Adopting AI in healthcare: Why change?

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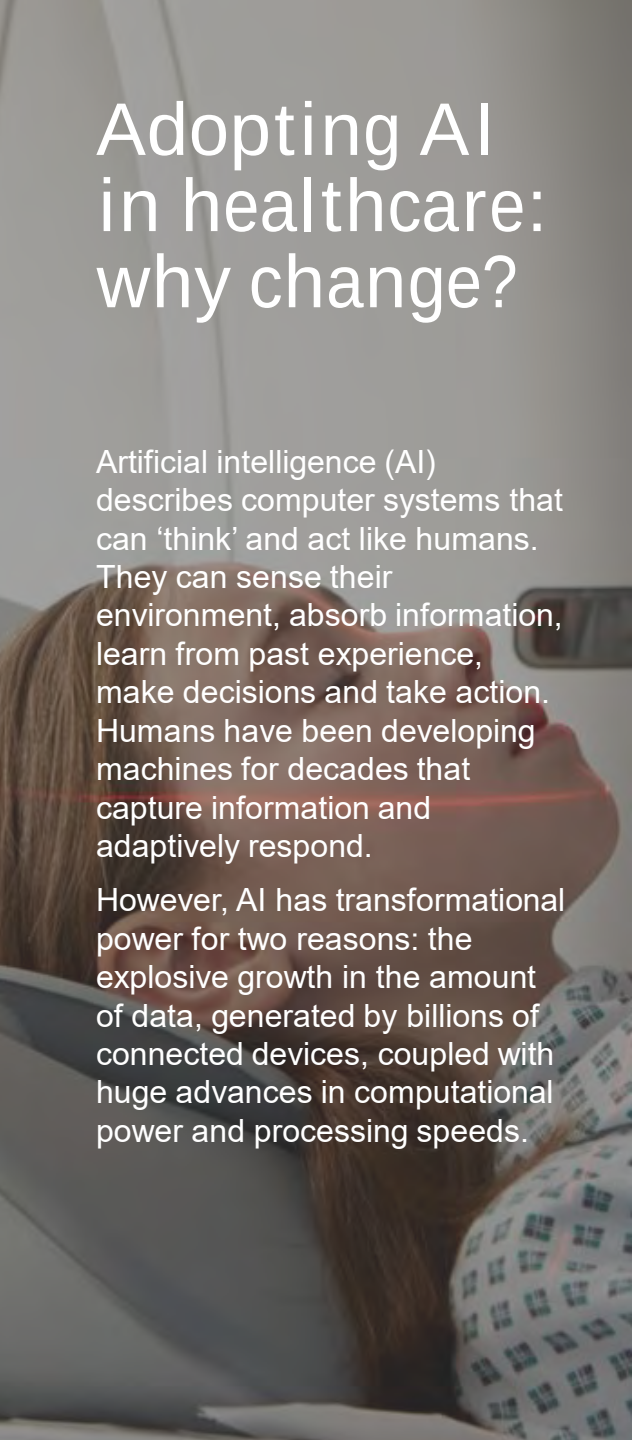


Artificial intelligence (AI) describes computer systems that can 'think' and act like humans. They can sense their environment, absorb information, learn from past experience, make decisions and take action. Humans have been developing machines for decades that capture information and adaptively respond.

However, AI has transformational power for two reasons: the explosive growth in the amount of data, generated by billions of connected devices, coupled with huge advances in computational power and processing speeds.

PwC has forecast that global GDP will be up to 14% higher in 2030 due to the accelerating development and take-up of AI. In healthcare, the potential for disruption is limitless due to the amount of available healthcare data. This includes population-level datasets, thousands of patient case histories, real-time digital data from smartphones and medical wearable devices, as well as unstructured sources such as CT scans and doctor's handwritten notes.

A key use case of AI is early detection and diagnosis. AI allows computers to identify small anomalies between an individual's health data and that of similar patients, or the wider population. Machine-learning algorithms can instantly analyse CT scans. Doctors can augment their ability to determine the most effective treatment or predict a condition's likely course. Already, the Queensland Government is using the CSIRO's Patient Admission Prediction Tool to forecast the demand on hospital and cut patient waiting times at 27 major hospitals across the state. AI solutions are also being developed to power 'virtual nurses', reduce unplanned hospital readmissions, predict eye disorders in diabetic patients and assess pain levels in people with dementia.

