Future of Work

Understanding the impacts of technology on medical specialties

Ministry of Health NSW
FINAL REPORT
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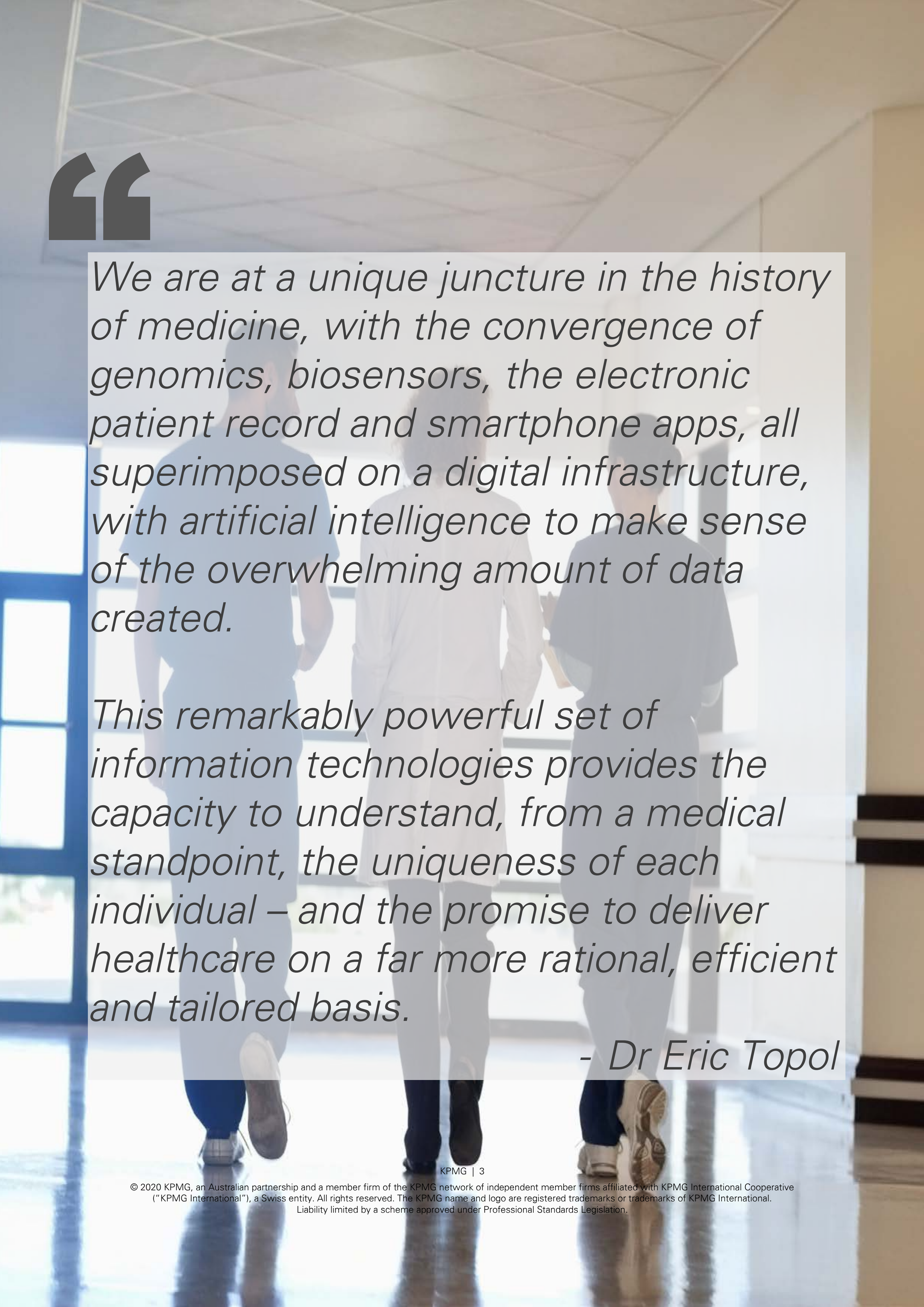

> *We are at a unique juncture in the history of medicine, with the convergence of genomics, biosensors, the electronic patient record and smartphone apps, all superimposed on a digital infrastructure, with artificial intelligence to make sense of the overwhelming amount of data created.*
>
> *This remarkably powerful set of information technologies provides the capacity to understand, from a medical standpoint, the uniqueness of each individual – and the promise to deliver healthcare on a far more rational, efficient and tailored basis.*
>
> *- Dr Eric Topol*

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Introduction

It is truly exciting to live at a point in time where the advent and implementation of ground-breaking technologies within health care is rapidly progressing. New technologies offer the opportunity for high quality care, with accuracy and safety at the forefront. The benefits of these opportunities to the health system include improved effectiveness, efficiency and quality, while also responding to the increasing demands of the population for more connected and digitally enhanced health care.

The medical workforce will play a pivotal role in the Future of Work, including in the advocacy for new and emerging technologies, assisting with the adoption of new technologies, and in leading the changes to clinical roles and functions across the health workforce.

Purpose of this paper

This is the second in a series of papers that considers what the Future of Work means for the NSW Health system. This paper will highlight emerging technology disruptions for the medical workforce as a starting point for ongoing horizons scanning.

Horizons scanning is an important feature of the NSW Health approach to workforce planning and assists in reviewing emerging opportunities for workforce development. The paper will examine key insights for the medical specialties of surgery, general practice, radiology, pathology and dermatology because these workforce groups were identified as being amongst those most likely to be impacted in the immediate and short term.

These findings will assist NSW Health, as an employer of the medical workforce, to consider the workforce implications for specific medical specialties and put in place a clear strategy and actions to support the medical workforce in embracing the digital future.

Scope and limitations

The scope of this paper is to identify the current 'state of play' for specific medical specialties in relation to technology and the impact this is having or may have on the nature of work of that speciality. The scope was limited to a scan of published and unpublished literature pertaining to the impact of emerging technologies on the five specialties; this includes peer reviewed literature, as well as 'grey' literature as at November 2019. In addition, six stakeholder interviews were conducted with individuals agreed by the NSW Ministry of Health, in order to provide further insight to the findings from the desktop review.

Technology impacts across the whole medical workforce

It is expected that there will be some technologies which will impact the roles, functions and / or ways of working across the whole medical workforce (and wider health professions), while there are other technologies which will impact individual medical specialities differently.

The key technologies which are predicted to impact the whole medical workforce in a similar way include eHealth, interoperable clinical systems, prescriptive analytics and command centres (each of these is described further in Table 2, below). To be able to effectively respond and adapt to these technologies it is expected that the medical workforce will need foundational digital literacy capabilities. Technologies which impact the whole medical workforce are unlikely to significantly alter the roles and functions of the medical specialties, but may change work processes from paper based systems, and improve the ability to analyse

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and interpret clinical information.

Medical speciality specific changes

While some technologies will impact the whole medical workforce in the same way, there are other technologies which will impact individual medical specialities differently. These differences arise from the fact that there are differences in the functions, knowledge, skills and desired outcomes for each medical speciality.

Technologies that are expected to impact medical specialties at different rates and in different ways include artificial intelligence, genomics, digital medicine and telemedicine. Taking a more nuanced view of how these technologies are expected to change specific specialities provides a more tangible understanding of the role and function changes expected for the medical workforce.

Technologies which are likely to impact medical specialities in a varied way are outlined in Table 2 and are discussed in greater detail in the medical speciality profile sections that follow.

Technology and the differing rate and degree of workforce impact

It is also important to understand that there are a number of factors that determine the rate of adoption and degree of impact on the medical workforce of the future. Key factors are summarised in Table 1.

Further key challenges

It will become increasingly difficult to not only keep up with the rapid evolution of these emerging technologies and to evaluate their benefits, but to also assess if and how they can be implemented effectively into practice.

