Diabetes care: Inspired by humans, powered by machines

Artificial intelligence (AI) is arguably one of the hottest buzzwords weaving itself into the fabric of our lives. AI often conjures up visions of apocalyptic landscapes decimated by super-intelligent machines with a penchant for destroying societies believing enough to place their trust in autonomous robots and android workers. This bleak vision of the future is often embedded in science fiction novels and portrayed in such films as *The Terminator*, *I, Robot*, *2001: A Space Odyssey*, *The Matrix* and *Ex Machina*. One wonders if these legacies, together with the exponential development in AI, are likely to activate Isaac Asimov's Three Laws of Robotics (*Box 1*) sooner than imagined.

In the context of health, this technology promises to revolutionise the landscape of healthcare delivery by driving efficiency and productivity, and to empower healthcare workforces worldwide by providing real-time data and clinical interpretation. Furthermore, the experience, knowledge and human touch of clinicians, together with the power of AI, will improve the quality of patient care, lower its cost and minimise human error. A recent study (Sullivan, 2017) suggested that about 35% of healthcare organisations plan to leverage AI within 2 years, and more than half within 5 years.

Definition

So, what is AI? Currently, there is no single, universally accepted definition. In the context of this commentary, however, the definition by John McCarthy, one of the founding fathers of AI, defines this innovative technology as "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, 2007). By inference, this would suggest computing technologies that resemble processes associated with human intelligence derived from large, diverse sets of digital data.

Box 1. Isaac Asimov's Three Laws of Robotics.

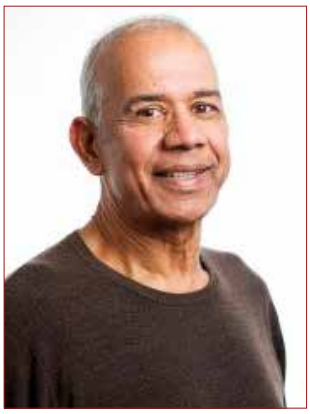
A robot:

1. may not harm a human being, or, through inaction, allow a human being to come to harm;
2. must obey the orders given to it by human beings, except where such orders would conflict with the First Law; and
3. must protect its own existence, as long as such protection does not conflict with the First or Second Law.

AI in healthcare

Obtaining experience and empirical evidence on a generalised basis was the working method of the medical community from Hippocrates until around the beginning of the 20th century. The experience base and the somewhat "trial-and-error" approach of medicine subsequently made way to evidence-based medicine. The recent fast-paced exponential, rather than the linear, progress in science and technology has created a platform for medicine being underpinned by disruptive technologies (Elenko et al, 2015) that are able to advance medical research and improve the process and efficiency of clinical care (Price, 2017). Cheap genome sequencing, advanced biotechnology, health sensors being used by people at home, and the collection by hand-held devices of information about patients' journeys in healthcare have all been producing a vast amount of "big data". With smartphones and health tracker revolutions under the name of digital health, it has become impossible for a physician to analyse all those data or simply even be up-to-date (Meskó et al, 2017).

In the field of diabetes, the volume of data generated by technological innovations, such as continuous glucose monitoring (CGM) devices, the FreeStyle Libre glucose management systems and the artificial pancreas (AP), means that healthcare professionals struggle to interpret every aspect of the data. However, by means of complex and refined methods, AI can provide useful management tools to deal with these incremental



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"Artificial intelligence technology, whilst necessary, is not meant to replace the established healthcare professional–patient relationship. Rather, these applications are designed to complement care delivered by clinicians."

repositories of data. In turn, this can provide additional time for human interaction, which can result in a scalable, cost-effective and powerful diabetes behaviour-change intervention.

Terminology

Terminology surrounding AI technologies continues to evolve and can be a source of confusion. However, AI is broadly classified into **machine learning** (ML), where computers can train themselves to make informed, accurate decisions, and **deep learning** (DL), which is inspired by the biological neural network and function of the human brain (Kassahun et al, 2016).

AI and diabetes

How can AI benefit the field of diabetes? Over the last decade, the entire paradigm of diabetes management has been transformed by the integration of technologies such as continuous glucose monitoring (CGM) devices and the development of the artificial pancreas. In the context of AI, ML could be programmed to recognise a hypoglycaemic event based on the blood glucose parameters inputted, while DL could recognise other variables, such as infection, stress, insufficient insulin or other medication intake, or unscheduled strenuous physical exercise, which can also contribute to hypoglycaemia.

The Look AHEAD longitudinal randomised clinical trial provides another interesting example. It concluded that weight loss interventions did not reduce cardiovascular risk in overweight people with type 2 diabetes. However, ML-based re-analysis identified a subgroup of participants for whom weight loss was beneficial, but this effect was being masked by another subgroup for whom there were detrimental effects (Baum et al, 2017).

AI-based systems have been shown to reliably recognise cardiovascular disease risk (Poplin et al, 2018) and diagnose diabetic retinopathy (Gulshan et al, 2016). AI research in screening for foot ulcers in primary care promises to reduce the number of people at low risk requiring specialist referral, thereby enabling people at higher risk to benefit from shorter referral delays (Yap et al, 2018).

The future

Several studies have demonstrated that AI can perform on a par with clinical experts in disease diagnosis. However, these tools have not been evaluated in controlled clinical studies to assess their effect on healthcare decisions and patient outcomes. From a cautionary perspective, until conclusive evidence has been established, premature deployment of this technology can lead to increased strain on the healthcare system, undue stress among patients and possibly even death, owing to misdiagnosis.

For many people, the growth and evolution of AI remains a black box, where the internal working of AI is not fully understood, and not everyone shares an unbridled enthusiasm for it. However, in the context of diabetes, management, to a large extent, involves pattern recognition, which positions it well for the application of AI. By automating routine key variables, such as blood pressure, blood glucose and weight, clinicians can devote less time to data entry and more time to their unique role of building relationships, exercising empathy and using their human judgement to guide and advise, so that people can be empowered in their self-care strategies. AI technology, whilst necessary, is not meant to replace the established healthcare professional–patient relationship. Rather, these applications are designed to complement care delivered by clinicians. ■

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