Artificial Intelligence in Health Care: Focus on Diabetes Management

From Darkness to Sight

Consider this scenario. During the times of "power cuts", one night, a house plunges into darkness due to the loss of electrical supply. To add to this blackness, thunderous rains rattle the windows. Sensing an opportunity, with a mischievous smile, the grandmother lights a candle. Children huddle around her and the candle flame, knowing that she would, any moment now, burst into a spine-chilling story of haunted houses, ghosts, and the like.

But a toddler watches all this, from a distance, fascinated by the fire. The dancing flames of the candle have kindled his curiosity. His face lights up, not just with wonder, but also by the glow from the flame. He cruises around the furniture and squeezing himself silently between the children, he reaches a finger to touch the dancing gold-dust of the candle flame.

A cry of pain pierces the night. Children and the grandmother rush to comfort the toddler. As he disappears into the all-encompassing comfort of a grandmotherly hug, he swears never to go near a flame again.

The toddler *observes* the flame, *explores* it with his finger, *understands* the pain of the burn caused by the flame, and finally, *learns* to avoid the fire. The letters in italics are all components of intelligence, we call it "real" intelligence to differentiate from the better known "artificial intelligence" or AI.

What is artificial intelligence or AI? Simply put, it is the ability of a computer program to think and learn like humans. It is also the field of study that tries to make computers smart, says Wikipedia.[1] The underlying assumption, of course, is that humans are "smart"!

Coming back to the analogy of the toddler and the flame, replace the toddler with a smartphone app and the candle flame with the diabetic retina. Just like the toddler observes the flame, the software *observes* the retina. Just like the toddler explores the flame, the smartphone *explores* the retina and photographs it. Like the toddler understands the pain of the flame, the smartphone *understands* the damage wreaked by diabetic retinopathy. And, just like the toddler has learnt to avoid the flame, the smartphone app *learns* to avoid blindness, by timely referral to the ophthalmologist. Simply put, the smartphone app is displaying AI.

The analogy isn't perfect, but probably manages to simplify AI for the clinical endocrinologists like me, for whom this article is written. Diabetic retinopathy diagnosis and referral are one of the most prominent applications of AI in diabetes. In a recent publication from Western India, using a smartphone-based AI algorithm to diagnose "referable retinopathy" had 100% sensitivity and 88% specificity.[2] Notably, this study was done in the community setting with a small sample size (n = 213), but using a smartphone-based AI algorithm that had the AI software available *offline*, meaning that it would also work in remote areas where internet penetration was suboptimal. Recently, the US FDA has, for the first time, approved the use of a smartphone-based AI algorithm for retinopathy diagnosis.[3]

This idea of artificial intelligence in health care is not new. IBM's Watson, the well-known question answer computing system, is already being utilized to assist in decision making for complex clinical situations. A recent publication looked at the concordance of Watson-directed cancer care decisions vs oncologist-directed ones.[4] The results showed that different cancer types showed different concordances, as far as decision making was concerned. Clearly, this evolving field has a lot of scope for more research.

The Fast Learner

Humans possess the ability to learn from their past experiences. Machines are designed to follow instructions given by humans. But wouldn't it be great if humans can train machines to learn from their past observations? Then, machines would be able to do the tasks humans can, but in a much faster and better manner. This is called "*machine learning,*" another aspect of AI.[5] Imagine millions of glucose sensors (from millions of people with diabetes) inputting data into an algorithm, which is also loaded with medication dosages and clinical information on a prospective, continuous basis. The AI software "learns" the data and determines the optimal medication, say insulin, and recommends the dosage. This would be an example of machine learning.

A simpler version of this is already happening. Let us take the example of continuous glucose monitoring (CGM) systems, which generate huge amounts of blood glucose measurements. Newer CGMs are also able to display the glucose levels real time, on a smartphone or reader.[6] Let us say that Ms. Y who has type 1 diabetes and is on a CGM system, finds that her current blood glucose reading is 183 mg/dl. By itself, the inference of this point measurement would just be that her current blood glucose level is high. However, what if the blood glucose reading just an hour ago had been 73 mg/dl? This would mean that the momentum of rise of blood glucose may carry the glucose levels into the hyperglycemic ranges. Predicting this, the CGM display screen shows an upward pointing arrow cautioning Ms. Y about the imminent hyperglycemia. Similarly, if the current blood glucose is 183 mg/dl, and the blood glucose an hour ago 592 mg/dl, then a downward-pointed arrow would warn Ms. Y about imminent hypoglycemia. In both these cases, humans have trained the machine to learn about not just hypo- and hyperglycemia, but also about predicting the rises and falls in glucose levels.

