Australian
Academy *of* Health and
Medical Sciences

Artificial Intelligence in Health: Exploring the Opportunities and Challenges

Report from a Roundtable Meeting

June 2020

EXECUTIVE SUMMARY

Health systems globally are facing increasingly challenging circumstances. Populations are growing, and more individuals live with complex arrays of chronic conditions. In this context, nations are constantly seeking greater efficiency and effectiveness – with the primary goal of care shifting to the prevention of ill health wherever possible.

These challenges are not new. But they are also not going away, and health systems are increasingly looking to technology for answers. Artificial Intelligence (AI) has the potential to amplify our technological capabilities in health – indeed, a recent report from the Australian Council of Learned Academies (ACOLA) concluded that AI is likely to affect the future of every sector.[1]

In health, AI technologies bring the potential to deliver better prediction, prevention, diagnosis and management of diseases, improvement of services to tackle future health challenges. There are risks and challenges, of course, such as the validation of AI technologies, the potential malevolent use of AI, data security or manipulation, or misdiagnosis leading to sub-optimal care. Furthermore, in health, things are not straightforward and in many cases, and the outcomes associated with using an AI in one context could be precisely the opposite in another. For instance:

- AI technologies could potentially **reduce stressful workloads** for clinicians by delivering some aspects of care; but in some fields the technologies could **increase stress levels** for particular specialists, for instance where their caseloads increasingly focus only on the most complex patients.
- Some uses of AI might deliver efficiencies that **lower the costs of care**, but others **could increase costs** due to the extra demands on resources and infrastructure.
- AI technologies could provide more geographical flexibility and access to services, resulting in greater choice for patients, who consequently feel **better informed and empowered**. However, for others, choice could bring unwanted complexity, and the comprehensive health analysis and predictions made by AI-driven technologies could bring an unwelcome awareness of their future health – all of which could cause **anxiety and potentially exacerbate mental health issues.**
- There is also likely to be a dichotomy between **those who feel confident and reassured** by the use of AI technologies in their healthcare and **those who feel uncertain or even fearful** about this prospect.

Careful consideration and deliberation are therefore required as we look to navigate this complex landscape and **we need to act promptly because decisions now will determine the pathway for an ethical, equitable and responsible future for AI development and implementation in Australia. We need to determine not only the problems that AI *can* solve, but the problems it *should* solve** in health, and use this to guide responsible development and deployment. This will depend on:

- How well we can solve a problem through our existing means – more intractable problems may lend themselves more to AI solutions.
- Whether the AI is seen as acceptable, for example in terms of ethics, safety and cost.

Deliberation should explore attitudes within the health system, including those of patients and publics, and it would be timely to do so now. At present, AI technologies have relatively narrow applications in health, meaning they can perform a single task (or a small number of tasks) very well. This can enhance health professionals' capacities and abilities, but the usefulness of technology is limited, and this will remain the case for the foreseeable future. However, when AI technologies start to be used in combination – with other AIs or technologies – we will potentially enter a new era in the way healthcare is organised and delivered. We therefore have an excellent opportunity, while technologies still have narrow applications, to consider what we as a society would like that to look like and make some informed decisions about how we should proceed.

[1] Walsh, T., Levy, N., Bell, G., Elliott, A., Maclaurin, J., Mareels, I.M.Y., Wood, F.M., (2019) *The effective and ethical development of artificial intelligence: An opportunity to improve our wellbeing*. Report for the Australian Council of Learned Academies, www.acola.org

The successful use of AI in health will also depend on our readiness as a nation to develop and use it. Australia, and its health sector, is currently at a critical point, where a strategic approach to technological infrastructure, workforce development, and investment will determine our ability to responsibly and effectively harness AI for the benefit of patients and the health system.

Strategic investment now could also help Australia make its mark in the global AI landscape and reap the economic benefits associated with this kind of innovation. We must look to:

- **Build capacity and expertise in the health workforce** so that they can make best use of AI technologies, including developing digital skills among health professionals.
- **Build technical and workforce capacity to generate, store and analyse the large volumes of high-quality data** that are required to drive the implementation of AI in the health sector.
- **Invest in a technical workforce that is able to drive the AI development of Australia** and avoid losing talent overseas to international markets such as the Silicon Valley.
- **Foster health-related academic AI research in Australia** to cultivate an innovative research landscape beyond only the private sector.
- **Strategically invest in AI research for health purposes** by creating agile funding structures that facilitate cross-disciplinary research between AI and the health sector and avoid a scenario in which this kind of research falls into the gaps between funding agencies.
- **Further enhance the Australian translational context** to enable a productive health-related AI sector.
- **Facilitate patient and public involvement** to help inform responsible development and implementation of AI in the health sector.

Overall, the current health care model will need to adapt to the technological changes and their impact on healthcare delivery, if we are to successfully harness the potential value of intelligent health technologies.

To safely guide the implementation of AI-driven technologies in Australia, **appropriate regulation that enables innovation** is needed to assure that all AI-driven technologies are used to the benefit of patients and in the publics' interests. Beyond this, regulation and guidelines will help develop **appropriate standards that meet the technical, data security and ethical requirements of the Australian health sector.**

INTRODUCTION

Artificial Intelligence (AI) is transforming the health sector. With increasing levels of sophistication, AI technologies bring the potential to improve the prediction, prevention, diagnosis and management of diseases – through computer-based classification algorithms that are at least as accurate as the average human clinician in the same areas. AI also promises to help the healthcare sector improve services and manage future challenges, such as the ageing population, by offering personalised treatment and self-management solutions.

