REVIEW ARTICLE

Artificial Intelligence for Managing Diabetes Mellitus in Indonesia: Implementation Challenge in Resource-Limited Settings

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ABSTRACT

The existence of Artificial Intelligence (AI) has shaped a significant transformation in healthcare. In the field of endocrinology, AI has been used in the treatment of diabetes mellitus which categorized as one of the leading causes of death in Indonesia. This study is based on a general article review that uncovered the function of AI and its utilization on diabetic care. Currently, AI has grown into a facility that plays a role in health care, such as screening, diagnosis, and recognizing problems. In the scope of diabetes, several AI-based methods and applications have been investigated and played a role in diabetes management such as monitoring blood sugar, setting therapy targets, and dietary adjustment in diabetic patients. Despite the sophistication of AI, there are still several potential risks and barriers, notably in Indonesia, where the limited resources still be an impediment to the use of advanced technology. Lack of data integration and limited accessibility are the common challenges to AI implementation in limited-resources areas. Nevertheless, the application of AI offers numerous prospective benefits, particularly in terms of convenience of use and its efficacy in diabetes management to optimize diabetes care with standardized digital data records, resource improvement, and workload decrease.

Keywords: *Artificial intelligence, diabetes, resource limited settings*

INTRODUCTION

Diabetes is a health problem that has been a concern for a long time in Indonesia with various complications. The prevalence of diabetes in Indonesia reached 6.2% with 10 million people living with diabetes, which is one of the leading causes of death in large numbers.[1] This can affect individual productivity and affect social scope if neither the intervention nor the proper management is provided. Indonesia is a developing country that still struggles to face the reality of limited facilities and infrastructure in some regions in supporting health management, including information provision, availability of diagnostic tools, and availability of access to monitor patient conditions. This also happens in diabetes management, where limited access to disease management can lead to an increase in comorbid diseases. It can be caused by the distance to reach adequate health facilities and the level of education that still varies within society.

Technology in the healthcare industry is continuously advancing, including the presence of Artificial Intelligence (AI). AI is a system that combines computer science, machinery, and adequate datasets to solve a problem.[2] AI has the potential to further improve patient care due to its ability to interpret more detailed and comprehensive data.[3] AI applications in medicine are emerging worldwide in resource-rich and resource-limited regions, including Indonesia. The Indonesian government strongly supports and encourages the use of AI as a part of digital transformation technology for public health in the future. Digital transformation is an influential agenda to encourage the realization of a Healthy Indonesia through data and technology.[3]

In the context of endocrinology, AI, and digital health intersection, type 2 diabetes mellitus (T2DM) is the most common non-infective, chronic disease observed in Indonesia, and remains the leading cause of morbidity and mortality. At present, AI has developed into a 'promising' technological advancement program in improving diagnosis and patient care. Regarding diabetes management, a study stated that the use of AI can be used to detect complications, support clinical decisions, and provide self-management tools.[4,5] It is expected that AI performs to help afford access to diabetes care in areas with limited resources. The purpose of this review is to provide a view about the utility of AI and its implementation challenges regarding diabetes management in resource-limited settings.

DISCUSION

AI in health digital transformation

Artificial Intelligence (AI) is a field of computer science that combines machinery and computer systems to think like human cognitive functions. An adequate dataset and specific computer codes were required to instruct machines how to interpret data and make conclusions or decisions. AI has the potential to further improve patient care due to its ability to analyze information and process complexity in a wide range of applications.[3,6]

AI is a human-made intelligence using some predictive algorithm properties. Through Machine Learning (ML) algorithms, computers can learn from experience without exact instructions by using large data inputs and outputs. This subclass of AI investigates the association among given training datasets and recognizes repetitive patterns. ML emphasizes to create autonomous resolutions on newly seen datasets.[6,7]