AI has the potential to both improve healthcare service delivery and lower the per capita cost of managing a growing and ageing population. In future, hospitals, GPs, allied health professionals, and aged care and disability service providers will need to 'do more with less'. The system will need to shift from crisis management and hospitalisation to wellness, prevention and management of chronic conditions in the community. Digital innovation will be crucial in connecting the different spheres of care; in particular, by creating a centralised warehouse of data on which healthcare AI applications can be built.

Definitions

Artificial intelligence (AI): the ability of a machine or a computer system to perform tasks or imitate behaviour that would normally require human intelligence – for example, visual perception, speech recognition, problem solving or decision making.

Machine learning: a subset of AI where statistical techniques are used to give computer systems the ability to improve their performance of a certain task over time – for example, sorting incoming emails into 'spam' and 'non-spam'. That is, the computer system has the ability to improve and 'learn'.

There are simple ways for organisations to start adopting AI

Go to the cloud

While much information still remains locked in documents, doctors are migrating practice systems to the cloud. The benefit of moving to the cloud is that organisations can focus on what they are good at – delivering care – while being liberated from having to maintain old, expensive computing infrastructure and software.

Human touch and leadership

Healthcare leaders must create a culture that supports AI, bringing the entire workforce along on the process of change. Yet they should also remember that technology best supports human capabilities, rather than replaces them, and that the human touch will remain integral to true healthcare.

Optimise and analyse data

Organisations need a plan to collect, optimise and analyse healthcare data, and develop an ethical and privacy framework to govern its use.

Collaborate and scale

Instead of going it alone, governments and healthcare providers should collaborate with an entire ecosystem of start-ups, technology partners, experts and researchers.

The role of AI in healthcare

AI can help every healthcare organisation harness its data to deliver higher-quality care with greater efficiency.

What is artificial intelligence?

Artificial intelligence (AI) describes computer systems that can 'think' and act like humans. This means they can sense their environment, absorb information, learn from past experience, make decisions and take action. We may be barely aware of it, but AI is already a part of our lives. It designs our Spotify playlist and helps us browse Netflix movie suggestions, based on the knowledge of our preferences and previous consumption habits. More companies are using automated chatbots to deliver customer service, taking the strain off call centre staff members.

AI is not new. Humans have been developing machines for decades that capture information and adaptively respond. However, there are two factors behind the truly transformational power of AI in today's society.

The first is the explosive growth in the amount of data from machines connected to what is known as the Internet of Things. Equipped with sensors, these devices can be deployed around a physical environment – such as a hospital, factory or farm – producing an information stream that is analysed and actioned in real time.

The second trend is the huge advances in computational power and processing speeds. Through machine learning, computers can quickly analyse patterns and trends in extremely large datasets. By building algorithms that continually refine and become smarter over time, they can learn and make decisions just like humans.

A major disruptor

PwC has forecast that global GDP will be up to 14% higher in 2030 due to the accelerating development and take-up of AI.

This is the equivalent of an additional $15.7 trillion in the world economy[1]. While the technology is still in its infancy, the possibilities for both disruption and competitive advantage in different industries are staggering.

For example, lawyers might use software powered by a form of AI known as natural language processing, detecting patterns in words to understand lengthy court judgments in seconds. Police might use complex image recognition technology to process security camera footage and identify a crime suspect. A supermarket retailer might place sensors on shelves to generate real-time data about how quickly food items are grabbed by customers. Combined with other inputs such as weather data, this can be used to accurately predict how much stock the supermarket will need the following week or month.

[1] PwC, Sizing the prize: What's the real value of AI for your business and how can you capitalise?, 2017

Explosive growth in health data

AI has limitless potential to similarly disrupt healthcare. This makes it vital for hospital administrators and front-line healthcare staff to explore potential investments. An extraordinary amount of healthcare data is now available, providing a basis for exciting AI applications. This includes population-level datasets, thousands of past and present patient case histories and real-time digital data from smartphones, medical wearable devices and other trackers (for example, those measuring a person's blood pressure, heart rate or sleep quality). Even data from supermarket purchases and citizen's social media interactions can be integrated to gain a more holistic picture of what affects the health of individuals and populations[2].