A recent analysis by the Australian Institute for Machine Learning warns that Australia may be falling behind in the global race for AI if investment is not boosted soon.[2] Their analysis shows that Australia invests 0.001% of its GDP in AI and machine learning – well behind comparable nations such as South Korea, Singapore, France, Germany and Japan, which invest between 0.011% and 0.026% of their GDP in these fields. AI has the potential to increase Australia's productivity by around 40%, however the challenge remains that two-thirds of Australian organisations have difficulties finding suitable staff with the skills to progress the integration of AI.[3] Potential benefits for Australia's health sector go beyond only productivity, since AI technologies may offer a whole range of opportunities to improve prevention and care. However, as with any emerging or disruptive technology, there are potential risks and challenges that we must carefully consider. For Australia to leverage these new opportunities in a responsible and ethical way, and to make its own mark in the AI industry, strategic planning and investment are key, as highlighted by ACOLA in its July 2019 report.[4]

To explore how Australia might navigate these complexities in the health sector, the Academy hosted a roundtable meeting on 5 July 2019, as part of our 'Shaping the Future' series. The meeting facilitated a cross-disciplinary discussion to analyse and explore the current status of AI in health, and to consider lessons that might be learned from medical specialities that are already active in developing and implementing AI. A full agenda is attached in Appendix A.

The roundtable was attended by 34 participants from health, technology, academia, industry and government. A full list of attendees is attached in Appendix B. The discussion was informed by a background paper including several case study examples from dermatology, ophthalmology, genomics, neurology and radiology. These fields were chosen because they are already seeing AI technologies emerge that can assist with detection and diagnosis, for example through medical image analysis and pattern recognition. Participants were asked to identify benefits, opportunities, risks and challenges associated with the use of AI tools and technologies in health, and then to rank each one in terms of importance and likelihood.

This report outlines the roundtable discussions. Section 1 introduces AI, and sections 2 and 3 then consider the potential benefits and opportunities of AI, following by the associated risks and challenges. We conclude by identifying next steps and considering the associated key stakeholders.

The roundtable meeting was kindly hosted by Findex and we are most grateful for their generous support in making the meeting possible.

FINDEX

[2] Australian Institute for Machine Learning (2019). *Media release: Australia Falling behind in Intelligence Race*. 2019 May 15. Available from: https://www.adelaide.edu.au/aiml/system/files/media/documents/2019-05/AIML%20final%20release.pdf

[3] Australian Institute of Machine Learning (2018). *Discussion paper: The Impact of AI on the Future of Work and Workers*. Senate Submission to Select Committee on the Future of Work and Workers Submission 152.

[4] Walsh, T., Levy, N., Bell, G., Elliott, A., Maclaurin, J., Mareels, I.M.Y., Wood, F.M., (2019) *The effective and ethical development of artificial intelligence: An opportunity to improve our wellbeing*. Report for the Australian Council of Learned Academies, www.acola.org

1. WHAT IS AI?

The term Artificial Intelligence (AI) was first coined by Professor John McCarthy in 1955 and is today understood to refer to computer methods that learn, extract information, predict, or provide insight from data.

Although there is no unified definition of AI, insights can be drawn from the various definitions and the term generally refers to computer technologies that resemble processes connected to human intelligence, such as reasoning, learning, adaptation, memory, sensory perception and interaction. In its recent horizon scanning report, 'the Effective and Ethical Development of Artificial Intelligence: An Opportunity to Improve our Wellbeing', ACOLA defined AI as 'a collection of interrelated technologies used to solve problems that would otherwise require human cognition'.[5] Machine learning, deep learning, natural language processing, speech recognition, vision and robotics are all part of today's AI toolkit.

AI technologies offer promising solutions that could revolutionise health technology and delivery – if developed and deployed responsibly. AI in health may not only improve the prediction, diagnosis, treatment and management of diseases but could also help the healthcare sector improve services and manage future challenges such as the ageing population and the rise of multimorbidity by offering personalised treatment and self-management solutions. AI technologies can also help patients actively self-monitor their health while providing health professionals with insights into patients' health status and risk factors, and then through predictive analytics – provide personalised treatments.

[5] Walsh, T., Levy, N., Bell, G., Elliott, A., Maclaurin, J., Mareels, I.M.Y., Wood, F.M., (2019) *The effective and ethical development of artificial intelligence: An opportunity to improve our wellbeing*. Report for the Australian Council of Learned Academies, www.acola.org

2. BENEFITS AND OPPORTUNITIES

Intelligent health technologies that make use of AI potentially bring a range of benefits and opportunities that could add value to the Australian health system in several ways are, summarised in this section. Roundtable participants were asked to consider both the potential importance and likelihood of these kinds of outcomes.

The complexity of developing and using AI technologies in health is evident throughout this section. We see that in many cases, the benefits and opportunities identified may also have a flip side – where they could also present a risk or a challenge, perhaps because the likely outcomes are not yet clear or because there is the potential for either outcome to emerge, depending on the choices we make.

To reap the sorts of outcomes summarised in this chapter, risks and challenges must carefully be considered, explored and addressed to ensure the safe, equitable and ethical implementation of AI technologies in health. These points are explored in the next section, which should be read closely alongside this one.

Opportunities to improve health outcomes and patient care

Participants identified a range of potential opportunities to improve health outcomes using AI. Some of the most important and most likely opportunities identified by participants include:

- Enhanced **clinical decision-making**, for example where diagnosis and disease management plans are supported and improved by AI tools. We are already seeing AI providing this kind of diagnostic support in cognitive image-driven specialties, such as radiology, surgical pathology, ophthalmology and dermatology where the AI may be able to find new patterns or spot abnormalities not visible to the human eye. Some examples from these image-driven specialties are provided in Box 1.
- This high diagnostic value potentially enables **better patient triaging** to facilitate a faster assessment of the severity of a patients' conditions and the appropriate treatment. This could not only improve health outcomes but also deliver health system efficiencies.
- Armed with clinical, pathological and genetic data we can also **improve risk prediction** and therefore drive population health outcomes by enabling better informed **prevention efforts and behaviour**.