Adoption of new technologies also raises ethical, quality and safety, and consumer-oriented questions around whether the implementation of specific technologies aligns with the core principle of healthcare: to do no harm.[1]

The roles and functions, general and specialist education and training, continuing professional development and professional registration for the medical profession in Australia are all nationally focused (including the Australian Medical Council, the Medical Board of Australia, the Australian Medical Association and each of the specialty medical colleges).This suggests that a partnership oriented approach will be essential into the future for NSW Health where these issues will be key as an employer of the medical workforce with accountability for the quality and safety of the services it provides.

Table 1: Factors that determine the rate of adoption and degree of impact on the medical workforce

Variance in application: Some technologies have the potential to positively impact a wide range of specialties in different ways. For example, application of predictive analytics using AI to population health data will enable medical practitioners to monitor and predict public health trends and identify initiatives with positive and negative impacts to population health. It will also allow for medical practitioners to increase the time spent with patients by automating mundane or repetitive tasks that do not require much human cognitive power.
Time to adoption: The length of time to adoption and the rate of adoption will have significant variations. For example, predictive analytics using AI is expected to affect 20 percent of the workforce by 2025 and will only reach 80 percent by 2040.[ii]
Funding mechanisms: Given funding constraints across health, funding mechanisms and reimbursement structures have a significant impact on the rate of adoption and implementation of emerging technologies.
Applicability to specialisation: The suite of technologies that can be considered in each specialty will vary. For example, while robotics and automated image interpretation using AI is of greater importance to surgeons while precision medicine, the use of apps and secure messaging will be of greater importance to general practice.[iii]
Maturity of technology: Along with suitability to a specific specialty, the maturity of the technology plays a pivotal role in its adoption. Technologies such as genome editing will have widespread use and accessibility in the long term but more mature technologies such as telemedicine and smartphone apps will have the greatest impact in the short term.[iv]
Legal and ethical frameworks: The legal and ethical implications of some technologies will be more nuanced or complex in comparison to others, and will require further exploration prior to implementation. For example, although the technology exists that enables the remote transfer of digital images of moles to dermatologists, there are legal and ethical concerns in making diagnoses using patient generated data as these images will be used by individuals untrained in the technology, and there is no assurance of data quality.
Consumer Demand: The need to incorporate emerging technologies will be driven by consumer demand. For example, the increasing rates of skin cancer prevalence at the same time as limited growth of dermatologist numbers may help drive the need for dermatologists to adopt emerging technologies including AI and teledermatology services.[v]
Human centred design: In order for new technologies to be adopted they need to improve the user experience and have a user friendly interface. Importantly, new technologies should consider the practicalities of implementation to support their more rapid adoption and integration.

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Overview of key technologies

Table 2: Overview of key technologies expected to impact the medical workforce

TECHNOLOGIES EXPECTED TO IMPACT THE WHOLE OF THE MEDICAL WORKFORCE

eHealth	Electronic Medical Records (EMR) and Electronic Medication Management (eMeds) enable the effective incorporation and flow of digital information throughout hospitals. These advances not only offer potential quality and safety benefits, but through their implementation, also establish a strong core and critical information technology (IT) infrastructure that can be a foundation for further innovation. NSW Health are well advanced in establishing a robust and future proof eHealth service delivery platform through the recent implementation of the EMR and eMeds. This aligns with Horizon 1 in the 10 year eHealth Strategy for NSW Health and will develop a strong information and communication technology (ICT) environment.
Interoperable clinical systems	The most immediate innovation advance afforded by a strong health ICT infrastructure is the integration of high quality EMR and eMeds data that is accessible to relevant staff across public, private, primary, community, and hospital settings. This can enable timely information flow and deliver a seamless continuum of care to meet patient needs, regardless of clinical setting. It can also improve the health outcomes of patients, and reduce the time and cost of the patient's journey through the health system. Aligning with Horizon 2 of the eHealth Strategy, interoperability of clinical and non-clinical systems will enable effective communication between services, blurring the boundaries of healthcare teams.
Prescriptive analytics	The exponential growth in information within the health system as a result of adopting EMR and eMeds will be especially useful to advance predictive analytics enabled by large datasets. Rather than the manual compilation of individual patient data to provide a knowledge base for diagnosis, data-enabled machine learning algorithms can detect useful patterns for prediction of health risks.[1] This will not only be beneficial to individual patients, but also to population health management. Individual users are provided with useful information about predicted health risks from assessment of data about their lifestyle, vital data trends, pre-existing conditions, and medications. Users or their physicians can also receive automated information about the most effective preventative measures.[2] This same data can also be used to analyse population health trends, assisting administrators in better allocating resources to at-risk regions or demographics. Based on decision optimisation technology, prescriptive analytics solutions will be able to detect increased prevalence of comorbidities in certain patient groups. For example, hypothetically, if the technology finds a pattern that there is an increased diagnosis of retinopathy in diabetic populations, the system would alert administrators in order to start an early detection scheme for this population.[3] Early stages of this technology can be seen within Australia's National Prescribing Service (NPS), which has established the MedicineWise program. The program gathers health information from medical records from over 800 GPs and provides this information to clinical researchers for analysis.[4] The program has yielded numerous quality improvement insights. These include identification of predictors and outcomes associated with inappropriate prescribing of antibiotics in general practices, and the monitoring and evaluation of the Heart Foundation's Risk Reduction Program.[5] Prescriptive analytics will take centre stage in Horizon 3 of the eHealth strategy for

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NSW Health to establish preventive health initiatives at the individual consumer level.[6]

Creation of command centres

Effective management of patient, hospital, and equipment related data and facilitation of capabilities like prescriptive analytics cannot be achieved through fragmented sites. The establishment of real-time command centres have shown to effectively manage and utilise large quantities of data and dramatically improve patient outcomes.

Johns Hopkins Hospital established a command centre powered by prescriptive analytics and high quality EMR data in 2016. Through effective coordination of services and equipment to respond to patient needs, they achieved a 35 percent decrease in emergency department wait times, and a 70 percent decrease in surgery wait times. In Australia, St John of God's Murdoch and Subiaco hospitals have implemented clinical command centres to ensure a patient's journey through theatres is smooth from start to finish.[7]

TECHNOLOGIES EXPECTED TO IMPACT MEDICAL SPECIALTIES IN DIFFERENT WAYS

Artificial Intelligence (AI)

AI software applications are capable of mimicking or surpassing human cognitive or analytical capabilities to perform tasks. AI also tends to possess the ability to "learn", where its capabilities are improved by performing its intended action with varied and more complex data. AI has a range of applications in image based diagnostics specialities such as radiology, where software can be trained to find specific markers that indicate abnormalities.[8] Augmented intelligence is another way of thinking about artificial intelligence, emphasising its role in assisting, rather than replacing, the human workforce.

AI will not have the ability to replace the medical workforce in the near future. However, AI does have the ability to improve workflow. Specialists can transfer workloads that involve repetitive and high volume tasks and low cognitive skills to supporting AI. In turn this enables them to either reduce workloads that were previously unsustainable, improve delivery of care by giving specialists more time to analyse patient data, and/or improve delivery of service by increasing time spent with the patient.[9]

Genomics

Genomics is the analysis of genomes to characterise and map them. This allows for the accurate prediction of how specific sub-types of diseases will progress and how individual patients will respond to different treatments, in turn providing guidance to clinicians regarding the most effective treatment pathway.[10]

Genomics research and genomics based care is already impacting the workforce today. The demand for genomics data has seen increased demand for skilled specialists to extract, interpret, and deliver patient genetic data for use in specialties such as pathology, radiology, and surgery. Recent Medicare Benefits Scheme (MBS) requirements dictate that genomics laboratories must be led by genetic pathologists, driving up their demand, which has in turn led to the creation of accelerated accreditation processes.[11]

Digital Medicine

Digital Medicine is the transition from paper-based data management to electronic data management. This enables both increased efficiencies in workflow, as well as a greater ability to process and transfer data. In areas such as pathology, sample slides can be documented in fully digital systems, eliminating the need for transportation of slides between facilities and enabling greater collaboration between sites.[12] To achieve the potential benefits, the whole medical workforce

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must have knowledge of the operation of data management systems, as well as the subsequent ethical implications and medico-legal barriers.

