the best results for the particular endeavor.Throughout the healthcare continuum, there are numerous opportunities to apply AI to enhance or improve the treatment provided to people with diabetes. Researchers worldwide are finding novel approaches to screening, prediction, diagnosis, treatment, and comorbidity management.AI uses in the field of diabetes.The application of AI could enhance screening and diagnostics, deliver more focused, earlier treatments, anticipate issues, lower morbidity, andmortality, enhance life quality, and lower medical expenses . Recently, Reyna et al. made thefollowing six recommendations for creators and consumers of AI-powered algorithms: Diabetes and its associated consequences are the conditions for which endocrinologists treat The greatest amount of data supports the application of AI technologies in disease prediction, detection, and evaluation of risk. Here, we give a summary and introduction to the six main areas of diabetes and the application of AI. We identified six prevalent and severe diabetes complications that contribute to substantial morbidity, mortality, and expenses: (1) gestational diabetes mellitus (GDM), (2) hospitalized hypoglycemia, (3) diabetic retinopathy (DR), and diabetic peripheral neuropathy (DPN), diabetic nephropathy, and diabetic foot ulcers (DFUs). (DN). This essay will highlight the significance of either of these clinical scenarios. identifying a problem early on or anticipating a trouble before it happens presently in place as a result of examining a complicated data set. Along with discussing the possible obstacles to AI applications, this article will also discuss the present state and future possibilities of AI technology in diagnosis and

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prediction. Even so, information from smart gadgets or personal
.It is anticipated that patient data would be incorporated into clinical information more and more. technologies and utilized in the upcoming decades for individualized health care, this evaluation primarily concentrates on information gathered in healthcare settings.

Table 1. Advice for Medical Professionals Creating and Applying AI to Provide Care.

1. Because standard measurements, like the area under the receiver operating characteristic curve, are typically not refined or validated for particular clinical situations, clinicians should not assume that they transfer to clinical consequences.
2. To guarantee that the algorithms generate results that are clinically meaningful, clinicians should be involved in directing the metrics' creation.
3. In order to make well-informed decisions about the optimal way to employ the algorithm, clinicians should give top priority to the usage of AI tools with clearly defined and comprehensible performance indicators.
4. To determine the algorithms' usefulness for real clinical outcomes, clinicians had to demand a prospective assessment of the algorithms in clinical settings.
5. AI tool adopters ought to mandate that algorithm creators release the entire algorithm's code, including the training data and code.
6. Since illnesses may manifest differently depending on a person's race, ethnicity, or sex, diagnostic performance metrics should take this into consideration.

AIM AND OBJECTIVE

AIM :

To explain how artificial intelligence can be used to predict and diagnose diabetic problems

OBJECTIVES :

- To determine which people are susceptible to complications from diabetes, including diabetic retinopathy, hypogylcemia, diabetic peripheral neuropathy, diabetic nephropathy, foot ulcers, and gestational diabetes.
- To monitor the course of the disease and modify treatment regimens.
- To lower medical expenses by averting problems.
- To increase patient participation in diabetes treatment.

II. LITERATURE REVIEW

Gestational Diabetes

- In line with Xiong Y, Zhou Q, Wu J, Li X, Xiao X, Ye Y, et al. AI increases the prediction accuracy of GDM (pooled area under the receiver operating characteristic [AUROC] = 0.85) as compared to the conventional use of clinical risk variables.
- Wu YT, Zhang CJ, Mol BW et al. state that prior research has shown trade- offs related to including various populations and elements of various kinds and quantities.
- In order to increase AI accuracy, Wyckoff JA, Brown FM et al. state that when choosing factors for an AI model, one should think about including a large amount of detailed laboratory and genetic data, or fewer variables that are only available with normal prenatal care, in order to improve clinical usefulness. Depending on the population, one must choose between using data from non-selected populations to increase generalizability (at the expense of accuracy) or solely high-risk populations to increase accuracy (at the expense of generalizability). Using new information from CGM, which isbecoming more and more common .
- Iftikhar P, Kuijpers MV, Khayyat A, Iftikhar A, DeGouvia De Sa M et al. claim that it might enhance AI's predictive power without compromising usability. To further enhance predictive capacity and guarantee that there are no racial or other biases, more research is required in sizable, multicultural, and diverse populations.