Another area of promise relates to **clinical trials**. As interventions such as new drugs become more targeted at smaller patient populations, the power of AI to identify potential trial participants could make trials more efficient and deliver these new interventions to the right patients more quickly. Similarly, using AI when analysing trial results could enhance the level of insight that can be achieved from the results and **add breadth to research by generating new levels of analysis through the application of new and advanced tools.** Likewise, **adverse events** can be identified more quickly, and potentially **harmful incidents reduced**. One of the case studies, provided ahead of the roundtable, outlines that AI-driven tools are expected to impact neurology, specifically epileptology. The use of AI-driven tools in neurology will for example help interpret neuroimaging, genetics and other clinical data of individuals, providing decision guidance or predictive tools beyond that possible with current human evaluation.

Roundtable participants considered how patients would perceive this increased technological component to their care – agreeing that there will not be a universal response. For example, for some, it may provide them with **greater confidence** in the accuracy of their diagnosis, prognosis or recommended treatment. This could in turn **increase compliance with treatment regimes**, supported for instance, by digital and AI-driven applications that offer medication reminders, mental health support or early detection of conditions such as melanoma – some of which are already available.[6] However, some patients may feel very uncomfortable with technology playing such a role in their care, which will need to be carefully considered – this is discussed further in the next section.

Though important, many participants felt that AI technologies might **not necessarily reduce waiting times** or the **workloads and stress levels** of health professionals – at least in the foreseeable future. Participants anticipated a

[6] For example, SkinVision which helps users check their skin for skin abnormalities such as melanoma. https://www.skinvision.com/

complex impact in this regard, which make this sort of outcome less certain. For example, while AI is expected to help reduce inefficiencies, the implications for health professionals will vary, depending on factors such as their speciality or type of work. Likewise, it is uncertain whether AI will decrease or increase waiting times since some tools may increase rates of diagnosis and therefore the number of patients that require treatment and care. Combined with AI-driven patient triaging, health professionals could end up spending most of their time with the most complex cases that cannot be dealt with by an AI alone, potentially increasing their stress levels. These sorts of impacts may depend on the role of the health professional – clinical staff, in particular, may face more high-priority cases, especially in the early stages of AI implementation when prevention and early diagnosis have not yet had the chance to impact substantially on patient numbers.

Similarly, participants did not necessarily anticipate a significant increase in **contact time between clinicians and patients**, though this may again vary with specialty or role. A French study including 600 radiologists found AI did help improve patient contact time and some of the roundtable participants reported that they felt this could be an outcome.[7] This was also reflected in some of the case studies considered at the meeting, in which the image-based specialities such as ophthalmology and dermatology, further detailed in Box 1, could see potential improvements in patient-clinician contact with the help of AI-driven pre-screening of medical imaging. While this is interesting, as those are some of the specialities that are furthest progressed in implementing AI, participants generally agreed this kind of outcome will be complex and hard to predict, for many of the reasons described above. Governments, health systems and providers may face a choice regarding how they choose to combine AI alongside health professionals.

Although AI could facilitate a more joined-up health system, this was not seen as likely in the near future. There may also be an opportunity to enhance the capacity of health systems to manage current and emerging health challenges, such as the ageing population and the growing number of patients with multimorbidity, by triaging resources and improving workflows. Such outcomes will become more likely when technologies have developed to the point where they can start to be combined and integrated. Similar opportunities also stem, for instance, from the possibilities for personalised screening.

Box 1. The implementation of AI in ophthalmology and dermatology

The case studies provided ahead of the roundtable briefly summarised some areas in which AI is being implemented. For example:

In **ophthalmology**, AI has been applied to ocular imaging. A range of AI systems have shown clinically acceptable diagnostic performance in **detecting several retinal diseases**, such as diabetic retinopathy, retinopathy of prematurity, glaucoma, macular oedema and age-related macular degeneration. Major programs in AI systems by global technology companies, including **Google and IBM**, are leading the development of retinal image analysis. For example, **Google's DeepMind** partnered with Moorfields Eye Hospital in the UK to develop AI technology that can detect three of the most widely recognised eye problems within a few seconds.[8]

In **dermatology**, AI is used in the form of **convolutional neural networks (CNNs),** which provide a promising **diagnostic aid for skin cancer image classification**. There are already a few diagnostic CNNs in development that can accurately **predict the diagnostic category including malignancy of any given skin lesion**. This has the potential to revolutionise dermatology and a study from 2017 shows that the under certain test conditions the **diagnostic accuracy of AI-driven diagnosis through CNNs is comparable to professional dermatologists**.[9,10]

[7] Waymel, Q. *et al.* (2019). Impact of the rise of artificial intelligence in radiology: What do radiologists think? *Diagnostic and Interventional Imaging:* 100, 327—336.

[8] Ravindran, S (2019). How artificial intelligence is helping to prevent blindness: Machine learning is being used to automate the detection of eye diseases. *Nature*. Available from: https://www.nature.com/articles/d41586-019-01111-y

[9] Esteva, A. et al. (2017). Dermatologist-level classification of skin cancer with deep neural networks. Nature, 542(7639), 115.

[10] Tschandl, P. *et al.* (2019). Comparison of the accuracy of human readers versus machine-learning algorithms for pigmented skin lesion classification: an open, web-based, international, diagnostic study. *Lancet Oncol.* 2019 Jul;20(7):938-947.