Deep Learning (DL) is a new concept of advanced AI and a more complex form of ML that emulates the neuronal connections of the brain by creating an Artificial Neural Network (ANN). This algorithm learns from unstructured and unlabeled inputs without supervision and segregates data input from low-relevance variables. In unsupervised learning, unlabeled datasets are explored and used as unidentified patterns or clusters to predict unknown outputs.[7,6]

DL has been widely applied to pattern recognition such as image analysis, given its computational power in analyzing data via intricate neural networks. Other forms of DL

include Deep Neural Network (DNN) and Convolutional Neural Network (CNN). DNN which contains multiple hierarchical levels of ANN, is required to improve data predictions and allow the development of models without explicitly programmed directions, while CNN is used for computer vision tasks including medical image analysis.[7,8]

One must consider the risks associated with AI, potentially causing harm to an individual or inadvertently revealing a patient's confidential information when collecting and studying data with AI. In order to create a safer AI technology, it is essential to include safe designs, safety buffers, and structured safeguards. It is also important to pinpoint any uncertainties with potential technical systems to prevent errors. Wearables, cell phones, and other technical gadgets can be advantageous for doctors to assist patients with health issues through their capability to keep track of symptoms and the development of the condition.[9]

Doctors can direct and help patients to choose applicable AI-supported treatment for their condition and obtain patients' consent for the interest of effective medical service. The challenges include paving the way for early implementation, not paying attention to the patient's perspective, and guaranteeing continuous utilization within the digital healthcare system. The realization of the digital health transformation also requires various parties, including health workers, the government, ministries/agencies from other sectors, academics, communities, and volunteers to work together for more effective health services.[3,6]

Indonesia's government strongly supports and encourages the use of AI as a part of digital transformation technology for health services in the future. The "Health Technology Transformation Roadmap" arranged by the Ministry of Health Indonesia is divided into some main activities. The roadmap plan activities for 2023 includes an increase in the number of individual data variables from the previous year, 2022. This increase will be made possible through implementing an AI-based analysis system. The introduction of this technology will be marked by the growth of licensing for biotechnology products and their implementation in hospitals, enhancing telemedicine services in First Line Healthcare Facilities (FKTP), and a policy for digital health.[10]

Utilization of AI in diabetic care

In this modernization era, AI has evolved into a facility that plays a role in health care, such as conducting screening, establishing diagnosis, and identifying complications. AI is defined as the science and engineering of making intelligent machines, through algorithms or a set of rules, which the machine follows to resemble human cognitive functions, such as learning and problem-solving.[11] AI has the potential to deal with issues as they come up and, as such, operate in an intelligent and adaptive manner.[12] The strength of utilizing AI is its ability to learn and recognize patterns in massive datasets. For instance, AI systems are capable of translating a patient's entire medical record into a single number that indicates a likely diagnosis.[13] Subsequently, AI has been crucial in the acceptance of these systems as common therapeutic tools for diabetes patients.[14]

In recent decades, the use of AI in diabetes management has undergone transformation with the latest technologies used, such as continuous glucose monitoring devices, artificial pancreatic development, and early detection of diabetic retinopathy with retinal camera.[14,15] Numerous AI-based methods (Table 1) have been used in the treatment of diabetes. The diagnosis of diabetes has advanced since the development of AI besides blood glucose levels and HbA1c tests.