Computers are most comfortable with analysing structured data such as numbers when creating models and making predictions. However, a key challenge in healthcare is that as much as 80% of data is unstructured – including doctor's handwritten notes, prescriptions, the language contained in electronic medical records and clinical studies, as well as audio visual content such as CT scans[3]. Natural language processing and image recognition are therefore key tools to process and analyse unstructured data that is stored in different places and formats; and to combine it with structured data.

Potential healthcare scenarios

A key use case of AI in healthcare is early detection and diagnosis. AI allows computers to quickly identify small anomalies between an individual's health data and that of similar patients or the wider population. Machine-learning algorithms can analyse CT scans in a fraction of the time that it takes the human eye. This is useful in determining whether a patient is at greater risk of developing a disease or is already affected. We could soon reach a point where AI becomes better at diagnosing diseases than human doctors. This is not to suggest that we should substitute the judgment of data algorithms for doctors; however, it underlines the very real role that AI could play in supporting clinical decisions in future.

This includes determining the most effective treatment; for example, the medication and level of chemotherapy provided for a woman in her 50s with cervical cancer could be tailored based on successful outcomes for thousands of similar patients. Predictive models can also help doctors understand the likely course of a condition. For example, it is possible to identify patients who are at higher risk of unplanned hospital readmissions or secondary bloodstream infections; or those for whom imaging diagnostic tests such as mammograms tend to produce false positive results.

[2] Fagella, Where healthcare's big data actually comes from, 2018
[3] Huot, Big unstructured data's contribution to health care, 2015

Incorporating this new intelligence into healthcare systems benefits everyone. Patients gain a higher quality of clinical care – potentially the difference between life and death. Healthcare systems also run more efficiently and their capacity is optimised. For example, governments can use AI to better target healthcare spending to the geographic locations or demographic groups that need it. Equally, hospitals can confidently predict key performance measures such as patients' average length of stay and the number of emergency department presentations in a given week.

Workforce costs are a large component of any hospital budget. Many organisations have been forced to supplement their workforce with contractors to ensure sufficient clinical support at any given time.

As a result of AI, hospitals will gain newfound abilities to set accurate staffing levels, minimise downtime during maintenance and ensure sufficient stock of medical supplies. Further efficiencies are possible by automating administrative tasks – for example, using virtual assistants to interact with patients, or voice-to-text transcriptions to help order tests, prescribe medications and write case notes[4].

Key benefits of AI in healthcare

Governments and regulators

- **Gain** a better understanding of population healthcare characteristics
- **Target** more effective policy interventions
- **Lower** the average cost of service delivery

Management

- **Optimise** the use of hospital capacity to meet growing demand
- **Tailor** planning of nurse rosters and overall staffing levels
- **Create** efficiencies by shifting from manual to digital processes

Clinicians

- **Achieve** faster, more precise care based on real-time data
- **Obtain** a single digital view of each patient
- **Pursue** better collaboration opportunities

Patients

- **Improve** health through earlier detection and more accurate diagnosis and treatment
- **Increase** ability to access their own healthcare information
- **Gain** more autonomy over care with the help of digital devices

[4] Marr, How is AI used in healthcare – 5 powerful real-world examples that show the latest advances, 2018

Adopting AI: Why change?

There is a clear case for Australian governments and healthcare providers to embrace digital innovation.

An economic imperative

Using AI as part of a data-driven approach to healthcare offers three big opportunities. The first is achieving new excellence in service delivery. The second is meeting rising citizen expectations for personalised healthcare experiences. Finally, governments can design a more efficient system, lowering the per capita cost of managing a rapidly growing and ageing population. These are challenges faced to a great extent by many developed countries, including the United States (US), the United Kingdom, Canada and Germany.

Australia spent $180.7 billion on healthcare in 2016–17, equating to more than $7,400 per person and 10% of the nation's GDP. This is a significant increase on the $115 billion spent on healthcare in 2006–07, representing 8.5% of GDP. Federal, state and territory governments were the main drivers of the recent growth in spending.