Social and ethical implications

As outlined above, AI offers the promise of better health outcomes and patient care, and more efficient services. Deployed in the right way, AI could deliver such benefits with a **positive social impact**, which advances the health of all Australians. There is some concern that AI could reinforce existing systemic biases in healthcare, or introduce new ones, if technologies are developed using existing datasets where such biases exist. This is discussed further in relation to risks and challenges and most participants agree that the underpinning algorithms must be interrogated and examined to ensure that this is not the case – especially where the algorithms are developed using machine learning, in which the decision-making process may not be fully explainable. However, this kind of risk also brings opportunity – for example, AI technologies could be used to **reveal previously unknown biases** in current systems.[11] Stepping beyond this, AIs could in fact be re-engineered to **remove, or at least reduce, bias** – a process that is arguably more challenging in humans.

At a more routine level, more flexible delivery of health services using AI could enable better and more equal access to care across different locations, settings and with the right specialist. Participants felt that **wider geographical access to services** was likely to be a valuable outcome of AI in health, which is highly relevant to the Australian context. For instance, individuals in rural and remote areas could have better access to specialist advice.

AI technologies may also help **democratise healthcare** by offering the public a greater involvement in their own care, for example, through lower screening costs that allow patients to make a more informed choice about their health. Furthermore, advancement in AI and digital technologies may improve health literacy, foster a broader **culture of innovation** and provide a technological infrastructure that in return can benefit society more broadly.

Financial impact and infrastructure costs

AI technologies can already perform beyond human capability in some areas.[12] For instance, roundtable participants considered developments in radiology and areas of oncology that offer better cancer prediction, survival and response to treatment. Combining image analysis with other human factors such as genomics may offer additional opportunities. Furthermore, AI in radiology and other disciplines has the potential to reduce workloads by acting as first or second screeners and readers, triaging and quantification of specific pathologic findings, such as tumour volume.

Participants agreed that there may be a number of financial benefits on offer from the use of AI – of particular importance opportunities related to:

- **Reduce unnecessary and ineffective treatments by improving clinical accuracy and better targeting of health interventions**. Personalised datasets, in combination with big data sets, can help AI-driven applications make highly accurate personalised and population-specific recommendations.
- **Improve logistics and safety in healthcare delivery** through process optimisation for administrative tasks, early symptom detection and faster identification of required treatment or management approaches.

Additionally, the group agreed that it is important, and somewhat likely, that AI may add benefits to the health sector through **personalised prevention**, and by offering healthcare solutions, tailored to the needs of individuals. Beyond this, there was also agreement that AI technologies can improve efficiency around resource targeting and deployment, healthcare delivery, and lower productivity and infrastructure costs.

The development and implementation of AI technologies in health can also help create a range of short-term and long-term **benefits for the Australian economy and research landscape**. The creation of new economies and the ability to attract new stakeholders and investors in the Australian health sector was seen as a valuable

[11] McKinsey Global Institute (2019). Tackling bias in artificial intelligence (and in humans). Available from: https://www.mckinsey.com/featured-insights/artificial-intelligence/tackling-bias-in-artificial-intelligence-and-in-humans?_lrsc=6a0e26df-3dfa-4368-9934-5840c21e8719

[12] Harwich, E & Laycock, K (2018) *Thinking on its own: AI in the NHS.* Reform. Available from: https://www.wiltonpark.org.uk/wp-content/uploads/Thinking-on-its-own-AI-in-the-NHS.pdf

opportunity, on which we must act to ensure that we do not lose out to competitors. Participants saw significant potential for AI to deliver economic benefits in terms of national income – if we choose to do so.

Participants were not convinced that AI would necessarily lead to lower **infrastructure costs**. This could be due to remaining uncertainties around the impact AI on the health sector and the cost for the digital infrastructure that is required to support AI technology. Although AI can help improve inefficiencies, and potentially lower costs by saving time, it is unknown if this would outweigh the costs required to build and maintain the kind of secure and well-functioning technological infrastructure required for AI.

The roundtable group agreed that AI offers the opportunity to improve efficiencies in the health system and to potentially offer greater continuity of care for patients.

Research and innovation

Research and innovation drive economic growth, create jobs and bring considerable societal benefits through the translation of research findings. [13,14] Australia has a world-class medical research sector which returns $3.90 for every $1 dollar spent on health and medical research.[15]

AI and other digital technologies offer Australia the opportunity to advance research, innovation and health delivery, which may bring not only economic benefits but also build our profile as an innovation leader in health.

The Australian federal government's 2018-19 budget allocated $29.9 million to strengthen Australia's capability in AI and machine learning over four years. The measures outlined in the budget include the development of a technology roadmap and framework for standards and AI ethics. However, there have been calls for this kind of investment to better match that of our potential competitor countries. AI technology is already disrupting the world's economy. It is forecast that the global GDP will be up to 14% higher in 2030 due to the accelerating development and take-up of AI across sectors, contributing up to $USD 15.7 trillion to the global GDP by 2030.[16]

Australia can leverage new opportunities to make its own mark in AI research and innovation by:

- Improving investment in health-related AI to **keep up with progress internationally**.
- **Retaining technical talent and intellectual property** within Australia.
- **Investing in a skilled workforce and offering an incentive for individuals to remain in Australia** to avoid a brain-drain to international markets such as the Silicon Valley.
- **Encouraging international AI talent** to come to Australia.
- **Fostering health-related academic AI research** and development to increase the breadth and depth of research in health-related AI fields.
- **Developing clinical-grade AI** that meets the safety standards of the Australian health sector.

Many of these points apply to AI very broadly, including in the health context.