Telemedicine

Telemedicine is the use of communication and information technology to provide patient care. It involves the transmission of images, voice, and data between two or more sites using telecommunications to provide health services, such as clinical advice, consultation, education and training services. Telemedicine has the ability to address barriers to appropriate care in rural health. Telemedicine is not only applicable to general medicine, but commercial products such as smartphone applications, wearables, and low cost speciality instruments also extend the reach and patient base of specialty workforces. For example, smart dermatoscopes that transfer patient generated clinical grade images of moles to dermatologists are available, enabling dermatologists to provide advice remotely. [13]

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Towards the future

Technology roadmap considerations for NSW Health

While medical specialities will be influenced by new technologies, NSW Health will play a pivotal role in determining when and how these are adopted in the NSW public sector context. Key factors that will determine whether a promising technology should be adopted into the NSW Health system are outlined below.

Benefit to patients: Any technology that is adopted needs to demonstrate a benefit to patients, for example, through improved patient experience or patient outcomes.[14] Ensuring these benefits are realised will be a key consideration in a time of fiscal constraints, increasing health service demand, and increasing consumer expectations.

Cost benefit of technology: New technologies are often expensive or may not be utilised effectively due to lack of clarity on when to use the technology, or a need to better understand its full capability.[15] It will be important to monitor the costs of any new technology and consider how this balances with its expected benefits across a range of areas including quality and safety, efficiency, reliability, and system and process improvement.

Governance and quality: The adoption of new technologies requires robust governance systems to ensure that it enhances or maintains the quality of patient care. Systems need to be in place to monitor the effectiveness of new technologies.

Use of data: Digital innovations have increased the demand for sharing personal data, such as that of genomics analysis. While the intention of sharing information is to drive personalised, patient centred care, it also presents issues for clinicians in terms of how and when sensitive information should be released and how patient privacy should be managed.

In addition, the coordination of a variety of data sources also requires the collaboration of a range of clinical professionals to gather genetic and biochemical data as well as lifestyle and environment information to inform clinical management of a patient's health. In this way, there is a need to integrate new technologies into daily general practice and build the trust and capability of the workforce in the usefulness and accuracy of medical records and information systems.

Partnerships: It will be critical that NSW Health works in partnership with other key stakeholders (such as researchers, innovators, vendors, developers and the medical colleges) to understand and drive the changes that are needed for contemporary and world-leading medical care into the future. This needs to be balanced with a recognition that NSW Health are seeking to play a leading role in preparing its medical workforce for a digital future and in adopting technologies that make a difference across New South Wales.

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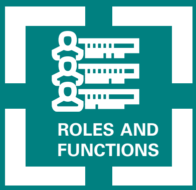
Ensuring the medical workforce are supported by NSW Health



In order for NSW Health to support the medical workforce through periods of technological change, workforce planning considerations should be centred on the changes to medical roles, functions and workplace processes (including how these differ across specialities). These are expected to alter the scope of practice, capability needs, models of care and ways of working into the future.

NSW Health will play multiple key leadership roles in helping to enable these changes, including as a large employer of the medical workforce in Australia; an organisation providing on-the job education and training for the medical workforce; a key investor in emerging health technologies that deliver consumer benefits; and through its role in providing accountability to the public of the quality and safety of care that is delivered in the public health system.

Enablers to support change

Five key enablers were identified in the first paper that need to be harnessed to support successful adoption of the expected changes to roles, functions and workplace processes. While these will be relevant across the whole NSW Health workforce, there are specific considerations for the medical workforce.

The NSW Health medical workforce vision and strategy will need to align with changes to roles, functions and practice determined nationally. Importantly, there will be a need to consider the changes to the medical workforce at a public and private level, especially given many in the medical workforce work in both public and private practice.

There will be a need for a combined education and training approach that considers future workforce needs (including general and specialist training pathways), the impacts on continuing professional development, and local education and training needs that emerge when new technologies are being introduced. The training strategy will need to take into account the mix between public and private settings, differing capability levels, scope of practice, and generalist and specialist skills.

Leadership will be required at a whole of system level to support the digital future, including the impacts and changes for the medical workforce. In addition, leaders will be required across the medical workforce to champion and support the workforce through the expected changes.

In order to capitalise on the most beneficial emerging technologies for the NSW population and realise improvements in health outcomes, quality and safety and efficiency, a culture of innovation and improvement is needed. NSW Health may support this through pilot programs, evidence-based-research on the benefits of new technologies (and potential negative impacts), and harnessing national and international examples of emerging practice with these new technologies.

Change management will need to identify for each technology the impact for the workforce, including supporting and enabling processes, systems and scope of practice changes that are expected. It may also include communication with consumers and the public about the technologies as new methods and approaches are used in practice.

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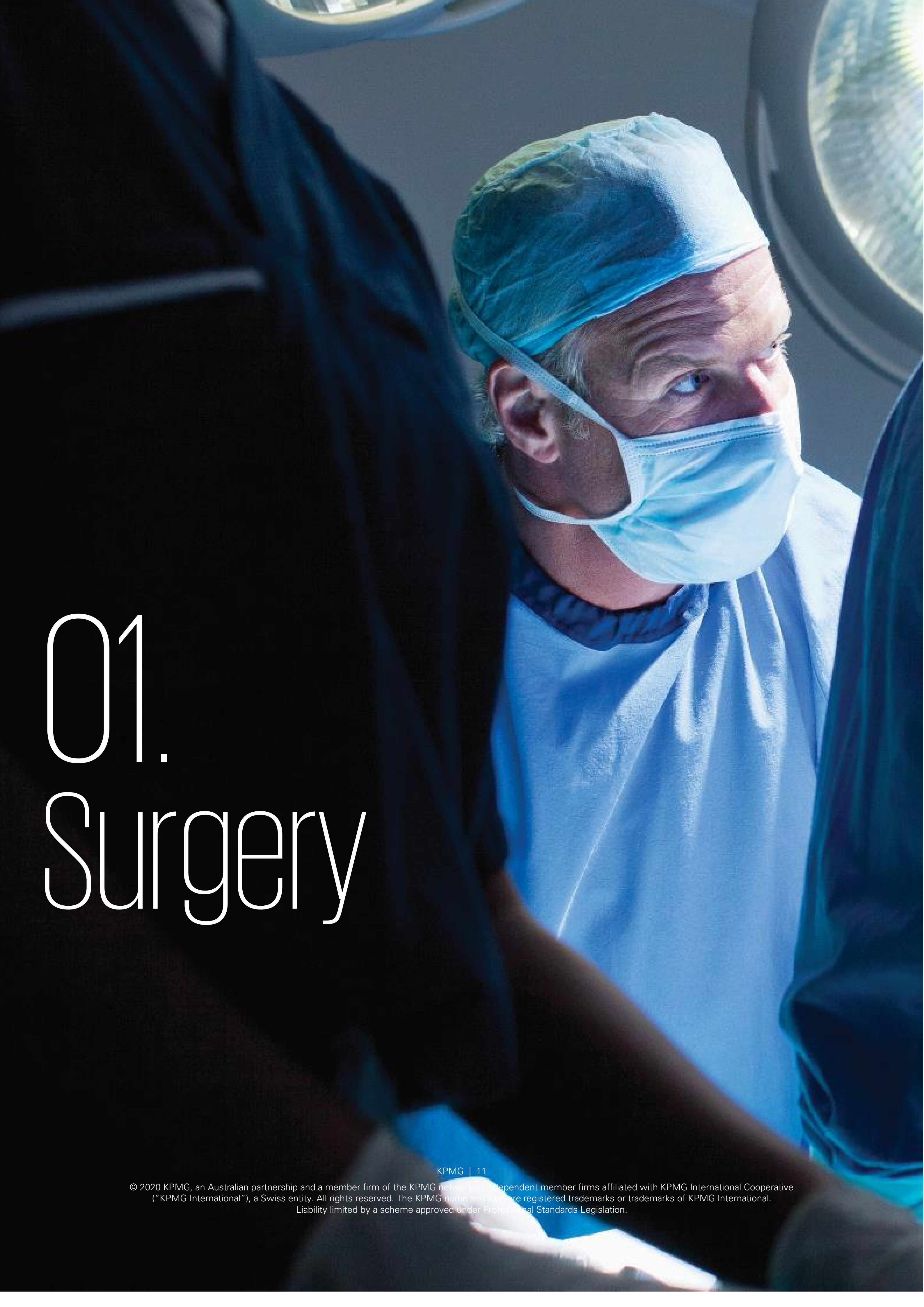

01. Surgery

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What are the emerging technologies in surgery?