The Use of AI to Predict Gestational Diabetes

- Reducing the risk of problems for both mothers and infants requires accurate diagnosis and treatment of GDM.
- Compared to traditional risk variables alone, artificial intelligence increases the accuracy of GDM prediction; nevertheless, it is unclear whether AI algorithm or combination of factors is best.
- AI may be better able to forecast the onset of GDM if it incorporates glucose data from continuous glucose monitors (CGMs) and data from studies of sizable, diverse populations.

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Current status of AI to predict Gestational Diabetes

Practice Bulletin for ACOG et al.AI has been employed more and more in the past ten years to forecast the onset of gestational diabetes mellitus (GDM) or impaired glucose intolerance during pregnancy. One of the most prevalent health issues, gestational diabetes mellitus affects 7% to 18% of pregnancies. Pre-eclampsia, cesarean delivery, birth trauma, large-for- gestational-age newborns, and hypoglycemia at birth are among the difficulties that maternal and infant complications are more likely to occur in women with gestational diabetes. While third-trimester diagnosis and therapy can reduce these risks, using AI to identify who would develop GDM early provides a chance for earlier intervention to avoid these consequences.

Expected Future of AI to Predict Gestational Diabetes

- As stated by Tarassenko L, Mackillop L, Khan R, Hamblin S, Clifton D, Velardo C, et al. Apart from forecasting a GDM diagnosis, we anticipate AI will play a crucial role in determining a person's best course of treatment once GDM has been identified.
- Ultimately, in predicting who would acquire type 2 diabetes later in life, Ilari L, Piersanti A, Göbl C, et al.

GESTATIONAL DIABETES

- According to Ye Y, Xiong Y, Zhou Q, Wu J, Li X, Xiao X et al. AI increases the prediction accuracy of GDM (pooled area under the receiver operating characteristic [AUROC] = 0.85) as compared to the conventional use of clinical risk variables.
- According to Wu YT, Zhang CJ, Mol BW et al. state that AI Prior research has shown that there are trade-offs when incorporating various populations and elements of various kinds and quantities.
- According to Wyckoff JA, Brown FM et al, When choosing factors for an AI model, one should think about using a lot of genetic and laboratory data to increase AI accuracy or less data that are only available with normal prenatal careto increase clinical applicability. Depending on the population, one must choose between using data from non-selected populations to increase generalizability (at the expense of accuracy) or solely high-risk populations to increase accuracy (at the expense of generalizability). Using new information from CGM, which is becoming more and more common
- According to Iftikhar P, Kuijpers MV, Khayyat A, Iftikhar A, DeGouvia De Sa M et al. might increase AI's capacity for prediction without compromising usability. To further enhance predictive capacity and guarantee that there are no racial or other biases, more research is required in sizable, multicultural, and diverse populations.

The Use of AI to Predict Gestational Diabetes

- Accurate identification and treatment of GDM is key to reducing the risk of maternal and infant complications.

Current status of AI to predict Gestational Diabetes

ACOG practice bulletin et al .In the last decade, AI has been increasingly used to predict development of GDM or the development of impaired glucose intolerance during pregnancy Gestational diabetes mellitus is one of the most common medical complications affecting 7% to 18% of pregnancies. Gestational diabetes increases the risk of maternal and infant complications, such as pre-eclampsia, cesarean delivery, birth trauma, largefor-gestational age infants, and hypo glycemia at birth. While these risks can be mitigated through diagnosis and treatment in the third trimester, use of AI for early prediction of individuals who will develop GDM offers an opportunity for earlier intervention to prevent these complications.

Expected Future of AI to Predict Gestational Diabetes

- According to Velardo C, Clifton D, Hamblin S, Khan R, Tarassenko L, Mackillop L et al. Apart from forecasting a GDM diagnosis, we anticipate AI will play a crucial role in determining a person's best course of treatment once GDM has been identified.
- According to Ilari L, Piersanti A, Göbl C, et al .successful in identifying those who will eventually develop type 2 diabetes.