[13] World Intellectual Property Organization (2019). Global Innovation Index. Available from: https://www.globalinnovationindex.org/analysis-indicator

[14] Australian Academy of Health and Medical Sciences (2019). Pre-election statement. Available from: https://aahms.org/policy/2019-federal-election-statement/

[15] KPMG/Association of Australian Medical Research Institutes (2018). Economic Impact of Medical Research. Available from: https://aamri.org.au/wp-content/uploads/2018/10/Economic-Impact-of-Medical-Research-full-report.pdf

[16] PwC (2019). Adopting AI in healthcare: Why change?. Available from: https://www.pwc.com.au/health/ai/pwc-adopting-ai-in-healthcare-why-change-19feb2019.pdf

3. RISKS AND CHALLENGES

Although intelligent health technologies present substantial opportunities and benefits, as with any new or disruptive technology there are risks and challenges that need to be carefully considered and addressed to ensure the safe, equitable and ethical use of AI technologies in health. As noted in the previous section, benefits and risks or opportunities and challenges are often two sides of the same coin and consequently, these two sections should be read alongside one another. Participants were again asked to consider both the importance and the likelihood of the risks and challenges identified.

The ethical use of technology and data

AI involves complex algorithms and intricate analytics. For clinicians, patients and the public, a common issue remains the so-called 'black box' challenge, in which the decisions of an AI cannot be explained. For the health sector, the black box issue remains a serious challenge as transparency and explainability remain key in the delivery of health services to maintain a trusting relationship between patients and health professionals. If a health professional cannot fully understand and explain the decision-making process of the AI, this could have a negative effect on with their relationship with their patients.

Beyond this, **ethical principles and guidelines need to be considered well in advance of implementation** to protect patient safety and maintain the high standards of healthcare and research in Australia. The Department of Industry, Innovation and Science, with the support of CSIRO Data 61, is currently developing a framework to provide guiding principles for the ethical use of AI in Australia.[17] These valuable principles will provide an overarching framework that will then need to be applied to individual sectors such as health. [18]

Participants discussed the impact of AI technology on the health sector. Some of the most important risks, which participants also deemed most likely, include:

- The use of **non-validated AI technologies** without clinical oversight, which could pose safety risks for patients and potentially erode trust in the health system. Furthermore, black box issues could make it difficult to follow up errors. Potential error caused by the AI may for instance raise liability issues regarding who is responsible for the action of the AI – the health professional or the developer of the AI technology.
- The potential **malevolent use** of AI could impact the security and privacy of patient data, which could in turn impact on patient safety. Furthermore, **data security** and **manipulation of data** can affect patients and the integrity of the health sector. While health data combined with genetic information can provide a basis for exceptionally accurate and targeted care, the poor management of these datasets has the potential to cause serious privacy issues. Careful thought is also needed regarding who can access sensitive data, which could potentially be used to discriminate against patients based on their current health profile or genetic predictions.
- **Misdiagnosis and lagging evidence due to the novelty of AI technologies in health** can lead to sub-optimal care, which can cause issues such as delays, unnecessary or ineffective treatments.
- **Public unaware of the use of their health data**. It is therefore important to support and build public understanding of their health data so that they are empowered to make decisions for their own benefit and also recognise how their data can contribute to research outputs and associated bias.

Participants emphasised the need for health professionals to **continuously assess and scrutinise the outputs of AI-driven tools**. As the reliance on AI and digital technologies grows, participants were somewhat concerned that health professionals may lose the ability to challenge recommendations put forward by an AI or to challenge the quality of the data used for training the AI. This issue would become increasingly difficult if patients begin to trust an AI-driven decision over that of a human. Currently, challenges remain in building **public trust and**

[17] Department of Industry, Innovation and Science and CSIRO Data 61 (2019). *Artificial Intelligence: Australia's Ethics Framework (A Discussion Paper).*

[18] The Academy responded to the consultation on the draft principles and our response can be read here: https://aahms.org/policy/artificial-intelligence-australias-ethics-framework-aahms-submission/

understanding of AI technologies.[19] For instance, patients may be unsure how AI will be used in their diagnosis, treatment or management of their condition. It is therefore vital to continuously engage with the public and patients to maintain trust and provide information to support the decision-making process. However, we must also **go beyond only this educational role by seeking to understand the aspirations and concerns of the public regarding the use of AI in health** (and beyond) – and we must do so from the outset, taking the time to discuss and respond to their perspectives. Opening a dialogue to consider these issues and understand these concerns would therefore be a beneficial exercise.

The implementation of AI technologies relies heavily on the input of data, consequentially a high level of **data security** will be crucial to protect public and patient privacy. Currently, individuals are often unaware of how their data is used and by whom. Participants agreed that the **use of patient data, and the associated consent**, need to be carefully considered, and this is not straightforward. For example, specialities such as ophthalmology and dermatology have already been considering how they can share data with their collaborators for legitimate research purposes without compromising privacy – and this requires careful thought, since medical images of a retina might in combination with other data points risk revealing identifiable information about a patient. In fact, the retina itself is so specific to an individual, that in future, it could potentially be identifiable on its own. These sorts of future challenges are being considered now by those communities to ensure that research endeavours are balanced with patient privacy. In the near future, it is likely that the Australian health sector will predominately be using **AI technologies developed by international or multinational companies**. The increased use of international technologies will require **appropriate regulation that enables innovation** which assure that these AI-driven technologies benefit patient and public interests, as well as the technical, data security and ethical requirements of Australia. Appropriate regulation will help address safety concern, privacy and liability issues, especially if the health data of Australians is analysed abroad.

Although deemed unlikely, participants also discussed the risk of AI implementation **eroding human values** in health, such as compassion and empathy. Intelligent health technologies could make the healthcare experience more abstract and there is also a risk that patients could increasingly be analysed through their data profile rather than the personal experience of their health status.