Table 1. AI-Based Methods In Diabetic Care

Methods	Utilities
Case-based reasoning (CBR)	CBR is an artificial intelligence technique to support physicians in their clinical decision-making process by customizing and optimizing insulin administration for various meal situations. CBR learns from previous comparable meal experiences, which are characterized in cases using a set of parameters (e.g., meal timing, exercise).[16] It also makes automated recommendations to the patient to enhance their habits and understanding of the condition based on the collected data and physician preferences.[17] The example of CBR-based tool is Advanced Bolus Calculator for Diabetes (ABC4D) in smartphone, with the ability to recommend the insulin doses given to the patient by measuring the amount of meal intake and various parameters such as alcohol and exercises.[18]
Machine learning	Digital help for diabetes treatment has been developed using a variety of machine learning techniques. They consist of k-nearest neighbor, support vector machine, artificial neural network, naive bayes, decision tree, random forest, classification and regression trees, and artificial neural network.[5] Machine learning enables mobile applications to connect with users in very engaging ways, hence promoting treatment adherence. An example is a program that suggests appropriate foods based on a person's current glucose levels and past glycemic responses.[19]
Artificial neural networks	A 'neural network' portrays data as a large number of linked neurons, comparable to the human brain; hence, such models may approach clinical problems in a similar way to a clinician by combining several sources of divergent information and offering a personalized solution.[14] The researchers developed a regression model based on ANN, an exercise guidance for diabetes' patients, that could be used to automatically evaluate the activity levels of patients using accelerometers and heart monitors, as well as track changes in glucose levels that happened while the participants were exercising.[16]

Several applications in the area of diabetes are currently designed and used to optimize the management of diseases listed in Table 2.

Table 2. AI-Based Applications In Diabetic Care

Applications	Utilities
Automated retinal screening	AI-based retina screening is a viable, accurate, and widely recognized tool for detecting and monitoring diabetic retinopathy. The automated screening of the retina has a high sensitivity and specificity of 92.3% and 93.7%, respectively. The system integrates the results of numerous, partially dependent biomarker detectors, some of which employ convolutional neural networks.[20,21] It included separate algorithms for quantifying image quality and the detection of haemorrhages, exudates, cotton wool spots, neovascularisation, and irregular lesions.[22]
Clinical decision support	Clinical decision support systems based on supervised machine learning have been created to predict short- and long-term HbA1c response following insulin initiation in patients with type 2 diabetes mellitus. These techniques also aid in the identification of clinical factors that may impact a patient's HbA1c response.[23]
Predictive population risk stratification	Predictive models have been developed to use big data analytics to evaluate the likelihood of problems developing in diabetic patients. Many similar models have been created to predict both long-term (eg, retinal, cardiovascular, and renal) and short-term (eg, hypoglycemia) diabetic problems.[24] Given an example of application called *FootSnap* with its objectivity in standardizing the capture of diabetic foot photographs for longitudinal/follow-up investigations of the plantar surface of the diabetic foot.[25]
Genomic	Advanced molecular phenotyping, genomics, epigenetic changes, and the development of digital biomarkers may be used in the approach to diagnosis and management of diabetes, where large data sets are created due to the disease's heterogeneous character and chronic duration.[9] For the past decade, the analysis of array-based genome-wide association studies (GWAS) has given the most powerful way to identifying genetic variations contributing to the risk of complex characteristics such as type 2 diabetes (T2D). This method has enabled the finding of many thousands of linked regions spanning hundreds of characteristics, including >120 loci increasing type 2 diabetes risk.[26]

Telehealth	Remote monitoring by Telehealth helps shortening follow-up visits and provides for better real-time monitoring of the patient's glycemic condition as well as general health. Virtual engagements and remote monitoring have the potential to replace 50%-70% of typical follow-up healthcare appointments.[27]
Visual dietary application	Mobile applications appear to be a useful approach to help young people with diabetes grasp the fundamentals of their condition and manage it with treatment challenges. Given the example of an application called *DiaMob*. This application uses smartphone camera to capture the actual diet of the patients and targets carbohydrate evaluation and insulin dosages. Actual insulin dose appropriate for the meal they planned to consume was input, and the app then launched the camera feature on the mobile phone, photographing the portion.[28]

AI enables informed and empowered patient engagement. As they affect patient comorbidities, behaviors, time spent in healthcare facilities, and interaction with healthcare professionals, digital solutions have a significant impact on the healthcare systems.[27] Patients have the opportunity to interact and gain knowledge from one another through online diabetic communities and support groups. Patients' desired results and general well-being are impacted by this cooperative approach to learn more about various conditions, which is interesting for both patients and caregivers.[29]

