
Could personalized healthcare reinvent medicine?
Medtronic
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Big data, digitization, and advances in AI are helping doctors tailor treatment to patients like never before

The digital age is proving to be an era of personalization. With social media, we can personalize the news we consume; new manufacturing technologies let us personalize our clothes from the comfort of our homes; artificial intelligence (AI) lets Netflix and other streaming services serve up personalized recommendations. Healthcare, too, is becoming more personalized.

Every patient is unique — as are the circumstances and progression of their conditions and treatments. And doctors have always worked to tailor care to individuals, but until recently effective options were limited, and "one-size-fits-all" therapies were often the norm. That can be problematic, and not just because of differences between individuals; patients themselves are constantly changing. "We know we're different from each other, but we are different from ourselves over time," says Dean Ho, head of biomedical engineering at the National University of Singapore (NUS). "If a person is going to be treated, a week later they're a different person."

Now, however, the burgeoning field of "personalized healthcare" is aiming to bring about a paradigm shift in medicine. There is no single definition of personalized healthcare, but the U.S. Food and Drug Administration explains it as "an innovative approach to tailoring disease prevention and treatment that takes into account differences in people's genes, environments, and lifestyles ... to target the right treatments to the right patients at the right time." This trend has been enabled by the twin revolutions of big data and digitization. Never before have we been able to collect so much data at the individual level. That's thanks to the spread of novel diagnostic techniques, as well as sensors, wearables, smartphones, fitness apps, and other digital devices.

The abundance of data from various sources — together with groundbreaking technologies developed to harness it — is enabling doctors to make more nuanced, earlier diagnoses and administer finer-tuned treatments, helping them to give patients tailored care. "Give me about five days' worth of individual data points," says Ho. "I can create a three-dimensional map using those data

points, and it will tell me exactly what I need to give you next week for you to respond in the most optimal way possible."

One of the advantages of taking a technology-driven approach to medicine is that it can scale to the benefit of all. "Right now, it's inefficient to deliver a Western European healthcare model everywhere around the world, as we know each region, each community, and each patient has different, complex needs," says Brett Wall, executive vice president and president of Neuroscience at Medtronic. "There also just aren't enough healthcare workers around the world. You're always going to need people to interpret the data, to understand some of the risks, but technology can help make the average better and the best extraordinary."

Much of the data enabling these new technologies over the past decade has been the result of advances in genomics — the study of a person's genetic makeup to predict whether they'll develop certain conditions, or how they'll respond to specific treatments. But genomics is only a component of a much wider technology landscape that is gradually changing medicine as we know it. "By using technology like AI, you can have a better outcome," says Wall. "You don't want to have to repeat a procedure three months later or six months later. The patient wants to get on with their life."

A data revolution

Personalized healthcare is first about prevention. Advanced monitoring and diagnostic devices are enabling a new wave of predictive approaches for identifying early signs of disease, and forecasting how they will react with treatment. This area has taken off fast thanks to the boom in wearables, including specialized devices such as intravascular blood monitors (for measuring glucose) and stick-on sweat sensors (for detecting electrolyte levels), but is chiefly being driven by consumer technology. Smartwatches have long been able to track heart rates, but increasingly can offer everything from cardiac monitoring to blood pressure readings.

"Consumer-grade wearables are coming of age," says Paolo Missier, professor of scalable data analytics at Newcastle University, and a fellow at the Alan Turing Institute. "People want to be aware of what's going on with their wellness status, and that goes from general lifestyle to things like 'Am I running into problems with my heart?'" The result of that, Missier explains, is that more and more people have started to "emanate data" about their health without needing to undergo medical tests or have access to medical-grade devices. That data can be combined with more conventional information — such as primary care records or family health history — to add context, and then analyzed with AI to return predictions. For example, in 2021 researchers at Cardiff University in the UK tested whether low-cost wearable devices could help predict which patients are more likely to experience health complications before undergoing high-risk surgery. The researchers found that data collected by wearables about cardio-pulmonary activity was good enough to be used in pre-surgery risk assessment.

Sometimes, the data can make more unexpected predictions. Take gait analysis: Continually monitoring the characteristics of a person's steps can help with diagnosing Alzheimer's disease. Or consider a recent study for the Turing Institute in which Missier and his team conducted an experiment: They took a data set comprising motion readings for 100,000 people over seven days and used that data (complemented by socio-demographic and lifestyle information) to train an AI system to predict whether someone would develop type 2 diabetes or cardiovascular diseases. "It turns out you can find some signal — despite the noise and despite the limitation in the data — that allows you to separate out the cases from the controls," says Missier.

Bringing wearables to new frontiers is challenging: Data can be "noisy" and trick AI into predicting things that aren't there; regulatory frameworks may not be in place; and it is often hard to understand why AI has made a certain prediction. But as these issues are addressed, Missier believes a healthcare technology revolution may become increasingly likely. "The consequences for

the healthcare sector can be vast. Digital health is now overlapping with the Internet of Things," he says. "It is basically the 'Internet of Human Things'."

The ultimate aim would be AI able to holistically predict what each and every one of us is likely to suffer from in the future — and what we should do to stave it off. But that scenario is still far away, explains Sobia Raza, head of science at the UK think tank PHG Foundation. To create a program able to just look at a person's data and create a complete picture of their present and future health, Raza says, many things still need to fall into place. "It requires the integration of richer data sets," she says. "And that is quite a complex feat at the moment for various reasons." These complications encompass everything from siloed and unstructured data to privacy and consent. "It's about asking the right questions: knowing what data sets to collect in the first place, knowing what it is that we want to create a prediction around, and what the most relevant data sets are," she says. "It's only after those aspects are addressed that we can start to think about holistic predictive analytics, at a greater scale outside of a discrete area."

