Technology is reshaping modern medicine

But ethical and economic challenges could limit the benefits medtech brings to healthcare.

The Nobel Prize in Medicine 2019 was awarded to three men for "their discoveries of how cells sense and adapt to oxygen availability".[1] The Nobel Prize in Medicine 2018 was given to two men "for their discovery of cancer therapy by inhibition of negative immune regulation".[2] The Nobel Prize in Chemistry 2017 went to a trio for developing "cool microscope technology" that "revolutionises biochemistry" by allowing researchers to study three-dimensional structures of biomolecules in their search for a cure for the Zika and other viruses.[3] One of the three chemistry winners of 2017, Joachim Frank of the US, said at the time that he "thought the chance of winning a Nobel Prize was minuscule because there are so many innovations and discoveries happening".[4]

Frank is still right about that. Technological leaps in medicine dubbed medtech are accelerating as researchers find better ways to treat more diseases, in more ways, for more people. Advances are occurring in biotechnology, immunotherapy, surgery, and foetal and neonatal care to name just some areas. Artificial-intelligence software trained on data from digitalised health records and devices can spot problems faster and more reliably than can humans. HCA Healthcare, the largest for-profit hospital operator in the US, for instance, now uses algorithms trained on 31 million cases to detect the sepsis infection that kills about 270,000 people a year in the US.[5]

More medtech advances are certain. Money is pouring into research and development[6] overseen by regulators and doctors to ensure benefits outweigh risks. Common sights soon might be robot physicians, remote surgery and mini 3D-printed organs.[7] Bacteria genetically reprogrammed to destroy tumours in mice could one day work on humans.[8] Genome scans and gene therapies could become routine.

For all this promise, however, medtech comes with two certain and one likely drawback. The first definite disadvantage is that medtech is raising ethical issues that could stop the deployment of key advances. The two most sensitive are the gene-editing of foetuses ('superbabies') that could alter human experience and protecting the privacy of patient data, an issue highlighted in November when it emerged that US healthcare provider Ascension had secretly handed over the records of tens of millions of patients to data crunchers at Google.[9] Medtech's other certain shortcoming is the cost. Many advancements might never become mainstream because they could prove too expensive for governments burdened with budget deficits and heavy debt loads that are already facing rising healthcare costs as their populations age.[10]

Medtech's contentious disadvantage is doctors are finding that self-monitoring via devices, which often detects harmless abnormalities and fuels hypochondria, is leading to unwarranted anxiety, incorrect diagnoses and unneeded treatments.[11] All up, medtech's value to society will be tied to the extent to which these disadvantages limit the spread of its unquestionable benefits.

Many of medtech's ethical issues could be resolved, to be sure, but that won't be easy. Some medtech advancements, especially those based on AI, are economical. Medtech needs to be assessed with the perspective that there is much it is not solving. Medtech advances, for example, aren't enough to avert the recent decline in life expectancy in western countries due to heart attacks tied to obesity.[12] Medtech pharmaceutically does little for autoimmune diseases such as arthritis that afflict one in four US adults[13] – though it is improving joint-replacement surgery. Researchers are yet to find a cure for infections made drug-resistant due to the overuse of antimicrobial drugs that the World Health Organisation says could kill 10 million people a year by 2050.[14] Nothing medtech has come up with is usurping MRI scans and X-rays.

Be these as they may, medtech advancements are ushering in treatments that produce better outcomes for patients. Only time will tell how much ethical, economic and other possible drawbacks limit mainstream access to medtech's benefits.

THE BIOTECH ERA

Eras become known for their medical advancements. From the 1920s to the 1950s, for example, the key medical leaps were vaccines and antibiotics. Later epochs might regard today's advances to be centred on cell and gene therapy, robotic surgery and perhaps AI.

Hope for cures from gene therapy, an area of research that emerged from the late 1980s, accelerated in the early 2000s[15] when the human genome was sequenced.[16] And treatments are underway now and more are likely. Biopolymers (nucleic acid) are injected into cells to treat inherited eye diseases and immune deficiencies while researchers are studying how gene therapy could treat cancer, heart disease and diabetes.[17] A stellar example of gene therapy improving lives is that a Novartis subsidiary has developed a one-time gene-based treatment (Zolgensma®) that is a curing treatment for children born with spinal muscular atrophy (who without this advance constantly need treatment over their short lives).[18] The problem is one dose costs US$2.1 million.

