



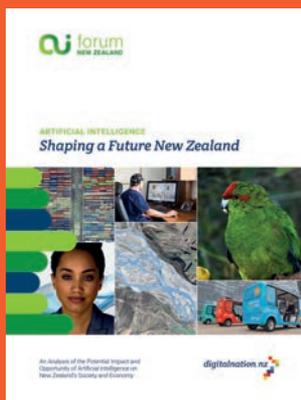
# Artificial Intelligence for Health in New Zealand

## Hauora i te Atamai Iahiko



Health Sector Partner

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# About the AI Forum of New Zealand

**THE ARTIFICIAL INTELLIGENCE FORUM OF NEW ZEALAND IS A NON-GOVERNMENT ASSOCIATION WITH A MISSION TO HARNESS THE POTENTIAL OF ARTIFICIAL INTELLIGENCE (AI) TO HELP BRING ABOUT A PROSPEROUS AND INCLUSIVE FUTURE NEW ZEALAND.**

The rapid development of AI technologies presents major opportunities and challenges for our country: from creating world leading AI businesses, nurturing a pool of talented AI engineers and applying AI technologies to our agriculture, government, manufacturing and service industries to holding a meaningful national debate on the broader implications for society, New Zealand needs to actively engage with AI now in order to secure our future prosperity.

The Forum brings together citizens, business, academia and the government to connect, promote and advance the AI ecosystem to help ensure a prosperous New Zealand.

# About Precision Driven Health

**THE PRECISION DRIVEN HEALTH (PDH) RESEARCH PARTNERSHIP IS NEW ZEALAND'S AWARD-WINNING HEALTH DATA SCIENCE COLLABORATION, BRINGING TOGETHER HEALTH PROVIDERS, TECHNOLOGY COMPANIES AND DATA SCIENTISTS.**

PDH uses world-leading data science expertise to improve the health of New Zealanders and their whānau and develop tools that enable people to live longer and healthier lives.

PDH advances the global precision health movement by supporting teams to develop tools that leverage new data, improve health outcomes, empower consumers and enable healthcare providers to operate more efficiently.

## Acknowledgments

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## Partners

The staff from our project partners and those who took time to provide reviews and feedback throughout the process.

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Please download a free digital copy of the e-report from the AI Forum website, [www.aiforum.org.nz](http://www.aiforum.org.nz)

# Contents

**About the AI Forum of New Zealand..... 01**

**About Precision Driven Health..... 01**

Acknowledgements .....01

Partners.....01

**AI Forum 2019 Research Project ....04**

**Foreword: Precision Driven Health..05**

**Executive Summary ..... 06**

**Key Highlights.....09**

## Section 1 10 Current State of AI in Health

**Introduction.....10**

Who Is This Report For? .....10

**New Zealand Health: Strategies and Trends.....10**

New Zealand Health Strategies.....10

Healthcare and the Health System in New Zealand...12

The Triple Aim.....12

How AI Can Help.....13

Special Features of Health as a Sector.....15

Solutions in Health must be Backed by Evidence.....16

Solutions in Health need to be Cost-Effective .....16

**Health and AI Globally..... 17**

International Reports ..... 17

Global Innovative Practices.....19

Estonian e-Health System.....19

NHS AI Strategy & the UK Biobank .....19

Data Access in China .....19

The Canadian Association of Radiologists.....20

Big Tech.....20

**Health and AI in New Zealand.....21**

Introduction to Health AI in New Zealand.....21

Events.....21

Private Healthcare in NZ .....21

Public Healthcare in NZ.....22

Research and Partnership .....22

Commercial Endeavours in New Zealand .....23

New Zealand Professional Organisations.....23

Education .....23

Further Information .....23

## Section 2 24

Transformational Use Cases:  
The Patient's Journey

**Introduction..... 24**

**Key Use Cases ..... 25**

Research and Generation of Evidence.....25

Literature Mining.....25

Drug Discovery .....25

Understanding Disease .....26

Service Delivery .....26

Improved Teamwork.....26

Workforce and Efficiency.....26

Preventing Disease.....27

Screening and Diagnosis .....27

Treatment Planning & Management.....29

Clinical Decision Support.....29

Acute Care .....29

Surgery.....31

Precision Medicine .....31

Patient Safety.....32

Survivorship and Follow-up.....32

Value-Based Healthcare: ZEDOC by the Clinician...32

End of Life Care.....33

Mental Health .....33

**Potential Major Innovative Disruptions ..34**

Radical Changes to Primary Care .....34

Radical Changes to Chronic and Hospital Care.....35

Future Trends.....35

## Section 3 36

### Nature and Scale of Impact

- Introduction..... 36**
- Benefits to the Health System ..... 36**
  - Economic Benefits..... 36
  - Enhanced Cost-Effectiveness ..... 38
  - Health Workforce Efficiency and Productivity ..... 39
- Benefits to the People of New Zealand .. 40**
  - Reduced Burden of Disease..... 40
  - Increased Access and Equity ..... 41
- Potential Impact on Healthcare Professionals..... 44**
  - Changes to Funding..... 44

## Section 4 45

### Early Adoption Opportunities

- Introduction..... 45**
- Early Adoption Opportunities in NZ ..... 45**
  - AI for Health System Research..... 45
  - Monitoring Patient Information..... 45
  - Eliminating Clumsy Interfaces ..... 45
  - Supporting Quality and Innovation ..... 46
  - Laying the Foundation for a Truly Intelligent Health System..... 46
- Developing Commercial Opportunities .. 47**

## Section 5 48

### Accelerating AI Adoption in Health

- How to get from Current State to an AI Enabled Future?..... 48**
  - Barriers to Implementation of AI in Health ..... 48
  - Philosophical Implication of AI for Health..... 48
  - Data Must be Accessible..... 49
    - Ministry of Health Guidance for Data in Healthcare .49
- Policy and Legal Issues ..... 49**
  - Algorithmic Bias and Error..... 50
    - Ministry of Health Guidance for Algorithms in Healthcare..... 50
  - Safety..... 50
  - Explainability..... 51
  - Malpractice..... 51
- Roles for Consumers, Providers and Funders ..... 51**
  - Institutional Readiness ..... 51
  - Role of Government ..... 52
  - Role of Providers..... 52
  - Role of Professional Organisations ..... 53
  - Role of Education Providers..... 53
  - Patient and Consumer Awareness..... 54
  - Best Practice ..... 54
- Agreed Ethics and Social License..... 54**
  - Data Governance ..... 55
    - Consent for Data Use ..... 55
    - Data Privacy ..... 55
    - Data Security..... 55
  - Fairness..... 55
  - Māori Data and Data Sovereignty..... 56
    - Te Mana Raraunga..... 56
- Funding and Investment ..... 57**
- Conclusion..... 58**
  - About Adapt Research..... 59
- References..... 60**

# AI Forum 2019 Research Programme

## TOWARDS OUR INTELLIGENT FUTURE TE HUARIHI ATAMAI IAHIKO Ō AOTEAROA

The AI Forum of New Zealand would like to extend our sincere gratitude for the generosity of all the Programme Partners and Supporters who have made this report possible.

### Principal Partners

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Adapt Research  
As we build our world we build our minds

## Foreword

# Precision Driven Health

## E NGĀ MANA, E NGĀ REO, E NGĀ KARANGATANGA MAHA, TĒNĀ KOUTOU KATOA.

### HEALTH BRINGS TO THE SURFACE EVERYTHING THAT IS INSPIRING AND CHALLENGING ABOUT ARTIFICIAL INTELLIGENCE.

Health is big business, yet highly personal. Our practices change slowly over time, preserving a high level of trust in our advisors and systems. We all have a story to tell, an experience of how health could be, should be, more effective, personalised and efficient.

Health, with costs growing unsustainably, needs disruption. Even when our services succeed, our longer, healthier lives cost more to maintain. And despite every effort to counter, the gains in health tend to favour disproportionately those who are already relatively healthy.

Our healthcare professionals seek to give the best possible advice. At a high level, this usually involves processing what they observe and hear from the patient in front of them, combined with their medical history. A clinician is explicitly or implicitly matching key observations to previous patients with similar features, or the latest in medical knowledge, and recommending what they believe is the best course of action. This pattern recognition and cognitive processing is the domain of data science and artificial intelligence, whose assistance could improve accuracy and efficiency.

Artificial Intelligence (AI) promises new ways of achieving health outcomes. Today, radiologists and dermatologists can be assisted to review and diagnose images. People can live independently at home for longer by interacting with technology that will remind them to take medication, sense when they have fallen, and communicate their progress with care teams. Looking forward, AI will increasingly outperform humans in translating the unmanageable volume and variety of data and research into practical advice for both our clinical carers and citizens.

From an equity perspective, it is critical that we deliberately develop AI to address the health needs of the most vulnerable and disadvantaged families



**Kevin Ross,**  
CEO

*Precision Driven Health*



and communities. We also need to recognise and address concerns around the capture, storage and use of personal data – and the risk of AI bias, which can exacerbate inequity. Emerging developments and principles from the Māori data sovereignty network are instructive in this regard. Data can be viewed as highly sensitive and valued by Māori – at a personal, whānau, hapū and iwi level. We therefore need to walk carefully, with Māori, to ensure the design and use of AI takes these factors into account and delivers benefit to Māori and other NZ communities. *“He aha te mea nui o te Ao? He Tangata”* The most important thing of all is people.

New Zealand is well positioned to lead this transformation. With high quality digital health records, innovative kiwi companies, an admired health system and a maturing understanding of the data governance and ethics required to develop this capability. Precision Driven Health, New Zealand’s formative health data science partnership, is proud to partner with the AI forum in developing this report. This serves to advance an important national kōrero, celebrating the innovation underway and exploring how we can unlock the benefits to our people, our industry and our nation.

# Executive Summary

**The health sector in New Zealand is facing challenges.** These include increasing demand, rising consumer expectations, and the pressures of an aging population. These factors are straining the health workforce, increasing costs and limiting access to care. DHBs are right now facing a \$500 million annual deficit.<sup>1</sup>

The Ministry of Health promotes delivery of care ‘closer to home’ through a ‘smart system’. These themes are included in the 2016 New Zealand Health Strategy. The Ministry is also preparing a Digital Health Strategy and has articulated a vision of technology enabled healthcare. However, the current reality is still a long way from this aspirational state.

**Artificial intelligence (AI) is a new general-purpose technology.** AI is transforming industries around the world. By augmenting human labour, automating processes and providing intelligent analytics, AI is enhancing healthcare research as well as service planning and delivery, from prevention of illness through to end-of-life care. AI can help personalise medicine, as well as perform many tasks as well as, or better than, experienced clinicians.

The New Zealand private sector is already adopting AI. Current uses include administrative process automation and diagnostic image interpretation. Providers are starting to use cloud data storage and this approach to data as infrastructure will facilitate future AI solutions.

Meanwhile, New Zealand’s public sector is starting to pave the way for an AI enabled future. In this future data and AI models will provide intelligent insight. But there is a long way to go and siloed data will need to be truly standardized, accessible, and available to AI tools.

**There may be a tradeoff between privacy and good health.** Government, providers (public and private) and society will need to engage with change and agree on fundamental principles around ethics, regulation, safety and fairness in order for New Zealand to use AI to leverage better, sustainable healthcare and enhanced national wellbeing, at affordable cost.

**AI will bring tremendous benefits through increased effectiveness and productivity as well as cost reduction.** Scaling international analysis to New Zealand shows that AI could help to manage 20 percent of unmet clinical need, enhance access to care as well as improve equity. AI is projected to contribute over \$700 million dollars of value and savings to the New Zealand health system by 2026. AI will also help save 20 percent of nurse time and allow doctors to see more patients, thereby increasing the effective workforce size. These changes will occur incrementally over a number of years as organisations explore and learn about the technology. Importantly, the use of AI could help to humanise medicine, by facilitating clinician presence and enabling more time for patient contact. This has been demonstrated to reduce hospitalisations and readmissions. By

## AI USES IN HEALTHCARE

There are already a number of successful AI uses in healthcare. Use cases include: predicting disease and injury, mining vast quantities of literature for research insights, assisting novel drug discovery, augmenting the work of human specialists through image analysis and robotic surgery, automating hospital processes, generating insight through predictive analytics, performing real-time research, reducing waste, improving outcomes through precision care, providing increasingly capable and complex health assistance through bots, intelligent assistants and clinical decision support systems, and even enhancing end-of-life-care through smart homes and robotic assistants.



helping to target care provision, such as screening only those people at risk of certain diseases, or identifying patients who would benefit from palliative enhancing the experience of patients and increasing dignity to choose where they want to die.

**Ultimately the top AI applications in health will ‘think and pay for themselves’.** Some AI applications will prove dominant in cost-effectiveness analyses, meaning they are more effective and less costly than present solutions. However, AI in health will also mean that some workforce tasks are phased out, such as processing test results or coding medical records, and new roles will be created, such as data science doctors.

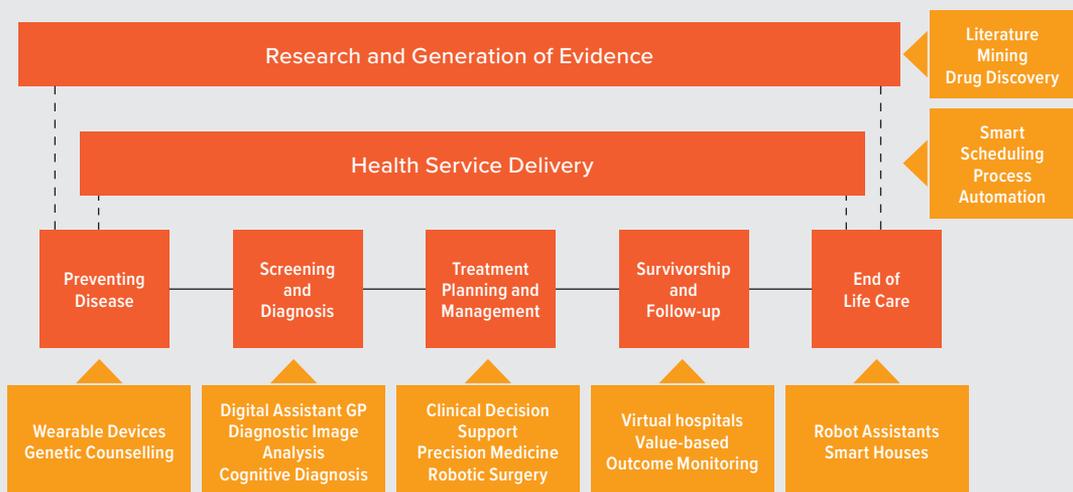
**AI could bring major innovative disruption to health services.** Adoption of AI could radically improve efficiency as well as augment or automate traditional healthcare workflows. Overseas initiatives such as Babylon Health and Accuhealth seek to replace present models of primary and hospital care with intelligent AI assistants that can triage and monitor patients, alerting clinical staff

only when needed. These Ubers and AirBnBs of the health sector could have wide ranging implications for how health is funded and where, by whom, or by what, healthcare is delivered.

**Key challenges for the adoption of AI in health in New Zealand include:**

- Changing the way health data is collected, stored, protected and made available for use, because accessible data has the potential to increase efficiency, improve care and save lives.
- Working through the ethics of ‘real-time’ research that self-improving AI will facilitate, and the implications this has for the present focus on randomized controlled trials as the gold standard of health research.
- Changing the current mindset, because true AI means that clinicians would not always have to validate the outputs of intelligent systems, this is a fundamental change to our conception of healthcare.

**FIGURE 1:** Examples of AI enabled healthcare



SOURCE: Adapt Research

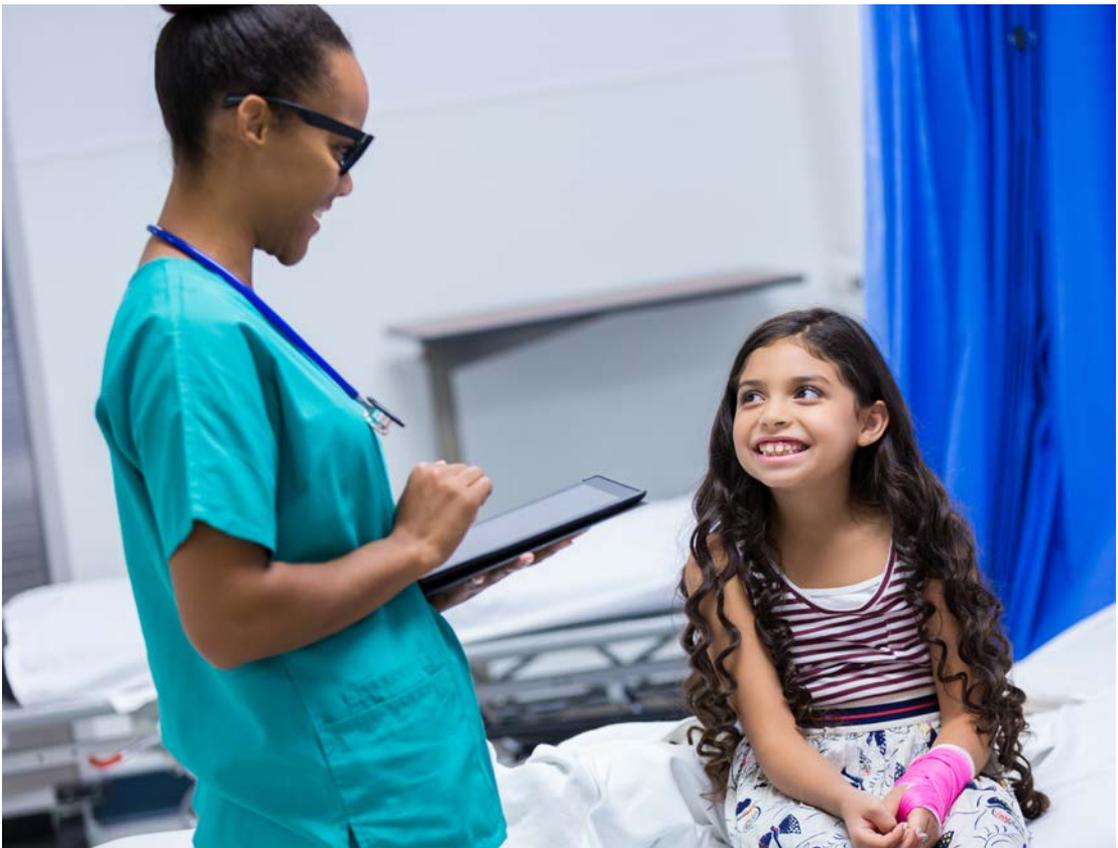
**Overcoming these challenges to leverage the opportunity that AI presents will require:**

- Top down vision and policy to facilitate bottom up local AI adoption and local AI solutions that can then be generalised across the system.
- Funding decisions that take account of these emerging trends, the importance of data as infrastructure, and potential major innovative disruptions on the horizon.
- Accessible, secure, interoperable cloud-based data and social license for its use.
- Awareness and practical policy at the level of professional organisations and health workforce educators, to ensure professional buy in, sufficient AI talent and a health workforce conversant in AI.

**Call to Action**

To optimise the benefits for the health of New Zealanders that AI offers, action is required by many parties:

- Government should create quality standards and a regulatory framework for AI use in healthcare.
- Healthcare professionals should increase understanding of how AI and robotics can help them.
- Patients and the general public need to become accustomed to AI and discover the benefits.
- Developers need to focus on the big issues of resource use that every health system faces.
- Provider institutions will need to ensure evaluation and an evidence base aligned with their adoption of AI.



# Key Highlights

## New Zealand's health sector is facing major challenges:

Increasing demand, rising consumer expectations, and the pressures of an aging population. These factors are straining the health workforce, increasing costs and limiting access to care.