Total government spending on healthcare grew by 6.8% in real terms in 2016–17, to $124 billion. This is well above the average growth rate for the previous five years of 2.6%[5].

A new focus on prevention and management of chronic conditions

Australia's healthcare system is far more cost-effective than those of nations such as the US. However, it is coming under pressure due to demographic, market and technological change. Federal health expenditure per person is projected to more than double over the next 40 years, with the largest growth area being Medicare services. By 2055, Australia will enjoy one of the world's longest life expectancies – 96.6 years for women and 95.1 for men. The number of people aged over 65 will have more than doubled from 3.1 million to 7 million. An estimated 900,000 Australians will have dementia by 2050 (nearly triple the number today), making it the nation's number one health-related expenditure[6]. Approximately 7 million Australians will suffer from arthritis[7], while the incidence of cancer and lifestyle-related diseases such as type 2 diabetes will significantly increase.

As an ageing population narrows the nation's tax base, government funding to Australia's healthcare sector is unlikely to keep up. Hospitals, GPs, allied health professionals, and aged care and disability service providers will all need to 'do more with less'. A major part of the solution will involve allowing elderly Australians to live in their own homes for as long as possible – potentially using wearable devices to monitor their own vital signs and seek telehealth services or in-person support as required. Yet healthcare consumers of all ages have rising expectations of providers – particularly Millennials, whose lives are mediated through the internet and personal devices.

The whole system will need to shift from crisis management and hospitalisation to wellness, prevention and management of chronic conditions in the community, likely using digital devices and apps.

[5] Australian Institute of Health and Welfare, Health expenditure Australia 2016–17
[6] Australian Institute of Health and Welfare, Australia's health 2014
[7] Arthritis and Osteoporosis NSW

Connecting healthcare – from hospital to home

Digital innovation will be crucial in connecting these different spheres of care. The potential exists to create a centralised warehouse of data on which healthcare AI applications can be built, as patients generate their own digital health data streams, and government bureaucracies and hospitals transition their core patient administration and clinical IT systems to the cloud. This data warehouse will inform better-targeted policy interventions and front-line operations and decision making.

Australians are open to improving the patient experience through technology, judging by the take-up of telehealth and video-conferencing services in regional areas. According to a recent survey, more than 80% are comfortable with AI being used to diagnose common medical problems and interpret test results; 58% say AI is a major step towards earlier disease detection and reduced incidence of death; 57% think it will result in approved accuracy; and 53% think it will keep long-term hospital patients comfortable at home[8].

[8] HCF, *Aussies ready to embrace artificial intelligence in health care,* 2017

Healthcare AI in action

There are many promising early examples of AI in healthcare in Australia and around the world.

Australian examples

Delivering supply chain efficiencies at hospitals through automation

A large Australian health provider is working with PwC to improve the efficiency and service levels of its medical consumables supply chain. The aim is to deliver the right products to the right locations, in the right quantities and at the right time.

A clustering algorithm was developed, categorising over 7,000 wards into seven "buckets" based on their individual weekly purchasing behaviours. A forecasting algorithm was developed that showed that over 70% of orders could be automated with 7 days' worth of safety stock. It is expected that the shift to automated ordering in locations with stable weekly product mixes will improve accuracy and lead to better demand management once supporting processes are well-established.

Converting electronic health records to structured data[9]

The Australian e-Health Research Centre is developing advanced natural language processing, information retrieval and machine-learning techniques to make unstructured free-text health data computable and ready for use in AI applications.

The reporting of cancer cases to cancer registries is one area of Australia's health system that remains paper-based. Manual processing means that statistics about cancer incidence are often outdated. The Centre, in partnership with Queensland Health, is extracting information from the free-text contents of pathology reports. This is allowing the establishment of a real-time cancer registry that processes pathology reports on a nightly basis and provides cancer incidence data to help inform activities such as cancer monitoring, health service planning and research.