Technology is already transforming surgery. New technologies are making surgery less invasive, more accurate, with more predictable outcomes, faster recovery times, and a lower risk of harm. Surgery is increasingly focusing on improving quality of life, with operations focused on prevention.[16]

3D printing

Three-dimensional (3D) printing is already one of the most innovative technologies seen in healthcare in recent times, with hospitals and surgeons already deploying this technology.[17] 3D printers use the computer-created designs to print a model, one layer at a time.[18]

These models have a broad range of potential applications across surgery including personalised implants, surgical guides, surgery planning and practice, customised surgical tools and prostheses, and customised synthetic organs.[19,20]

For example, in cases where patients have suffered from severe bone degradation (from accidents or diseases), researchers are able to scan the defect site, and 3D print a bone scaffold out of biodegradable materials in the exact dimensions of the replacement area.[21] Growth factors can be implanted onto the scaffold to promote bone regrowth in the defect area.[22] The degradation rate of the scaffold can be controlled so that the scaffold dissolves at the same rate that the bone is formed.[23]

The field of 3D printing is expected to grow exponentially with the healthcare sector predicted to be the fastest growing segment of the market.[24] The next evolution in 3D printing is in organ bioengineering and bioprinting. Examples include providing organs to patients on transplant lists, restoring function to organs, producing dissolvable scaffolding, and bioprinting mesenchymal tissue which can differentiate into different structures like connective tissue, blood, cartilage and bone.[25]

Tailoring devices and procedures to the patient is expected to eliminate rates of implant rejection, reduce the time required for surgery, treatment or recovery, while increasing the accuracy and success of the outcome.[26]

Bioprinting

Advances in tissue engineering and three-dimensional printing techniques have seen scientists reach significant milestones in the printing of human skin substitutes for clinical uses. In 2016, scientists from the University of Lyon devised the use of "bio-ink" which contains various skin cell types to print large skin objects such as an adult-sized ear.[27] This technology has immediate potential to be used for scar tissue replacement, physical abnormalities and burn patients.

The Wake Forest School of Medicine, partnered with the Armed Forces Institute of Regenerative Medicine, to build and test a bio-ink printer which is designed to print skin cells directly onto burn wounds.[28] The system first scans the burn area to determine the dimensional properties of the burn area and then proceeds to apply skin cells.[29] This technology minimises the need for skin grafts as it requires only 10 percent of the patient's skin sample to "grow" the bio-ink needed for printing onto the burn area.

Robotics

Robotics encompasses the design, construction, operation and application of intelligent machines and has been a feature of medicine for more than 30 years.[30] Most current robotic surgery is performed through a master-slave system, where the surgeon sits at a console and controls the movement of the robotic arms.[31] This allows movements that a human cannot perform and access to difficult to reach anatomy. It also eliminates tremor risk and the fulcrum effect (where the surgeon needs to move in the opposite direction from the target on the monitor to interact with the target).[32]

Significant changes to robot-assisted surgery are thought to be imminent with new technologies advancing the development of robotics.[33,34] It is expected that the new generation of robots will be

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significantly smaller and less expensive, which will see a significant uptake in the use of robot-assisted surgery.[35]

New surgical robots will include systems that will record the entire procedure, as well as capturing telemetric data from the robotic arm and instruments. This will enable better evidence-gathering and the refinement of surgical techniques, leading to better surgical outcomes. [36]

It is also likely that AI will become a part of robotics, automating tasks that are mundane or repetitive or automating tasks that are beyond human capabilities.[37]

There are a number of potential benefits of advanced robotics, including:[38]

- Improved access to minimally invasive surgery as devices become smaller and cheaper leading to greater uptake
- Reduced variability of surgical outcomes through the analysis of data gathered through procedures and refinement of techniques
- Increased patient safety through use of AI mechanisms and on-screen checklists to minimise errors, with the possibility of remote support from specialists
- Development of new surgical interventions for complex conditions such as head and neck cancer that provide both good oncological outcomes while reducing functional morbidity issues associated with traditional treatments.[39] This is achieved through novel and specific robotic surgical instrumentations that are optimised to perform the surgery.

In the longer term, robotic advances will see the implementation of nano-robotics, where surgeons can utilise miniaturised devices that dramatically increase the accuracy of surgical treatments.[40] Nano-robots less than one millimetre will be able to automatically or manually navigate anatomical systems to deliver drugs to targeted areas or perform surgical interventions at the cellular level.[41] Raising the standard for minimally invasive surgery and further reducing, or even eliminating, patient recovery times.

Augmented reality and virtual reality

Conventionally, surgeons rely on static 2D images during surgery, and are required to constantly switch views between the image and the patient, creating interruptions and disrupting the surgical workflow. This also requires the surgeon to transform the 2D image into a 3D image in their mind.[42]

Although 3D imaging enabled through cameras is currently in use through commercial robotic surgery solutions such as Intuitive's daVinci Xi, the future of imaging in surgery sits in augmented reality (AR) or virtual reality (VR). AR allows for the superimposition of digital information on the physical world.[43] For example, a surgeon using an AR headset would be able to see digital images and other data directly overlaid in their field of view – such as vital signs data and the characteristics of the surgical target directly above the surgical field.[44]

One recent piece of technology being tested is the HoloLens – a wearable AR system operated with head gestures and voice commands.

AR allows for image overlay on the patient during surgery, with relevant information built into the patient hologram, meaning that targets can be identified in relation to the underlying anatomy of the patient. This allows the surgeon to tailor their approach according to the anatomical variations of the patient. [45]

The HoloLens has been used during reconstructive surgery to allow the surgeon to essentially see inside the leg – the bones, blood vessels, and the target areas to perform a more tailored and precise surgery.[46]

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Image guided surgery

Head mounted displays such as the HoloLens also allow increased capabilities in image guided surgery. Patient anatomy such as vasculature and tumours are recorded using Magnetic Resonance Imaging (MRI) or Computed Tomography (CT) and can be displayed on a screen in front of the surgeon in order to inform surgeon's actions.[47] This can be significantly enhanced through the use of head mounted displays which provide real time, and three dimensional views of the target and surgeon locations, in turn improving visualisation and surgeon workflow.[48]

The capabilities of image-guided, minimally invasive surgeries are dramatically increasing. They are also preferred due to faster recovery times for the patient.

AR and VR also have the potential to change the way planning and training for surgeries is conducted. Universities in the US and UK are already employing VR technology in their training of students and professionals, with the intention to replace cadaver-based courses with AR and VR technology.[49]

Testing of students has shown that those taught only using AR or VR technology scored as well as those taught using traditional methods.[50]

Genomics and preventive surgery

Advances in genomics will bring new understanding of diseases to surgical practice, with many conditions having at least some genetic predisposition.[51]

With genomic testing, risk prediction and clinical decision making will be improved, along with the potential for preventive surgery. This is already occurring in women carrying BRCA1 or BRCA2 mutations, where they may opt to have a risk-reducing mastectomy and/or ovary removal.[52]

As genomics advances, precision medicine will become more widespread, allowing patients and clinicians to choose the most effective treatment based on the genomic data.[53]

There is a risk however that this could lead to overtreatment or overuse of risk reduction surgery for patients who would not have otherwise had surgery, which could lead to cost escalation.[54] It will be important to monitor the use of such surgery in the future to ensure this does not occur.