**AI PROMISES TO BRING SIGNIFICANT CLINICAL, WORKFORCE AND COST BENEFITS TO THE HEALTH SECTOR, AS WELL AS PERSONALISE MEDICAL CARE.**

## HEALTH AI USE CASES INCLUDE:

- Predicting disease and injury
- Mining vast quantities of literature for research insights
- Assisting novel drug discovery
- Augmenting the work of human specialists through image analysis and robotic surgery
- Automating hospital processes
- Freeing up more time for doctor-patient interaction
- Personalised treatment.

## SOME NEW ZEALAND HOSPITALS AND DHBS ARE INVESTING EARLY IN AI AND DATA INFRASTRUCTURE:

Capturing more clinical data digitally and enabling better data visualisation

- Robotic process automation of backoffice processes
- Optimised diagnostic image interpretation
- Development of an automated triage system for cardiology referrals.

**Māori data** should be collected with a Te Ao Māori perspective in mind, and with **Māori input and leadership.**

Scaling international economic analysis to New Zealand's health sector, AI could contribute **over NZ\$700 million** of added value and savings to the New Zealand health system by 2026. This could rise to **NZ\$1.6 to 3.6 Billion** by 2035 as reported in the AI Forum's 2018 *Shaping a Future New Zealand Report.*

**AI CAN HELP LEVEL THE HEALTHCARE RESOURCE IMBALANCES BETWEEN URBAN AND RURAL AREAS, AND BETWEEN MORE DEVELOPED & LESS DEVELOPED REGIONS.**

**AI IN HEALTH RAISES ETHICAL ISSUES INCLUDING:** The potential for erroneous decisions, questions of responsibility, difficulties in validating outputs of AI, bias in data used to train AI systems. **Ethical standards are needed** to ensure safe and effective use of **AI in healthcare.**

Finding a reliable way to de-identify unstructured data is a **big opportunity and challenge.** Solving this problem will unleash the power of data in electronic health records for research and developments. However there are also concerns that algorithms have the potential to de-anonymise data.

**NEW ZEALAND NEEDS A REGULATORY FRAMEWORK AND ASSOCIATED POLICIES FOR AI AND DATA CONTROLS IN HEALTH.**

## BARRIERS TO IMPLEMENTATION OF AI IN HEALTH

- Low levels of digital literacy among the healthcare workforce
- **Inflexibility of legacy technological systems**
- Insufficient awareness of where and how AI is being applied in the sector
- **The need to slowly introduce clinical staff to new workflows to avoid resistance**
- Difficulties experimenting in health, when lives are potentially at risk.

# Section 1:

## Current State of AI in Health

### Introduction

#### WHO IS THIS REPORT FOR?

The aim of this report is to explain how the health sector can utilise AI, the global state of play, and what research and innovation is occurring right now in New Zealand. We outline what is possible, the scale of the impact, and how New Zealand might move forward. Clinicians, managers and decision makers can use the content to increase their awareness of AI in Health and guide thinking around AI and its benefits for the health sector and the wellbeing of all New Zealanders.

Healthcare systems globally are experiencing unprecedented demand for increased access, outcomes and quality of services.<sup>2</sup> There is also the need to 'bend the curve' of costs that are rising faster than GDP. The health industry produces a large amount of data, but there is a shortage of health professionals and the industry is inefficient with The World Health Organisation estimating that between 20 and 40 percent of global spend is wasted.<sup>3</sup>

AI is a catch-all term for a range of automation technologies that most often use "machine learning" to make predictions using data. We include within our definition a range of computational techniques which can be applied to problems in healthcare including: **robotic process automation, computer vision, natural language processing, reinforcement learning** and **generalised deep learning**. For a fuller explanation of AI and machine learning, see the AI Forum's recent report *Towards Our Intelligent Future: An AI Roadmap For New Zealand*.

Recent enormous increases in computing power, algorithms and the emergence of very large datasets and cloud services have enabled powerful new applications of AI. These applications are leveraging new methods such as deep learning. Healthcare, facing the challenges just mentioned, is seen as a sector with some of the greatest potential to be revolutionized by artificial intelligence (AI).<sup>4 5</sup> After reading this health sector report we hope that interested parties will have a better understanding of how AI can enhance productivity and outcomes in health, where to begin, and what obstacles may be faced. We also hope that patients and the general public will use this report to understand how AI in health can work for them.

### New Zealand Health: Strategies and Trends

#### NEW ZEALAND HEALTH STRATEGIES

Healthcare in New Zealand is provided by both public and private systems with the majority of funding, \$18.2 billion in 2018/19,<sup>6</sup> coming from the government. There is pressure on resources, as demonstrated by recent public debates about the funding of cancer pharmaceuticals.<sup>7</sup>

**The Ministry of Health's 2016 'New Zealand Health Strategy'** emphasises five strategic themes:<sup>8</sup>

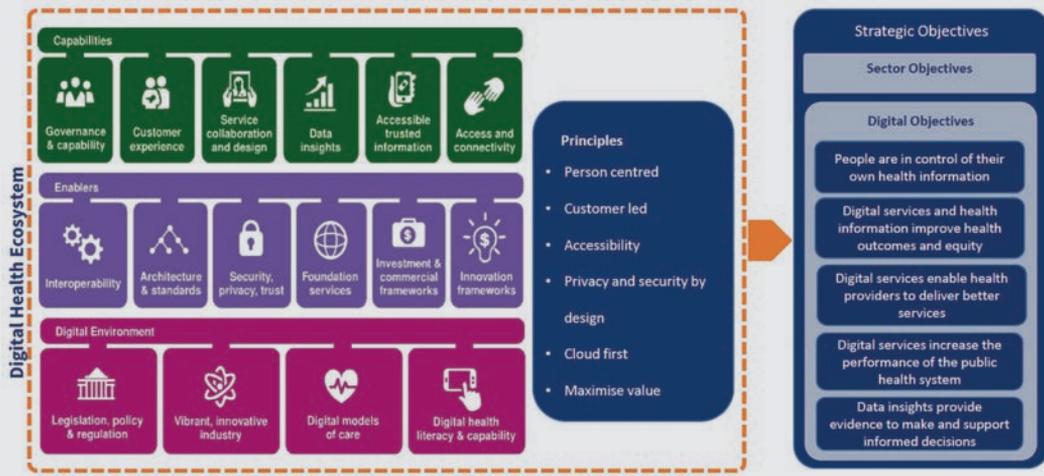
- People-powered
- Closer to home
- Smart system
- Value and high performance
- One team

Under this Strategy, the theme of 'smart system' aims to ensure that the system can leverage new and emerging technologies.

**A 'Roadmap of Action' is associated with the New Zealand Health Strategy.** This highlights the need to develop analytical capability and the quality of data at a national level as well as keep up with the development of health technologies such as robotics, genomics and nanotechnologies.<sup>9</sup> Moreover, the Ministry of Health's Digital Health 2020 project aims to progress core digital technologies, laying the foundation for future innovation in digital health.<sup>10</sup>

**A New Zealand Digital Health Strategic Framework is currently under development.** This framework is underpinned by a "person-centred" approach - and the Ministry states on its website that they "will continually revise the framework as the digital future emerges". There is a need to actively scan for best practices and identify, evaluate and introduce important health technologies across the system, including AI.

**FIGURE 2:** Graphical Outline of New Zealand Digital Health Framework<sup>11</sup>



SOURCE: Ministry of Health NZ, Used Under CC By Licence.

The Ministry’s aspirational document ‘New Zealand Vision for Health Technology’ foresees AI assistants for nurses and doctors, as well as the use of robots and other automated systems to carry out repetitive and predictable processes, advanced analytics to provide new insights into complex health problems, and research breakthroughs in human science that make ‘personalised medicine’ a reality.<sup>12</sup> But the vision also emphasises technical issues and standards such as the need for innovators and developers to ensure applications are secure, fully interoperable and that data is joined up to enable research. Herein lie some of the big challenges for health.

In addition to these plans, MBIE and the Ministry of Health have emphasised the importance of health research in the ‘Health Research Strategy 2017-2026’, which provides \$120 million for health research (generally) by 2020. The strategy notes that research will advance the ‘smart system’ theme by evaluating new digital technologies.<sup>13</sup>

The scene is set for adoption of AI in healthcare, and AI has many benefits to offer, the vision is in place, but more action is needed to achieve these goals.

**FIGURE 3:** The New Zealand Vision for Health Technology



SOURCE: Ministry of Health NZ, Used Under CC By Licence.

**HEALTHCARE AND THE HEALTH SYSTEM IN NEW ZEALAND**

**The New Zealand health system faces major issues.**

**Population growth and aging will challenge the New Zealand health sector.** The New Zealand population is currently aging. A population which is growing older will place greater demands on the current health system. For example, the number of people with dementia is expected to rise from 60,000 to 170,000 by 2050.<sup>14</sup> Life expectancy is rising and treatment outcomes are improving. These factors, while positive, will likely increase strain on limited health resources. A technological solution is the only realistic solution to the problem of increasing health sector costs, increasing demand, and rising patient expectations.

**New Zealand faces a shortage of skilled providers in rural areas.** Many communities are frequently served by locum practitioners or patients need to travel for care. Indicators show that there are discrepancies in health outcomes across the New Zealand population, both by region and by ethnicity.

**Life expectancy is lower for Māori and Pacific people by approximately six years.** Jackie Cumming, Professor of Health Policy and Management, Victoria University of Wellington notes that these groups are also more likely to die of avoidable conditions.<sup>15</sup> There are systemic barriers to access and equity. There is a high rate of unmet need due to cost. This is particularly so for Māori and Pacific women and women of lower socio-economic status.<sup>16</sup>

**There are health data collection and interoperability issues.** A range of systems still integrate digital and paper-based solutions. Furthermore, data from patient records are often inconsistent, episodic, exist in various formats, and can be incomplete.<sup>17</sup> There is duplication, inefficiency, and these issues can lead to patient harm.

**The Triple Aim**

In conjunction with the Ministry of Health, the Health Quality & Safety Commission works with clinicians, providers and consumers to improve health and disability support services<sup>18</sup> and operates under a

‘Triple Aim’ with the objectives being: improved quality, safety and experience of care; improved health and equity; and better value. Recent thinking, such as that adopted by NZ’s first AI in health conference ‘Hack Aotearoa’<sup>19</sup> has added a fourth aim, that of the experience of health providers.<sup>20</sup> These are the goals that the entire health system is focused on achieving.

**HEALTHCARE CLOSER TO HOME**

The New Zealand Health Strategy identifies the need for care closer to home, which should improve access and reduce costs. Ahmad Jubbawey the CEO and founder of New Zealand health tech company Vensa, writes that, “The community based health approach is very important as there needs to be a shift from a hospital based economy to a community provider based economy... There is a need to move priority setting beyond new and marginal expenditure to address systemic factors, with a view to the long-term impact on costs and resource use.”<sup>21</sup>

**FIGURE 4: New Zealand Health Quality and Safety Commission Triple Aim**



## HOW AI CAN HELP

**AI has the potential to improve productivity through augmentation and automation** (thereby releasing some of the burden on an overstretched health workforce) and also to enhance healthcare products (thereby improving the quality of care).

**Intelligent analytics should help to reduce waste.** For example, one third of cancer diagnoses when screening for cancer may reflect 'over diagnosis', where the person does not actually have cancer. Overprescription and over-testing are also problems.<sup>22</sup> This leads to wasted resource use. With the use of AI, a more efficient and accurate precision medicine approach is becoming possible.

**AI has the potential to reduce costs as well as enhance health outcomes.** Unlike many health technologies that enhance care but also increase costs.

**AI can provide increasingly capable and complex health assistance.** Starting with structured decision support, AI has the potential to augment and ultimately replace planning and diagnostic assistance in the healthcare sector.

**There is currently too much information for human clinicians to process.** Orion Health has described this data explosion as a 'tsunami'<sup>23</sup> and notes that doctors will need high powered computing and analytic tools to ensure best practice. Some ways that AI can help manage the information tsunami include:

- Combining diverse datasets including quantitative, textual and image data, into actionable insights
- Analysis of vast troves of patient data, impossible for clinicians in short consultations
- Predictive analytics to target health resources where they are needed
- Image recognition to support human practice

**There is "great potential for synergy between AI systems and the human intellect already delivering care"**<sup>24</sup> Data will become 'the new scalpel'<sup>25</sup>, but AI and advanced analytic tools are needed. Cloud storage and interoperable datasets will be essential but will enable the delivery of improved, more precise healthcare. Individualised care began with practices such as cross-matching

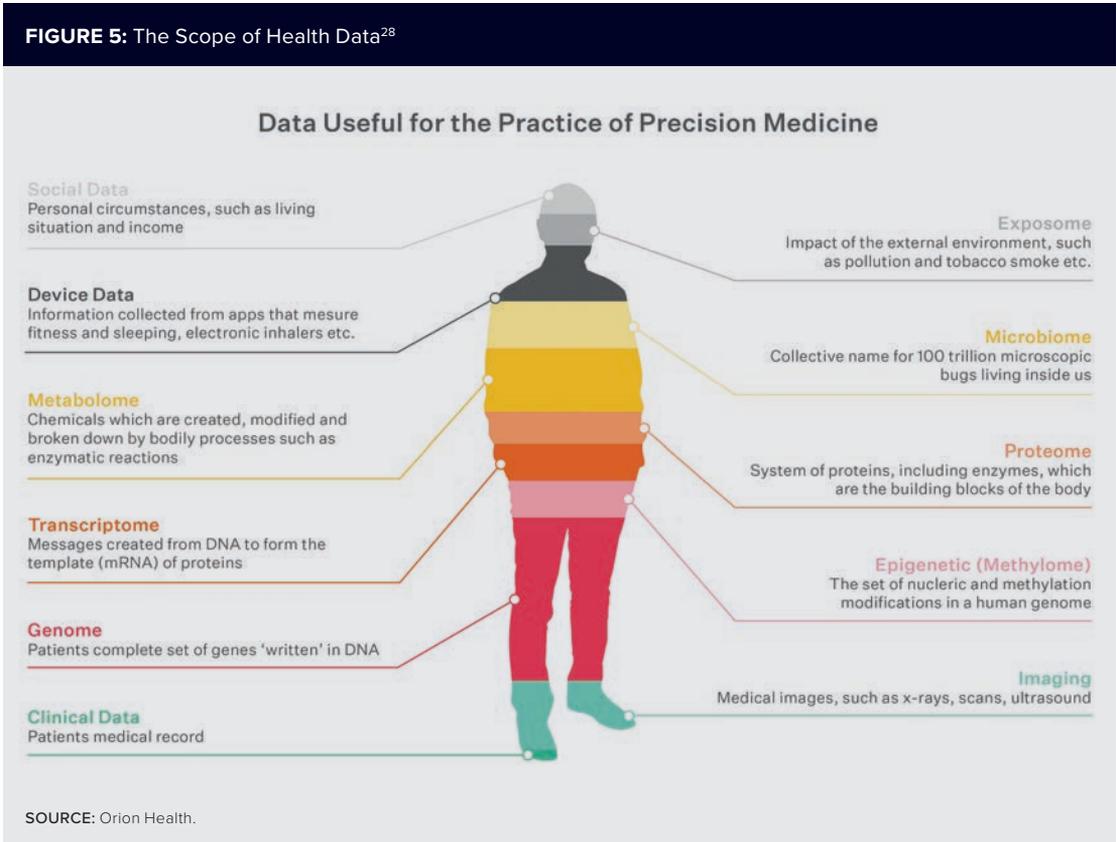
blood for transfusion. But as the cost of genome sequencing continues to fall, precision medicine will be able to be applied much more broadly.<sup>26</sup>

## WHAT IS NEEDED TO LEVERAGE CLOUD?

Electronic health records will soon contain so much information they will need to be cloud based to function. In order to leverage cloud computing in health, New Zealand will need to develop a less conservative approach to health data. It is sometimes thought that for security reasons personal health data must be stored locally and not leave the physical site of a hospital or other provider. However, commercial cloud options are highly secure. *"The [Microsoft] Azure platform meets the highest security standards globally while at the same time being accessible. It allows us to securely store the images we need to further develop and deploy our AI solutions"*, says Dr Ralph Highnam, Volpara Health Technology's Chief Executive.<sup>27</sup> To save regulatory costs, New Zealand could piggyback off Australian certifications for the security of the major providers. At present New Zealand's health data cloud policies are unclear.



FIGURE 5: The Scope of Health Data<sup>28</sup>



## Identifying AI's Impact In Health

**GLEN WILLOUGHBY, A NEW ZEALAND INFORMATICS AND ANALYTICS CONSULTANT AND HEALTH IT RESEARCHER, SEES AI AS HAVING AN IMPORTANT IMPACT ACROSS THREE AREAS IN HEALTH:**

- **Organising health investment and efficient delivery of care:** New Zealand has high quality health datasets including data about health service delivery. AI can be used to forecast prevalence and patterns of disease, predictive analytics can inform investment in healthcare. At the level of hospitals these same approaches could be used to avoid waste. Predicting ED demand or identifying potential non-attendances at appointments are two ways that providers could benefit from data and predictive analytics.
- **Image identification:** AI can augment the human component in interpreting medical images such as mammography images, but it can also be deployed over previous image reads to detect anomalies by comparing the previous images to previous clinical reports.
- **Precision Medicine:** Genome mapping projects have produced so much data, which might be used to predict and prevent illness, that using AI is really the only way to analyse it.
- **But success stories are needed:** Glen says that people need confidence in the proposals. Two opportunities stand out. First, New Zealand's radiology workforce is strained, and yet image categorization is something machines are good at. Second, predictive analytics to help forecast expenditure and prevalence of disease. Once AI has been proven in three or four key projects, we can take these lessons to scale-up.

### SPECIAL FEATURES OF HEALTH AS A SECTOR

The health sector has a number of specific features that make the use of AI more challenging:

- **Data silos:** data is often held separately by primary care, hospitals (and departments), laboratories, and pharmacies.
  - **Interoperability issues:** even if datasets are connected, the data is not always interoperable; along with data silos, non-standardised data is a major barrier to the use of analytics in health.
  - **Lack of access to data:** due to privacy concerns (as well as silos and interoperability issues) health data is not always available to developers, clinicians and policymakers.
  - **Shortage of data science talent:** traditionally the health sector is slow to adopt new technology, this means that cutting edge talent must be contracted, this can be expensive and the talent is not always conversant in clinical issues.
- **Ad hoc projects:** Many health IT projects are ad hoc, to solve a particular problem at a particular organisation, this means solutions may not be scalable or generalisable.
  - **Social license:** Any solutions in health require social license (in particular people must authorise the use of personal information about them) and must also be acceptable to the public.
  - **Ethical approval:** Health research and development is usually subject to ethical approvals. Locality and sometimes national approvals are required to develop and test many solutions.

## AI Day 2019

**KEVIN ROSS THE CEO OF PRECISION DRIVEN HEALTH SPOKE AT AI DAY (AUCKLAND, MARCH 2019)<sup>29</sup> AND CALLED FOR BETTER ACCESS TO HEALTH DATA.**

“In health we use data less than people assume we do,” he said. Why should a referral contain only one PDF summarizing the patient’s problems? Why not send access to all the data? Why not use natural language processing to extract all the relevant information? Ross challenged the sector to consider how patients might be able to donate their data for research and analysis. He asked how might we ask every patient in New Zealand about using their data to improve health? “New Zealand doesn’t have great consent processes for understanding what’s acceptable to do with that data,” says Ross, “We need to engage people.” He also noted that the use of data must not merely automate existing biases, such as low referral rates for Māori.