Forecasting demand at hospitals[10]

The Queensland Government is using the CSIRO's Patient Admission Prediction Tool (PAPT) to forecast the demand on hospital resources and cut patient waiting times at 27 major hospitals across the state. The software analyses historical data to predict, with around 90% accuracy, how many patients will present at emergency departments and when. The tool also predicts a patient's medical needs and urgency of care, and how many patients will be admitted or discharged.

Hospitals benefit via the improved availability of beds, better staff resourcing and more efficient scheduling of elective surgery. Patients benefit from faster delivery of emergency care, better quality of care and reduced time spent in hospital. It has been estimated that the system could deliver efficiencies of $23 million per year if implemented across Australia's health system.

[9] The Australian e-Health Research Centre, Annual Report 2016/17
[10] CSIRO, Annual Report 2012¬13

Developing an AI solution to reduce unplanned hospital readmissions[11]

AI Australia is a Brisbane-based company that has been working with a rural health district in NSW experiencing high rates of unplanned hospital readmissions, which require enormous financial and staffing resources to manage. The hospital wanted an AI solution to automatically detect patients with a high risk of readmission.

AI Australia integrated more than a decade of electronic medical records to create an AI-powered machine learning model, taking into account characteristics such as patient demographics, case histories and treatment results during admission. The model has shown 70% accuracy in identifying patients who had an unexpected readmission within 28 days. This information is being used to help doctors and clinicians make real-time decisions that improve care quality.

Testing diabetic patients to predict eye disorders[12]

The CSIRO has developed new AI-powered technology that enables GPs to test diabetic patients for diabetic retinopathy. This debilitating condition affects one in three diabetic people and can lead to blindness if untreated. Previously, only specialists could screen for the condition.

The TeleMedC eye screening test was successfully trialled at the GP Superclinic at Midland Railway Workshops in Perth.

The technology, which uses images of the eyes and clinical risk factors to make its diagnosis, was found to be as effective as an ophthalmologist at detecting signs of diabetic retinopathy and grading its severity. GPs using the technology will be able to screen patients for signs of the condition and its severity, and refer them to an ophthalmologist for further investigation, prioritised by the severity of their symptoms. Plans have been established to extend the system to a further 20 GP clinics in Western Australia.

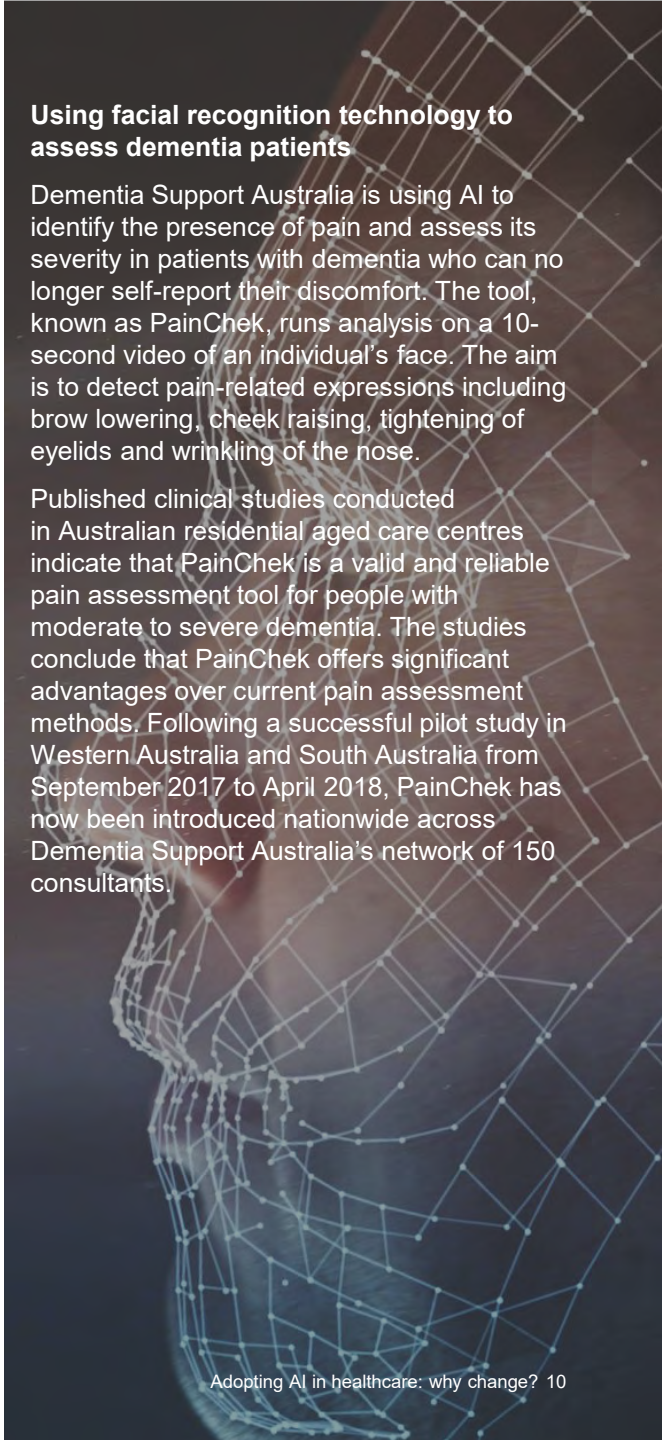
Using CT scans to predict mortality[13]