Impact on the public and patients

It is clear from the discussions at the roundtable (and elsewhere) that AI could have profound impacts on healthcare and health outcomes, in terms of potential opportunities to drive more efficient and targeted care, and in terms of the associated risks and challenges. It is therefore critical, as outlined above, that we engage and involve patients and the public as we progress – thereby cultivating a community that is empowered to make informed decisions about their own health. Participants highlighted several risks that demonstrate why this is so important, including:

- **Fragmentation and polarisation** in the community between those who can access AI technologies and those that cannot – for example due to affordability, technological capability or geography. Fragmentation may also occur between those in society who are comfortable with the use of AI technologies and those who are not, if there is no alternative available to this latter group.
- **Exacerbation of health inequalities** due to **unequal distribution of care**. Health inequalities may be caused by the uneven distribution of AI-driven care due to economic, socio-economic or geographic factors.
- Putting **minorities and vulnerable population groups** at a further disadvantage. Health inequalities caused by data biases, and the transfer of these biases into the AI algorithms, may have serious implications for population groups that already experience discrimination and marginalisation.
- **Low public engagement** in AI technologies could cause serious communication gaps in the understanding of patient and public needs, aspirations, expectations and concerns regarding the application of AI technologies in health.

[19] Walsh, T., Levy, N., Bell, G., Elliott, A., Maclaurin, J., Mareels, I.M.Y., Wood, F.M., (2019) *The effective and ethical development of artificial intelligence: An opportunity to improve our wellbeing*. Report for the Australian Council of Learned Academies, www.acola.org.

Many participants felt that the use of AI-driven technologies in health needs to be transparent so that patients can be informed if an AI-driven tool is involved at any level of their treatment. They agree that privacy issues regarding the **sharing and use of health data** need to be carefully considered if the data is used for the machine learning process.

AI-driven technologies can help patients be more informed about their health and help them make empowered and informed decisions. Participants, however, also discussed how greater patient empowerment may **exacerbate inequalities** in the health system since those who already experience disadvantage are also more likely to experience a barrier to their using these new technologies. Such divisions could result from the affordability for those who understand and make use of AI and those that do not. Beyond this, the increased use of AI in diagnosis and treatment may risk **inflating healthcare costs**, which could seriously affect patients, potentially exacerbate inequalities and decrease equity of access. Participants also discussed how the interaction with technology may lead to patients missing out on the interaction with health professionals, which may have implications for maintaining trust and explainability (although this is likely to vary between individuals). The digital changes through AI may cause a change in the fiduciary relationship, which represents the ethical and legal relationship between patients and doctors. This may, for instance, apply when the decision-making process involves an AI tool, although this was deemed less likely by participants.

Furthermore, participants considered the impact of AI on the patient's mental health. While some may embrace the opportunities and choices associated with the 'democratisation' of healthcare supported by AI, in which they can play a more active role, the sheer volume of information may have a negative impact on others, for instance leading to paralysis in decision making or exacerbating mental health issues associated with such decision-making. The insights provided by AI technologies must therefore be carefully considered, including their role in providing an in-depth picture of a patient's current and future health, which may be difficult to process without the support of a health professional.

Workforce and training

The implementation of AI is already having an impact on the workforce. According to a report from the Australian Council of Learned Academies, AI is likely to impact on particular tasks and processes rather than affect whole occupations, at least in the foreseeable future.[20] To meet the demands for a technically enabled health workforce in Australia, participants agreed that:

- More attention and resources need to be directed towards the **reskilling of health professionals** to prepare them for the digital future and assure patient safety.
- Changing roles and skills-needs of clinicians risk causing large **workforce gaps**, which need to be considered.
- Increased use of AI technologies in health risk causing **stress and burnout** among specialists due to the potential focus on complex cases in most need.
- Reliance on AI technology risks **reduce competence and deskilling of health professionals**.

Participants emphasised the needed for more resources, education and training to support workforce to curate data inputs in order to avoid data bias and for delivering more comprehensive patient protection in the increasingly digital and data-driven healthcare landscape. In a case study provided for the discussion at the roundtable, it was highlighted that the area of genomics faces the challenge regarding the significant costs for the multidisciplinary expertise which is required for the analysis of AI-powered research. A brief overview of the implementation of AI in genomics is provided in Box 2.

[20] Walsh, T., Levy, N., Bell, G., Elliott, A., Maclaurin, J., Mareels, I.M.Y., Wood, F.M., (2019) *The effective and ethical development of artificial intelligence: An opportunity to improve our wellbeing*. Report for the Australian Council of Learned Academies, www.acola.org.

Box 2. The implementation of AI in genomics

Roundtable participants considered cases studies in genomics, including two examples of areas in which machine learning is, or soon will be, having a positive impact:

- The recent development of novel algorithms to accurately **identify and catalogue all genetic variants of an individual from next-generation DNA sequencing data**. A leading example in this space is the accurate **DeepVariant** analysis pipeline developed by Google that makes use of a deep neural network to call genetic variants from raw sequence data.
- A perhaps more challenging problem space is machine learning **assisted variant curation**. Starting with the extensive catalogue of all genetic variants of an individual, it is a **challenging process to curate and prioritise each variant to identify the small subset of variants** that most likely to be contributing to a particular disorder. This is a complex process at present, requiring multidisciplinary teams of clinicians, bioinformaticians and clinical scientists to curate the data. Studies in this area are showing promising results, but more research is needed to make this a reality in the Australian healthcare context.[21]

Infrastructure and system challenges

As mentioned earlier in relation to the benefits and opportunities, Australia has the potential to create high-quality AI technology. However, the loss of intellectual property to international markets, such as Silicon Valley, make it difficult for Australia to build and retain its own AI sector. The loss of intellectual property and the import of overseas AI technology could mean that Australia becomes increasingly reliant on technology developed in another social, ethical, legal or geographical contexts. Moreover, this could also create liability and compliance issues should an AI malfunction or not perform as expected.