HYPOGLYCEMIA

- According to Zale A, Mathioudakis N et al. Over the past decade, there has been growing interest in leveraging large EHR data sets to develop prediction models for hypo glycemia using ML algorithms.

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- According to Ruan Y, Bellot A, Moysova Z, et al. By including large numbers of predictor variables known to influence glucose homeostasis from very large cohorts of patients, AI technologies can fill an evidence gap by identifying and weighing clinical factors that affect glucose levels in ways that would be difficult for clinicians to recognize from clinical experience alone. Various ML techniques have been used to develop prediction models

The Use of AI to Predict Hypoglycemia in the Hospital

- One of the most frequent adverse medication events in hospitalized patients is hypoglycemia, but manual evaluation of numerous dynamic clinical parameters in the electronic health record (EHR) can make it challenging for clinicians to forecast this potentially fatal outcome.
- Several clinical indicators are being incorporated into machine learning models to predict hypoglycemia in intense care unit (ICU) and non-ICU settings.
- It is anticipated that future patient outcomes would be enhanced by the use of machine learning models using EHR data to forecast hypoglycemia and AI- generated therapy suggestions for physician

Current Status of AI to Predict Hypoglycemia in the Hospital

- Many hospitalized diabetic patients have several risk factors for both hyperglycemia (steroids, for example) and hypoglycemia (nil per os status, renal failure), according to Kulasa K et al. Combining these dynamic and even conflicting indicators to identify individuals at high risk of iatrogenic hypoglycemia might be challenging for atreating clinician. Clinicians may be able to prevent such an adverse outcome by making proactive therapy modifications with the help of accurate early detection technologies.

Expected Future Use of AI to Predict Hypoglycemia in the Hospital

- According to Mathioudakis N, Everett E, Golden SH et al. The highly unbalanced classification of hypoglycemic outcomes can also lead to misleading interpretations ofthe AUROC, which is frequently reported as a measure of model performance. The metric has a high overall accuracy but a relatively low positive predictive value or positive likelihood ratio. Since ML models have not previously been used as clinical decision support tools for hypoglycemia prediction in the EHR, it is unknown how to appropriately balance the trade-off between false positives (alarm fatigue) and increased sensitivity (outcome detection). Furthermore, considering the high prevalence of overt hypoglycemia episodes and clinical lethargy
- According to Mathioudakis N, Aboabdo M, Abusamaan MS, et al. Additionally, researchers would need institutional authorization before integrating such models into their EHR systems. Informatics warnings concerning hypoglycemia are anticipated to be most successful when paired with useful treatment recommendations for doctors.
- According to Singh LG, Satyarengga M, Marcano I, et al. AI technology may also be able to fill in evidence gaps in this area. taking into account the rising popularity of telemetry-based care models that employ CGMs for patients in hospitals.

DIABETIC RETINOPATHY

- According to Ipp E, Liljenquist D, Bode B, et al. The US Food and Drug Administration (FDA) approved IDx, an AI diagnostic system that uses DL to diagnose patients with DR on its own, in 2018. This was the first autonomous AI system authorized by the FDA in any medical discipline. The FDA also approved the Eye Art AI diagnostic system in 2020 for the self-diagnosis of DR. The Automated Retinal Disease Assessment (ARDA) (Google Health Palo Alto, California), the AEYE AI algorithm (AEYE Health, New York, New York), IDx, Eye Art, and other commercial programs have demonstrated high sensitivities and specificities above 90% for the detection of referable DR (defined as greater than mild DR) in clinical trial.

Expected Future Use of AI to Diagnose Diabetic Retinopathy

- According to Pedersen ER, Cuadros J, Khan M, et al. Workflows in health systems will need to be modified in order to fully utilize this new technology. For instance, there have been significant improvements in follow-up care

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adherence when patients with sight-threatening DR are triaged right away.