Researchers at the University of Adelaide have designed a computer program to predict with 70% accuracy which of 48 patients would die within five years, based on images of their organs.

The technology uses deep learning, a subset of AI, to recognise complex imaging appearances on CT scans. It calculates the brightness of pixels on each photograph and assigns the pixel a numerical value, enabling a pattern to be analysed across those numbers. Important factors such as the patients' age, gender and genomics were excluded from the research to ensure the results were based solely on image analysis.

The researchers believe the technology has the potential to allow early diagnosis of conditions such as heart disease.

[11] AI Australia, *Machine learning prediction of admission within 28 days*
[12] CSIRO, *AI technology to help prevent blindness*, 2017
[13] The Lead, *Artificial intelligence to predict patient death*, 2017



Using facial recognition technology to assess dementia patients

Dementia Support Australia is using AI to identify the presence of pain and assess its severity in patients with dementia who can no longer self-report their discomfort. The tool, known as PainChek, runs analysis on a 10-second video of an individual's face. The aim is to detect pain-related expressions including brow lowering, cheek raising, tightening of eyelids and wrinkling of the nose.

Published clinical studies conducted in Australian residential aged care centres indicate that PainChek is a valid and reliable pain assessment tool for people with moderate to severe dementia. The studies conclude that PainChek offers significant advantages over current pain assessment methods. Following a successful pilot study in Western Australia and South Australia from September 2017 to April 2018, PainChek has now been introduced nationwide across Dementia Support Australia's network of 150 consultants.

International examples

Using 'virtual nurses' to monitor patients[14]

Leading healthcare providers including the National Health Service (NHS) in the UK have trialled an AI-powered app, developed by US-based company Sense.ly, to monitor post-operative patients and those living with chronic illnesses.

Featuring virtual nurse 'Molly', the app can check in with patients, answer their health questions and pull data from a range of devices that patients use. The data is then rolled into a medical record that can be accessed by healthcare professionals. The app also responds to patients' moods and can pick up when they're experiencing feelings of depression or anxiety as a side effect of medication or lifestyle changes.

The Harvard Business Review estimates that virtual health assistants could save US$20 billion annually by reducing the time nurses spend communicating with patients by 20%.

Diagnosing debilitating eye conditions in seconds[15]

Google's DeepMind has partnered with leading eye health provider Moorfields Eye Hospital NHS Foundation Trust in the UK to develop AI technology that can detect three of the most widely recognised eye problems within seconds. The platform's algorithm can recognise indications of glaucoma, age-related macular degeneration and diabetic retinopathy in 3D retinal scans, prioritising patients in urgent need of care.

Currently, eye-care professionals use optical coherence tomography scans to help diagnose the eye conditions. However, the number of scans that clinicians have to perform can result in long delays in diagnosing and treating these eye conditions. Clinical studies suggest the technology is 94% accurate, on par with the accuracy of clinicians at Moorfields Eye Hospital who have more than 20 years' experience.

