Is artificial intelligence the key to better foot self-care in diabetes?

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Key words

- Artificial intelligence
- Patient knowledge
- Self care
- Technology

Article points

1. Artificial intelligence has been shown to influence and improve certain aspects of diabetes care.
2. Self care and patient education are key to avoiding complications such as diabetic foot ulcers.
3. Artificial intelligence has as-yet unleashed potential in the field of foot self care and ulcer management, especially in the context of patient education and driving foot self-care behaviours.

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This article explores the growing role of artificial intelligence (AI) in patient self care in diabetes and considers the opportunities and risks associated with it in the context of foot self care in diabetes. AI has yielded many advances in individual and public health, although it does also present unique and emergent challenges. Certainly, AI enables us to consider and re-evaluate diabetes care, screening and management.

There are 4.9 million people in the UK currently living with diabetes (Diabetes UK, 2022). The chronic impact of diabetes involves vascular and neurological impairment, particularly when glycaemic levels are not well controlled (International Diabetes Federation, 2023). Diabetic peripheral neuropathy (DPN) is a serious complication that affects up to 50% of people with diabetes and along with reduced vascular supply to the foot, acts as a precursor to the development of a diabetic foot ulcer (DFU) (International Working Group on the Diabetic Foot [IWGDF], 2023). DFUs, in turn, act as a precursor to serious lower-limb infection, gangrene, amputation and even death (Jeyaraman et al, 2019).

Kerr (2017) estimated that in the UK, more than 64,000 people have a foot ulcer at any given time. There are more than 7,000 diabetes-related lower-limb amputations performed every year in England resulting from ulceration (equating to roughly 19 per day) and that the cost of DFUs and amputation to the NHS is £1 for every £150 that it spends – a total of approximately £780m per year. However, it is widely believed that with appropriate disease management and effective self-care behaviours, many complications, including DFUs, may be entirely avoided (Ellahham, 2020).

Furthermore, the IWGDF (2023) cites good foot self-care behaviours as a key approach to prevention of DFUs. However, good self-care behaviours in diabetes — particularly around foot self care — appear to often be under-utilised and the reasons for that are myriad (Matricianni and Jones, 2015). Adherence to care is a multidimensional phenomenon, determined by the interplay of several factors, including social and economic, patient-related, health-system-related and condition-related factors (Kardas et al, 2013). Of these domains, the patient-related factors are arguably the most modifiable of all at the individual level and typically involve the person's existing knowledge, skills and beliefs around their illness and the benefits of care (Gale et al, 2008; Beattie et al, 2014; Chithambo and Forbes, 2015; Guell and Unwin, 2015; Hill and Dunlop, 2015).

A study by Hill et al (2022) sought to explore patient and healthcare professional perspectives on foot self care in diabetes and found that complex issues surrounding patient motivation, lived experiences, knowledge, access to health services and interpersonal relationships between patients and the healthcare professionals engaged in their care ultimately contributed to the foot self-care behaviours of people with diabetes. This complex interplay may mean that 'one size fits all', standardised approaches to patient advice and education are not the most effective way to improve patient self-care behaviour in diabetes.

Technological advances in diabetes have overcome many of the hurdles that existed for people trying to manage their condition. These include insulin pumps, smart glucose monitors, smart phones and wearables among others (Ellahham, 2020). Thus, it raises the question of whether technologies may play a vital role in helping to overcome the complex hurdles that surround self care in diabetes.

Artificial intelligence (AI) has been described as a form of computer science that can use or create methods/systems that can handle complexity in a wide variety of settings by allowing large volumes of information to be analysed quickly (Contreras and Vehi, 2018). AI has already found widespread use in three key areas in diabetes care — automated retinal screening; clinical decision support; and predictive population risk stratification — and increasingly, a fourth domain for AI in diabetes care is emerging in the form of patient self-management (Ellahham, 2020; Pappachan et al, 2022).

This article seeks to explore the growing role of AI in patient self care in diabetes and specifically considers the opportunities and risks associated with it in the context of foot self care in diabetes.

AI and technologies used in diabetes care

There are two types of AI systems in use today — reactive machines and limited memory. The examples given below are variations of these two systems. Reactive machines require a limited training set to determine simple outputs usually a probability and it is these which are used for things like pattern recognition and diagnosis in most cases. Operators refine the algorithm until it achieves optimum predictive value and then the machine repeats this rapidly and reliably. Limited memory machines need large training sets, for example, thousands of retinal images, to 'learn' what is and is not abnormal and adapt their algorithm accordingly to achieve the peak efficiency.