## SOLUTIONS IN HEALTH MUST BE BACKED BY EVIDENCE

‘Evidence-based practice’ is pervasive in healthcare. This means that any new solutions must be proven to be at least comparable (non-inferior) to existing solutions, and preferably better. To be compelling, evidence is currently gathered through well constructed clinical trials. This is because failed experiments in health can cost not just money, but also lives. This means that AI innovations that enhance hospital management and administrative efficiency are likely to gain traction before clinical applications. Ongoing evidence also needs to be collected, because of the risk of a ‘reproducibility crisis’ where solutions look good in small highly controlled trials, but do not scale successfully to generalised use. Dr Soumya Swaminathan, the World Health Organisation’s (WHO) first chief scientist, has said that, “There is a risk that unevaluated apps could end up doing more harm than good.”<sup>30</sup>

## SOLUTIONS IN HEALTH NEED TO BE COST-EFFECTIVE

Even if solutions are demonstrated to be effective, we still need to understand the cost-effectiveness. This is particularly important where public funds are being spent. Many health technologies and pharmaceuticals are demonstrably effective, however, they cost so much that money is more wisely spent on alternative, cheaper solutions, perhaps across other areas of healthcare. However, AI is a technology that has productivity enhancing effects, and therefore has the potential to provide very cost-effective, and even cost-saving solutions.

Developers of AI in health will need to understand the current conservative nature of healthcare and may need to work to address concerns from the outset through collaboration, ethical approvals, evidence gathering, and by demonstrating cost-effectiveness, safety, and acceptability of the solution. There may be institutional and professional resistance. However, a plan to address these concerns will increase chances of success.

## Health and AI Globally

In this section we present the view of AI in health globally that emerges from analysis by PwC, Emerj, and Accenture. We also illustrate current practices laying the foundation for AI in health in Estonia, the UK and China, as well as the work of "Big Tech" in health, including Google, Microsoft, Apple and IBM. The section concludes with future trends and possible pitfalls.

### INTERNATIONAL REPORTS

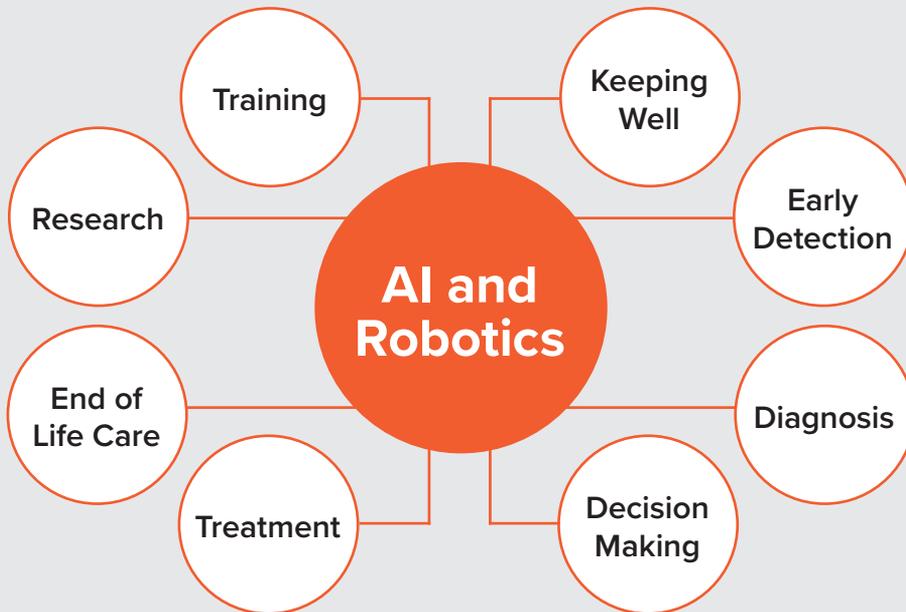
Analysis by PwC highlights eight key ways in which AI will impact healthcare.<sup>31</sup> Gurpreet Singh, U.S. health services leader at PwC has said that, "We're finding that many of the top academic medical centers have created enterprise divisions or innovation divisions to investigate the use of new technologies in their health systems. They're partnering with pharma and

tech companies to come up with new products and solutions that could be a new revenue stream."<sup>32</sup>

Emerj Artificial Intelligence Research produced a sector overview of AI in Health illustrating use cases and case studies in action around the world right now.<sup>33</sup> Emerj has reported on how AI is already impacting on the pharmaceutical industry,<sup>34</sup> health insurance industry,<sup>35</sup> nurses,<sup>36</sup> hospitals,<sup>37</sup> and health in the developing world.<sup>38</sup> "The healthcare industry is one with numerous uses for nearly every AI approach, including machine vision, predictive analytics, natural language processing, and in the case of health insurance, anomaly detection for fraud detection purposes." A number of use cases are presented in Section 2 below.

Accenture reports on the top ten AI applications in health, and projects that these will bring US\$150 billion in savings to the US health system by 2026.<sup>39</sup>

FIGURE 6: PwC Areas AI will Impact Healthcare<sup>64</sup>



SOURCE: PwC Analysis.

**Figure 7:** Accenture's Top Ten AI Applications and Projected Value Generated for the US Health System.



**TOTAL = \$150B**

SOURCE: Accenture analysis, 2017.

\*\* "Value" is the estimated potential annual benefits for each application by 2026.

\*\* Orthopedic surgery specific

**The upshot of international analysis is that healthcare is embracing AI** as a solution to a number of difficult problems. AI will affect every aspect of healthcare and is likely to bring substantial economic benefits to the sector (we illustrate this impact in Section 3 below).

### GLOBAL INNOVATIVE PRACTICES

Before the benefits of AI can be realised, health systems must digitise their information and make data on context, clinical management and patient outcomes available for AI tools to learn from. A number of forward thinking undertakings have occurred around the world.

#### *Estonian e-Health System*

**Estonia has invested in a single comprehensive e-health system** that integrates nationwide health data from all providers into a single patient record for each patient. More than 99% of the data generated by hospitals and doctors has been digitised and 99% of prescriptions are electronic.<sup>40</sup> Citizens can easily access their own medical records. The technology is underpinned by blockchain and provides efficiency and a range of safety applications such as warnings about potential drug-drug interactions.<sup>41</sup> The Estonian system includes applications for paramedics to access health data when en route to an individual's home, and also facilitates telemedicine with AI applications aiding with interpretation.<sup>42</sup>

More importantly, the digitisation of health records (ideally in a common format) is a prerequisite for deployment of powerful AI technologies. Estonia seems to be on the way to an ideal health data system that would consist of a single platform storing all of an individual's health data from any source, from birth. This data would be controlled by the individual, who could grant permission for those who need to access it to do so.

#### *NHS AI Strategy & the UK Biobank*

**The UK AI in health vision is driven by top down policy.** Former Prime Minister Teresa May said in June 2018 that she was, "determined to position the UK at the forefront of the revolution in Artificial Intelligence and other technologies that can transform care and create whole new industries in healthcare, providing good jobs across the country."<sup>43</sup>

**Artificial intelligence is at the forefront of thinking in the NHS.** The UK Government has committed to increase the budget of NHS England above inflation by an average of 3.4% each year until 2023/24. This includes a £50m investment in five new AI medical technology centres in 2019.<sup>44</sup> Furthermore, health and care leaders in the NHS came together and developed a Long Term Plan. The plan aims to make the NHS fit for the future, and to increase the value that patients receive. The Long Term Plan includes key themes of 'doing things differently' and 'making better use of data and digital technology'. The plan states that the NHS aims to be a world leader in artificial intelligence within 5 years, and will digitise outpatients services, while also deploying AI to interpret medical imaging.<sup>45</sup>

Professor Eric Topol, a prominent expert on AI in health, was invited to evaluate the NHS and his 'Topol Review' published in 2019 makes a number of wide-ranging recommendations for enhancing the performance of the NHS. This includes embracing and embedding advanced technology such as AI. The report concludes that, "artificial intelligence and robotics, should not just be seen as increasing costs, but rather as a new means of addressing the big healthcare challenges of the 21st century." Recommendations include ramping up the training of data science capable clinicians, attracting talent in a competitive global market, and ensuring that patients are front and centre in the process of AI design and development.<sup>46</sup>

**The UK Biobank provides a vast information resource** for technological developments in big data and AI. The UK Biobank contains information on 500,000 people aged 40-69 years who were recruited in 2006-2010.<sup>47</sup> Participants provided detailed information about themselves as well as blood, saliva and urine samples for future analysis. They have consented to be followed over time through linkage of the information with electronic health records. All the genetic, biochemistry, imaging and health linked data are being made available for research. As AI applications develop, this resource should be able to act as a massive training dataset.

#### *Data Access in China*

**Chinese tech companies are harvesting data to train machine learning systems.** For example,

WeDoctor a subsidiary of Chinese AI giant Tencent, provides mobile healthcare to rural Chinese and through this mechanism obtains patient data. There are some concerns about openness and *Wired* has reported instances where none of the equipment or staff deployed to provide mobile healthcare mention WeDoctor, yet all the data is uploaded straight to the company's servers. On the basis of this data WeDoctor provides clinical decision support in the form of an 'auxiliary treatment system for general practice' to Chinese doctors.<sup>48</sup>

### *The Canadian Association of Radiologists*

**Professional colleges around the world are embracing a future of AI in health.** The Canadian Association of Radiologists is leading the way with a comprehensive white paper.<sup>49</sup>

This report anticipates a major role for AI in the future of radiology and covers critical preparatory steps, including:

- Essential AI terminology
- Key issues and best practices pertaining to educational needs of CAR members
- Issues of compliance with the principles of evidence-based medicine
- Research and development
- Clinical applications and implementation
- Structure and governance
- The role of radiologists and potential impact of AI

### **BIG TECH**

Most of the major international technology companies have embraced AI and health research, development and service provision, for example:

**Google Cloud Health API:** Google offers "Standards-based APIs powering actionable healthcare insights for security and compliance-focused environments."<sup>50</sup> Solutions developed by Google include projects such as training deep learning models to diagnose diabetic retinopathy from photographs of retinas.<sup>51</sup>

**Google DeepMind:** DeepMind competed in, and won, the 'Critical Assessment of Structure Prediction' competition, otherwise known as the protein folding

competition, with its AI system AlphaFold.<sup>52</sup> However, DeepMind's activities are not without controversy and the company has been challenged over its data acquisition processes. The UK government ruled that DeepMind had gained inappropriate access to medical data from 1.6 million patients when developing Streams. DeepMind Health has now been acquired by Google Health, raising concerns that NHS data may be leveraged by the US branch of Google.<sup>53</sup>

**Microsoft:** Microsoft Azure Health Cloud is a purpose built secure and private health data storage service. The Azure Health API allows siloed health datasets to 'talk' to each other and will be a platform across which AI analytic tools can be deployed. Microsoft is also making a set of healthcare bots available to help patients find clinical trials, and understand prescriptions and medical terminology.<sup>54</sup> <sup>55</sup> The Microsoft healthcare bot includes healthcare intelligence, and a built-in symptom checker. It is also customizable so organisations can use it to solve their own business problems, and the bot can connect to health systems, like electronic health records.<sup>56</sup> Finally, Microsoft Genomics is helping to advance precision care by providing services for computational biology projects using big data.

Microsoft Senior Director Health and Social Services Asia, Gabe Rijpma, has said that the New Zealand South Island Alliance (of South Island providers) is now capturing more data digitally and building repositories so clinicians have a broader view of a patient across the health system, with presentations, labs, medications, family history and more. This is an important foundational step on the way to using data to inform care and to predict and intervene earlier for the better well-being of all New Zealanders.<sup>57</sup>

Microsoft has also partnered with the University of Pittsburgh Medical Center (UPMC) on a \$2 billion project to create three advanced digital hospitals. The project includes EmpowerMD, an AI that can listen to doctor's conversations with patients and learn from them. Microsoft has also joined with the Cleveland Clinic deploying the Cortana virtual assistant throughout the clinic's eHospital system.<sup>58</sup>

**IBM Watson:** IBM's cognitive suite Watson helps clients use the combination of data, cloud, and AI services to improve health outcomes.

Over 50 scientific papers have been published demonstrating the potential of Watson.<sup>59</sup> IBM notes that, “Automated analysis of all available data can help providers prescribe personalized, data-driven treatment plans for more patients.”<sup>60</sup>

**Apple:** Apple is focusing on growth in healthcare, leveraging their existing hardware and software technology to enable clinicians and patients to access health records, work more effectively within hospitals, connect remotely with patients, and conduct medical research. Apple’s stated vision is that healthcare becomes more efficient and more personalized.

Recent US Food and Drug Administration (FDA) certification of the Apple Watch as an electrocardiogram (ECG) device points towards Apple’s moves into the healthcare market as being likely to involve the tracking of user data for further analysis by AI. Apple has moved chipmaking in-house and its new A12 chip is focused on running AI applications.<sup>61</sup>

Furthermore, due to Apple’s enormous and loyal existing consumer user base, it is well placed to work towards a health billing model based on cost-savings by building upon its already-released technology and services.

## Health and AI in New Zealand

### INTRODUCTION TO HEALTH AI IN NEW ZEALAND

AI adoption and uptake in New Zealand’s health system is still at a very early stage. There are isolated instances of innovation and experimentation – explored below - and great potential.

#### Events

New Zealand’s first ever AI in Health Conference was held in January 2019. This ‘Hack Aotearoa’ meeting is planned again for January 2020. The meeting brought together a number of local and international speakers on AI in health, with a playlist of recorded presentations available to view online,<sup>62</sup> along with a polished event programme.<sup>63</sup> There were also talks about AI at the Emerging Tech Health Symposium in Christchurch in May 2019 and HealthTech week took place in Auckland in July 2019.

### PRIVATE HEALTHCARE IN NZ

#### Case Study: Mercy Ascot

Some private healthcare providers in New Zealand are embracing AI. MercyAscot has been preparing for AI by initiating cloud storage, automating processes with software robots, and using AI to enhance clinical safety:

- **Preparing for AI:** Experimenting with cloud services for non-clinical data such as HR and project management-related materials, helped MercyAscot learn about and understand the security implications and benefits of the cloud.<sup>65</sup> MercyAscot has partnered with Umbrellar<sup>66</sup>, a Microsoft Azure and Azure Stack partner, so that their new electronic medical record system can be hosted in the cloud. The data will be stored at a New Zealand based data centre. This move will allow MercyAscot to leverage tools such as machine learning and advanced analytics. Interoperability will improve along with speed, and the potential for agile development and scale.
- **Process Automation:** Mercy Radiology has also implemented a robotic process automation solution for invoicing, developed in partnership with New Zealand firm Virtual Blue. Using the Blue Prism platform, Virtual Blue trained a software robot ‘Matilda’ in six weeks. Matilda automates invoicing and associated ‘paperwork’, operating the invoicing software system, every day, 24 hours a day,<sup>67</sup> releasing humans to focus on more challenging tasks that otherwise wouldn’t get done.
- **Clinical Safety:** MercyAscot uses Volpara Health Technologies’ breast screening solution, employing AI to optimize breast screening imaging and interpretation of the images (see Section 2 below). Looking to the future Lloyd McCann, CEO Mercy Radiology & Clinics, sees machine learning tools such as image recognition as an important safeguard in clinical care, identifying discrepancies between images and clinical reports. With the workflow proceeding from clinician to AI there is less risk that the clinician will miss things by putting too much trust in the AI. AI can be used a safety layer.

## PUBLIC HEALTHCARE IN NZ

### Case Study: Waitematā DHB

**WAITEMATĀ DISTRICT HEALTH BOARD DOES NOT YET MAKE EXTENSIVE USE OF AI BUT HAS EMBARKED ON THE IMPORTANT JOURNEY OF DIGITISATION WITH A PROGRAMME CALLED ‘LEAPFROG’.**



**Waitemata**  
District Health Board

Best Care for Everyone

The aim is to capture more clinical data digitally including analysis of patient vital signs, voice to text systems and e-prescribing. All data captured will be stored allowing for deployment of future analytics.

Waitematā also aims to help clinicians to visualise and use their data through business intelligence tool ‘Qlik Sense’, which provides real-time data reporting and analytics. If clinicians can get used to seeing how data can work for them, then clinician driven AI solutions are possible and much more likely to be adopted. The aim is to start with interested staff, the ones who love data, and these champions can motivate broader uptake of data solutions.

The Leapfrog innovation won Waitematā the CIO award for ‘Business Transformation through Digital and IT’. The programme could be a first step towards organisation-wide use of AI and machine learning in the future.

Waitematā is also monitoring leading AI use cases around the world (such as those in China and the UK) but requires a high burden of proof to ensure that opportunities are seized while trendy but non-optimal solutions are avoided.

Moving forward Waitematā will look to pilot programmes, and to build international and national networks. Clinical Director of Innovation, Robyn Whittaker, told us that the DHB aims to create an ‘AI Lab’ and partner with external academics so personal health data doesn’t have to leave the institution, yet there is an opportunity for researchers to help create solutions for Waitematā. AI fellowships are also a possibility.

It is not just clinical applications, Waitematā sees huge potential for intelligent analytics to improve efficiencies, throughput, scheduling, and logistics, alongside clinical work. Waitematā is also part of the Precision Driven Health partnership (see below).

## RESEARCH AND PARTNERSHIP

### Case Study: Precision Driven Health

**FOUNDED IN 2016, PRECISION DRIVEN HEALTH (PDH) IS A RESEARCH PARTNERSHIP BETWEEN ORION HEALTH, THE UNIVERSITY OF AUCKLAND, AND WAITEMATĀ DISTRICT HEALTH BOARD.**



PDH is investing \$38 million over seven years in collaborations. PDH develops tools to personalise healthcare by running machine learning on data. It seeks to provide research and development for precision health initiatives. Studies and early technology adoption are key focuses of this partnership. PDH also maintains

a Memorandum of Understanding with New Zealand Health IT (NZHIT). A key Precision Driven Health project is developing an automated triage system for cardiology referrals that will predict who should be seen first and ought to save clinician time and help to overcome bias (see page 42 for case study on this project).

## COMMERCIAL ENDEAVOURS IN NEW ZEALAND

New Zealand has a small but thriving commercial health AI sector. Actors range from large consultancies assisting public organisations develop and deploy AI solutions, through to small New Zealand start-ups finding success on the world stage. Examples include:

- **Nicholson Consulting** has been helping the ACC develop predictive statistical models and automate claims processing.<sup>68</sup>
- **Vensa Health** has been helping medical centres digitise and is working with Precision Driven Health to research and develop the use of artificial intelligence to analyse lab results.<sup>69</sup>
- **Deloitte** has been partnering with Canterbury District Health Board to deploy Amazon Echo-like devices in hospital patient rooms to triage and relay patient concerns.<sup>70</sup>
- **Performance Lab** have developed their ARDA AI platform that integrates intelligent analytics and wearable devices to provide personalised coaching for athletic performance and disease prevention and management.<sup>71</sup>
- **Isogonal** is a small start-up providing bespoke AI solutions to New Zealand customers, including healthcare resource utilisation management.<sup>72</sup>
- **Volpara Health Technologies** has developed an AI breast cancer screening solution to assist with mammography. The company has expanded into the US market and holds a first mover advantage. Volpara also acquired MRS Systems in June 2019, a medical tracking and reporting system.<sup>73</sup>
- **oDocs** has developed a platform for AI-based image recognition that allows clinicians to build their own AI solutions, such as developing image classifiers without having to do any coding.<sup>74</sup>

## NEW ZEALAND PROFESSIONAL ORGANISATIONS

Globally some professional organisations such as the Canadian Association of Radiologists are leading the way with research and policy statements around AI in health. Locally, there has been limited activity.

- The New Zealand Medical Association provided feedback to the World Medical Association on the 'Proposed WMA Statement on Artificial or Augmented Intelligence in Medical Care', generally supporting the statement.<sup>75</sup>

- Organisations such as the Royal New Zealand College of General Practitioners, the New Zealand Nurses Organisation, and the Pharmaceutical Society of New Zealand do not appear to have policy or position statements on AI. However, the RNZCGPs notes that AI and ML will have a significant impact in the future.<sup>76</sup>
- The Royal Australian and New Zealand College of Radiologists appear to be leading the way locally with an AI Working Group and Draft Ethical Principles. The organisation calls for appropriate regulation to ensure safe and clinically appropriate AI deployment and emphasises the importance of testing and deployment processes to avoid a 'Wild West' situation.<sup>77</sup>

## EDUCATION

The Topol Review in the UK (2019) recommends, "Education providers should ensure genomics, data analytics and AI are prominent in undergraduate curricula for healthcare professionals."<sup>78</sup>

To date neither the University of Auckland nor University of Otago schools of medicine are specifically teaching AI concepts or uses, and neither is using AI to facilitate teaching. The University of Otago told us that they are, "exploring the requirements of a fit for purpose, and [fit for] the future, curriculum in digital health/future health technologies at the moment."