Aside from the costs, gene therapy comes with other challenges too. The finicky nature of genes has made progress slow.[19] Other hindrances are rejection, side effects such as cancer, and the risk that other genes might be delivered to a cell. Some treatments are so risky authorities have halted them.[20] Some 'breakthroughs' have proved false – a recent study debunks that a certain gene causes depression.[21] That the ethical issues surrounding gene therapy are unresolved became an urgent issue in 2018 when two Chinese babies were born with modified genes.

Inventions to assist surgeons have proved faster to everyday use (and less problematic). Robots have aided orthopaedic surgeons since the mid-1980s and now help with general, transplant, urological and other procedures. One measure of their widespread use is that Intuitive, the US-based maker of the 1999-launched da Vinci® surgical system, counts that tens of thousands of surgeons have conducted more than six million procedures in at least 66 countries using its equipment.[22] The benefits of robotic-assisted surgery are less invasive, more precise and safer procedures due to fewer and tinier incisions (microsurgery) and reduced human error.

While less-invasive surgery shortens hospital stays and robotic surgery's lower margins of error reduce the need and costs of further treatment, robotic-assisted procedures are expensive. Assuming cost issues can be overcome, technology will expand its role in surgery and robots could use AI more extensively to help surgeons make more decisions.

AI's use in healthcare goes well beyond surgery too. AI programs including chatboxes[23] are diagnosing heart disease and cancer,[24] identifying retinal damage,[25] analysing suicide risk,[26] streamlining drug-development processes,[27] proposing remedies for multiple sclerosis,[28] even helping the dumb speak.[29] AI's promise is more timely, economical, convenient and streamlined treatments.

AI's usual drawbacks apply, however. Personal data needs privacy protection, which can impede research. Data can be dodgy and data-training algorithms can be flawed and biased, which could lead to misdiagnosis.[30] AI is vulnerable to hacking, whereby malicious tweaks lead to errors.[31] AI's deployment often runs ahead of peer review and ethical considerations.[32]

A NEUROTIC WORLD?

One medtech achievement is to elevate the practitioner 'Doctor Me'. The term (sometimes stated as Doctor You) is for when people use devices and self-testing to monitor their health or genetic risks.

Self-monitoring comes with many advantages. It can save lives. The unwell can gain comfort if their vital signs are normal. The data collected can help everyone's health and allow people to find others with similar issues, which could provide clues for treatments and moral support.

The problem, however, is that Doctor Me has ushered in the 'nocebo' effect, essentially a form of hypochondria. The nocebo effect occurs when patients think they are experiencing a side effect to a greater degree than possible or when people fret they are suffering from an ailment that a test showed they are at risk of – say people self-tested as prone to Alzheimer's imagine they have the affliction when they forget something.[33]

A Stanford study of 2018 found the nocebo effect is ripe in self-testing genetics, a flagship area of medtech that is not foolproof.[34] The expression could become ubiquitous soon because more people are testing their disposition to Alzheimer's, cancer and obesity – by 2017, already one in 25 in the US knew their genetic data.[35] If the nocebo effect becomes widespread, authorities may need to limit self-testing.

While future Nobel Prizes await those making medtech advances, perhaps others lie ahead for those who find ways to resolve medtech's ethical, economic and hypochondriac challenges.

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1 The Royal Swedish Academy of Sciences. nobelprize.org/prizes/medicine/2019/summary/

2 The Royal Swedish Academy of Sciences. https://www.nobelprize.org/prizes/medicine/2018/press-release/

3 The Royal Swedish Academy of Sciences. nobelprize.org/uploads/2018/06/press-41.pdf

4 Financial Times. 'Nobel chemistry prize for developers of 'cool microscopy'. 5 October 2017. ft.com/content/ba8069a6-a8e6-11e7-ab55-27219df83c97?segmentId=6132a895-e068-7ddc-4cec-a1abfa5c8378

5 HCA Healthcare. 'HCA Healthcare using algorithm-driven technology to detect sepsis early and save 8,000 lives.' 16 May 2019. investor.hcahealthcare.com/press-release/hca-healthcare-using-algorithm-driven-technology-detect-sepsis-early-and-help-save-800