Participants identified several important and likely risks and challenges that may hinder Australia's technological development in the AI space if not addressed:

- Insufficient funding of AI infrastructure may inhibit Australia's ability to build and retain its **technical capacity** in this space.
- The **loss of intellectual property** may impede Australia's ability to make a mark in the international AI marketplace.
- The use of AI applications in health may require the system to prepare for **increased healthcare costs** in the short term, at least in some fields, although AI may ultimately reduce costs – at least for some aspects of care. However, it is unclear at this stage what the overarching impact will be here.
- Australia's current challenges in terms of **innovation and translation**, and the relatively low level of business expenditure on research and development present a challenge here because AI technologies are mostly developed by or in collaboration with industry.[22] Attracting industry to Australia not only brings translation and economic benefits, but also ensures we have a seat at the table in determining the nature of the technology itself – for example in terms of how data is used.
- The current **health care model will need to adapt to the technological changes** and their impact on healthcare delivery, if we are to harness successfully the potential value of intelligent health technologies.

Without a strategy and associated investment in health-related AI, we risk falling further behind our competitors a point that is also raised in the report from the Australian Council of Learned Academies.[23] Governments and business need to **invest in the technical infrastructure** to improve Australia's capacity to prepare for the digital future in the health sector and beyond. Participants also discussed that increased access to care and availability of AI-enabled screening may lead to **overservicing in the health sector**, which can result in unnecessary and costly treatments. However, the likelihood of these risks occurring was deemed relatively low.

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[21] Clark MM, *et al* (2019). Diagnosis of genetic diseases in seriously ill children by rapid whole-genome sequencing and automated phenotyping and interpretation. *Science Translational Medicine*, 2019: vol 11, Issue 498, eaat6177.

[22] Australian Academy of Health and Medical Sciences (2019). Pre-election statement.

[23] Walsh, T., Levy, N., Bell, G., Elliott, A., Maclaurin, J., Mareels, I.M.Y., Wood, F.M., (2019) *The effective and ethical development of artificial intelligence: An opportunity to improve our wellbeing*. Report for the Australian Council of Learned Academies, www.acola.org.

4. CONCLUSIONS AND NEXT STEPS

There are several issues to consider regarding the implementation of AI in Health in Australia. Firstly, there is a need to address questions on how health-related AI research should be funded here. Research into AI applications in health currently sits between multiple agencies, stakeholders and funding areas, which can restrict the funding options available to health and medical researchers pursuing AI related research, and also the reverse – i.e. AI or other non-clinical researchers pursuing research funding for health-related AI research. **There is an urgent need for more agile funding structures that facilitate cross-disciplinary research between AI and the health sector**. Greater flexibility or an overarching strategic approach would enable a more responsive funding environment for this kind of multidisciplinary field.

Furthermore, increased investment will require a better understanding of how Australian companies and international companies can be encouraged to invest more in AI-related R&D.

For AI technology development to thrive in Australia, appropriate legislation and regulation need to allow for the development of AI in health to generate benefit on a national and international level. To assure the safe, equitable and ethical use of AI technologies, more clarity is required as to how health-related data should be shared and accesses to maximise the potential benefit of AI in health.

Stakeholders such as clinicians, researchers and academia in health and technology are crucial in driving innovation of AI in health in Australia. In its Horizon Scanning report on AI, the Australian Council of Learned Academies highlighted that the 'effective regulation and governance of AI technologies will require involvement of, and work by, all thought-leaders and decisionmakers and will need to include the participation of the public, communities and stakeholders directly impacted by the changes.' [24] To enable the implementation of AI and to support the development of a digital infrastructure**, government, industry and healthcare providers are all key stakeholders in supporting Australia's AI landscape** and play a crucial role in creating and maintaining a technologically enabled workforce that can drive innovation in AI in Australia. As previously mentioned, the fostering and retaining a technically enabled workforce, and the building of a strong AI technology sector, will require appropriate investment to allow Australia to compete with other markets and retain its intellectual property. **Healthcare will benefit from an increasingly data literate workforce** and good data analysis will be critical for the improvement of clinical decision making, innovation and improvement of care, resource allocation and process management, patient flows and the implementation of innovative tools to benefit patients. There is however a **need to better identify the skillsets health professionals, working with AI in health and digital health, need to have.**

From a health system perspective, there is a need for a **clearer formulation of an Australian health plan which specifies how AI-driven digital health can contribute to the national health strategy.** Additionally, the health sector needs to better understand which health issues to best address through AI and what the infrastructure of the health sector, including health care and research, needs to look like to support the development and implementation of AI in health. The **general public is a key stakeholder** here that needs to be heard, considered and informed so that AI-driven technologies are able to add the most benefit to patients and the public. Beyond this, prerequisites and enablers need to be understood so that AI-driven technologies can improve the patient and consumer journey.

There is an **opportunity to engage the public in dialogue around** the use of AI in health. A dialogue with the public would help:

- **Understand the publics concerns and apprehensions** towards the implementation of AI technologies in the health sector.
- **Identify the publics expectations on their health system** to better inform the areas for the use of AI in Australia and to target the use of AI to help meet these expectations.