At professional practice level, a Memorandum of Understanding (MoU) jointly signed by medical colleges in Australia, New Zealand and Canada lists artificial intelligence as one of the education topics that are the focus of Tri-nation Alliance members. Members include the Royal Australasian College of Surgeons (RACS), Royal Australasian College of Physicians (RACP), Royal College of Physicians and Surgeons of Canada (RCPC), Royal Australian and New Zealand College of Psychiatrists (RANZCP), and the Australian and New Zealand College of Anaesthetists (ANZCA).

## FURTHER INFORMATION

Additional general information and reporting on artificial intelligence and digital technologies in healthcare in Australia and New Zealand can be found in eHealthNews (via HINZ, the Health Informatics New Zealand organisation)<sup>79</sup> and in Pulse+IT (an Australasian health IT news resource).<sup>80</sup>

## Section 2: Transformational Use Cases: The Patient’s Journey

“The healthcare industry topped PwC’s list of industries ripe for significant disruption, sharing the number one spot with the automotive sector. Every part of healthcare is lining up for change: providers, pharma and life sciences, payers, and consumers should all prepare for deeper integration of artificial intelligence into their processes and experiences.”

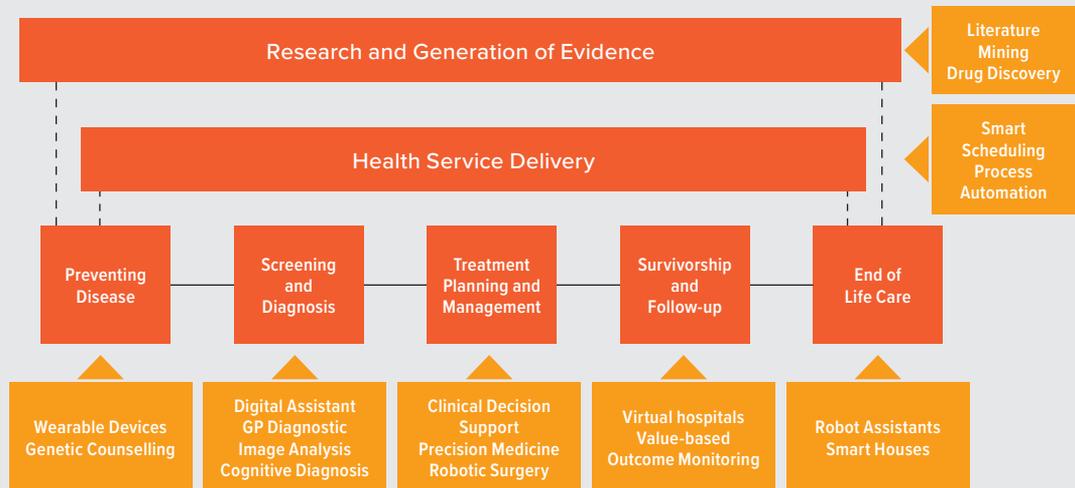
JENNIFER BRESNICK, xtelligent Healthcare Media<sup>82</sup>

### Introduction

The health sector includes diverse activities ranging from fundamental research, through product development, logistics and service delivery, as well as the complete patient journey from prevention of illness through to end-of-life care. Artificial

intelligence is set to impact on every aspect of the sector. In what follows we describe just some of the use cases for AI in health. Many more exist and further information can be found from sources such as the 2019 book ‘Deep Medicine’ by Eric Topol.<sup>81</sup>

**Figure 8:** The Patient Care Pathway: AI will impact every aspect of healthcare



SOURCE: Adapt Research

## DEVELOPING AI SOLUTIONS IN HEALTHCARE

A range of computational techniques can be applied to problems in healthcare. For example, **computer vision** can help interpret medical images, **natural language processing** can extract information and insight from electronic medical records, **reinforcement learning** is used to train robotic surgical devices, and **generalised deep learning** methods are being used for genomic analysis. However, the development process can be involved, the product needs to easily integrate into clinical workflow, and this requires planning and forethought on a range of issues. At the outset developers and clinical leads should be asking:

- Is there a defined business problem to be solved?
- Is AI the right solution?
- What explanation, awareness and buy in are needed from clinical staff?
- Is access to the right clinical input available at the outset?
- Is the right data available in the right format?
- Has locality ethical approval been sought and obtained?
- Has ethical approval from the Health and Disability Ethics Committee been sought and obtained if needed?
- What kind of model is needed and how will it be tested?
- Has a UX expert been engaged to work with clinicians?
- Is there a plan to seek clinicians' input on prototypes?
- Is there a plan to revise and update the model?

## Key Use Cases

### RESEARCH AND GENERATION OF EVIDENCE

Research and the generation of an evidence base support healthcare decisions across the entire patient journey. AI is already helping medical research and the development of new and improved treatments.

#### *Literature Mining*

**No human can keep up with all the research information in healthcare.** Every year there are tens of thousands of scientific papers published. By deploying natural language processing tools to conduct 'literature mining' researchers can reduce the time and effort required to retrieve information and generate novel hypotheses.<sup>83</sup> Of course, developers and users will have to be mindful of the fact that many scientific studies prove to be mistaken, or unable to be replicated. Also, most genetic studies draw their data from studies of white Europeans, so there are limitations to what AI can infer, but these limitations are the same for human researchers too. This just underscores the importance of collecting baseline, management, and outcome data across the entire diverse population.

#### *Drug Discovery*

**AI will play a key role in the discovery of new drugs.** Artificial intelligence, including recurrent neural networks, is being deployed in drug design to help inform on the likely safety, metabolism and excretion of drugs from the body, without laboratory experimentation being required at every step.<sup>84</sup> There has already been some success in using generative AI to design novel synthetically feasible compounds that have the desired effects in the body.<sup>85</sup> In 2015, Atomwise partnered with the University of Toronto and IBM in an effort to develop treatments for Ebola virus. Using an IBM supercomputer and AtomNet, a deep convolutional neural network for bioactivity prediction, the team identified a molecular region of interest and screened 7000 drugs for their likely effects. They identified a candidate drug which when tested turned out to have previously unknown antiviral activity.<sup>86</sup>

### Understanding Disease

**Computational statistics and machine learning will help us understand disease.** With so much genetic and clinical information now available researchers have started to use these approaches, particularly in biostatistics and statistical genomics, to bring together all the 'multi-omics data'. This data is comprised of DNA sequences, methylation patterns, transcriptome information and patient records. The aim is to improve our biological understanding of disease and how that underlies outcomes and selection of treatment. AI can also help us broaden our knowledge by deriving insights from data sets. One AI system was trained to predict blood potassium levels from analysis of ECG traces. Doctors already knew that characteristics of the 't-wave' of the ECG correspond to certain potassium disturbances, yet the AI system only worked well when it evaluated the whole ECG not just t-waves. Future AI systems will be able to point clinicians to important information that may not be obvious.<sup>87</sup>

### SERVICE DELIVERY

#### Improved Teamwork

**AI could enhance interdisciplinary care.** Failures in teamwork and communication are well documented in healthcare and can result in harm to patients. This fact underpins the emergence of structured multidisciplinary rounds and team communication techniques intended to prevent errors and omissions. Enrico Coreia, the director of the Centre for Health Informatics at Macquarie University, has suggested that soon multidisciplinary teams will include AI members.<sup>88</sup> The AI will provide input to aid clinical decision making and the multidisciplinary team will determine the best course of action.

#### Workforce and Efficiency

Healthcare is not only about diagnosis and treatment. There is a substantial administrative infrastructure supporting clinical care, and many clinical tasks involve relatively mundane, repetitive, although important, processes such as documentation and ordering.

**Robotic software and process automation will increase efficiency in healthcare.** New Zealand's Mercy Radiology has already automated its system

for invoicing the Accident Compensation Corporation, saving hours of administrative time. Studies have previously shown that the use of human medical scribes can improve clinical efficiency in emergency departments.<sup>89</sup> Intelligent voice to text systems are already proving to be 40 percent faster than writing clinical notes in South Tees Hospitals, UK.<sup>90</sup> Speech recognition systems look set to pay for themselves through increases in clinical throughput. Japan is planning ten 'AI hospitals' to help ease shortages in the health workforce. AI assistants will automatically fill in sections of the patient record based on conversations doctors have with patients and the AI will analyse blood tests and medical images.<sup>91</sup> Analysis by Accenture predicts that AI can save 20 percent of nurse time through avoided unnecessary visits and virtual nursing assistants will improve their abilities to provide triage and recommendations around patient treatment.

Robot assistants also look set to enhance efficiency in healthcare, and free up clinical staff to attend to the most important tasks, such as seeing patients. Robots can be used to deliver medicines and meals to patients, to assist with walking, standing or sitting, and to communicate with and entertain patients.<sup>92</sup> For example, TUG robots from Aethon provide secure autonomous delivery around hospitals of pharmacy medications, laboratory specimens together with heavier loads such as meals, linens, and environmental services.



TUG Robot in action  
Image: Aethon

## PREVENTING DISEASE

The patient journey in healthcare starts with prevention of disease. Smart coaching devices that pair wearable sensors with intelligent analytics will help to prevent many diseases by not only prescribing lifestyle interventions such as exercise, but also tailoring the programme based on what the person has actually done.<sup>93</sup> Genetic counselling is a growing business. Thanks to the wealth of genetic information that has been unlocked by AI, people can now take a \$100 genetic test and be screened for a large number of genetic risk factors.<sup>94</sup> AI in health expert, and author of 'Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again', Professor Eric Topol has said that we waste a lot of health resources targeting prevention to people who don't actually need it. For example, we know that a large proportion of people prescribed statins for high cholesterol would never have actually had a heart attack anyway. Machine learning and predictive analytics will allow us to analyse big health datasets and target preventive treatments to those who actually need it, and those who will actually benefit, thereby reducing waste.<sup>95</sup>

## SCREENING AND DIAGNOSIS

A number of factors can lead to biases and pitfalls in diagnosis. For example, well known psychological biases and heuristics mean that personal clinical experience can distort hard data. Also, there is often no mechanism for feedback as to the accuracy of clinical diagnosis. Diagnosis and screening for disease can be aided by AI systems.

Many screening programmes rely on visual inspection or the acquisition and interpretation of medical images. These include screening for skin cancer, eye disease, bowel cancer, breast cancer and many other conditions. Interpreting and categorizing images is something that computer vision is very good at.

Research by Google on machine interpretation of retinal images has demonstrated that even when a screening model predicts wrongly, the fact that it saw 'some evidence' for disease can help human clinicians improve their diagnostic accuracy.<sup>96</sup> AI that explains its reasoning, for example by highlighting suspicious areas on images, can improve the accuracy of human specialists.

**Figure 9:** Screening mammography using AI



**Machine learning systems have proven effective in screening for disease** and are deployed in New Zealand to aid the diagnosis of breast cancer (Volpara Health Technologies) and skin cancer (MoleMap). Importantly, AI can help reduce the false positive rate in screening, meaning that less patients are called for follow-up testing when they do not have the disease.<sup>97</sup>

**Automated screening using machine vision or intelligent analytics can be integrated into the clinical workflow in a number of ways.** The AI could screen all cases first, passing those that are not clearly normal to a clinician to review. This is the case with Christchurch-based company MoleMap who use IBM-supplied AI to screen out normal moles and leave suspicious ones for human doctors.<sup>98</sup> Or the AI could screen images after they have been reported by a clinician, thereby acting as a backstop. At present many medical images are evaluated and reported by two human specialists to prevent errors. If AI tools can be proven reliably accurate, a hybrid system of one human plus AI could prove to be a more efficient, cheaper and more accurate screening configuration.

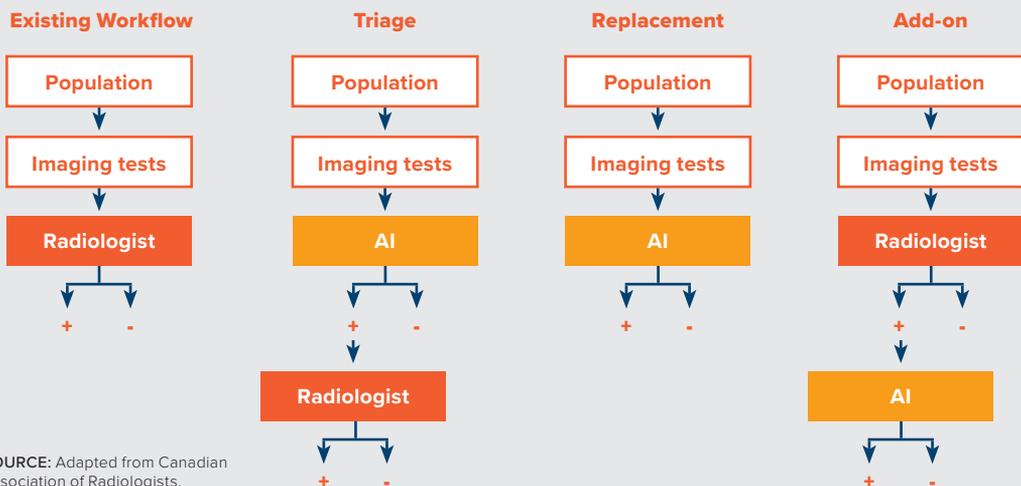
Screening combined with an automated e-referral process including automated triage could

see patients get a much earlier first specialist appointment than if they had to wait for a human clinician to review a stack of forms.

Currently many diagnostic tools that use AI are based on computer vision using static images. However, machine learning can also be used to track laboratory results, or read video captured from colonoscopies or cameras that pass through the body, or data from wearable sensors, or use natural language processing to gather information from the electronic health record to aid in diagnosis.

IBM's Watson's Medical Sieve Cognitive Assistant is being developed to interpret scan images in the context of the patient's notes. This could be a great improvement over the work of radiologists who often do not have the notes, or the time to read the notes. IBM's system collects clinical, textual and imaging data from the electronic health record and analyzes it to detect anomalies. The results are fed into a reasoning engine that combines evidence from clinical knowledge databases of similar patients to provide a differential diagnosis thereby assisting clinical decision making.<sup>99 100</sup>

**Figure 10:** Possible configurations of how to use AI in the screening workflow<sup>100a</sup>

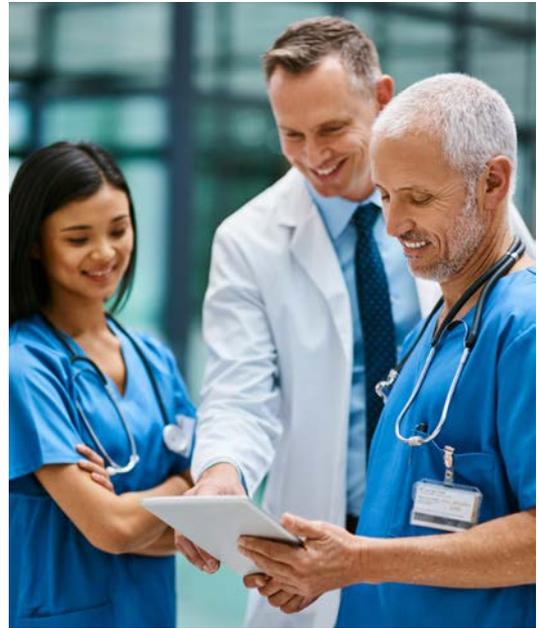


**AI enhanced diagnosis has the potential to greatly assist GPs.**<sup>101</sup> This is because GPs see a number of diseases rarely, and at an early stage of presentation when diagnosis is more difficult. GPs are also expected to not miss a diagnosis, yet at the same time refer only those patients that need it for further care.

**AI won't just enhance the screening process, it will help identify who needs to be screened.** We know that 12 percent of women will get breast cancer, but any given woman's risk is not exactly 12 percent. AI is likely to be able to trawl large datasets and learn who is at highest risk, and just as importantly, who is not at risk. This would then reduce inconvenience, risk, anxiety, and cost through not screening.

**“AI will enhance the capabilities of grassroots-level hospitals and doctors, so that their diagnostic abilities will be on a par with premium-level hospitals and doctors... the performance of a junior doctor assisted by AI has no statistical difference from that of a veteran doctor. For events such as strokes, as well as for diseases, the superiority of artificial intelligence in auxiliary diagnosis is particularly prominent. Hence AI can help level the healthcare resource imbalances between urban and rural areas, and between more developed and less developed regions.”**

– KUAN CHEN, Founder of Infervision.<sup>102</sup>



## TREATMENT PLANNING & MANAGEMENT

### *Clinical Decision Support*

Rich semantics in clinical records can be combined with natural language processing and published clinical guidelines. For example, IBM's Medical Sieve (described above) provides assessments of what diseases similar patients were diagnosed with and what their treatment was.

### *Acute Care*

In a review of AI in acute care,<sup>103</sup> Lawrence Lynn notes that many complex decisions need to be made quickly and existing treatment guidelines often call for decisions to be made at blunt thresholds, such as at certain blood pressure levels, or heart rate. However, acute illness is a complex dynamic process and data show complex and subtle relational time-series patterns. These are exactly the kinds of patterns that AI is good at recognising and predicting and it is likely that AI based protocols will supercede the present threshold based clinical protocols, with AI noting patterns and predicting problems before they occur.