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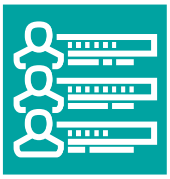
How will these emerging technologies impact the NSW surgical workforce?

Changes to the role of surgeon



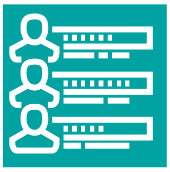
The specific ways in which technology will impact surgery will be different for different subspecialty areas, and will be dependent on the nature and extent of the use of technology. Some subspecialties are already undergoing significant change, e.g. urology and cardiothoracic surgery. [55]

It is expected that the skills and knowledge required of a surgeon in the future will become larger and extend across subspecialties and other specialties. The role of the surgeon is likely to change, with potential cross-over in the role with that of other clinicians and health professionals, particularly where non-surgical interventions become more preferable. Surgery may be undertaken in fewer cases, with more surgeon time spent on diagnosis, non-surgical interventions and care of the patient pre and post intervention. [56]

This change is already occurring in some specialities, such as urology. A urological surgeon may now spend more time being involved in diagnosis, using non-surgical interventions and performing surgery on just a minority of patients. [57]

Some of the interventions and treatments in the future may be able to be delivered by other specialists in addition to surgeons; for example, pre and post-surgical care could be provided by a physician or health professional from outside medicine. [58]

Multi-disciplinary surgical teams



As the types of surgeries and interventions change, the composition of the surgical team is also likely to change, as will the surgeon's role within this team.

Surgeons are becoming more sub-specialised, and these sub-specialities are creating highly specialised tools for specific procedures. For example, a surgeon may specialise in upper gastrointestinal tract (GIT) procedures while another may specialise in lower GIT procedures with no overlap between them. Hence, to achieve the best care for patients, will require surgeons to work in a broader team of surgeons and other medical staff, with collaboration across the health system – breaking down barriers that often exist across disciplines.[59]

Members of the wider surgical team are likely to take on a greater role in the delivery of small procedures and diagnostic interventions with the aid of technology. As such, the role of the surgeon may lie in the coordination and oversight of such procedures. [60] With the rise in minimally invasive surgeries, there will be a skill overlap in some endovascular procedures, where cardiothoracic surgeons, vascular surgeons, cardiologists, and interventional radiologists are all skilled to do the procedure. Surgeries are beginning to bring together these multiple disciplines for collaboration, as differences in opinions and insights in the team on case management, improve patient outcomes and reduce cost.

As robotics advance, surgeries may be performed by team members who have experience in using robots, with the surgeon providing a supervisory role, potentially even remote from the surgery itself. [61]

How can we best prepare the surgical workforce in harnessing new technologies to improve patient experience/outcomes?

As the role of the surgeon becomes more multi-faceted, surgeons will require training in a range of areas they may have previously had little exposure to, or formal training in. This includes computing, engineering, molecular biology, data literacy, leadership, team building and communication.[62]

As technology increasingly enables minimally invasive procedures in the majority of cases, there will be a need to consider how surgeons maintain capabilities and recency of practice in "open" procedures for complex or extreme cases.

In particular, human factors training (training that delves into factors that influence people and their behaviour and how to manage this to improve performance) will become increasingly important. Surgeons will need to be able to communicate increasingly complex information to patients and

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surgical teams.[63] Training in communication skills should include the process of supported decision-making, and to empower patients in their health care as the range of treatment and intervention options increases with emerging technologies.[64]

The way that surgeons undertake training may also fundamentally change. Simulation training through AR and VR can accelerate and enhance training. As these technologies develop, more time is likely to be spent building competencies and skills before entering the operating theatre.[65] It will also be possible for training to be tailored to the patient and/or surgeon, with technology able to analyse data on prior performance and tailor training to each surgeon to improve areas that require further training.[66]

Accreditation and due diligence for the safety and quality of emerging technologies such as robotically-assisted surgery must also be investigated. Governance processes and structures must be in place to ensure that surgeons have the necessary skills and capabilities to safely use new technologies.

Considerations for NSW Health

In considering these new technologies, system managers with responsibility for the oversight of the medical workforce and the introduction of these new technologies must first assess:

Will the implementation of the technology improve patient outcomes or experience? This is critical so that technology is not simply adopted because it is available. Technology must achieve benefits to consumer health outcomes, drive improvements in quality and safety, create efficiencies, or improve access to surgeries that would not be possible without it. For example, there is concern regarding overuse of risk reduction surgery for patients due to advances in genomics and preventive surgery.[67]

Is the technology cost-effective? Many clinical studies have shown that robot-assisted surgery has a significantly higher cost than traditional procedures, however, not all costs can be offset with faster recovery times.[68] For example, review studies have shown that robotic surgery is cost effective in localised treatment of prostate cancer while costs are not currently offset in urologic surgery.[69,70]

What are the appropriate avenues to train and credential surgeons for the use of these technologies and how can collaboration with Colleges assist in this? Through harnessing best practice at a whole of system level amongst the Colleges, and other jurisdictions, it is expected that improvements and efficiencies in training and credentialing will be possible. New technologies will require changes to continuing professional development and professional practice. In addition, as surgical teams become more important, the focus of education and training may need to shift to reflect these changes to models of care.

What both physical and virtual spaces can be created to support innovation and testing? Creating safe zones for experimentation, auditing and researching new technologies (including for example research spaces shared between NSW Health and universities) are key to testing the viability of new and emerging technologies. In addition, virtual testing spaces or "sandboxes" may also assist in experimentation and research for new technologies. It will be key to link evidence based practice and research to the use of technologies to support their adoption and demonstrate benefits of adoption to the health system.

What robust audit processes should be implemented to evaluate the results of the technology adoption?[71] System managers should consider concentrating the implementation of high cost and advanced technologies to major centres and where there is close supervision and governance, as well as a higher volume of procedures. These will need to be closely monitored to ensure that the intended benefits of the new technologies in surgeries are realised.

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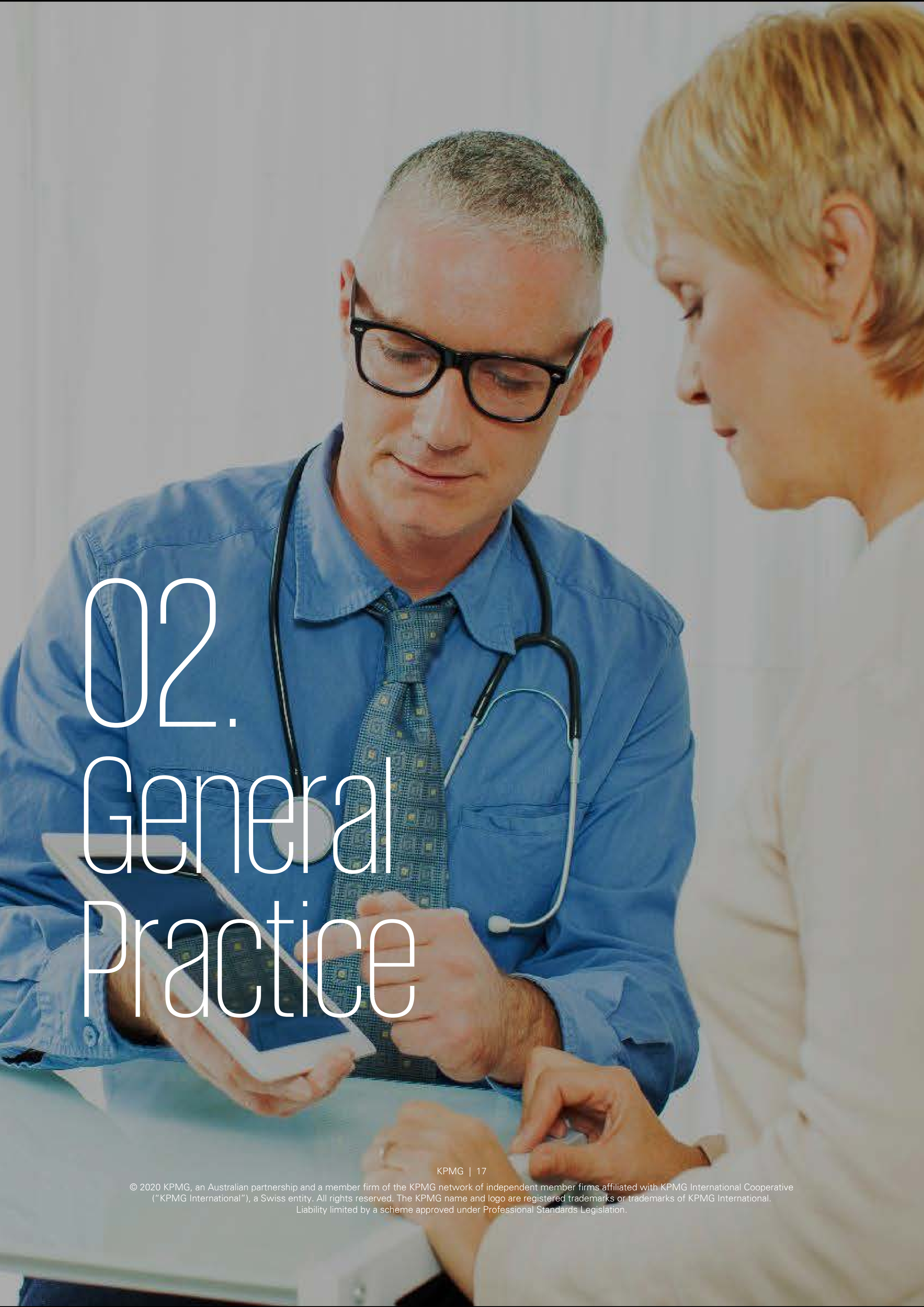