DIABETIC FOOT ULCERS

- According to Yudovsky D, Nouvong A, Schomacker K, Pilon L et al. The ultimate goal is to identify patients who will acquire DFUs before clinical indicators, like skin disintegration, appear, even though we can identify which patient photos now show DFUs. Other technologies, such as multispectral photography and thermography, have enabled this kind of advanced warning.
- The Use of AI to Diagnose Diabetic Foot Ulcers
- Present-day machine learning algorithms are able to: (1) identify if a picture contains diabetic foot wounds; (2) pinpoint the area of the picture where the wound is located; and (3) segment the borders of the wound.
- The ultimate objective is for machine learning algorithms to forecast a patient's likelihood of developing a wound before any clinical symptoms appear.
- To accomplish this, larger, clinically annotated data sets and better algorithms are required.

Current Status of AI to Diagnose Diabetic Foot Ulcers

- According to Xie P, Li Y, Deng B, et al. Over the past ten years, DFU managementhas made use of machine learning methods.
- According to Goyal M, Reeves ND, Rajbhandari S, Yap MH et al. DFUs in photos may now be identified, located, and segmented using sophisticated machine learningmethods.
- According to Yap MH, Chatwin KE, Ng CC, et al. developed an application that enables users to identify if an image has a DFU. This is a particularly helpful tool forphysicians in areas with little DFU management training or for patients with visual impairments.
- According to Stefanopoulos S, Ayoub S, Qiu Q, et al. Used ML to retrospectivelyassess which individuals in the Nationwide Inpatient Sample (a data- base which covers approximately 20% of all US hospital admissions) with active DFUs were identified to have a range of risk factors

Expected Future Use of AI to Diagnose Diabetic Foot Ulcers

- According to Cassidy B, Kendrick C, Reeves ND, et al. There isn't a central DFU repository yet. Currently, the largest repository, which is publicly accessible from Manchester Metropolitan University in the United Kingdom (UK), is at least an order of magnitude too small to accomplish the goal of predicting DFUs before clinical signs appear. It consists of 11,000 images withground truth labeling of DFUs.
- According to Swerdlow M, Shin L, D'Huyvetter K, Mack WJ, Armstrong DG et al, et al. Furthermore, while new tools are making it easier for individuals tophotograph their own feet, the majority of DFU photos now in use are obtained during medical visits and are therefore stored in medical recor

.

DIABETIC PERIPHERAL NEUROPATHY

- According to Baskozos G, Themistocleous AC, Hebert HL, et al. . AI can be used to diagnose DPN using three different test types: anatomical, physiological, and qualitative. An ML algorithm that uses key clinical criteria, such as the Euro Qol-5 Dimension (EQ5D) health-related quality of life exam, which is a qualitative test to identify painful DPN and nonpainful DPN, has been created to better discriminate subsets of DPN.
- According to Dagliati A, Marini S, Sacchi L, et al. To categorize the severity of the condition, a consistent scoring system for nerve function testing is required. Physiological responses for severity stratification across several anatomical sites and across time for the same site can be measured using artificial intelligence techniques.
- According to Teh K, Wilkinson ID, Heiberg-Gibbons F, et al. Anatomical information, such as magnetic resonance imaging scans, is gathered in addition to quantitative data as biomarkers to identify uncomfortable DPN based on functional connection.
- According to Preston FG, Meng Y, Burgess J, et al. In a similar manner, peripheral nerve ultrasound pictures can be used as anatomical inputs to a convolutional neural network that can recognize patterns in peripheral nerves that point to DPN. The diagnostic accuracy for peripheral neuropathy increases when an AI algorithm processes the photos.
- According to Themistocleous AC, Hebert HL, et al. In contrast to a different strategy that makes use of CCM, these AI systems have a low throughput. CCM can identify corneal nerve loss, which correlates with the degree of

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diabetic neuropathy and can anticipate when it will start. In order to diagnose DPN, corneal confocal microscopy is a quick and non-invasive imaging method that automatically classifies nerve fiber pictures of the cornea—where nerves are not covered

- According to Kerr D, Klonoff DC et al. In order to prevent qualitative fallacies, which occur when poor decisions are made solely on the basis of quantitative metrics without taking qualitative factors into consideration, it is also anticipated that the data input to algorithms will diversify and include quantitative data from high-definition imaging as well as increasingly secificqualitative biomarkers.