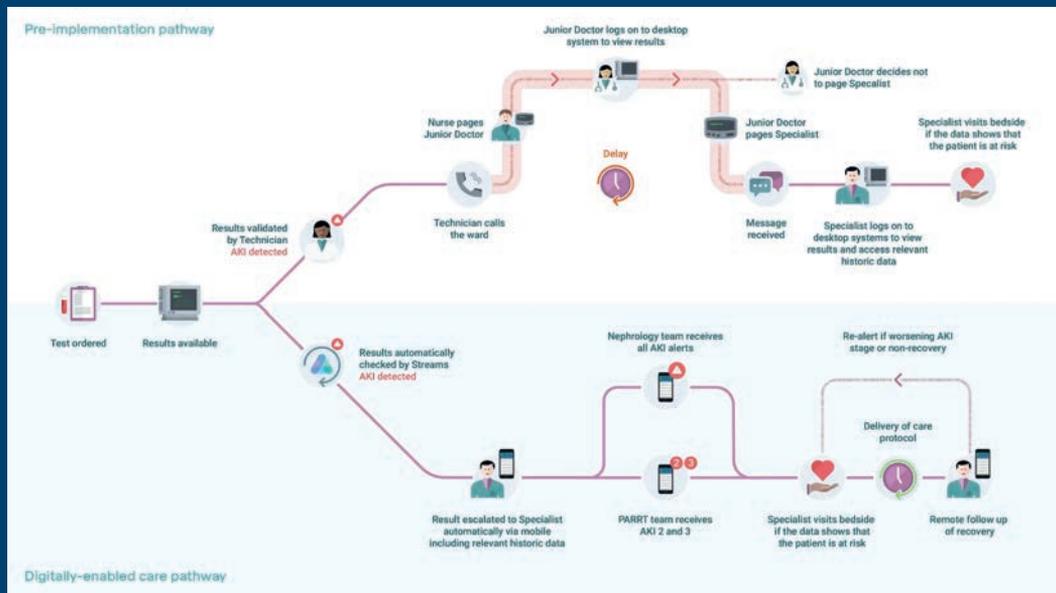


## AI by Google DeepMind can already predict acute kidney injury up to 48 hours before it occurs.

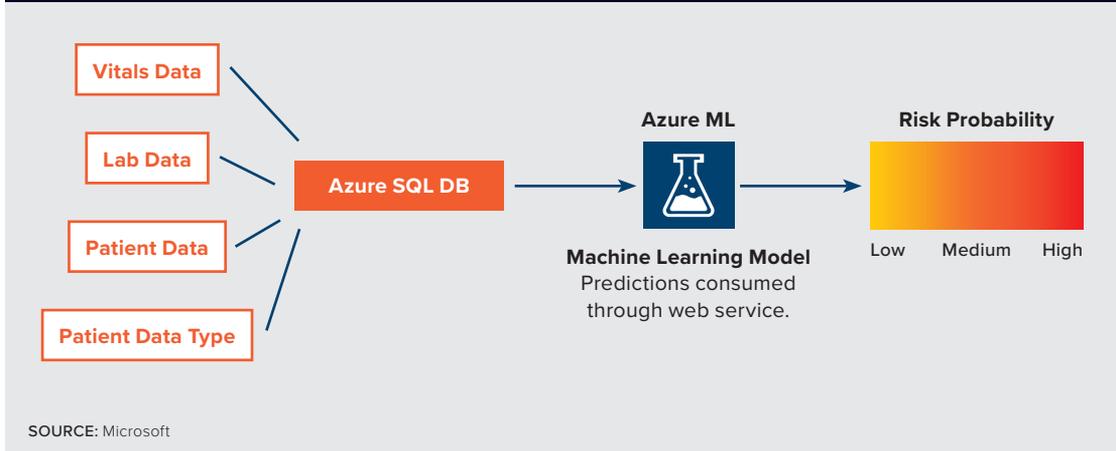
A PAPER PUBLISHED IN *NATURE* SHOWED THAT THE SYSTEM CORRECTLY IDENTIFIED 90.2 PERCENT OF PATIENTS WHO WOULD GO ON TO NEED DIALYSIS.<sup>104</sup>

DeepMind achieved this by training their model on Veterans' Administration electronic health records of 700,000 adult patients (mostly male). The model explains its reasoning by highlighting the factors that lent most weight to the prediction, as well as predicting the future results of certain laboratory variables. Importantly, DeepMind's model is an exemplar and the technique could now be applied to other acute conditions such as sepsis and across other more representative populations. Google has also been working on an application called 'Streams'<sup>105</sup> that integrates mobile technology to review test results and send alerts to the

right clinicians when a patient deteriorates, or is predicted to deteriorate. By using Streams, specialists reviewed urgent cases within 15 minutes or less (a process that might otherwise have taken several hours) and fewer cases of acute kidney injury were missed (3.3 percent rather than 12.4 percent), with the cost of admission for a patient with AKI falling by 17 percent.<sup>106</sup> Moving forward, models such as the acute kidney injury predictive AI model could be integrated with Streams leveraging the best of both these technologies.



SOURCE: Deepmind

**Figure 11:** Microsoft/Cleveland Clinic predictive cardiac arrest model

**AI applications could identify patients at high risk of cardiac arrest.** The Cleveland Clinic has partnered with Microsoft to upload data from intensive care units to Microsoft's Azure SQL Database, which is a cloud-based database for app developers. Data includes patient vitals and lab data. A machine learning predictive model is built from the data.<sup>107</sup>

### Surgery

**Robots have been assisting with surgery for years.** Mazor Robotics in Israel makes robotic guidance systems for spine surgery. In 2017 a robot dentist developed at the Fourth Military Medical University's affiliated Stomatological Hospital in China was the first to completely autonomously fit implants in a patient's mouth.<sup>108</sup> The Da Vinci robot can help surgeons with very fine grained steady work and is used in many minimally invasive surgical procedures. Da Vinci has many advantages, including improved sight, a steady robotic arm, and faster patient recovery. Da Vinci is not uncontroversial however, and concerns about lack of training for users and high rates of patient harm and complications underscore the need for robust evidence before deploying robots widely in healthcare. Analysis by Accenture predicts that robotic surgery will create US\$40 billion in value in the USA by 2026.

### Precision Medicine

**AI and machine learning will help personalise treatment for individual patients.** At present much treatment in healthcare is generic. Doctors consult the medical literature to establish that in general treatment A is better than treatment B. However, patients are not generic, and this partly explains why the outcomes seen in clinical trials show variations. Not everyone responds the same to every treatment and what doctors actually want to know whether *this patient* will respond better to treatment A or B. Healthcare can do better, by targeting treatment more precisely. Precision medicine is a new field which



**Image:** Da Vinci Surgical Robot  
**Source:** Wikipedia, used under CC-BY-SA 4.0 License

takes into account individual variability in genes, environment, and lifestyle. Given the vast volume of data contained in information about a person's genes, environment and lifestyle, AI and machine learning techniques such as predictive analytics are critical.

Early steps towards precision medicine are coming in the field of radiotherapy dosing. Researchers at the Cleveland Clinic used CT scans and the electronic health records of 944 lung cancer patients treated with high-dose radiation, along with a deep learning approach to prescribe appropriate radiation doses for individual patients. By using a combination of classical machine learning and neural network approaches the model needed less training data than pure deep learning approaches.<sup>110</sup>

In cancer genomics, analyses of genetic data help shape how we diagnose and treat cancer. In the UK researchers from Imperial College London and the University of Melbourne, have used AI to predict the prognosis of patients with ovarian cancer and what treatment is most effective for individual patients following diagnosis. The model appraises subtle differences in the structure, shape, and size of their cancer on CT scans as well as genetic make-up, rather than the type and stage of cancer as used in traditional methods. The model was four times more accurate than doctors in predicting deaths.<sup>111</sup> AI promises to teach us a great deal about the nature of pathology and medicine.

## Oncologists are optimistic about AI

A survey of 180 oncologists by Cardinal Health Specialty Solutions indicates that when looking beyond three years, most of the oncologists thought AI will improve quality of care (53%), clinical outcomes (57%) and operational efficiencies (58%). About half (47%) thought it will reduce costs. However, they were concerned about the lack of clinical evidence (29%), potential bias (27%) and clinicians lack of understanding (27%).<sup>109</sup>

## Patient Safety

**A number of AI applications will improve patient safety.** For example, San Diego health provider Sharp Healthcare has demonstrated how predictive analytics and machine learning can be used across data including blood pressure, temperature, and pulse rate, to predict which patients are at risk of requiring a rapid response team intervention within the next hour.<sup>112</sup>

In New Zealand, a Precision Driven Health project applies this same thinking to patient monitoring during surgery. The Early Detection Decision Information (EDDI) system can alert staff to an imminent patient decline, it can also detect medication errors, such as incorrect medication, overdosing or under-dosing.<sup>113</sup> Such applications, if trained across the right data sets might be able to monitor and predict a range of potential harm to patients before they occur.

## SURVIVORSHIP AND FOLLOW-UP

Following diagnosis and treatment, patients often need to be monitored and followed-up over time. However, many follow-up appointments turn out to be unnecessary as the patient is doing well. Similarly, if things start to go wrong clinicians need to be alerted.

**Chatbots can facilitate information exchange with patients.** This can be used to schedule follow-up, record how the patient is doing, and ensure adherence to treatment. Services can be text-based or audio, web-based or mobile, or leverage digital assistants such as Siri, Alexa, Cortana or Google Assistant.<sup>114</sup>

In the future informal carers are likely to be aided by AI assistants, and this virtual workforce will contribute to the productivity, safety, efficiency and improved outcomes in the health system.

## END OF LIFE CARE

Palliative care is crucially important but is not always offered when it is needed. Less than half of patients admitted to hospital who would benefit from palliative care receive it. Yet the vast majority of patients would prefer to die at home. A number of AI applications have been used to predict which patients will die in the near future, with remarkable accuracy. Such tools could be used to aid end of life decisions and target the right resources to the right patients at the right time.<sup>115</sup>

## Value-Based Healthcare: ZEDOC by The Clinician

Value-based healthcare focuses on outcomes that matter most to patients and allocates resources according to the health outcomes delivered by the system (value = outcomes/costs). As health systems move away from the current pay for service models and in response to a global demand for applications to support the implementation of value-based healthcare models, The Clinician (based in Auckland and Singapore) developed ZEDOC.<sup>127</sup>

ZEDOC integrates a range of applications developed by The Clinician into one platform, which can be delivered as a hybrid cloud service, allowing for local storage of personal information where required.

Founder and CEO Ron Tenenbaum says that this software-as-a-service tracks the patient journey from admission, through treatment, discharge and follow-up by gathering data from wearable devices, querying the patient about their physical and mental condition, and also incorporates cost-data for treatments received. The data tells a story about every treatment encounter and

patient milestone allowing for the measurement of validated outcomes and calculation of value.

Artificial intelligence is used to adjust the questions presented to patients removing unnecessary questions based on the patient's other responses and responses from the population as a whole significantly improving patient engagement and response rates.

The application also adjusts the user interface according to patient behaviour such as speed of responses, or mood, to optimize the 'digital bedside manner' for each patient. The application informs the patient what data has been received and where it is being sent to help manage any anxiety the patient might have. If responses fall outside acceptable limits alerts are sent to providers who can then decide to adjust the patient's treatment if required.

ZEDOC is already helping to reduce unscheduled patient readmission rates and increase consumer satisfaction with healthcare.

Analysis by PwC has determined that robots could revolutionise end of life care. Robot assistants can help people be independent in their homes for longer. This assistance could reduce the need for hospitalisation and reduce the demands on caregivers or nursing staff by monitoring vital signs and reminding people to take medication.<sup>116</sup> The Robot-Era programme in the EU is funded by the European Community and aims to develop, implement and demonstrate a range of complete advanced robotic services including intelligent environments, to help older people live independently with improved quality of life.<sup>117</sup>

Massey University researchers are investigating how the use of simple sensors (such as motion sensors, power sensors registering the use of appliances, or contact switches on cupboard doors) can be combined with machine learning to build intelligent houses that can provide support, reassurance, assistance and comfort to residents.

The aim is to enable older people in particular, to live independently in their own homes, for longer.

### MENTAL HEALTH

Mental wellbeing is a particularly salient area of health in New Zealand. The Labour Government's 2019 budget saw \$2 billion allocated to mental health issues, thereby recognising the magnitude of the problem in Aotearoa. There are scenarios in which AI is a strong fit for assisting with mental health, and some applications show great promise, with several initiatives already underway locally.

Evidence demonstrates that people would often rather discuss mental health issues with a bot than a person. This was practically demonstrated by the vast uptake by users of WoeBot, "a charming robot friend ready to listen 24/7".

Youthline uses an AI assistant. eHealthNews reports that Sam (the assistant), "uses conversational AI and

natural language processing, including sentiment analysis, to recognise questions and learn from interactions over time.”<sup>118</sup> Sam can provide information in response to 200 common questions about stress, confidence, self-esteem, anxiety, depression and bullying. Users can find Sam on Facebook’s Messenger platform, or they can visit the Youthline website.

New Zealand’s John Kirwan has been a champion for mental health issues for a number of years, and is now partnering with local AI business UneeQ to develop AI powered digital mental health coaches, which can then be included in treatment programmes.<sup>119</sup>

AI could be used to identify those at risk of mental health issues. Researchers from Harvard and Emory Universities have found that automated analysis of language used by individuals, including vector unpacking to measure how much information is in sentences, automated across 30,000 social media conversations, can predict if individuals will later develop psychosis. The accuracy of this tool in the study was 93 percent.<sup>120</sup> Other researchers have found that linguistic markers in social media can predict depression up to three months before a formal diagnosis.<sup>121</sup> Other studies have also used such ‘digital phenotyping’ and predicted depression from Instagram photos prior to clinical diagnosis. Intelligent phone apps could be developed to offer appropriate cognitive behavioural (‘talking’) therapy.<sup>122</sup>



## Potential Major Innovative Disruptions

### RADICAL CHANGES TO PRIMARY CARE

**Primary care could be provided by smart digital assistants.** Even in busy cities it can be hard to access a doctor when needed. So Babylon Health in the UK created an AI solution. Through an app users can describe their symptoms and receive advice based on a statistical model that uses speech recognition. The app does not make a diagnosis, but if required the user can then make an appointment with a GP via telehealth and be ‘seen’ much sooner than usual. In a future iteration such technology could provide prescription of regular care without seeing a clinician. Combine the digital assistant and AI model with personal sensors such as blood pressure, pulse and temperature measures, voice tone and pitch analytics, or mobile phone cameras and diagnostic image analysis and many patients may no longer need to see a primary care provider if a smart system can provide reassurance or a fast-track referral to a specialist as needed. There is great potential to unburden overworked and strained GPs and PHOs.

**AI may mean that health funding models will need to change.** Babylon Health advertised for people to join its ‘GP at Hand’ smart doctor system. However, a furore about advertising ensued when it was not made clear that people would have to leave their current GP in order to use the service. The overarching issue is one of funding.

Babylon’s approach has not been without its teething problems, with patient referrals falling between the cracks in a system that is structured around location of domicile. Systemic changes to funding and family practice enrollments are likely to be needed.<sup>123</sup>

In New Zealand Primary Healthcare Organisations are funded according to a capitation rate. The PHO gets money on a per patient enrolled basis, not a per service delivered basis. Disruptive technologies that, for example, change the way we see a doctor may require changes to the way that public healthcare is funded. It will be important to avoid both “double dipping” and healthcare provision that is not reimbursed.

## RADICAL CHANGES TO CHRONIC AND HOSPITAL CARE

**Virtual hospitals could help reduce the burden of chronic illness.** Many patients with chronic illnesses slowly become unwell at home, and access healthcare services only once they are suffering a serious exacerbation of their illness. Through AccuHealth's 'virtual hospital' approach, patients are provided with a set of individualised sensors and monitoring devices, allowing them to assess their own health at home. All the information is uploaded to AccuBrain, AccuHealth's AI and advanced analytics engine. Accubrain combines the patient's biometric, self-assessment, and demographic data with machine learning algorithms and predictive models that are based on population data. AccuBrain can identify health issues before they escalate. Once alerted the patient, carers or health professionals can take action to proactively improve care, quality of life, avoid hospital admissions, and decrease the overall cost of care.<sup>124</sup>

AccuHealth's virtual hospital enables a single nurse to monitor up to 50 patients and has reduced emergency department visits by 42 percent and costs to health insurers by 32 percent across 15,000 users.<sup>125</sup> With approaches like AccuHealth, there is great potential to decrease the burden of chronic illness, meet the New Zealand Health Strategy's goal of care 'Closer to Home', and free up health system resources.

The New Zealand health sector has the potential to embrace consumer-facing services where people see direct value from AI that offers a radically different model of care. However, an entrenched public system may struggle with these developments and policymakers and funders will need to anticipate and prepare for these changes.

## FUTURE TRENDS

The Future Today Institute's Future Trends Report (2019) indicates that all of the Big Nine companies: Amazon, Google, IBM, Apple, Microsoft and Facebook in the US, along with Baidu, Alibaba and Tencent in China are progressing health initiatives. Investments include programmes in big data and genomics, cloud privacy and medical data storage compliance, reimagining insurance and healthcare, and at-home medical diagnostic kits. In-home devices like Alexa will aim to diagnose whether you've got a cold (and automatically order in medication...) and we may see the consumerization of healthcare with Big Tech owned and operated health clinics. An explosion of wearables, connected clothing, touch sensitive prosthetics, smart glasses and head mounted displays is forecast. No doubt many of these innovations will incorporate AI to monitor and enhance health.<sup>126</sup>



## Section 3:

# Nature and Scale of Impact

### Introduction

The Institute for Health Improvement's Triple Aim emphasises that healthcare should seek to improve population health, at efficient cost, with good experiences of care. The New Zealand Health Quality and Safety Commission has adopted a similar Triple Aim. It is against this that the nature and scale of AI impact on healthcare should be measured. A fourth consideration being the wellbeing of healthcare practitioners.

**In New Zealand the majority of spending on healthcare is publicly funded, so the effectiveness and value for money of healthcare are paramount.**

Development costs of AI solutions can be high once expert consultation, high powered computing, and evaluation of effectiveness are taken into account. This could make deployment of a product that is only equal to human performance less than cost-effective. However, the marginal cost of scaling an AI solution may be close to zero. This could be an incentive for government to invest in development of solutions that can be generalised.

**In the coming decade, “Developers will have a greater impact on the future of healthcare than doctors,”<sup>128</sup>**

says MMC Ventures, which also reports that there are more AI startups in health and wellbeing than any other sector.

### Benefits to the Health System

#### INCREASED EFFICIENCIES

**AI will help reduce the twenty to thirty percent of the health spend that is wasted.** The reasons for this waste include system inefficiencies that could be addressed and prevented such as failures in care delivery, over-treatment, and improper care delivery.<sup>129</sup> Artificial intelligence can help reduce inefficiency, streamlining administrative processes and delivery of care.

**In tomorrow's hospitals AI will track the occupancy of every bed and use predictive modelling to forecast demand.** Already at Johns Hopkins in Baltimore, United States, intelligent 'command centres' are being used to increase efficiency and maximise capacity. James Scheulen, chief administrative officer for emergency services and capacity management, has said that, "emergency room patients are assigned a bed 30% faster; transfer delays from operating rooms have been reduced by 70%; ambulances are dispatched 63 minutes sooner to pick up patients from other hospitals; and the ability to accept patients with complex medical conditions from other regional and national hospitals has improved by 60%."<sup>130</sup> Intelligent technology has the potential to solve the crisis of our overburdened health systems at scale.

#### ECONOMIC BENEFITS

**Several major consultancies have published reports on the economic benefits of AI.** Focusing on the impact on US healthcare, Accenture reported in 2017 that AI would deliver US\$150 billion in savings by 2026,<sup>131</sup> this is approximately 2.7 percent of the entire US\$5.5 trillion healthcare spend projected for 2026. Accenture projected the health AI market to see a 40 percent compound annual growth rate through 2021, growing ten fold over 5 years 2017-2021. The economic impact of AI will span all aspects of healthcare, for example Kheiron Medical indicates that AI in medical imaging will be a US\$2 billion global industry by 2023.<sup>132</sup>



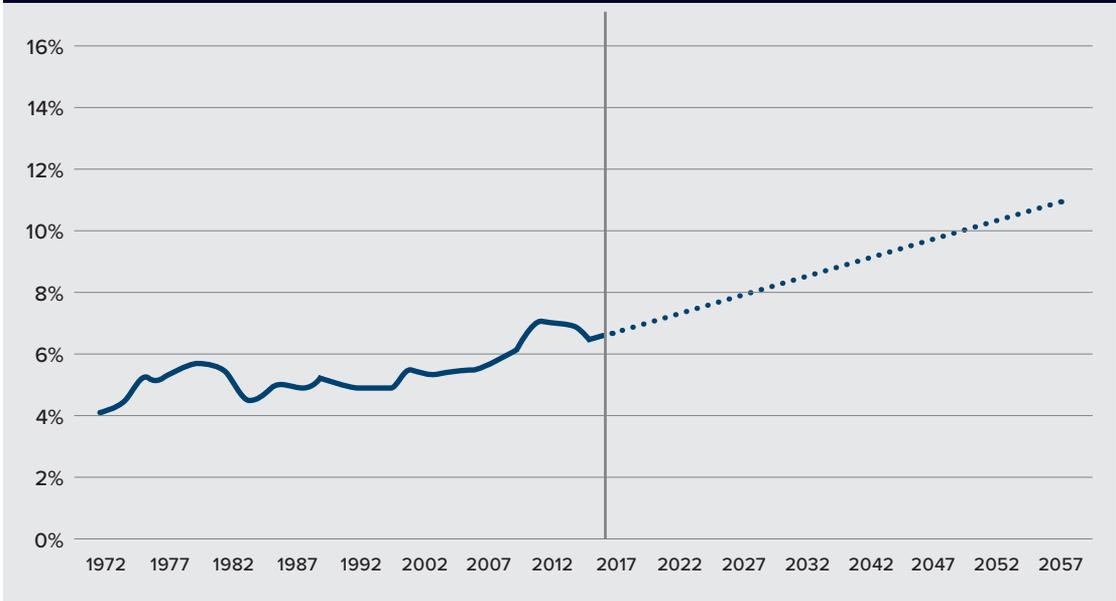
New Zealand Treasury forecasts suggest that New Zealand will be spending nearly 8 percent of GDP on public healthcare by 2026 (see Figure 12). The OECD forecasts New Zealand GDP will be US\$213 billion by 2026.<sup>133</sup> This means a potential spend of US\$17 billion on New Zealanders' health in 2026. At a macro analysis, scaling Accenture's 2.7 percent impact of AI by 2026 in the US to the New Zealand health sector, this equates to AI generating at least US\$460 million of added value and savings (over \$700 million in NZD at USD to NZD 1.60) by 2026. This could rise to NZ\$1.6 to 3.6 billion by 2035 as reported in the AI Forum's 2018 *Shaping a Future New Zealand* report.<sup>134</sup>

**These benefits will accrue incrementally with full impact over a number of years<sup>135</sup>** and may help solve the problem of healthcare's 'iron triangle'. This is the predicament where the three interlocking factors of access, affordability, and effectiveness tend to require negative trade-offs. AI can help by increasing access, or affordability, or effectiveness, or all three, without diminishing the others.