02. General Practice

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What are the emerging technologies in General Practice?

While General Practitioners (GPs) have widely adopted clinical systems and have been open to telehealth, the next wave of technologies are expected to disrupt traditional approaches. Technologies, including applications, smart devices, and wearables, will enable a greater focus on consumer empowerment in the management of their health.

Telehealth

The Australian College of Rural and Remote Medicine defines telehealth as 'the use of communication and information technology to provide patient care'.[72] It involves the transmission of images, voice, and data between two or more sites using telecommunications to provide health services, such as clinical advice, consultation, education, and training services.[73] There are three main categories of telehealth technology:

- Remote patient monitoring - monitoring patient health and clinical information at a distance
- Store-and-forward - transmission of images or information from one provider to another
- Real-time audio/video encounters – connection between patient and provider through a video-enabled device.[74]

Telehealth will also mean significant benefits to those with limited physical access to healthcare. One third of Australia's population living in rural or remote locations are experiencing poorer health outcomes due to limited access to services. Telehealth offers a means of delivering health care services at a distance. [75]

The widespread useability of telehealth for this purpose is evident through the success of a number of initiatives implemented throughout Queensland, northern NSW, Western Australia and the Northern Territory.[76,77,78]

Secure Messaging

Currently, online systems are available to book appointments with GPs and specialists. However, in the near future, better ICT infrastructure and provision of secure clinical communication platforms will enable two-way communication between patients and clinical staff. The ADHA has submitted the 'Secure Messaging Industry Offer' which invites providers to collaborate with the ADHA to deliver the following two types of software packages:

- An Applicable Clinical Information System (ACIS) that include core clinical information systems and practice management systems that enable the sending and receiving of messages over secure messaging infrastructure to other clinical information systems
- An Applicable Secure Messaging System (ASMS) that manages a provider directory and delivers messages to other secure messaging systems.[79]

The ACIS and ASMS will allow for the exchange of messages between healthcare providers that use different secure messaging providers.[80] NSW Health envisions these platforms will be used for patient and provider video conferencing, secure messaging, eReferral management, and remote patient monitoring.[81]

Mobile health and wearables

Smart devices and wearables provide a way to monitor the individual's different dimensions of health to build a more accurate profile. This allows early identification of risks that can only be detected through long-term monitoring.[82] With this

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information, GPs are able to coordinate with other clinical staff to address concerns before the condition progresses and the patient requires emergency treatment. This is supported by the convenience and affordability of consumer owned mobile devices, tablets, and wearable monitoring devices.[83] Seventy nine percent of all Australians own a smartphone, while six out of 10 mobile consumers own multiple mobile devices.[84] These existing mobile technologies present innovative possibilities for the healthcare sector in the form of 'mobile health'.

Various commercial smartphone and smart watch applications, and accessories such as Zephyr's BioPatch, can automatically log and upload basic health data such as heart rate, respiratory rate, physical activity, and sleep cycles.[85] Dedicated regulatory approved biosensors that track blood pressure, temperature and blood glucose are also available.

It is estimated that within 10 years, the most accurate individual health information will exist outside the hospital system.[86]

There are a growing number of examples demonstrating how these technologies can be used, and deliver benefits, in practice. For example in the UK, the Liverpool Clinical Commissioning Group developed a program to help patients with chronic obstructive pulmonary disease, heart failure and diabetes, using technology to assist them to manage their health.[87] Patients use applications and everyday wireless technology to measure weight, blood pressure and heart rate, and in some instances, blood sugar. Readings are fed into a managed triage hub where nurses monitor their condition and can selectively target home visits as required.[88] This has led to a reduction in the workload of GPs as well as the provision of greater independence and control to patients.[89]

Locally, NSW Health aims to integrate data from patient biometric monitoring devices with existing health records to improve remote patient monitoring and enhance their telehealth capabilities.[90] The current barriers to adoption include the clinical validity of healthcare applications and whether a commercial application is classified a "lifestyle application" or a medical device. It is understood the Therapeutic Goods Administration is currently reviewing the regulatory framework for software as a medical device in Australia.[91]

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How will these emerging technologies impact the NSW GP workforce?

Linkage to the practice business model and funding

Despite the significant benefits of telehealth in improving access to health care for patients, the uptake and integration into mainstream practice has been relatively slow.[92,93] This may be partly attributed to GPs not being comfortable with using consumer technology for self-diagnosis or self-management.[94] However, the major limitations are reported to be due to funding barriers and the lack of convenience and security of systems.

Although two-way communication between GPs and patients enables greater access to services, funding models do not account for the increased agility and flexibility required by GPs to provide services through this medium. For example, there are questions yet to be answered in relation to how a GP can be reimbursed for the time that they may spend responding to a question sent by a patient through secure messaging, or the review of clinical information made available through home monitoring or implantable devices. Funding models that account for this extra service and the time required for its delivery may assist digital uptake.

Collaborative telehealth health consultations with specialists require all three parties (i.e. GP, specialist, and patient) to be present at the same time. However, this can be impractical due to scheduling and technical difficulties in coordinating video consultations. All these aspects can lead to wasted time and sacrifices in financial revenue. For this reason, it is understood that "store and forward" telehealth is preferred to real-time audio or video approaches, despite not having the same MBS funding support as real-time telehealth.

Access to greater training and support networks

Irrespective of these issues, numerous pilot studies demonstrate positive benefits for patients and the clinical workforce by using telehealth.[95,96] Results from pilot studies indicate that telehealth assists in addressing issues of expertise distribution, skill base, recruitment and retention, and healthcare use. However, evidence also suggests a need for greater training and informal support networks, particularly during set up and on-boarding of new GPs and specialists in using telehealth technology.[97]

How can we best prepare the GP workforce to harness new technologies to improve patient experience/outcomes?

The Royal Australian College of General Practitioners (RACGP) continues to play a leading role in the design and implementation of e-health initiatives in the Australian Healthcare setting.[98] The RACGP supports telehealth delivery and has released a range of resources to support GPs, specialists and their practice teams to implement video consultations.