AI-based diabetic care in Indonesia: Potentials and Limits

Indonesia's AI National Strategy has identified five key areas, including healthcare. AI may provide several benefits to the health industry, particularly in accelerating the diagnostic procedure to achieve findings.[30] The usage of technology in the form of telecommunications network devices in Indonesia is still on the rise, by means of improvements in multimedia, images, computers, information systems, and telecommunications.[31] The Ministry of Health Indonesia has a vision to digitize the health sector which is stated in the Regulation of the Ministry of Health Republic of Indonesia (Permenkes RI) No. 21 of 2020 concerning Health Governance Reform including the integration of information systems, health development, and research.[10]

AI-based tools might possibly minimize the costs of screening and treatment plan selection for disorders that need expensive technology and specialized skills that are not accessible in most low or middle-income countries, particularly in rural and remote locations.[32,33,34] Indeed, when new digital technologies, like AI, are available in local contexts, they can allow the creation of more inexpensive, higher-quality, and accessible innovations while overcoming the local resource-constrained environment.[35]

Routine data integration is a crucial part of digital services. The lack of sufficient data to build logical and accurate algorithms is a frequent challenge in diabetes care with AI. More than 80% of health service facilities in Indonesia have not yet implemented digital technology. Although technology is still not optimally used in Indonesia, it is essential for the adoption of AI in health services.[10,36]

Incomplete, inconsistent, and inaccurate data recording is the main factor affecting the quality of digital patient management. More than 270 million patients' data is still documented manually and not

integrated digitally. Several regions in Indonesia still use paper to record medical history, prescriptions, and health-finance claims. To create effective solutions by AI, datasets need to be increasingly developed and structured. The seamless acceptance of digital applications in the treatment of diabetes is also being constrained by patients' worries about security, data protection, and regulatory issues. Indonesia still lacks regulations regarding the standardization of data input and output flows, protection, and rights of privacy from patients' data.[10,36,37]

Cost, access, and implementation are also obstacles to using AI for the treatment of diabetes. Indonesia is one of the developing countries with rural areas which may lead to unequal access to AI-powered technologies due to the inadequate infrastructure, lack of public health worker training in AI, lack of computational resources, skilled labor, or internet access.[38] Meanwhile, until 2023, Indonesia has more than 400 healthcare-related applications. Interoperability is a typical possible impediment to the use of a rising number of devices and applications in diabetes care. Many health applications have been created by the central government, local governments, and the commercial sector separately, resulting in fragmented data that is dispersed across very diverse systems, incomplete, and inefficient services.[9,39,40]

Diagnostic and screening machine learning applications are designed to assist physicians in enhancing their skills. However, relying solely on AI to automate patient care without reviewing or updating the latest healthcare research may lead to deskilling physicians by introducing dependence on AI and potentially replacing healthcare workers.[41-43] Nevertheless, most studies claim that AI is unlikely to replace healthcare workers since the development and adoption of healthcare AI applications are slow, and healthcare work still requires a combination of cognitive and emotional skills.[44,45] Moreover, AI in diabetic care is still in need of regular refinement by professionals.[6] Physicians must be adaptable and consider both the causes and effects of medical issues, as well as the methods and models used to assist them in their decision-making process.[6,37]

Currently, The Ministry of Health Indonesia has formulated a Blueprint for Digital Transformation Strategy 2024 with collaboration from various parties in the health sector and industry under the Indonesia Health Services (IHS) platform. This platform is a system that provides data connectivity, analysis, and services to support and integrate various Indonesian health applications. It provides Indonesia with a way to achieve a measurable and focused digital transformation for the development of an integrated and sustainable healthcare system.[10]

CONCLUSION

A large amount of health data input, routine data integration, and routine refinements by professionals are still required for the training of the AI model especially for AI-based diabetic care in Indonesia. However, Indonesia still confronts various challenges in integrating AI-diabetic management due to low-resource areas that do not have equitable access to technology. Complete and standardized digital data records also facilitate evidence-based AI development, improve the competence of staff in health services, and reduce administrative workload.

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