Streamlining drug discovery and drug repurposing processes[16]

Pharmaceutical companies are increasingly looking to AI to help make the drug discovery and drug repurposing process more efficient. The goal is to cut the time it takes to launch a new drug on the market and the cost of developing it. Patients will also benefit from lower prices. Pharma.AI, the Pharmaceutical Artificial Intelligence division of US-based Insilico Medicine, is working on drug discovery programmes for cancer, Parkinson's disease, Alzheimer's disease and other age-related health issues.

Reviewing mammograms faster, with fewer errors[17]

Researchers at Houston Methodist Research Institute in Texas have developed AI software that interprets mammograms and patient data 30 times faster, with 99% accuracy. Clinicians have used results, such as the presence of tumour proteins, to accurately predict the probability of a patient receiving a breast cancer diagnosis. The technology reduces the need for unnecessary biopsies, as well as the emotional stress of a misdiagnosis.

A Danish study published in *The Annals of Medicine* found that nearly one-third of women diagnosed with cancer after undergoing a mammogram later discovered their tumours were either not malignant or did not require immediate treatment.

[14] Kalis, Collier, Fu,*10 Promising AI Applications in Health Care*, 2018
[15] Moorfields Eye Hospital NHS Foundation Trust
[16] PwC, *What doctor? Why AI and robotics will define New Health,* 2017
[17] Houston Methodist, *Artificial intelligence expedites breast cancer risk prediction*, 2016

Critical success factors

While adopting AI may seem complicated, there are simple steps that organisations can take to maximise their chances of success.

Go to the cloud

This is an exciting but daunting time for Australia's healthcare providers, with our system already building the foundations required to support AI.

General practitioners (GPs) are migrating their practice systems to the cloud. Along with hospitals, they are gradually implementing electronic medical records, although much information still remains locked in documents. The Australian Government has established My Health Record, providing all Australians with a digital health record unless they opt out.

The benefit of moving to the cloud is that organisations can focus on what they are good at – delivering care – while being liberated from having to maintain old, expensive computing infrastructure and software. Of course, the cloud offers more than just an efficient IT outsourcing or data storage solution.

Rather, it creates a foundation for centralising data and, with appropriate patient consent, building advanced applications in AI and robotics.

Optimise and analyse data

An AI tool is only as good as the data that it uses for decision making. Accordingly, organisations need a comprehensive plan to collect, optimise and analyse healthcare data. They should also develop an ethical and privacy framework to govern its use. Sources of data could include electronic medical records; information from pharmacists and health insurance providers; readings from medical devices, apps and sensors that are connected to the Internet of Things; and other unstructured forms such as clinical notes and social media posts.

Organisations need to consider what solutions are available to collect, clean, validate, standardise, link, enrich, analyse and visualise data. They should also collect data in a way that allows it to be integrated with other relevant systems and answer key clinical questions.

Collaborate and scale

The shift to digital records creates new opportunities for partnerships and data-sharing.

Adopting AI will not be successful if governments and healthcare providers attempt to go it alone.

Collaboration must be pursued with an entire ecosystem of start-ups, technology partners, experts and researchers who are given accessto data in a secure environment in order to experiment, innovate and drive progress.

Human touch and leadership

Above all, the adoption of AI into Australia's healthcare system requires the shedding of legacy thinking. Moving from a reactive healthcare system that treats patients at the point of crisis to one that is proactive, preventative and focused on ongoing wellness requires the coordination of infrastructure, platforms, devices, data and personnel. To embrace AI, healthcare leaders must understand technology, be capable of using it, and create a culture that supports it, by bringing the entire healthcare workforce along on the process.

Everyone, from doctors to nurses and support staff, need to accept that physical healthcare environments will change, and they must embrace new skills and ways of working. At the same time, healthcare will always require a human touch. Those incorporating AI should never lose sight of the fact that technology best supports human capabilities, rather than replaces them, and that compassion, intuition and emotional intelligence will remain pillars of true healthcare[18].

[18] PwC, *AI and Robotics Roadmap, Interview with Hamish Clark, PwC Middle East Partner*

PwC contacts

National Health Analytics Leader

Emily Prior
Partner
emily.prior@pwc.com

Emma McKeown
Director, Health Analytics
emma.mckeown@pwc.com

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