**“To fully comprehend the opportunity, healthcare organisations must understand the full taxonomy of AI applications – and the potential value each delivers financially, but also by way of organisational and workflow improvements.”**

– Accenture<sup>136</sup>

**Figure 12: Long Term Fiscal Projection for Health Spending in New Zealand**



SOURCE: Health Projections and Policy Options for the 2013 Long-term Fiscal Statement from the Treasury.

**ENHANCED COST-EFFECTIVENESS**

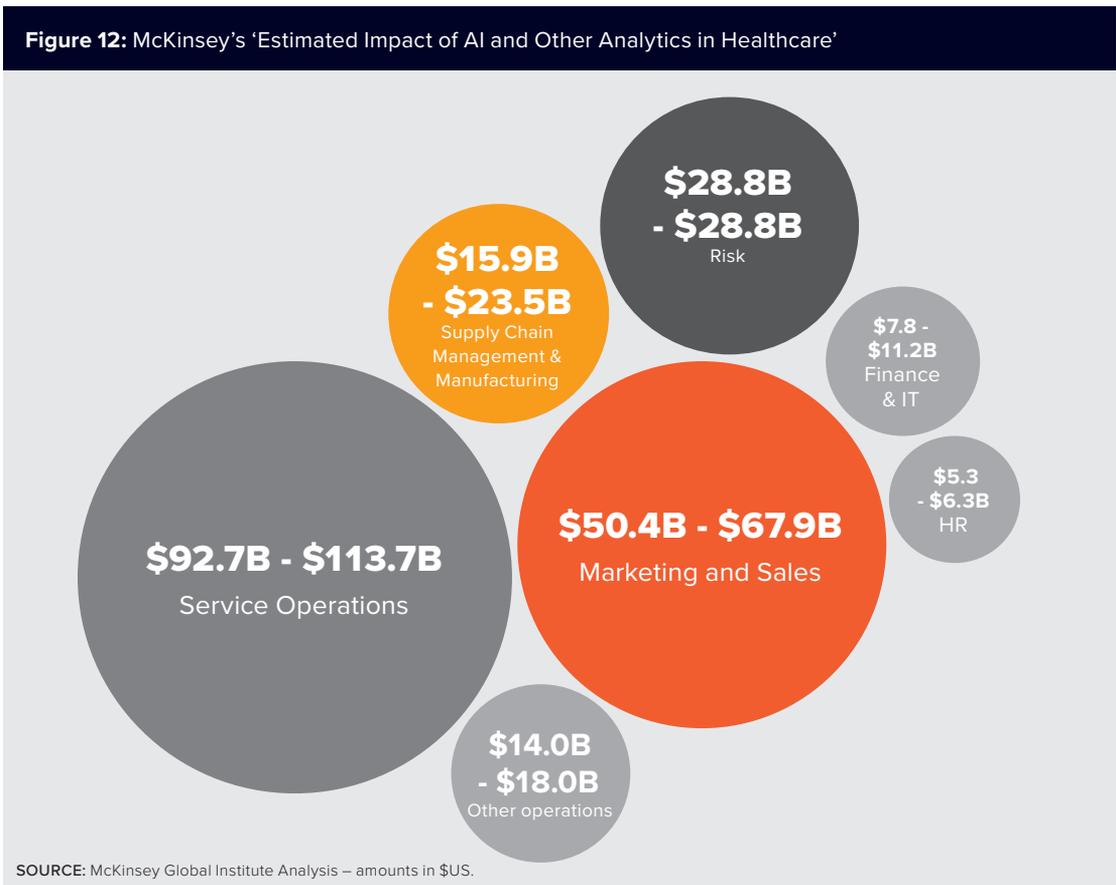
McKinsey Global Institute predicts large gains in non-clinical aspects of healthcare. This means that AI will enhance the cost-effectiveness of care.

McKinsey examined ways that AI might create more value in the business of healthcare systems and services. It estimated these potential savings at up to \$269.4 billion annually, shown in Figure 12.<sup>136a</sup>

The ‘top 10’ AI in health applications will ‘think and pay for themselves,’ is the conclusion of the analysis by Accenture.<sup>137</sup> Cost-effectiveness is a perennial talking point, whether some treatment is too expensive for the amount of health gain produced.



**Figure 12: McKinsey’s ‘Estimated Impact of AI and Other Analytics in Healthcare’**



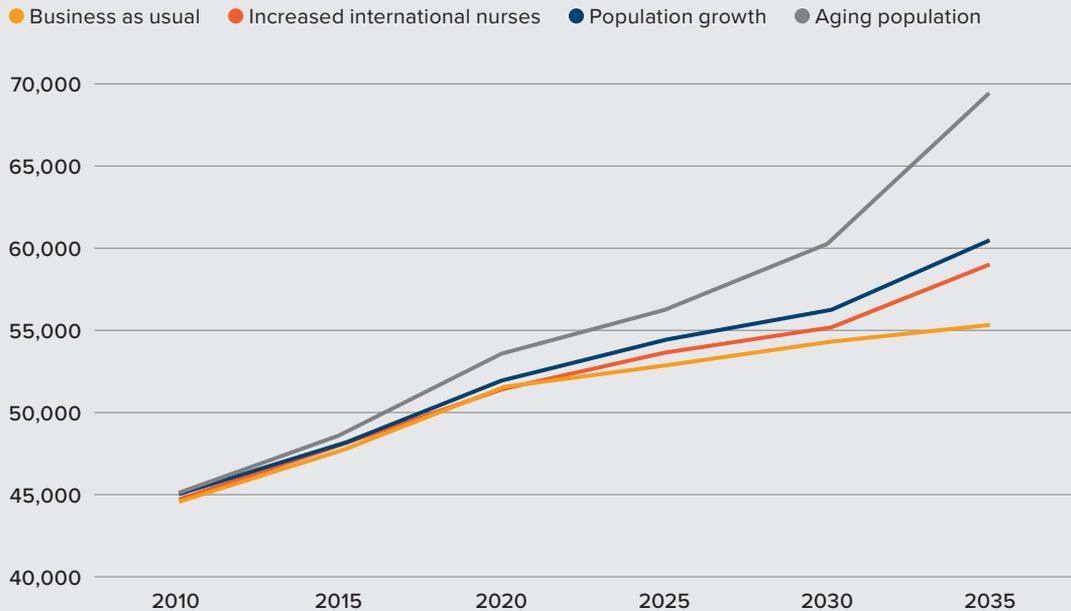
AI has the potential to decrease costs for the same, or better, health outcomes. The process of Health technology assessment (HTA) seeks to identify healthcare interventions with a positive difference in treatment effects, while either not costing too much, or ideally being cost-saving. Many new health technologies are expensive and provide marginal health gain. AI has the potential to be low cost (at least once up-front development expenses are paid) and effective (bottom right quadrant in figure 13). Cost utility analysis like this should be mandatory for new health technology.

### HEALTH WORKFORCE EFFICIENCY AND PRODUCTIVITY

New Zealand will need a much larger health workforce by 2030. This is due to the care needs of an aging population and rising public expectations. The Prime Minister's Business Advisory Council Report by McKinsey projected the creation of 82,000 net jobs in healthcare by 2030. Labour productivity growth in health has been -0.6 percent across 2016-2018. There is a looming workforce crisis in health, and automation will be a key contributing solution. The 'Future Nursing Workforce' report by the Nursing

Figure 13: The Cost-Effectiveness Plane: AI could be 'dominant'.



**Figure 14:** Nursing Council of New Zealand Workforce Forecasts

SOURCE: Nursing Council of New Zealand<sup>137a</sup>

Council of New Zealand notes that business as usual will lead to a nursing shortage increasing after 2020 to a shortage of 15,000 nurses by 2035. Currently there are between 50,000 and 55,000 nurses in New Zealand. The good news is that AI can help.

**Conversational AI firm Sensely has partnered with health organisations worldwide, including the NHS in the UK. Their early deployments indicate that AI has the potential to save 20 percent of nurses' time.<sup>138</sup>** This equates to a 25% increase in the effective nursing workforce. This promises that AI applications could effectively add the equivalent of up to 13,750 nurses in New Zealand without changing the current workforce. The impact on efficiencies for other kinds of clinical staff (such as radiologist's time, pharmacists' time) and back office staff (such as invoicing time) could be comparable.

## Benefits to the People of New Zealand

### REDUCED BURDEN OF DISEASE

**Accenture predicts that AI could help healthcare by addressing 20 percent of unmet clinical need.<sup>139</sup>**

Reductions in the burden of illness will emerge via the use cases detailed in Section 2. Improved population health is one of the Triple Aims of healthcare and better prevention, screening, diagnosis, treatment, follow-up and end-of-life care will enhance population health. Improvements in patient safety, reduced misdiagnosis, and precision targeting of appropriate care all reduce the burden of illness.

However, it will be important to demonstrate unequivocally the effectiveness of AI applications

across the care pathway. The Canadian Association of Radiologists' white paper clearly states that, "More than most conventional information technology tools, AI applications may directly influence the diagnosis and management of a patient. Hence, this professional responsibility should be taken seriously and cautiously by radiologists and computer scientists working in this field."<sup>140</sup> Quantitative evidence of impact on health will be needed.

One area where patients are likely to see benefits is due to the enhanced engagement and presence of clinicians. A range of automated processes such as voice to text will free up clinician time. Less focus on screens will mean that eye contact between clinician and patient is enhanced. Furthermore, the time available for consultations becomes longer. Evidence shows that even a one minute longer home visit can reduce hospital readmissions by 8 percent. Longer medical consultations reduce hospitalisations by 20 percent. Focusing on patients rather than administrative tasks will enhance care and save costs.<sup>141</sup>

### INCREASED ACCESS AND EQUITY

It is important that the health system provides access options so that all people can get health advice and treatment when they need it. It is also important that healthcare is delivered equitably, so that no one is disadvantaged because of their circumstances. AI is helping improve access and equity

in health as well as empowering patients to make informed and better decisions about their health.

### AI can bring healthcare to hard to reach populations and regions.

In low income nations access to healthcare can be particularly difficult. However, computer vision applications such as New Zealand company oDocs' eye screening tools, or Google DeepMind's smart eye diagnostic applications could be deployed to screen thousands of people for eye disease without them ever having to see a doctor. Health chatbots, coupled with computer vision and intelligent analytics could soon extend basic healthcare to millions of underserved people at almost zero marginal cost.<sup>142</sup> Even if the systems deployed are not perfect, some healthcare may be better than no healthcare for many people. There are many possibilities for AI enabled delivery of care to remote and rural regions.

### AI can help enhance equity in patient management.

In New Zealand there is often a discrepancy between the specialist referral rates of Māori and non-Māori.<sup>142a</sup> To improve equity and eliminate implicit bias in healthcare referrals, Precision Driven Health is developing a machine learning model that will assess and triage cardiology referrals (see case study). By training the AI to recognise who needs to be seen first based on medical information from multiple sources, patients should be referred based purely on their health need.<sup>143</sup>



## CASE STUDY HEALTHCARE

# PRECISION DRIVEN HEALTH: Triageing Cardiologist referrals from General Practitioners

Managing patient referrals has traditionally been a paper-based process. The time consuming manual process requires prioritising referrals according to urgency levels and protocol.

Founded in 2016, Precision Driven Health (PDH) is a research partnership between Orion Health, the University of Auckland and Waitemata District Health Board. PDH is investing \$38 million over seven years in collaborations to personalise healthcare by running machine learning on data. Studies and early technology adoption are key focuses of this partnership.

Waitemata District Health Board (WDHB) identified cardiologists were spending too high a proportion of their time triaging patient referrals and reviewing paperwork. Unsurprisingly, cardiologists would prefer to spend more time treating patients and less time processing referrals!

PDH aims to use transfer learning to reduce the time taken for hospital cardiologists to prioritise patient referrals from general practitioners. Reducing the triage time allows cardiologists to spend more time with patients, reduce patient waiting time and improving delivery of the right treatment and care.

Dr Edmond Zhang, a data scientist at PDH, is using different machine learning models on different data types, including images, scans, text-based data, and structured data such as laboratory test results. These outputs are combined into a unified model to triage patients.

PDH will use 14,000 existing WDHB cardiology triage records to create the base machine learning model for this project. To complete the transfer learning aspect of the project, this base model will then be fine tuned for other contexts. As at June 2019, PDH is currently mid way through base model production and a functional triaging model for cardiologists should be ready later this year.

Ultimately, PDH will develop the research outputs into a commercial platform. Orion Health's Smart Data Platform will enable clinicians to use these tools to support their decision making.

Challenges that PDH are facing on their journey include:

- **Data Access:** PDH has access to 14,000 cardiology triage records from WDHB, however gaining access to a wider set of historical triage records has proven difficult. PDH needed to gain data ethics approval as well as anonymising free text data.
- **Moving the models into clinical practice:** The time delay between a proof of concept and deploying a model can mean situations change, inconsistencies develop, or datasets may look different
- **Gaining access to a high performance computer:** Due to privacy and for security, the computer remains on the premises during the project.

The benefits of using the Smart Data Platform include:

- time and cost savings
- combining multiple data sets means better insights
- transferring a base model to different specialisations and hospitals

The plan for the Smart Data Platform is to include a base model that will apply to specific industries and offer Data Science as a Service, either on premise or cloud based.



Learn more at [www.precisiondrivenhealth.com](http://www.precisiondrivenhealth.com)



## Potential Impact on Healthcare Professionals

It is well-known that doctors 'hate their computers,' because of the interruptions to workflow and the fact that doctors spend half of their consultation time staring at their screens.<sup>144</sup> Currently available technologies such as voice to text promise to revolutionise the way that clinicians interface with the electronic health record.

**The implications of AI for health professionals include reduced workload and less stress,** as well as less burnout, fewer administrative tasks and more time to focus on human aspects of care. Physician burnout is a significant problem and over three-quarters of physicians experience intermittent feelings of professional burnout.<sup>145</sup> Data entry requirements and clunky electronic health records contribute to this problem. Through streamlining workflow, intelligent dictation, and automating clinical records, intelligent software could help reduce the burden of physician burnout.<sup>146</sup> AI is not likely to replace clinicians anytime soon,<sup>147</sup> but should make many aspects of their jobs easier and more efficient.

**Some health tasks will be eliminated and new roles will be created.** Health roles that can be reduced to repetitive operations (even those requiring high skill levels) are likely to be candidates for automation. For example, intelligent systems are likely to get very good at:

- Processing test results or scans (such as in radiology, dermatology, pathology)
- Coding medical records (converting free text to medical ontologies)
- Planning and auditing
- Scheduling

Workforce planning should ensure that staff performing these kinds of activities transition to performing other activities that are important to healthcare but difficult to automate. However, many changes will take time. For example the vast range of diagnostic work done by a radiologist is not going to be completely automated overnight, if ever.

**It is likely that new specialties will arise in clinical training.** With improvements in automation some specialties will recede and others will thrive.

In the near future there may be roles for 'data science doctor' and 'clinical machine learning expert'. There is a strong case for New Zealand to train more doctors in data science.

### CHANGES TO FUNDING

**Planning and funding will need to preempt the arrival of transformative AI applications.** For example, PHO funding by capitation may not be optimal in the future context of primary care provision by a smart digital assistant provider. Similarly, DHBs may need to redirect funding from hospital care to community monitoring as AI systems facilitate care closer to home.

**Advances in diagnostic tools, including AI applications may increase diagnosis rates.** This could happen as applications are deployed at commercial locations such as optometrists (or spectacle shops), or pharmacies for example. Such consumerisation of healthcare may bring to light a large amount of unmet health need to be addressed. However, diagnosis of unmet need also has the potential to raise costs.<sup>148</sup>

**"Data infrastructure" projects will need to be advanced** to capture and store the vast health data upon which successful AI systems can learn. New Zealanders might reasonably expect to see additional investment from the Government to progress these foundational data steps towards a more holistic AI enabled health system. Such projects could be funded either directly to DHBs or via bodies such as the Health Research Council or Precision Driven Health.

**Additional investment in research, development and evaluation of novel solutions will be needed** so that the AI solutions that are approved are those that are robustly demonstrated to enhance the Triple Aim by adding clinical value, enhancing patient experiences or reducing costs.

**New Zealand could consider partnering with pharmaceutical companies or health technology firms** to generate by partnering to provide access to non-identifiable New Zealand health data, which private companies need to help develop innovations, in exchange for cheap access to cutting edge medicines and treatments for the public system.

## Section 4:

# Early Adoption Opportunities

### Introduction

AI presents a number of broad opportunities for positive change in the New Zealand health sector. These include:

- New Zealand, as a small and potentially agile nation, with a unique national health identifier for each individual, has an opportunity to take proven innovative AI technology from overseas, evaluate it and then apply it in short time frames across our excellent health datasets to generate insights.
- With an increasingly burdened workforce, there is an opportunity to use the AI that is already available today to release clinician and nurse time and enhance the efficiency of the health system.
- There is an opportunity to apply machine learning and AI to New Zealand's unique Māori data and gather insight to prevent illness, enhance equity and enable Māori health and wellbeing.

### Early Adoption Opportunities in New Zealand

#### AI FOR HEALTH SYSTEM RESEARCH

Research is essential for updating our understanding of health, disease and the functioning of the health system. New Zealand invests substantial amounts in traditional health research through a number of research funds.

AI is a tool that can learn about health, disease and the health system in real-time, updating its performance and potentially producing insights similar to, and in addition to, those obtained through traditional health research. This also means that the recommendations of AI systems may change over time in response to increasingly comprehensive, locally relevant evidence in the data. This process runs counter to the current prevailing mindset in health that randomised controlled trials are the gold standard for determining optimal clinical care.

Standard models for research planning, funding, approval, and ethical oversight do not straightforwardly fit AI used in this way. For example, is this clinical care? Or a research project? However, there is an opportunity for New Zealand to plan and then

experiment with AI firstly in research and analysis of health system processes, or epidemiological predictions to gain confidence that such tools can be trusted to identify appropriate clinical care.

New kinds of ethical approvals and new approaches to funding may be needed to facilitate this approach. A plan to invest in these analytics can enhance New Zealand's health research capacity and output. There are clear opportunities to invest in analytics and AI models that could provide insight and efficiencies that mean these new systems pay for themselves.

#### MONITORING PATIENT INFORMATION

Early adoption in New Zealand could focus on areas that are particularly problematic locally. These include our large unmet health need in mental health, and also difficulties in service delivery and access to care in rural areas.