6 Health giants such as Roche and Novartis of Switzerland have bought biotechs to pioneer genetic treatments for inherited diseases, by way of one example. Another is that Microsoft has paired with UK biotechnology firm Oxford Biomedica to repair the genes of people with life-threatening diseases. An Apple update in 2018 injected a Health app into iPhones. The pink-heart-on-white-box icon allows users to view, manage and share their health records held by healthcare providers and store health activity, heart, sleep and other data recorded by the device. Google parent Alphabet's Verily is conducting clinical trials on data from wearable devices, while its Calico arm is dedicated to anti-ageing. Google's Deep Mind focuses on AI and has already built a device that can diagnose complex eye diseases. Amazon's move on healthcare includes forming a partnership with Berkshire Hathaway and JPMorgan Chase to form a fresh channel through which to deliver healthcare – their plan is to start first with their employees. Another is that Amazon is readying Alexa-linked devices to access people's health data. Slowing ageing is "the mission" of Google's Calico Life Sciences.

7 See Advanced Science. '3D printing of personalised thick and perfusable cardiac patches and hearts.' Nadav Noor, Assaf Shapira, Reuven Edri, Lior Wertheim and Tal Dvir. 15 April 2019. onlinelibrary.wiley.com/doi/full/10.1002/advs.201900344

8 Sreyan Chowdhury and others. 'Programmable bacteria induce durable tumour regression and systemic antitumor immunity.' Nature Medicine. 3 July 2019. nature.com/articles/s41591-019-0498-z

9 See The Wall Street Journal. 'Google's 'Project Nightingale' gathers personal health data on millions of Americans.' 11 November 2019. wsj.com/articles/google-s-secret-project-nightingale-gathers-personal-health-data-on-millions-of-americans-11573496790

10 The Congressional Budget Office forecasts cost growth in major health care programs to boost spending on healthcare to 30% of US federal outlays within the next decade. cbo.gov/publication/45087

11 The US Food & Drug Administration, when writing to Apple in 2018 to approve the latest Apple Watch as a Class II medical device, warned the device could lead to unneeded treatment. accessdata.fda.gov/cdrh_docs/pdf18/DEN180044.pdf

12 US government's Centers for Disease Control and Prevention. 'United States life tables, 2017.' National vital statistics report. Volume 68, number 7. 24 June 2019. cdc.gov/nchs/data/nvsr/nvsr68/nvsr68_07-508.pdf

13 US government's Centers for Disease Control and Prevention. 'Arthritis' information page. "Arthritis affects 54.4 million US adults, about 1 in 4." cdc.gov/arthritis/

14 Wealth Health Organisation report to the secretary-general of the UN. 'No time to wait: Securing the future from drug-resistant infections.' The antimicrobial classification includes antibiotic, antiviral, antifungal and antiprotozoal drugs. April 2019 who.int/antimicrobial-resistance/interagency-coordination-group/final-report/en/

15 Eve Hanna, Cécile Rémuzat, Pascal Auquier and Mondher Toumi. 'Gene therapies development: Slow progress and promising prospect.' Journal of Market Access & Health Policy. 2017: 5 (1): 1265293. ncbi.nlm.nih.gov/pmc/articles/PMC5328344/

16 A genome is an organ's set of Deoxyribonucleic acid, or DNA, the chemical compound that holds the instructions living things need to develop. Its sequencing meant the order of the four bases within DNA was discovered. See 'A brief guide to genomics' by the National Human Genome Research Institute. https://www.genome.gov/about-genomics/fact-sheets/A-Brief-Guide-to-Genomics

17 Gene therapy is treating the inherited eye disease Leber's congenital amaurosis and the immune deficiencies Adenosine deaminase deficiency and X-SCID.

18 Novartis. 'AveXis announces innovative Zolgensma® gene therapy access programs for US payers and families.' 24 May 2019. novartis.com/news/media-releases/avexis-announces-innovative-zolgensma-gene-therapy-access-programs-us-payers-and-families

19 Of the 1,698 gene-therapy trials commenced or approved between 1989 and 2010, only 1% showed clinical benefit Victorian state government. 'Gene therapy.' betterhealth.vic.gov.au/health/conditionsandtreatments/gene-therapy

20 US Food & Drug Administration. 'Federal court issues decision holding that US stem cell clinics and owner adulterated and misbranded stem cell products in violation of the law.' 4 June 2019. fda.gov/news-events/press-announcements/federal-court-issues-decision-holding-us-stem-cell-clinics-and-owner-adulterated-and-misbranded-stem