As the role of technology in general practice grows, it is important that all future GPs be exposed to the benefits of evolving digital technologies.[99] This should demonstrate how these new technologies can be a valuable and positive aid to providing optimum clinical care and improving the overall health of the community in a streamlined and efficient manner.[100] In a training and clinical sense, GPs and trainees need to be educated to maximise the benefits that technological innovations can bring to patients. This will include how to best navigate the health system on behalf of the patient and collaborate with telehealth specialists.[101,102]

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Other support avenues to accelerate the implementation of telehealth in general practice should address funding and practicality barriers. The development of a comprehensive and robust funding model that accounts for the agility and loose structure of telehealth services will be instrumental in enabling GP clinics to realise the financial benefits of implementing a telehealth service in their practice, and must be a priority. Investment into, or co-development of, telehealth software that accounts for the varied schedules of GPs, specialists, patients, and other clinical staff could also be explored.

The GPs of the future will need the skills and expertise to ensure that technological advancements are used strategically, where they can add value to patient care and help address workload demand pressures.[103]

Considerations for NSW Health

Part of the challenge for NSW Health will be in working collaboratively with other organisations and systems given that GPs are predominantly employed in the private sector in NSW. However, NSW Health have a role to play in consideration of these new technologies and the impact they will have on the NSW Health system more broadly. Technology will play a key role in improving the integration between primary, secondary and tertiary care. In this context, system managers must first assess:

How is the patient experience impacted by technology and what is the impact of this for NSW Health? Further, use of technology in general practice is expected to empower consumers in the management of their own health (particularly in relation to chronic disease), which consumers will come to expect from all their health services. NSW Health will benefit from digitally enabled models of care that promote preventative behaviours, reduce unnecessary care, enable early intervention and reduce hospitalisation.

What systems and policies are needed to encourage data sharing and interoperability between the providers from different sectors and settings while maintaining data security, privacy and quality? NSW Health can play a key role in supporting the interoperability of information systems and secure messaging platforms. This will be critical to enable secure data sharing of health information into the future.

Collaborations across the primary and secondary healthcare systems have highlighted areas where linked datasets and interoperability could significantly improve health information and improve outcomes for patients as they move through the health system. This shows that a collaborative approach that supports interoperability and data linkage will be key to providing better value care.

How can GPs and other stakeholders be engaged in this process? It will be important to work closely with GPs and primary care medical stakeholders (such as, but not limited to Aboriginal Medical Services) to drive improvements across the system. Through connecting and working in partnership with GPs, NSW Health will be better placed to work collaboratively to identify the ways that technology can be utilised to prevent people from presenting to acute care settings. In particular, rural centres that employ medical staff in both a GP and medical generalist role in hospitals may provide unique perspective on how technologies could be used to best support the needs of primary care as well as other settings, such as hospitals.

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03.
Radiology

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What are the emerging technologies in radiology?

The current radiologist is met with ever increasing demands and higher workloads, and the practice is under pressure to accurately diagnose with little margin for error. Further, some diagnoses are reached through subjective decisions, and reported with inconsistent standards.[104,105] However, technological advances within the field are solving these problems, and will enable radiology to be the biggest winners through its effective adoption.

AI-assisted diagnosis in clinical radiology

AI diagnosis techniques within image-based radiology are undertaken through the assessment of visual characteristics of scans, and radiologists rely on training to recognise these features.[106] Hence, the capabilities of image recognition using AI is set to have a significant impact in radiology, specifically in the detection of tumours and other abnormalities in scans.

AI software trained with quality datasets are currently mature enough to perform "narrow" or well defined tasks with pace and precision.

For example, HeadXNet is an AI tool developed by researchers from Stanford University that assists in the detection of brain aneurysms from computed tomographic angiography (CTA) scans.[107] The AI tool detects the presence of aneurysms at each section of the scan and develops an annotated version of the final scan. This has shown to reduce rates of missed detections and increase likelihood of diagnosis agreement between clinicians.[108] It is important to note it augments the radiologist's role, and does not replace it.

Commercial initiatives include products like ProFound AI by iCAD. This uses AI to analyse 2D mammography scans to detect and annotate areas where tumours may be present.[109] It has just received the European CE Mark approval for use.[110] In addition, AiDOC have released an AI package for the identification and triage of stroke in CT scans, reducing "door to needle" time for patients suffering stroke, in turn improving outcomes for those patients.[111]

Narrow AI also has high potential in easing the workload in mammography. Mammography primarily involves specific and high volume tasks and AI has shown cancer detection accuracy comparable to an average breast radiologist in recent studies.[112] This could potentially free up time of the radiologist to focus on other, value-adding tasks.

AR & VR in interventional radiology

Interventional radiology is an exciting specialisation that provides minimally invasive diagnosis and treatment of diseases. Procedures in interventional radiology rely on angiography techniques (imaging of lymph and blood vessels) that are extremely complex.

Interventional radiologists (IRs) are required to undergo substantial amounts of training and require ongoing training to increase proficiency in specific procedures.[113] Traditionally, intern IRs are trained practically within the angiography suite under consultant IRs.

Advances in virtual reality capabilities will allow IRs to improve their skills in angiography procedures, while reducing the need to perform clinical training on patients and eliminating unnecessary exposure to radiation.[114]

VR systems such as the VIST Virtual Patient by Mentice creates a simulation of the patient on the display monitors in the angiography suite.[115] The system uses previous case files or is given patient MRI and CT scans to provide real-time feedback to procedure steps to simulate a real procedure.[116]

The system can be used to accelerate training for inexperienced IRs and can also be used by

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experienced clinicians to improve their skills for certain types of cases.

Computational advancements and Big Data applications in radiation oncology

The increasingly powerful computational hardware and software will have significant benefits within radiation oncology.[117] Increased computational power and cloud computing will enable "fast physics" that adapt treatments to individual patients for increased effectiveness.[118]

Computing advancements can also automate treatment planning, and coupled with refined and intuitive user interfaces, minimise the need for manual interaction, reducing human errors, and improving treatment quality by allowing radiologists to increase the time they spend with patients. *119*

Upgrades in IT infrastructure, computational advancements, and integration of systems will also enable Big Data capabilities.[120] Big Data can facilitate the integration of databases across radiation oncology sites. Its impacts include the ability to establish 'Virtual Clinical Trials' over a number of sites, accelerating clinical validation of new treatments, and the use of informatics tools that allow for monitoring of the quality of oncology care at the point of delivery.[121]

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How will these emerging technologies impact the NSW radiology workforce?

Impact of AI-assisted diagnoses in radiology

The primary driver of AI within medical imaging is the aim of increasing efficiency and accuracy in diagnoses, while reducing the burden of low value work. Within a manual diagnosis workflow, a radiologist will visually inspect multiple scans, relying on cognitive skills and training to identify abnormalities.[122] Experience and subjective reasoning plays a key role in decision making. The average radiologist working in CT or MRI modalities is required to analyse a scan every four seconds during full work day to meet workload demands.[123] The high workload and manual workflow will inevitably result in errors. AI assistance is expected to increase efficiency of workflow and accuracy of diagnoses while improving the working conditions of radiologists.[124]

AI application within diagnostic radiology is limited by its modality and task-specificity. This means that a specific product used to analyse abnormalities in the brain in CT scans cannot be used to assess the presence of malignant growths on a PET scan of the lungs.[125] Annotated scans may also contain false positives. Hence, the role of the radiologist will not be altered significantly, they will simply have an additional tool which will increase their speed and confidence in diagnosis.

There are also non-diagnostic applications of AI that can improve a radiologist's workflow. Radiology reports tend to be time-intensive and repetitive. Further, due to its place at the end of the typical workflow, reports are error-prone and may lack clarity and contain non-standardised terms, reducing its impact when examined by the physician.[126] AI-run, automatic report generation can assist in standardising terminology, increasing report quality, and decreasing radiologist workload.[127] However, there may be new tasks required of radiologists to undertake routine quality and safety checks of the AI.

Consideration also needs to be given to the future education and training of radiologists if AI increasingly interprets x-rays and drafts reports in routine cases, but this foundational knowledge is also needed by radiologists for complex or non-routine cases.