**Providers could consider adopting smart remote patient monitoring**, and patient outcome assessment with applications similar to ZeDoc by The Clinician,<sup>149</sup> or AccuHealth's virtual hospital.<sup>150</sup> This could help reduce the need to access healthcare when patients are well, and help target resources in plenty of time when they are not. These kinds of recommendations were made by global AI in Health expert Professor Eric Topol after he was commissioned by then UK Health Secretary Jeremy Hunt to review the future of the NHS.<sup>151</sup>

**Smart tools for evaluating patient wellbeing could be adapted to facilitate patient-centred care discussions.** Gathering this kind of information from patients using queries intelligently tailored to their situation means better care for the patient and a smarter health system.

#### ELIMINATING CLUMSY INTERFACES

**Adopting technologies that already exist can increase the efficiency of administrative workflow, and free up clinician time** for providing care. Eric Topol has said that 'keyboards are the enemy'.<sup>152</sup> He favours eliminating interfaces that impede the synergy between clinician and information. Some hospitals in the UK have removed keyboards from emergency departments altogether by favouring voice activated speech to text systems. This allows clinicians to record clinical notes in real-time without workflow interruption. Siddhartha Mukerjee, author of 'The Emperor of All Maladies: A Biography of Cancer', agrees, saying that

'keyboarding is a source of physician burnout'.<sup>152a</sup> Removing poor user interface burdens from healthcare (such as keyboarding or reading medical imaging) and frees up clinicians to be humanistic, to learn about the patient, and what is important to them.

### SUPPORTING QUALITY AND INNOVATION

**Quality and Innovation Hubs** can help researchers and companies with new technology to navigate red tape. Such hubs could facilitate access to sandboxed data or act as a test-bed with a low threshold for entry, prior to developers having to apply for approval to access and evaluate across patient critical data or systems.

**Clinical champions are needed** who understand how the use of data and intelligent analytics can enhance healthcare, improve patient outcomes and save money. These champions can help disseminate knowledge and highlight opportunities.

### LAYING THE FOUNDATION FOR A TRULY INTELLIGENT HEALTH SYSTEM

**New Zealand at present scores only a 3 out of 5 on the Global Digital Health Index.**<sup>153</sup> According to our scorecard there is an opportunity to improve strategy and investment as well as standards and interoperability. The Ministry of Health is working in these areas, but more can be done. Improving our digital health strategy and ensuring cross-system interoperability will lay the foundation for early adoption of transformative AI.

**From the perspective of enabling AI and machine learning a commercial cloud data solution is likely optimal, delivering economies of scale and access to the latest international AI innovations at low cost.** The Government could provide clarity on where and how New Zealanders' health data may be stored. Some organisations are unclear about what is permitted. The question of data sovereignty for health data needs to be resolved finally. There is a strong argument that where data is physically stored is less relevant than whether the right groups of people have control of data and access to it. If cloud service by big tech providers is really not an option then the government could invest in the next best option from an AI point of view, which is an integrated cloud solution for the whole New Zealand health system. There are

cloud data providers in New Zealand that can ensure identifiable data remains under local sovereignty.

**There are existing machine learning solutions that could be deployed right now.** These include predictive scheduling optimisation, among others. Early deployment will cultivate local experience with these tools. As already noted, key decision makers need to be on board upfront, or there is a high risk of losing their support if something doesn't work as expected in an early iteration.

## Is AI the right solution? ACC and Claims Processing:

**SOMETIMES THERE MIGHT BE AN AI SOLUTION TO A PROBLEM, BUT AI MIGHT NOT BE THE OPTIMAL SOLUTION.**

The Accident Compensation Corporation investigated AI solutions to automate processing of claims approvals. Given that 96% of claims are approved, the goal was to find a way of automatically approving the straightforward cases, leaving unclear cases for humans to decide. However, AI can be an expensive solution to develop. In this case ACC partnered with Nicholson Consulting and determined that a combination of business rules and a set of statistical models was sufficient to automate the process, enhancing consistency and saving labour. The models were built based on eight years of claims data. ACC's own quality assurance testing suggests the automated system makes as few as 2 incorrect approvals in 18,000. Humans now only need to look at about 14% of claims. This process automation ensures faster, more accurate processing, whilst ensuring the algorithm cannot deny claims.<sup>154</sup> Experience developing and deploying statistical models like ACC's can help build a data science foundation to facilitate subsequent use of AI solutions. To enable government departments to decide if AI is the right approach, the UK Government Office for Artificial Intelligence has published guidance for the UK public sector on determining if AI is the right solution.<sup>155</sup>

## Developing Commercial Opportunities

As AI solutions become more widespread, private health organisations from dentists to medical clinics to aged care will seek AI-based solutions for competitive differentiation.

The New Zealand Health Research Strategy 2017 outlines a vision for investing up to \$120 million by 2020. Among the four strategic priorities are the goals of building and strengthening pathways for translating research findings into policy and practice; and advancing innovative ideas and commercial opportunities.

**It will be important that work is undertaken with clinicians** or commercial endeavours risk failure. Many technological solutions in the past have seen clunky administrative interfaces imposed upon the clinical workforce rather than being elegant solutions to problems encountered in clinical workflow. Workflow integration is a key opportunity – a good AI model is not enough. In the medical world solutions must be integrated seamlessly into the workflow.

**There is an opportunity to partner with big technology platforms** to ensure that important public health information is available when people need it. Studies have shown that intelligent digital assistants such as Siri are particularly unhelpful in sourcing information about such topics as how to quit smoking.<sup>156</sup> In the UK the government is partnering with Amazon's Alexa to help offer health advice.<sup>157</sup>

**Partnerships with pharmaceutical companies are possible** and New Zealand could consider sharing non-identifiable data in exchange for discounted therapeutics to help address the issue of Pharmac's budget constraints.

**There is an opportunity for commercial development of reliable, validated sensors** that collect medical quality data 'in the wild' to support home-based care and intelligent monitoring. A number of currently available sensors are not sufficiently accurate or robust. One example of this is a fitness band that records a 'heart rate' when wrapped around a roll of toilet paper.<sup>158</sup> There is a lot of skepticism about the accuracy and clinical relevance of metrics collected by many wearables. However, Apple is now manufacturing devices which have received FDA certification for certain measurements and more companies are sure to follow.

**AI assistants could facilitate healthcare teamwork and communication.** We know from teamwork and patient safety research in healthcare that important communication techniques such as speaking up, sharing information, briefing and debriefing, escalating concern and closed loop communication all help to prevent adverse events and avoidable harm. There is an opportunity for AI assistants to facilitate these practices, perhaps even speaking up themselves.

**Finding a reliable way to de-identify unstructured data is a big opportunity** and challenge. Solving this problem will unleash the power of data in electronic health records for research and development.



## Section 5:

# Accelerating AI Adoption in Health

### How to get from Current State to an AI Enabled Future?

We've seen in Section 2 the potential for AI to impact across the whole patient care journey (thereby improving population health outcomes). Section 3 illustrated how this impact is of significant financial and economic benefit (thereby reducing healthcare costs). Section 4 uncovered some of the opportunities for New Zealand to enhance the experience of patients and healthcare workers. However, there are some barriers to moving to a future state where these innovations are commonplace in the New Zealand health sector and deliberate policy and action is required in order to reap these benefits.

#### BARRIERS TO IMPLEMENTATION OF AI IN HEALTH

There are a number of practical barriers that need to be overcome to enable widespread adoption of AI in New Zealand healthcare. Some of these are:

- A low level of digital literacy among the healthcare workforce
- Inflexibility of legacy technological systems
- Insufficient awareness of where and how AI is being applied in the sector
- The need to slowly introduce clinical staff to new workflows to avoid resistance
- Difficulties experimenting in health, when lives are potentially at risk

#### PHILOSOPHICAL IMPLICATIONS OF AI FOR HEALTH

These and a number of other key issues around the practical use of AI in healthcare will need to be researched and clarified in policy. This process needs to be well resourced, locally relevant, and underway already.

However, there are also some potential barriers that are more philosophical, pertaining to mindset and approach to healthcare. For example, achieving true AI in health would mean that eventually there would be some processes which would not require a clinician to validate. This could only occur once an AI system was proven to a sufficiently high standard of evidence to be as capable or more capable than a clinician. Training such a system could take

place in parallel with human clinical verification. The human could then step back once the system was performing as required. In fact the human might be *required* to step back if the AI system was reliably performing better than the human. Transitions like this to an artificial health intelligence are likely to require substantial reassessment of the desire for, need for – and role of – humans in some processes.

A lot of healthcare is currently provided because high quality clinical trials, such as randomised controlled trials, have demonstrated the superiority of some treatments and approaches over others. Clinical practice changes when new trials refine previous results or provide new information on effectiveness and outcomes. But some machine learning AI systems "learn by doing" – every patient provides new data that can improve the precision of the system in near real time. This incremental improvement of already well-functioning systems is just as if clinical research is taking place in real time. New patient management might be recommended as the experience of the system grows. At present there are different approaches to ethics and approvals for research and for clinical practice. Some deep thinking and consensus may need to be reached on how to deal with systems that cross the boundary between practicing medicine and researching new methods.

#### ROYAL AUSTRALIAN AND NEW ZEALAND COLLEGE OF RADIOLOGISTS REPORT ON AI

RANZCR have published a report on the State of Play of Artificial Intelligence in Radiology and Radiation Oncology 2019.<sup>159</sup> They report key regulatory, legal and ethical priorities, including:

- A regulatory framework and associated policies for data controls
- Ethical standards to ensure safe and effective use of AI in healthcare
- Profession-led work to define appropriate uses of AI
- Broader discipline-led structures to ensure performance of AI algorithms
- Workforce transition planning and support.

## DATA MUST BE ACCESSIBLE

The AI Forum's *Towards Our Intelligent Future* report identified data as the fuel for AI systems.

Careful collection, curation and standardisation of data is required to unleash the power of AI. Also data must be accessible. Less than twenty percent of the world's medical data is available in a machine readable format.<sup>160</sup> Zhigang Chen, Director of the Healthcare Big Data Lab, at Chinese AI firm Tencent says that, "Without that foundation of data and the digitalization, it's hard, or it's almost impossible to get really good models out of it."

**Data must not merely exist, it must be used.** Health data is considered private, and is only shared for clinical purposes. However, with informed consent it may be that many people are happy to share their health data, perhaps in non-identifiable form, with those researching and developing applications to improve health. Provided reasonable assurances can be given that data will not be used to prejudice individuals in any way, then a programme of data donation could be explored. If an individual's health data were all stored in one place, perhaps in a data trust (see our discussion of data trusts in *Towards Our Intelligent Future*), then GPs could ask patients if they wish to donate their data, not entirely differently to how we choose to donate our organs on driver licenses.

**New Zealand has a number of 'self-imposed' barriers including restricted access to non-identifiable data, a lack of standardisation, and little cloud data storage.** To optimise training of AI systems then medical data and images (such as those of radiology, pathology, ophthalmology, dermatology, and so on) will need to be stored in the cloud to facilitate training.

**"Health data is a public good, but people have to trust the WHO and governments that it won't be used for commercial reasons without their consent or to discriminate against people."<sup>161</sup>**

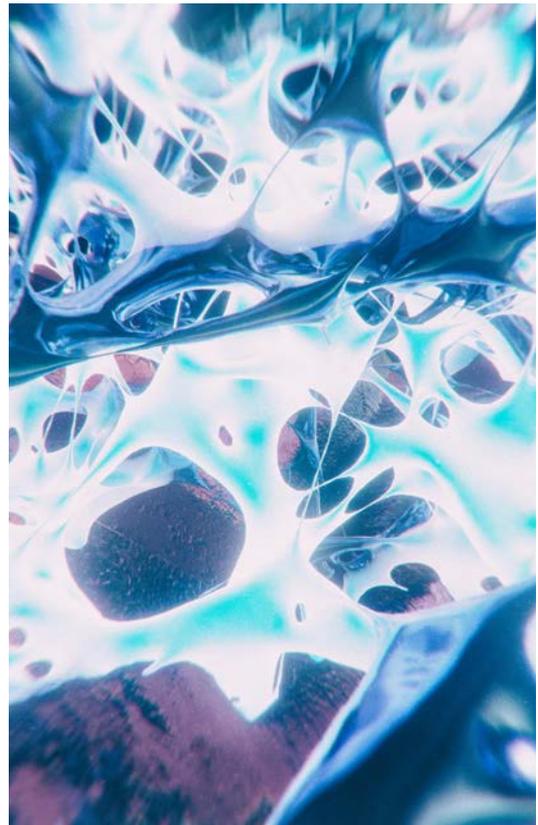
**SOUMYA SWAMINATHAN,**  
World Health Organization

## Ministry of Health Guidance for Data in Healthcare

The Ministry is drafting a 'Data Strategy' for healthcare and will be considering how a 'Platform Strategy' will enable health data in New Zealand to be aggregated and made available across the different services within a DHB and between DHBs across the country.

## Policy and Legal Issues

A number of policy and legal issues surround the use of AI in healthcare. To leverage the benefits AI provides for health, governments will need to ensure appropriate policy and safeguards around issues of bias and error, safety, explainability of AI decisions, accountability and malpractice and the use of identifiable data.



## ALGORITHMIC BIAS AND ERROR

As is the case with other sectors and government service delivery algorithms, there is a risk that AI algorithms exhibit bias and error. Similar measures to those discussed in *Towards Our Intelligent Future* will be important to mitigate this risk and these may include a government algorithm oversight body for public sector algorithms. Work such as Precision Driven Health's cardiology referral algorithm is an active attempt to overcome existing bias in the health system by using machine learning. Algorithms based on physiological and anatomical data (e.g. diagnostics) are likely to be more robust due to the greater completeness of the data, and less contextual variability. Whereas algorithms based on social and preference data are more of a grey area (e.g. some predictive analytics) because of the inherent heterogeneity of such data.

### *Ministry of Health Guidance for Algorithms in Healthcare*

The Ministry of Health held a workshop in August 2018 with representatives from the health sector including ethicists, clinicians, policy makers, researchers and industry partners. The workshop focused on the use of algorithms in healthcare. Four key themes were identified as key aspects in the development of algorithms that hold the most risk: Governance, Bias, Operationalisation, and Assurance. The Ministry is now in the process of finalising and releasing guidance for algorithm development and a publication titled, 'Emerging Health Technology Introductory Guidance' is has been available in draft form since January 2019.

## SAFETY

**A key issue in the area of medical device development is the approval process.** Approval of devices has a lower threshold than that for medicines. This has led to significant problems with devices such as surgical mesh, pacemakers and gastric balloons that have all caused harm even after having FDA approval.<sup>162</sup>

**In order to ensure that AI technologies in healthcare are safe regulation is likely to be needed.** In the US the FDA has released a white paper proposing greater oversight of AI algorithms in health, which calls for

proof that any algorithm that has the ability to learn and change is demonstrated effective in a clinical, real world environment, ideally in a prospective study and that no AI algorithm will be approved only on the basis of retrospective dataset analysis.<sup>163</sup> One reason for this is that algorithms have performed poorly in clinical settings when they have only been trained on 'synthetic data' produced by engineers.<sup>164</sup> At present the FDA has approved static algorithms (which are frozen at deployment and do not change over time). For example, an algorithm that interprets CT scans when the images are available and automatically notifies a specialist if a stroke is probable. The idea is that this reduces time to care, when speed is all important in the early stages of stroke treatment.<sup>165</sup>

In New Zealand at present, software as a medical device embedded in devices has to pass some regulatory hurdles, but there is no regulation of software for logistics or decision support. There is no approval system for medical devices under the Medicines Act 1981. There is no mandatory requirement for medical devices to be approved by any medical device regulator prior to being supplied in New Zealand. However, devices must be notified on MedSafe's WAND database and safety and effectiveness documentation must be available if requested.<sup>166</sup>

However, there may be some upcoming changes in New Zealand as a Therapeutic Products Bill is currently before Parliament. Consultation on the Bill has closed and as of July 2019 the Bill was scheduled for its second reading. Under the new scheme, the intention is to apply the full range of pre- and post-market controls in accordance with risk-based models.

It is not clear to what degree software and analytics will be captured by the final Bill, nor how it would apply to in-house solutions developed by providers that are not for commercial deployment. However, as software and robotics begin to play a more pivotal role in healthcare, these technologies will need to be proven safe. The track record with many 'dumb' technologies suggests that there is a need for robust regulatory checks on new intelligent health technologies. The risk is compounded if AI technologies are not transparent and explainable.

## EXPLAINABILITY

Artificial intelligence algorithms are often criticised for being opaque. This is important in the context of the General Data Protection Regulation (summarised in *Towards Our Intelligent Future*), which mandates the right to explanation when algorithms make decisions about human beings. However, it must also be noted that there are similarly opaque processes in clinical medicine already, many randomized controlled trials are unable to provide the mechanism that explains how or why a drug works, sometimes it just does and the proof is in the results of the carefully designed trial.

**Ideally there would be requirements that health AI can explain itself**, so that clinicians can interrogate the system to identify the reasons for an output. There have been some steps towards explainable medical AI and this may be crucial in order to convince doctors that the systems are reliable, particularly given the legal accountability and ethics issues in clinical decision-making.

Projects supported by Precision Driven Health are working to provide 'explainable AI'.<sup>167</sup> For example, Quentin Thurier at Orion Health supervised a project in which a neural network was developed to identify skin cancer from photos but also creates easily-interpretable images showing the features that led to its conclusion. A user can look at the images and it is clear if the algorithm analysed a section of the image that was not relevant.<sup>168</sup> An international initiative ABOUT-ML facilitated by the Partnership on AI aims to establish evidence-based machine learning transparency best practices throughout the system lifecycle from design to deployment.<sup>168a</sup>

## MALPRACTICE

Associated with explainability are the notions of responsibility and liability. This is not specific to healthcare, and similar issues arise in other AI fields such as autonomous vehicles. Who (or what) is responsible when things go wrong? It may be difficult to bring cases against companies that develop the technology. This is because companies aren't actually practicing medicine, the clinicians are. But if clinicians do not understand every possible inner working and result from medical AI devices, then it's also hard to see how they can be held accountable. The standard

of care with respect to AI is not clear. Should an AI have to identify all anomalies that a competent clinician would? Or should we have an expectation that competent clinicians use AI once systems are available in their area of practice?<sup>169</sup> Potential liability for physicians using AI is explored in a recent paper by W. Nicholson Price II et al.<sup>169a</sup> Clarity is needed.

## Roles for Consumers, Providers and Funders

In this section we list the actions that various groups and organisations might need to take in order to bring the New Zealand health sector from present state to a future that leverages AI for improved health.

In their report 'What Doctor?' on AI and Robotics in health, PwC summarizes these actions and identifies five areas for activity.<sup>170</sup>

- **Governments:** should create quality standards and a regulatory framework. Also, AI and robotics should be used to enhance accessibility and affordability and not be limited to the rich.
- **Healthcare professionals:** should understand how AI and robotics can help them in a clinical setting and throughout the healthcare system, and be open to change.
- **Patients and the general public:** need to become accustomed to AI and discover the benefits. The adoption of AI in daily lives suggests this will occur naturally.
- **Developers:** need to solve the "big issues of demand and resource that every health system faces."
- **Provider institutions:** will need to develop an evidence base, measure success and effectiveness and implement in prioritised phases according to demand and need.

## INSTITUTIONAL READINESS

A number of institutions are not yet ready to deploy AI in health. Partly this is because of mindset. Health IT researcher Glen Willoughby suggests that there needs to be willingness to change, and that there is a need for change. New Zealand providers prioritise focus on deficits and restructuring to tighten spending. But Willoughby told us that "realistically

there is not much more water that can be squeezed from this stone” and a new approach leveraging investment in new technologies is needed.

**Healthcare organisations can incorporate AI expertise in their organisation’s structure and governance.** One strategy is to assign a lead to keep apprised of AI adoption and scan for successful use cases. Explicit AI strategy and governance will help as will efforts to build an AI savvy workforce and culture.<sup>171</sup> Our *Towards Our Intelligent Future* report details ways organisations can enhance their AI readiness and self-assess their maturity to adopt AI.