AI has been shown to influence and improve certain aspects of diabetes care. These are patient-specific, healthcare professionals and healthcare systems (Ellahham, 2020). Patient-specific care is the newest of these three and seeks to incorporate technologies to assist in self care and patient education. The use of AI in the healthcare professional dimension is best exemplified by tools that speed up and increase reliability of clinical decision making. The healthcare systems domain has most ostensibly been served by AI in the form of creating more flexible appointments, triage and optimisation of resource utilisation (Ellahham, 2020; Pappachan et al, 2022). Several AI-based techniques have been incorporated and utilised within diabetes care and this has pushed the role of technology in diabetes management beyond just that of monitoring of individuals' blood glucose. AI-based techniques utilised in diabetes care include the following.

Case-based reasoning

This is an AI technique designed to solve emergent problems based on smart learning from similar previous experiences (Schmidt et al, 2001; Marling et al, 2012). An example of this is a support system that could automatically detect problems in blood glucose control and propose tailored solutions to the individual based on previous experience of effective and ineffective solutions previously offered (Pesl et al, 2017).

Machine learning and deep learning

This utilisation of AI involves machine learning processes which aim to build digital support in diabetes care. Such programmes have been developed which identify people at high risk of diabetes based upon genetic and metabolic factors (Buch et al, 2018).

A specific example of how deep learning algorithms have been used in ongoing diabetes management and care can be seen in the example of AI-based retinal screening (Grzybowski et al, 2020). This technology also incorporates a type of artificial neural network (see below) to enable generation of lesion-specific probability maps for haemorrhages, exudates, abnormal retinal appearance, neovascularisations and microaneurysms (Lam et al, 2018). Similar principles of AI have allowed tools to be developed that interpret images of feet to analyse DFUs and even predict when DFUs may emerge (Pappachan et al, 2022).

Deep learning has also provided clinical decision support for physicians. For example, tools have been developed to aid clinic decision making as they help to predict short-, medium- and long-term HbA_{1c} responses after insulin initiation (Ellahham, 2020). By extension, machine learning has been used to develop a smart customisation approach for interventions in medication adherence and predicting hospitalisation risk in diabetes (Lo-Giganic et al, 2015).

Artificial neural networks

This type of AI links and analyses diverse and disparate pieces of information to try and build personalised solutions for people. This has been widely used in helping clinicians diagnose diabetes and diabetes complications (Odedra et al, 2010); study the impact of different factors on glycaemic levels and indicators (Buch et al, 2018); and develop tools for retinal screening (Lam et al, 2018) and DFUs (Pappachan et al, 2022).

The above examples all show the increasingly prominent role(s) that AI is having in diabetes care and the most recent and emergent domain in which this may further help patients with diabetes manage their condition (and specifically reduce the risk of DFU development) is that of patient self-management.

Patient self-management tools

Self-management is a key component of diabetes care and good foot self care, specifically, is a crucial approach to prevent DFUs (IWGDF, 2023). One of the key concepts of good self care in diabetes is empowerment and autonomy (Scambler et al, 2014). Ellahham (2020) points out that with the advent of AI, people with diabetes have more tools to facilitate their autonomy over self care and this, consequentially, empowers them to manage their diabetes; generate data for their own health markers and be their own experts for health. These opportunities that AI provide to help self care in diabetes centre on increasing patient knowledge and the technical facilitation of self-care practices.

Increasing patient knowledge

Digital platforms allow for more targeted patient education and these can seamlessly be incorporated into web-based programmes and mobile phone/tablet smart apps (Rollo et al, 2016). AI could analyse a patient's health data, including medical history, test results, and lifestyle factors, to create personalised education plans. This ensures that patients receive information relevant to their specific health needs (Li et al, 2020).

AI-powered 'chatbots' (and/or 'virtual assistants') can offer real-time support and information to patients. These chatbots can answer common questions, provide medication reminders, offer guidance on managing chronic conditions, explain medical terms and reinforce healthcare provider instructions (Magyar et al, 2019). One additional advantage of AI and its potential in tailoring health advice and education is that it could enhance patient education through interactive learning platforms. These platforms may include virtual reality (VR) experiences, simulations and even gamified educational content to make learning more engaging and memorable (Heinrich et al, 2012; Talley et al, 2019).

Furthermore, AI-powered language translation services can break down language barriers in healthcare settings. This ensures that patients from diverse linguistic backgrounds can access educational materials in their preferred language. AI is also capable of monitoring patient behaviours and health metrics, providing timely feedback and education. For example, it can offer suggestions for improving adherence to treatment plans or provide insights into lifestyle changes that may positively impact health (Ellahham, 2020). It is here where there is some crossover between increasing patient knowledge and the technical facilitation of self-care practices.

Technical facilitation of self-care practices

As pointed out in the above example, AI could help people with diabetes to take daily decisions around self care by not only providing them with important information but also in more practical terms by devising plans to improve self care. This could come in the form of predictive analytics in which AI algorithms analyse patient data to predict health risks and suggest preventive measures and incorporate deep learning principles in helping to harness patient motivation to undertake these measures (Li et al, 2020).