Right now, AI is also making notable headway in diagnostics, and that's only set to grow. The prevailing AI paradigm known as machine learning is — at its most basic level — a computer model trained with large databases to recognize patterns and spot similarities or anomalies in information. This can be applied to various formats, including spreadsheets, voice recordings, and pictures. That includes medical images, one field in which machine learning's potential is already shining through. AI tools are being used to identify cancers from scan imagery, and most importantly to flag people who are at risk of developing specific kinds of cancer (including breast cancer and colon cancer). An AI-powered endoscopy system by Medtronic helps identify colorectal polyps during colonoscopy; a report published earlier this year found it led to a 50 percent reduction in missed polyps. Brain scans, too, are rich with the opportunity for AI analysis. A June 2022 study conducted by researchers at Imperial College London revealed that a single MRI brain scan might help forecast whether a patient was

developing Alzheimer's disease, thanks to a machine learning tool able to spot very early signs of the ailment. It works by analyzing 660 different characteristics of 115 brain regions; the algorithm is able to find patterns and make predictions. In 98 percent of cases, it could accurately predict the presence of the disease. This could help patients get a diagnosis at an earlier stage, with multiple benefits. For patients, it allows treatment and management to start sooner; for researchers, it will help them better understand the disease's progression and develop new therapies.

Treatment gets personal

The rise of personalized healthcare is improving not only the realms of diagnostics and prevention, but also treatment. Already, digital technology and big data are bringing about many new approaches, including targeted therapy regimes, bespoke 3D printed implants, and smart medical devices. A deep brain stimulation (DBS) device from Medtronic can deliver electronic pulses to help treat conditions such as Parkinson's disease and epilepsy. It works by implanting small electrodes in the patient's brain and sending electrical impulses to specific neurological regions.

"When you stimulate a certain part of the brain, you can relieve some of the symptoms of Parkinson's to help rigidity or excessive movement. But many patients are also on a drug regimen — and it's really important to listen to the brain and understand what's happening," Brett Wall explains. "We have technology in our Neuroscience portfolio that enables the measurement and recording of electrical signals from the brain and allows the physician to titrate and personalize the impulses and the level of therapy an individual receives." The effects of such a personalized approach to DBS can be dramatic. Wall shares a story of a Parkinson's patient who had been using a wheelchair for years and suffered from rigidity and severe motor fluctuations. Data gathered from Medtronic technology helped physicians make specific programming decisions. Before the technology was switched on, the most he could manage was a slow shuffle.

Afterward, the patient's mobility improved, and he was able to walk unassisted; reducing tremors improved his quality of life. "The ability to understand how we're stimulating, and to be able to strip out that information and allow the physician to ultimately adapt the stimulation pattern, is really important."

In Wall's opinion, personalized healthcare often boils down to using technology to augment physicians as much as to improve outcomes for patients. The combination of quality data and advanced algorithms makes it possible to achieve better results even when it comes to surgery. For instance, if a patient is undergoing a spinal procedure to correct their spine's curvature by installing implants, Medtronic technology can analyze X-ray imagery and chart a workflow of how the operation should be carried out. "The planning tool looks at what could be the best possible correction for that patient. It creates a plan for the surgeon of how the implants should be in place," Wall says. "The machine helps make the surgery personalized."

Treatment planning is a burgeoning area in its own right. Dean Ho, the NUS professor, has developed a personalized approach to chemotherapy. Patients treated for cancer are often given fixed doses of chemotherapy — but too high a dose at the wrong time can have serious side effects. "They get toxicities, they get warded, admitted into the hospital. Some of them die from the actual treatment," says Ho.

In a clinical trial carried out between August 2020 and April 2022, the NUS team used an AI tool that analyzed data such as cancer biomarkers to fine-tune chemotherapy doses depending on how they were responding. "Cancer evolves over time, and the human response in fighting that cancer evolves over time, not just with the chemo, but with their immune system," says Ho. When patients in the study were given an optimal dose as opposed to the standard high dose, Ho explains, it significantly improved outcomes.

"When someone is not responding [to treatment] at this high dose, our data suggest that if you drop the dose by, for example, 50

percent — this was the first time that not only we improved their outcome by dropping the dose, but patients flipped from being non-responders to responders." What's more, across the study the average dose was reduced by around 20 percent.

This might be the start of a whole new way of thinking about medicine and healthcare, one that ditches a one-size-fits-all approach and embraces personalization. But an effective shift to personalized healthcare mindset, says PHG's Sobia Raza, will require practitioners, technologists, and policymakers to address some urgent questions. First, diversity: People of non-European descent are often underrepresented in genomic databases and datasets used to train machine learning tools, and that risks undermining those tools' overall effectiveness for the population at large. Second, for patients to trust healthcare providers with their data, they need to be reassured that their information will not be misused. "It's about making a concerted effort to demonstrate trustworthiness around the use of healthcare data with the public," Raza says. That trust will not be won unless the marvels of AI and its personalized healthcare technology applications are provided to everyone, regardless of their financial means or geographic location. "Many of these developments are happening in parts of the country that have greater resources to do this kind of work," Raza explains. "Policymakers need to ensure that these benefits can be diffused across the country and across many countries."

To Brett Wall, these questions can be dealt with thoughtfully and effectively – but they should be tackled sooner rather than later because the potential benefits are so profound. "Personalized medicine can be the answer to some of the biggest healthcare challenges around the world. We have both the responsibility and the tremendous potential to improve the lives of more people in more places."