AI can also be used to interpret large amounts of data so that the clinician can understand complexity in simpler terms. An example is the ambulatory glucose profile graph generated via flash glucose monitoring, which helps the doctor interpret intra- and inter-day glucose variability as well as high and low blood glucose levels in a somewhat simple graphical image.[7]

Compassion from a Chatbot

Chatbots have been already employed for glycemia management.[8] A chatbot is a computer software that mimics a human voice, via both audio and text communication. Mimicking an output from the human brain, which has about a 100 billion neuronal connections, is no easy task. Naturally, this form of AI is referred to as *neural network computing*, a common terminology in the realm of AI. Another term that is common is *deep learning*, a form of AI that describes how neural networks handle large sets of data, typically of a multilayered type.[9]

Currently, scientists are researching the use of a chatbot to understand and motivate people with diabetes.[10]

A conversation between a chatbot with a person with diabetes (Mr. X) may proceed in this manner -

Mr. X: *"I feel very tired. Problems at home. Problems at work. Too tired to do anything. Feel Exhausted."*

Chatbot: *"I understand how you feel. Don't worry. Everything will turn out just fine. Remember, be active, because exercise will release endorphins into your brain to make you happier! And do remember to eat healthier meals today."*

Note that here, there is an input from Mr. X and an output from the chatbot. But what happens in between? Does the chatbot really "understand" and empathize with Mr. X? No. The chatbot is simply processing sets of data and coming out with the most appropriate output. And what about Mr X? Would Mr X be consoled with the output from the chatbot once he knows fully well that the chatbot is only providing an "output" without any genuine empathy? After all, a chatbot, at least at this point of time, may not have feelings!

Such a conversation, as every endocrinologist would say, would remove the warmth and the human touch, an essential part of the doctor–patient relationship. However, chatbots are quick learners, and future research could work to endow chatbots with better empathy and to mimic the flaws in human nature, the qualities that make us more vulnerable, and more human. Japan has been using real robots for care in the elderly.[11] Preliminary research suggests that they may provide better care than the conventional methods, and exciting research is helping to endow robots with "artificial empathy".[11,12]

The Sorting Hat

For those not yet initiated into the Harry Potter lore, the Sorting Hat is a hat worn by children, before they begin studies at the fictional Hogwarts School of Witchcraft and Wizardry.[13] There are four houses in the school. When each child wears the Sorting Hat, the hat analyses the brain, and sometimes even has a short conversation before assigning a child into a particular house in the school. Given the complexity of this task, the hat has been called "magical".

In a stunning parallel to the Sorting Hat, researchers have applied a similar sorting process for people with diabetes from Europe.[14] This sorting was based on six variables: glutamate decarboxylase antibodies, age at diagnosis, BMI, HbA 1c, and homoeostatic model assessment 2 estimates of β-cell function and insulin resistance. Advanced "sorting" was carried out with prospective data from patient records on development of complications and prescription of medication. The subjects were sorted into five clusters with differing disease progression and risk of diabetic complications.[14] While one cluster predicted kidney disease, another cluster was associated with severe insulin deficiency. This new sub-stratification represented a first step towards *precision medicine* in diabetes. The future could see the combination of such cluster data on phenotype, combined with genotype as well as behavioral/social-media-based data to generate specific clusters of diabetes requiring specific approaches with lifestyle as well as medications. This would include personalized nutrition or exercise advice as well. This would evolve with time, as *personalized health care* is becoming a buzzword for the future.

Why are such clusters important? We know that not all people with an illness respond to a medication similarly. Let us assume that a hypothetical treatment Z works excellently only in 10% of people with a disease. As it did not work well in 90%, the treatment was not approved for all subjects with the disease. But if via AI we are able to discern the characteristics of the responders (who are 10%), could treatment Z be a personalized health care for this minority with the illness? This is the hope behind the integration of AI in personalizing medical care.

The Rise of the Type Ones

It is well known that linking glucose sensor readings to insulin pump output perfectly could result in a true artificial pancreas. The algorithms and complexities of this task are so gargantuan that not even the most perfect sensor-augmented pumps can lay a claim to having solved the artificial pancreas. Moreover, these high-end pumps come at an exorbitant price. A more recent advance is the 'bionic pancreas" which utilizes a combination of insulin and glucagon delivery to more closely mimic the physiological glucose metabolism. However, even the bionic pancreas has had limited success so far.[15]