AI could assist patients and healthcare providers in making data-driven decisions and AI-enabled remote monitoring tools could allow healthcare providers to keep track of patient progress as reinforce pertinent (and tailored) advice (Buch et al, 2018). And, of course, arguably the most ostensible use of AI in patient self-management has materialised in the form of wearable devices which provide real-time insights, tips, monitoring and educational content related to the user's health and wellness (Rodriguez-León et al, 2021; Domingo-Lopez et al, 2022).

From the literature, it appears that in the specific context of foot health in diabetes, AI has been mainly used as a tool to aid clinicians in terms of patient monitoring, provision of more e-health consultations and screening tools to aid clinical decision-making.

As yet, outside of the use of virtual assistants/chatbots, there has not been much use of AI to drive foot self-care behaviours. This may be because these things take time to be incorporated into healthcare, but it also could be that AI is not equally effective and successful in different domains.

Knowing that patient behaviours are a complex phenomenon in which beliefs, motivation, capability and opportunity (among others) interact in complex ways (Hill et al, 2022), it may be that AI needs to evolve further before its efficacy at provoking improved foot self care in people with diabetes is more consistently realised.

Limitations of AI in self care

Sng et al (2023) wrote an article exploring the possibilities and pitfalls that large-language models like ChatGPT present for diabetes education. ChatGPT is a chatbot developed by OpenAI and is an example of a large-language model, which is readily accessible to the general public (Biswas, 2023). Sng et al (2023) explored this by instructing ChatGPT to answer a series of questions regarding diabetes self-management. What they found was that ChatGPT was able to answer all of the questions posed to it, appeared to demonstrate a systematic approach to answering and laid out these answers in a clear and concise way that was easy for the audience to read and absorb. The concise, well-organised, free-from-jargon yields from these ChatGPT interactions were considered positives of this sort of AI utilisation and the answers to the questions consistently ended with a suggestion that the reader consult their healthcare provider.

However, Sng et al did also note some serious limitations to the interactions. Most notably, there were some quite serious errors in some of the answers that ChatGPT provided — some of which may have the potential to cause any patient following them some harm. Also, ChatGPT seemed inflexible in its responses to some questions and scenarios and on occasion required a series of prompts before more useful and detailed answers were generated. These prompts were provided by individuals with good knowledge of the subject and this may mean that people with diabetes without such a level of understanding may not yield as good a response from the chatbot.

Sng et al (2023) summarised that ChatGPT does not source information and filter it based upon a sense of a knowledge base, but instead relies upon frequency and likelihood of words or phrases occurring together. They point to this making ChatGPT prone to "hallucinations" in which untruthful or inaccurate information is presented in a coherent and fluent way which may serve to misinform an unsuspecting layperson.

Limitations of AI are not just found in the context of emergent large language models like ChatGPT, however. There are limitations in the application of AI in diabetes care and self care more broadly. These limitations include the following.

Technical factors

Barriers to the use of AI in diabetes care may be the result of as-yet ineffective implementation; prohibition of cost; and limitations to access. Also, with a growing range of apps and devices leading to a plethora of possible AI-based options for people with diabetes, interoperability may well prove to be another barrier to full and effective utilisation of AI in diabetes self care (Fagherazzi et al, 2019).

Data limitations

The building of accurate algorithms that AI can operate on is a common problem in diabetes (especially in the context of DFUs and foot self care). These algorithms are notoriously difficult to develop because there remains a paucity of data needed to build them (Ellahham, 2020). Furthermore, concerns around data protection and security in the realm of AI continue to pose a challenge (Mamiya et al, 2017).

Human factors

AI could pose a risk of de-skilling physicians by clinicians developing a reliance on the technologies. Aside from any associated immediate clinical risk this poses, this may also have the effect of reducing

AI efficacy over time as the success of the algorithms depend upon their refinement and periodic tweaking by experts (Buch et al, 2018).

Conclusion

AI continues to draw much focus and attention due to its seemingly limitless possibilities and incredible data processing speed and power. It is beyond question that this has yielded many advances in both individual and public health, although it does also present unique and emergent challenges – not all of which are yet known. AI certainly enables us to consider and re-evaluate diabetes care, screening and management. The predictive power that AI can yield has already been seen and has demonstrated real-time impacts on how clinical decision-making could be supported and how people living with illness could be provided help to manage their health. The full potential of this in the field of foot self care and DFU management and prevention is yet to be fully unleashed — especially in the context of patient education and driving foot self-care behaviours. It appears that further development and evaluation of AI-based interventions in this specific clinical domain is one important short- and medium-term focus of research in the foot in diabetes. ■

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