[24] Walsh, T., Levy, N., Bell, G., Elliott, A., Maclaurin, J., Mareels, I.M.Y., Wood, F.M., (2019) *The effective and ethical development of artificial intelligence: An opportunity to improve our wellbeing*. Report for the Australian Council of Learned Academies, www.acola.org

All of these prospects are not without risk and there will be challenges that need careful consideration as the community progresses as capturing the benefits and opportunities on offer depends on the choices made in relation to those risks and challenges.

APPENDIX A: AGENDA

Time	Session	Session lead
9:30	*Tea and coffee on arrival*	
10:00	**Welcome from AAHMS**	Prof Ian Frazer
10:15	**Introduction to the day's activities**	Dr Donna Cohen
10:20	**AI applications in health: Case studies** ▪ Review each case study and incorporate input from participants ▪ Identify any benefits, risks, opportunities and challenges not covered by these case studies ▪ Rate/rank each benefit/risk/opportunity/challenge in terms of *importance* and *likelihood*	Group discussion
12:15	*Lunch*	
12:45	**Optimising the use of AI** ▪ What is needed to improve the likelihood of the most important benefits and opportunities? ▪ What is needed to make the biggest risks less likely? ▪ What is needed to address the biggest challenges?	Group discussion
14:00	**Key policy issues that need to be addressed** ▪ What are the most pressing policy issues? ▪ Who are the key stakeholders and how should they be engaged in the development of policy?	Group discussion
14:45	**Concluding remarks and next steps**	Prof Enrico Coiera
15:00	**Close**	

APPENDIX B: PARTICIPANTS LIST

- **Associate Professor David Abbott**, Laboratory Head, Epilepsy Neuroinformatics, The Florey Institute of Neuroscience and Mental Health
- **Professor Tim Baldwin**, Director, ARC Centre in Cognitive Computing for Medical Technologies, The University of Melbourne
- **Dr Fern Beavis**, Policy Analyst, Australian Academy of Technology and Engineering
- **Professor Jeffrey Braithwaite FAHMS**, Founding Director, Australian Institute of Health Innovation, Macquarie University
- **Professor John Christodoulou AM FAHMS**, Director, Genetics Research Theme, Murdoch Children's Research Institute
- **Professor Enrico Coiera FAHMS**, Director, Centre for Health Informatics, Australian Institute of Health Innovation, Macquarie University
- **Dr Michael Costello**, *Former General Manager, Innovation and Gateway Services Healthdirect Australia*
- **Professor Barry Drake**, Industry Professor, Digital Health Cooperative Research Centre
- **Katrin Forslund**, Policy and Projects Officer, Australian Academy of Health and Medical Sciences
- **Professor Ian Frazer AC FRS FAA FTSE FAHMS**, President, Australian Academy of Health and Medical Sciences
- **Rachel Frost**, Manager, Strategy Section, Technology Strategy and Policy Branch, Strategic Policy Division, Department of Industry, Innovation and Science
- **Professor Robyn Guymer AM FAHMS**, Deputy Director, Centre for Eye Research Australia
  Head, Macular Research, The University of Melbourne
- **Dr Stefan Hajkowicz**, Senior Principal Scientist, Team Leader, Data 61 Strategy and Foresight
  Data61
- **Dr David Hansen**, CEO, Australian e-Health Research Centre, CSIRO
- **Professor Ian Hickie AM FASSA FAHMS**, Co-Director, Health and Policy, Brain and Mind Centre, University of Sydney
- **Dr Penny Leggett**, Head of Science Policy, Office of the Chief Scientist, Department of Industry, Innovation and Science
- **Professor Louisa Jorm FAHMS**, Director, Centre for Big Data Research in Health, The University of New South Wales
- **Associate Professor Sarah Lewis**, Senior Lecturer, Medical Radiation Sciences, Director of Student Affairs, Faculty of Health Sciences, University of Sydney
- **Professor Jie Lu**, Director, Centre for Artificial Intelligence, University of Technology Sydney
- **Catherine Luckin**, CEO, Australian Academy of Health and Medical Sciences
- **Professor David Mackey AO FAHMS**, Director, Centre for Ophthalmology and Visual Science, The University of Western Australia
- **Sue MacLeman FTSE**, Chair and Non-Executive Director, MTP Connect
- **Professor Meredith Makeham**, Chief Medical Officer, Australian Digital Health Agency
- **Professor Iven Mareels FTSE**, Lab Director, IBM Research Australia
- **Professor Grant McArthur FAHMS**, Director, Melanoma and Skin Services, Peter MacCallum Cancer Centre
- **Dr Lauren Palmer**, Interim Chief Executive Officer, Director of Policy and Projects, Australian Council of Learned Academies (ACOLA)
- **Dr Ken Pang**, Clinician Scientist Fellow and Consultant Paediatrician, Murdoch Children's Research Institute, Royal Children's Hospital Gender Service
- **Professor Anushka Patel FAHMS**, Chief Scientist, The George Institute
- **Professor Malcolm Pradhan**, Director and Chief Medical Officer, Alcidion
- **Professor Peter Soyer FAHMS**, Director and Chair in Dermatology, Dermatology Research Centre, The University of Queensland
- **Professor Heiko Spallek**, Academic Lead, Digital Health and Health Service Informatics, University of Sydney

- **Professor Anton van den Hengel**, Director, Australian Institute for Machine Learning, The University of Adelaide
- **Associate Professor Peter van Wijngaarden**, Deputy Director, Centre for Eye Research Australia, The University of Melbourne
- **Professor Svetha Venkatesh FTSE**, Director, Centre for Pattern Recognition and Data Analytics, Deakin University
- **Professor Toby Walsh FAA**, Scientia Professor of Artificial Intelligence and Group Lead, The University of New South Wales and Data61
- **Peter Williams**, Healthcare Innovation Advisor, Oracle

Facilitator: Dr Donna Cohen