21 Border R and others. 'No support for historical candidate gene or candidate gene-by-interaction hypothesis for major depression across multiple large samples.' The American Journal of Psychiatry. May 2019. Paper found at ncbi.nlm.nih.gov/pubmed/30845820

22 See Intuitive company website at intuitive.com

23 UK start-up Babylon has created a video consultation and AI chatbox app called 'GP at Hand' that is being rolled out in the UK as part of the National Health Service. The AI symptoms checker asks patients questions to analyse problems. See gpathand.nhs.uk/

24 See Google AI blog. 'Improved grading of prostate cancer using deep learning.' 16 November 2018. ai.googleblog.com/2018/11/improved-grading-of-prostate-cancer.html

25 Nature Medicine. 'Clinically applicable deep learning for diagnosis and referral in retinal disease. 13 August 2018. nature.com/articles/s41591-018-0107-6. Alphabet's Deep Mind was involved in the study. Its release can be found at deepmind.com/blog/moorfields-major-milestone/

26 Crisis Text Line is a US-based organisation that uses AI to analyse texts for signs of depression and risk of suicide. Volunteer counsellors respond to texts for help. See blog 'Embracing AI to save lives.' 19 July 2017. https://www.crisistextline.org/blog/ava

27 See 'How artificial intelligence is changing drug discovery.' Nature. 30 May 2018. nature.com/articles/d41586-018-05267-x

28 One UK-based study, for instance, claims AI analysis of brain scans of people taking natalizumad for multiple sclerosis could lead to better treatments and new drugs. Baris Kanber, Parashkev Nachev, Frederik Barkhof, Alberto Calvi, Jorge Cardoso, Rosa Cortese, Ferran Prados, Carole H. Sudre, Carmen Tur, Sebastien Ourselin and Olga Ciccarelli. 'High-dimensional detection of imaging response to treatment in multiple sclerosis.' Published in the science journal NPJ Digital Medicine 2, Article number: 49 (2019). Published 10 June 2019. nature.com/articles/s41746-019-0127-8

29 See University of California San Francisco. 'Synthetic speech generated from brain recording.' 24 April 2019. ucsf.edu/news/2019/04/414296/synthetic-speech-generated-brain-recordings

30 See the study by Danton S Char, Nigam H Shah and David Magnus. 'Implementing machine learning in health care – addressing ethical challenges.' 15 March 2018. National Center for Biotechnology Information. ncbi.nlm.nih.gov/pmc/articles/PMC5962261/

31 See 'Adversarial attacks on medical machine learning.' Science magazine. 22 March 2019. science.sciencemag.org/content/363/6433/1287. The US Justice Department has charged Chinese nationals for the hacking of health insurer Anthem when the records of 78 million people were stolen. The motive for the hack is unknown. See US Department of Justice. 'Member of sophisticated China-based hacking group indicted for series of computer intrusions, including 2015 data breach of health insurer Anthem Inc. affecting over 78 million people.' 9 May 2019. justice.gov/opa/pr/member-sophisticated-china-based-hacking-group-indicted-series-computer-intrusions-including

32 The US Food and Drug Administration is accused of approving AI for medical use when no peer review has tested the concepts. See claim in 'Opinion: AI efficacy in healthcare still needs to be proven in clinical studies.' HealthData Management. 17 August 2018. healthdatamanagement.com/articles/ai-efficacy-in-healthcare-still-needs-to-be-proven. See tweet on 12 August 2018 by Eric Topol, physician-scientist and author of 'Deep Medicine'. He lists 13 FDA approvals over the previous month or so that had no peer review. twitter.com/EricTopol/status/1028642832171458563

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34 Bradley P Turnwald, J Parker Goyer, Danielle Z Boles, Amy Silder, Scott L Delp and Alia J Crum. "Learning one's genetic risk changes physiology independent of actual genetic risk.' 10 December 2018. Nature Human Behaviour 3, 48-56 (2019)nature.com/articles/s41562-018-0483-4

35 MIT Technology Review. '2017 was the year consumer DNA testing blew up.' 12 February 2018. technologyreview.com/s/610233/2017-was-the-year-consumer-DNA-testing-blew-up/

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