DIABETIC NEPHROPATHY

- According to Allen A, Iqbal Z, Green-Saxena A, et al. Using different combinations of demographics, vital signs, and laboratory testing, artificial intelligence (AI) has been used to predict the development of DN in ten populations of individuals with type 2 diabetes.
- According to Song X, Waitman LR, Hu Y, Yu ASL, Robbins DC, Liu M et al. In twoof these papers, a sensitivity analysis comparison was made between the predictionsand updated datasets.
- According to Makino M, Yoshimoto R, Ono M, et al. One study identified data fromthe EHR using natural language processing in addition to conventional data extraction.
- According to Kitamura S, Takahashi K, Sang Y, Fukushima K, Tsuji K, Wada et al. .DN can be differentiated from other glomerular disorders using this process. AI wasable to diagnose DN using immunofluorescence images, which pathologists hardly ever look at, even though one set showed no distinctive features.
- Long-term, untreated diabetes can result in diabetic nephropathy (DN), which can lead to renal failure and ultimately dialysis, kidney transplantation, or death; improving patient outcomes requires early intervention and improved predictive models.
- Artificial intelligence has beaten other systems in predicting DN risk by combiningdata from laboratory testing, vital signs, and demographics.
- ML algorithms need to be trained using data that is representative of the patients receiving the AI-derived treatment because the risk and rate of DN progression arehigher in some populations than others.

Expected Future Use of AI to Diagnose Diabetic Peripheral Neuropathy

- According to Baskozos G, Themistocleous AC, Hebert HL, et al . The diagnosis of DPN will benefit greatly from machine learning methods. The best accuracy and result can be obtained by combining several data sets and algorithms into ensembles. It is anticipated that further advancements in theseAI-based algorithms will be crucial in DPN diagnosis, either as online risk or diagnosis calculators for patients or as clinical diagnostic to

Current Status of AI to Diagnose Diabetic Nephropathy

- According to Hsu C, yuan Iribarren C, McCulloch CE, Darbinian J, et al The clinical state known as diabetic nephropathy is typified by albuminuria and a steady deterioration in renal function. The primary cause of end-stage renal disease (ESRD) is kidney problems associated with diabetes.

Expected Future Use of AI to Diagnose Diabetic Nephropathy

- According to Loftus TJ, Shickel B, Ozrazgat-Baslanti T, et al. These algorithms must, first and foremost, be appropriate for the people they are intended for. This is due to the fact that some groups have a higher risk and rate of DN development than others, and forecasts that discourage future action must be made using data that represents the patients receiving the AI-based treatment.
- According to Savage N et al. Second, a judgment made by an AI model—often referred to as a "black box"—will need to be trusted by clinicians. They must determine the inputs and outputs and use more result data to suppert.

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Prognosis of CKD by GFR and albuminuria categories: KDIGO 2012

GFR categories (ml/min per 1.73 m²) Description and range				Persistent albuminuria categories Description and range		
				A1	A2	A3
				Normal to mildly increased	Moderately increased	Severely increased
				<30 mg/g <3 mg/mmol	30–300 mg/g 3–30 mg/mmol	>300 mg/g >30 mg/mmol
	G1	Normal or high	≥90			
	G2	Mildly decreased	60–89			
	G3a	Mildly to moderately decreased	45–59			
	G3b	Moderately to severely decreased	30–44			
	G4	Severely decreased	15–29			
	G5	Kidney failure	<15			

Green, low risk (if no other markers of kidney disease, no CKD); yellow, moderately increased risk; orange, high risk; red, very high risk.

III. CONCLUSION:

Diabetes complications, such as (1) gestational diabetes, (2) hospitalized hypoglycemia, (3) retinopathy, (4) foot ulcers, (5) neuropathy, and (6) nephropathy, can be predicted and diagnosed using artificial intelligence. The accuracy of these predictive programs is anticipated to increase with the size and detail of data sets comprising risk factor and outcomedata. It is anticipated that algorithms driven by artificial intelligence will someday be used extensively to diagnose and forecast a variety of diabetic complications.

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