**ROLE OF GOVERNMENT**

In conjunction with strategies discussed above, government can:

- Make strategic investments as listed below under ‘Funding and Investment’.
- Regulate therapeutic devices and applications appropriately for safety.
- Develop capacity to then assess and approve the safety and effectiveness of technologies to avoid a regulatory backlog.
- Inform the general public about the value of health data as a public good.
- Support workforce education and awareness of the role of AI in health.
- Advance the Smart System theme of the New Zealand Health Strategy by leveraging data and technology to, “increase service effectiveness, reduce cost, improve engagement with people who access health services, promote healthy behaviours and self-management, and aid people-led design.”<sup>172</sup>

**ROLE OF PROVIDERS**

In conjunction with the strategies discussed above, providers can:

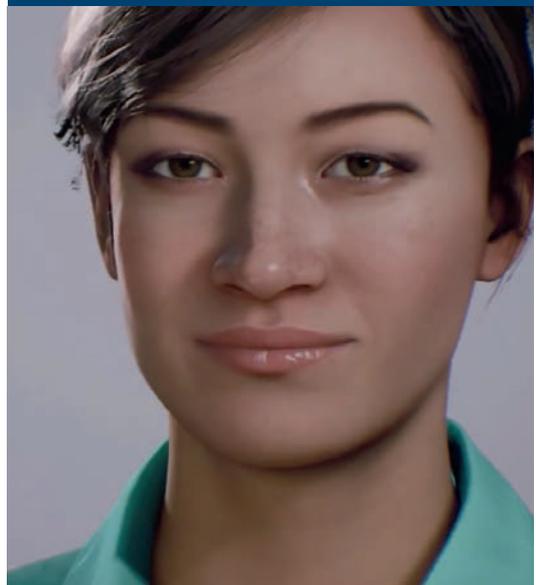
- Conduct horizon scanning activities and learn from proven use cases around the world.
- Develop and deploy digital humans and assistants that empower patients to understand and engage with services, including appointments.
- Eliminate paper and value organised data.

- Experiment with pilot uses of AI to develop institutional understanding.
- Educate patients and end-users about AI in health.
- Understand that early AI deployments may demonstrate only marginal gain at increased costs, but as we explained in *Towards Our Intelligent Future* the payback from AI experiments comes late and large.

**Southern Cross Digital Humans**

**SOUTHERN CROSS HEALTH SOCIETY HAS BEEN PARTNERING WITH UNEEQ AND PLANS TO LAUNCH A DIGITAL HUMAN LATER IN 2019 WITH THE AIM OF OFFERING NEW ZEALANDERS A NEW WAY TO LEARN ABOUT HEALTH INSURANCE 24/7.<sup>173</sup>**

The digital human assistant will be able to offer information about the New Zealand health system, health insurance options and pre-existing conditions. The digital human will be an extension of Southern Cross’s values of care and empathy and be able to learn from its interactions with customers.



### MANAGING HEALTH DATA

Everyone collecting and managing health data today and into the future needs to start considering how it can be made available for machines to learn from. The American Health Information Management Association provides some guidance<sup>174</sup>:

- Educate clinicians and other data-creators about the importance of information and its governance.
- Improve the quality of data at the time it is collected in clinical documentation and use improvement initiatives.
- Invest in open, standards-based data warehousing infrastructure to eliminate data silos completely.
- Ensure that all data assets include metadata so datasets are usable.
- Maintain high standards of data privacy and security.

Furthermore:

- As well as investing in data preparation to leverage the present and important future benefits of AI, organisations should ensure that clinicians, data scientists, developers and business process owners work together.
- Identify shortfalls in data collection.
- Consider instituting semantic data lakes that aren't necessarily targeted to a specific use case.<sup>175</sup>



### ROLE OF PROFESSIONAL ORGANISATIONS

Professional organisations such as the New Zealand Medical Association, professional speciality colleges and nurses organisations can help to raise awareness about AI in healthcare as well as formulate guidance and recommendations for how best to take advantage of this technology. Organisations can help develop standards and ethical principles, as well as provide education for their members.

International leadership is being demonstrated by the Canadian Association of Radiologists whose white paper details the activities of six working groups with 18 mandates spanning research and development, technique and applications, education, legal and ethics issues, a writing group and industrial partnerships.<sup>176</sup>

### ROLE OF EDUCATION PROVIDERS

**Education providers have a responsibility to monitor developments** in the field and tailor curricula to emerging needs. This is likely to require that learners are exposed to AI use cases and are encouraged to understand the potential for AI and consider its possible applications. A focus on the importance of data and data capture would help develop a new generation of data responsible and data savvy clinical practitioners. Given that AI might perform a lot of the heavy intellectual lifting in the future of healthcare, we may not need 'brainiacs' in medicine moving forward, but rather those medical students with the highest emotional intelligence, empathy and social concern. As recommended in the UK Topol Review, education providers should also look to facilitate intercalation of health focused qualifications with engineering or data science courses.<sup>177</sup>

**Micro-credentialing could help keep the existing health workforce agile.**<sup>178</sup> In New Zealand for example, Otago Polytechnic's micro-credentialing initiative EduBits, has been supporting Dr Lance O'Sullivan's project iMOKO that enables certified teachers at participating kohanga, day-care centres and schools to notify a digital health team using a cloud environment about children's health issues. The team then promptly responds with a diagnosis and plan.<sup>179</sup> Micro-credentialing helps ensure competent users and can be deployed to upskill the workforce in uses of AI.

## PATIENT AND CONSUMER AWARENESS

**Discussion with the public about the benefits of health AI in a range of settings is needed.** A survey by Accenture on US attitudes to AI in health indicated that only half of respondents said they would be likely to use an intelligent virtual clinician. Of the 1100 respondents who would be unlikely to use an AI doctor, one in five said this was because AI is too new. These results suggest that raising consumer awareness of the benefits of AI in health, and a track record of proven effectiveness is likely to be needed to gain public trust in health AI.<sup>180</sup>

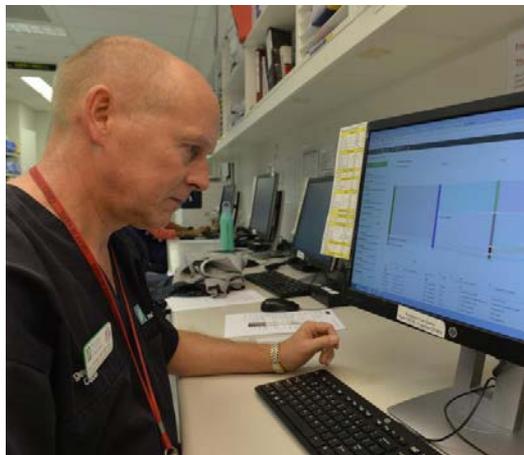
However, somewhat in contrast to the Accenture survey, a survey of 12,000 people across 12 countries by PwC and YouGov Research indicated that the public in Europe, the Middle East and Africa, “is ready and willing to substitute AI and robotics for humans.”<sup>181</sup> It is possible that these results partly reflect difficulties accessing healthcare in some locations. But important questions remain about what is the role of the human doctor (or healthcare provider)? And what is the role of the AI doctor (or healthcare provider) in different contexts?

## BEST PRACTICE

**It will be important to develop and adhere to standards of good practice for AI in health.** In an April 2019 viewpoint article, Michael van Hartskamp and colleagues at Philips Research proposed six recommendations for ‘Artificial Intelligence in Clinical Health Care Applications.’<sup>182</sup> These ‘six Rs’ ought to improve AI health projects and aid communication between developers and doctors:

- Relevant and well-defined clinical question first;
- Right data (ie, representative and of good quality);
- Ratio between number of patients and their variables should fit the AI method;
- Relationship between data and ground truth should be as direct and causal as possible;
- Regulatory ready; enabling validation;
- Right AI method.

In addition, it will be important for end-users, the general public, to be involved in the design and development of AI solutions in health from the beginning. The needs and preferences of patients must be the focus of AI in health.



## Agreed Ethics and Social License

Social licence refers to the ongoing acceptance of a company or industry’s standard business practices and operating procedures by its employees, stakeholders and the general public.

**The Nuffield Council on Bioethics has said that AI in health raises ethical issues** including: the potential for erroneous decisions, questions of responsibility, difficulties in validating outputs of AI, bias in data used to train AI, protection of sensitive data, securing public trust, effects on dignity and social isolation, effects on workforce skill requirements, and malicious uses.

What is needed according to the Council’s report are assurances that AI is developed and used transparently and in a way that coheres with public interest. At the same time it will be important to stimulate innovation in the sector.<sup>183</sup>

**A discussion about the ethics of AI in health, and public consent for use will be important.** The ethical discussion needs to be ongoing, but shouldn’t obstruct progress. This dialogue should anticipate problems, which can then be averted, and should respond to issues, as and when they arise, to improve the process and outcomes. There is no doubt that with big health data comes risks and challenges and interested readers should also turn to our *Towards Our Intelligent Future* report, where we discuss data and AI ethics in more general terms.

## DATA GOVERNANCE

### Consent for Data Use

**Identifiable Data will need to be managed according to legal and regulatory requirements.** A Precision Driven Health Project is currently evaluating the legal and regulatory requirements pertaining to consent to use health-related data in New Zealand, Australia, the European Union and the United States. Recommendations arising from this project include changes and enhancements to existing practices, which could include “dynamic consent”. Dynamic consent would enable patients to easily approve or withdraw their consent for the use of identifiable data about them. Patients would also remain informed about any uses of their data.<sup>184</sup> Innovations along these lines will be needed moving forward given the anticipated explosion of new data sources and applications.<sup>185</sup>

It is also notable that the Prime Minister’s Business Advisory Council report ‘A Future that Works’ (May 2019) has advised that, “outdated personal data legislation, for example, may be preventing innovative solutions and business models for the healthcare or social sectors.”<sup>186</sup>

There is legislative provision for the New Zealand Government to use non-identifiable health data to improve services, but as indicated above de-identification of unstructured health data is a challenge. It will be necessary to obtain social license for these uses.

### Data Privacy

**The New Zealand National Ethics Advisory Committee (NEAC) is in the process of a review on the use of anonymised data.** New NEAC National Ethics Standards for Health and Disability Research are expected to be published in 2019.<sup>187</sup> One important issue is that new techniques, including some using AI, can re-identify data that has been deidentified. These techniques include the analysis of free text and medical images. For example, machine learning applications can identify the gender (and perhaps other defining characteristics) of individuals from retinal photographs.

The Ministry of Health is concerned that people engaging in the development of algorithms need

to understand that algorithms have the potential to de-anonymise data. This fundamentally threatens the ability to use data for research. In response, the Ministry is working with the Department of Internal Affairs to understand how a working implementation of a consent and delegation model could be used to mitigate some of this risk and to increase trust (or social license).

University of Otago Law Professor Colin Gavaghan has noted that questions of privacy are at the fore when considering AI in health. Gavaghan has said that foreign health providers are not subject to New Zealand law and it can be unclear how information will be used when it leaves the country.<sup>188</sup>

However, Angela Ballantyne of the Department of General Practice at the University of Otago has said that there is a danger in underutilizing AI solutions in health. If we remain overly concerned with the barriers, then we may persist with avoidable levels of error in the system and the associated patient harm.<sup>189</sup>

### Data Security

**Cyber attacks pose a significant threat to data security.** There are three key issues. First, healthcare is a key target for ransomware. Second, clinicians are very concerned about the integrity of critical care systems. Third, the number of points for attack is expanding.<sup>190</sup> However, AI can be an important part of the solution in health data security. Machine learning, for example, can help detect anomalous behavior including logins from non-standard locations, even when data sets are large and dynamic.

## FAIRNESS

As AI applications continue to generate insight into health datasets it will become possible to make more and more accurate predictions about the health outcomes of individuals. On the one hand this can guide more individualised and precise treatment choices, but on the other hand each individual can be labelled as a ‘locus of risk’ as Dr Siddhartha Mukerjee puts it.

**Understanding risks that individuals may have little control over opens the door to treating people differently** based on their risk, perhaps by charging them higher insurance premiums. These

practices may not be fair. Dr Siddhartha Mukerjee has said that thinking of humans in terms of a 'locus of risk' changes the structure of human relations. Do you share risk information with your spouse?<sup>191</sup>

**If algorithms are not trained on appropriate datasets then they may perform better for some populations than others.** We know that machine vision applications to detect skin cancer risk performing better on caucasian people than those with dark skin due to an unrepresentative training data set.<sup>192</sup> This may not be fair. Other issues of fairness arise. For example, if biobanks contain only the data of rich white people, then inferences on the basis of this data may not be able to help poor minorities.

Although AI could enhance access and equity, it could also unfairly reduce it by proving too costly for smaller regional and rural healthcare providers to implement.

### MĀORI DATA AND DATA SOVEREIGNTY

**New Zealand is unique in that our health system aims to reflect the principles of Te Tiriti o Waitangi.** Decisions about health are made in partnership between the Crown and Māori. In particular, Māori data should be collected with a Te Ao Māori perspective in mind, and with Māori input and leadership. Whenever Māori data is accessed it should be with a view to benefitting collective Māori health over private interests.

Data sovereignty typically means that data is subject to the laws of where it is stored. Indigenous data sovereignty understands that data is subject to the laws of the nation from which it is collected with Māori data sovereignty respecting Māori governance of Māori data. Māori data sovereignty means that tribal sovereignty is recognised to enable Māori and Iwi to reach their aspirations.

Data Scientist Andrew Sporle (Ngati Apa, Rangitane, Te Rarawa) summed up some key Māori data issues at the Hack Aotearoa conference in January 2019. In his view it is important to:

- Ensure that data is used to promote improvement, rather than simply model deficits.
- Have Māori researchers leading, or having a lead role on the research team in order to thoroughly embed the correct principles and methodology for projects.



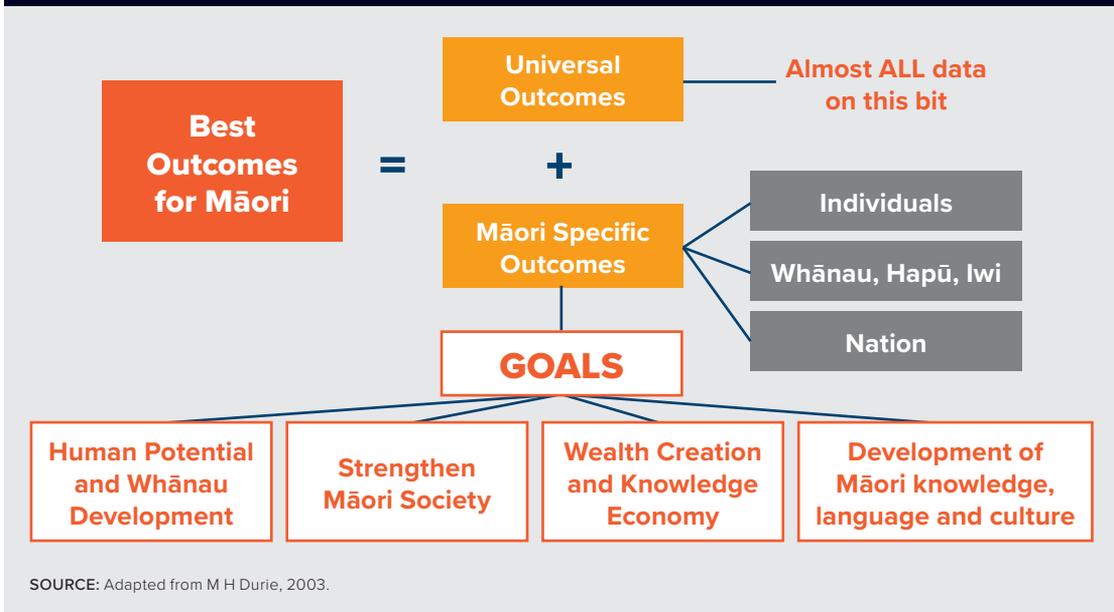
- Provide resources to support Māori-led research thereby improving capabilities.
- Ensure explicit awareness and maximisation of informed consent where data is being used for significant commercial gain in software development.
- Ensure autonomy of data sharing.

### Te Mana Raraunga

**Te Mana Raraunga is the Māori data sovereignty network.** It aims to enable Māori Data Sovereignty and to advance Māori aspirations for collective and individual wellbeing by:

1. Asserting Māori rights and interests in relation to data.
2. Ensuring data for and about Māori can be safeguarded and protected.
3. Requiring the quality and integrity of Māori data and its collection.
4. Advocating for Māori involvement in the governance of data repositories.
5. Supporting the development of Māori data infrastructure and security systems.
6. Supporting the development of sustainable Māori digital businesses and innovations.

Figure 15: Data and Māori Advancement.



The Te Mana Raraunga website provides a range of resources to help people understand Māori data sovereignty.<sup>193</sup> This includes a Māori Data Audit Tool to assess an organisation's readiness to address the principles in the Te Mana Raraunga Charter.<sup>194</sup>

Professor Mason Durie of Massey University has illustrated how Māori health outcomes are achieved. These outcomes result from the combination of universal health outcomes and Māori specific outcomes. However, Māori specific outcome data collection in practice has taken a back seat to universal outcome data. This can change through recognition of Māori goals (see Figure 15).

## Funding and Investment

To maximise the opportunity that AI in health presents, a number of investments are needed, as well as some reorganisation of health system funding.

Initial investments in the operational side of healthcare could help adoption of existing AI

technologies such as robotic software automation and demand prediction to drive administrative efficiencies, thereby cutting costs and freeing up resources for investment elsewhere.

**Investments in evaluating the performance of AI in health will be important** because healthcare providers need to trust algorithms to use them and will be skeptical about adopting AI tools until a large body of proof verifies their outcomes in clinical settings.<sup>195</sup>

**Government needs to lead investment in national data and digitisation.** This means ensuring that data is captured consistently, reliably and efficiently and that paper-based processes are eliminated. Systematic nationwide investment is required in:

- Data storage infrastructure or services, including cloud storage for massive medical image and genome databases.
- Speech recognition technology and new data collection methods to enhance the efficiency of the clinical workforce.

- Applications for de-identifying data and making it accessible to approved users.
- Elimination of paper processes, which are a safety risk in a digital system because of the risk that information goes missing.
- A New Zealand biobank to enable tracking of health outcomes and a host of causal and interacting variables, in our unique setting, which includes sufficient Māori data to benefit Māori.

Without comprehensive, structured, accessible data, the chance to benefit from AI applications will be minimal.

**Investment in health AI research is an opportunity for New Zealand.** The AI Forum's *Towards Our Intelligent Future* report identified the health sector as a local AI research opportunity, based upon the strength of the underlying domain knowledge and existing datasets. Investment in research will be needed to help grow local capability, which is important given the highly competitive AI talent market. Investment should include funding for Māori researchers embedded in AI projects as the correct lens is needed to gather the best data, and build Māori capability.

## Conclusion

AI promises to bring significant clinical, workforce and cost benefits to the health sector, as well as personalise medical care. AI should also enhance safety, equity and access to healthcare. However, AI may also bring fundamental disruption to established provision of healthcare by changing how and where healthcare is delivered, and who the providers are. There will be initial uncertainty as to what aspects of care the human workforce and AI technology should focus upon. This will require broad awareness of the coming changes and a coordinated national strategic approach to AI in healthcare that focuses on accessible data as infrastructure and a public good, relevant workforce transitions, and strategic investment.

*“The explosion of healthcare data combined with the rise in demand from aging populations around the world, rising costs, and a shortage of supply – both in the number of healthcare professionals needed to treat and care for an increasing number of sick people and the availability and access to a broader range of necessary services than ever before – has left a monumental gap that only technology can fill.”<sup>196</sup>*

- PwC

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**AI for Wellbeing**  
**AI for Sustainability**  
**AI for the Economy**



# TOWARDS OUR INTELLIGENT FUTURE

## TE ARA MŌ TĀTOU ATAMAI O ĀPŌPŌ



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