All this has led to a form of AI-focused support group, among people with type 1 diabetes, as the title of this paragraph suggests. This group uses open source software to develop a true, closed loop artificial pancreas. This phenomenon, called “Do-it-yourself (DIY) Closed Looping” has many supporters around the world, including both people with type 1 diabetes and their relatives, and even clinical experts, who do not wish to wait for such technology to become formally approved.[16] The problems with these devices include security concerns, lack of an adverse event reporting mechanisms, lack of approvals by regulatory bodies, lack of published high-quality trials as well as doubtful reliability. Diabetes UK recently came out with a position statement saying that people on DIY Closed Loop should continue to receive support and care from their diabetes care team.[16]

The Case Against AI

Not everyone is excited about AI. AI in health care is at a nascent stage and AI-generated reports could sometimes be erroneous. But there are other arguments against AI. Stephen Hawking, the renowned physicist, had famously warned humanity about computers taking over the world.[17] Yuval Noah Harari, the well-known historian, has also predicted that AI, coupled with overall scientific progress, could change humanity by creating *three* different kinds of “super” human beings, who are better than *Homo sapiens*.[18] The first type of superhuman could be a genetically engineered human, chosen to have a perfect body and brain by cherry picking the best genes. The second type of superhuman would be a “cyborg”: or humans having both organic and inorganic parts. Bionic hands, feet, or even a bionic pancreas (as discussed earlier) could revolutionize the world of the future. The third type of superhuman who might evolve could be a completely inorganic person, not even requiring a human brain—but having a much more powerful inorganic brain with artificial intelligence. All this sounds a little too futuristic! Will these super humans ever come to be? However, the point is, if they ever make it to existence, how will they interact with lesser mortals like *Homo sapiens* (read: us)? Will they make us their workhorses or their pets? Will they exterminate us, just like we humans attempt to eradicate mosquitoes?

AI experts often debate about the point of “singularity,” the time when artificial intelligence would overtake human intelligence.[19] If humanity stumbles at the point of singularity, then, some of these experts hypothesize that artificial intelligence could dominate the world, and the race of *Homo sapiens* as we know today could face extinction.

A final argument against AI, particularly important for health care is regarding data privacy and the ownership of data. This is very important, especially because increasingly, clinical trials are being conducted using technology like never before. Recently, a diabetes reversal trial was conducted remotely, in part, with web-based education via the Internet.[20] In another examples, people with type 1 diabetes were recruited for a clinical trial via social media.[21] In this era, where data is called the “new oil,” people who control and own data wield enormous power. At present, regulations seem to be ambiguous on data ownership. Surely, it stands to reason (both ethical and moral) that all personal health data must primarily belong to the patient. Given the increasing use of wearables (like smartwatches, sensors, and fitness trackers) in monitoring health parameters, ownership of data assumes greater importance to prevent “cyberattacks.”

AI is here to Stay

A detailed analysis of AI applications in diabetes is beyond the scope of this general article. However, it seems clear that AI is here to stay. If AI can diagnose and help in treating disease, could it take over our jobs one day? AI could have a strong role in taking over tasks which depend on automation and pattern recognition such as anatomic radiology and pathology.[22] However, in general, as clinicians, it is safe to assume that AI is not after our jobs! Clinical assessment, empathy, the human touch and judgement—all continue to be important skills for the next century. However, AI scores high in situations where there is a large amount of data to interpret, and when there is uncertainty about the right choice of treatment. In these situations, AI becomes an additional tool for the clinician. In other words, a good clinician who is not empowered with AI-based support is likely to be less effective than a good clinician who has the additional option of harnessing the benefits of AI.

Notably, there are experts who feel that AI could make health care humane again.[23] This is because when the doctor is assisted by an AI-based analysis of complex clinical and laboratory data, it would free up some time which the doctor can spend in interacting with the patient.

Another emerging frontier the field of “in silico” drug discovery.[24] This uses AI-enabled computer software to precisely develop and test molecules that bind to receptors in medically effective ways. This takes away drug discovery from the laboratory, allowing simulation of controlled experiments in the virtual realm.

In conclusion, it is always good to know that AI is a *tool*, and that it is not a *goal* in itself. It is the goal of every endocrinology specialist to provide high-quality diabetes care and AI is only a *tool* to achieve that goal. The tool can never replace the caregiver or the goal. As endocrinologists, we must recognize that AI is here to stay. While understanding the merits and demerits of AI in diabetes care, we could still welcome it with a cautious optimism.

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Access this article online	
Quick Response Code:	**Website:** www.ijem.in
	DOI: 10.4103/ijem.IJEM_549_19

How to cite this article: Unnikrishnan AG. Artificial Intelligence in Health Care: Focus on Diabetes Management. Indian J Endocr Metab 2019;23:503-6.