Accelerated training and increased application of IR

VR training for interventional radiology can be incorporated to simulate procedures with a high level of detail while reducing the need for clinical training on patients and exposure to radiation. The system also provides a method to evaluate potential performance of trainees and adapt training schedules which allow for potentially unlimited repeated simulations in areas where trainees may be less skilled.[128] VR also provides opportunities for experienced consultant IRs to expand their skillset and proficiency in specific or rare cases.

How can we best prepare the radiology workforce to harness new technologies given current workload and workforce pressures?

The 2016 Australian Clinical Radiology Workforce Census Report found that 40 percent of the respondents consider their overall workload to be too heavy.[129] There was also a common sentiment among respondents that there were incentives in both public and private sectors to increase the number of reported cases with diminished focus on the quality of reported cases.[130] Feedback also found that there were increases in unpaid over-time work; perceptions of an over-burdened public sector; and calls for increases to Medicare reimbursements to restore quality and work-life balance.[131] The incorporation of AI-assisted diagnoses and workflow automation within the speciality could be utilised to address the high rates of dissatisfaction of workloads.

Limited increases in Medicare reimbursements have occurred in radiology.[132] However, through widespread establishment of automated processes in laboratory workflow, services in Australia are able to contain costs and also remain as the global benchmark for workforce efficiency and accuracy.

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The Workforce Census Report also identified a shortage of interventional neuroradiologists (INRs).[133] Their demands are high, given the need for time-critical, 24-hour acute stroke clot retrieval and thrombolysis therapy.[134]

Considerations for NSW Health

In considering these new technologies, system managers with responsibility for the oversight of the medical workforce and the introduction of these new technologies must first assess:

What is the role NSW Health can play in ensuring sufficient IRs and INRs within the NSW Health system? Currently there are discussions within the profession as to how to classify, certify and train IRs and INRs as a result of technology and its impact on roles and functions.[135] A proactive and collaborative approach to assess the utility and clinical validity of AR and VR technologies for training of IRs and INRs could result in an accelerated or more accessible course progression to certification. This is expected to assist in addressing the workforce pressures within radiology and needs to be considered in the context of scope of practice changes that may occur across radiology with the introduction of AI. This in turn may free capacity for diagnostic radiologists to re-train in interventional radiology, or to move into new roles that may be created to manage radiology specific AI tools.

What are the systems and processes in place that govern the safe and ethical use of AI? For example, there will be circumstances where clinical judgement will indicate a diagnostic or therapeutic outcome that differs from the decision supported by AI solution(s). These events will give rise to ethical, medico-legal and safety implications. Clear governance and policies will be needed to support the workforce in determining the appropriate course of action in these situations. These governance arrangements may also need to be considered in the context of ethical frameworks being created regarding use of AI more broadly across health, both within Australia (such as the Colleges) and internationally.

What are the appropriate avenues to train and credential radiologists for the use of these technologies and new workforce roles? It is expected that with the uptake of AI new roles will be required. For example, it is predicted that there will be a role for a radiologist to regularly audit AI algorithms. This will require NSW Health to consider how to harness the profession's interest in these new technologies, as well as supporting training pathways to assist this emerging workforce need.

What are the policies and procedures that need to be put in place to ensure the quality and safety of the AI technology? It is expected that NSW Health will need to create guidelines and policies that outline the audit process, check that relevant standards are being complied with, and to ensure that these checks are undertaken on a regular basis. Research and evaluation on the accuracy of AI diagnosis will be essential in ensuring that quality and safety is enhanced through its use, and consideration may need to be given to factors or circumstances that are more suitable for clinician diagnosis. This may require consideration of a certifying authority for safe use of algorithms in healthcare and further consideration of regulatory responses to ensure the safety of AI is required.

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04. Pathology

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What are the emerging technologies in pathology?

100 percent of cancers are diagnosed by pathology and 70 percent of all medical decisions rely on pathology services.[136] Increases in capability, accuracy, and time-sensitivity brought about from emerging technologies, and its effective adoption into clinical practice will result in significant benefits for the whole healthcare system.

Clinical digital pathology

Traditionally within histological pathology (histopathology), slides containing tissue samples are prepared by laboratory technicians, then stored for examination under the microscope by the pathologist.[137] This process has a number of drawbacks, including the cost of time in the preparation of slides, and the need for pathologists to individually review each slide.[138] There are also logistics challenges with the transportation of fragile slides prepared in rural sites to larger pathology sites, and given Australia's wide and sparse population this remains a significant challenge. Further, pathology laboratory accreditation requires slides to be retained for a minimum of 10 years, which causes strain on laboratory space.[139]

Clinical digital pathology systems are providing significant advantages in reducing the time to prepare and assess slides. Following preparation and staining by a technician, the slides can be loaded into fully automated scanners that take high quality digital microscopic images at high volumes for analysis by pathologists.[140]

Commercial scanners can also offer a suite of technologies such as a dedicated pathology image viewer system, automated counting of cells highlighted by special stains, and server and storage software that integrates with electronic medical records, dramatically reducing logistical barriers associated with transport and storage of slides.[141]

Clinical digital pathology systems are currently being implemented across Australia. Some private pathology services are on track to become fully digitised pathology networks by incorporating commercial scanner solutions at all sites which can assist in challenges associated with servicing rural and remote regions of Australia.[142]

Genomics

Genomics is the analysis of genomes to characterise and map them. This allows for the accurate prediction of how specific sub-types of diseases will progress and how individual patients will respond to different treatments, in turn providing guidance to clinicians regarding the most effective treatment pathway.[143] Genomic information can also be considered together with other patient information sources, such as their medical history, in order to inform clinical decision making.

Pathology has changed significantly as a result of genomics, and every sub-specialty of pathology is impacted by it. For example, traditional anatomical pathology conducts analysis of tissue morphology to provide a diagnosis. If cancerous cells are found, traditional treatment methods generally involve use of standard chemotherapy and radiotherapy.[144]

Integration of genomic medicine with existing morphology techniques greatly increases the quantity and quality of information available to support a diagnosis. Genomic medicine enables increased stratification and subtyping of cell types. The detailed characterisation of cell types enabled by genomics generates information about how subtypes of cancerous cells will respond to different therapies.

Genomic sequencing not only provides a more accurate diagnosis of disease, but also a more detailed prognosis and prediction of response to treatment.[145]

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This is especially useful in cancer diagnosis and therapies, where stratification of different tumour cell subtypes drives targeted therapies for each subtype, reducing the need to use standard chemotherapy and radiotherapy, both which may have significant side effects.[146]

AI-assisted diagnosis

AI has significant potential to advance pathology. Although still in the research phase, AI technologies can identify regions of interest in histological slides, employing image correction techniques to highlight areas for human analysis.[147]

Researchers are also training AI to diagnose based on whole slides, bypassing human interaction until the final stage of analysis.[148] Accuracy of diagnoses have reached up to 94.96 percent in one study analysing slides for breast cancer.[149] However, this is not yet on par with manual analysis accuracy of 99.4 percent.[150] Training of AI requires high quantities of good data to be fed into the software for it to "learn" and improve its abilities.[151] Good quality data from digital tissue slide images is becoming increasingly available with the widespread use of digital pathology, hence the clinical validity of AI-assisted diagnosis will be achieved at an accelerated rate.

Internet of Things and Cloud technologies

Internet of Things (IoT) technologies, combined with the benefits of cloud technologies, are emerging in pathology to help with point of care diagnostics and reduce the time taken to identify disease. An example is a voice pathology detection system. This uses local binary pattern recognition and extreme machine learning to detect the pathology.[152] IoT technologies can also be used to remotely detect viral outbreaks that enables early quarantining of the infected. This has been useful where disease is spread in remote areas and is spread by insects.[153]

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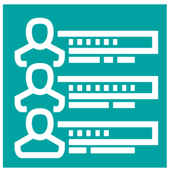
How will these emerging technologies impact the NSW pathology workforce?

Impact of digital pathology



A fully integrated digital pathology service provides many benefits for both patients and the pathology workforce because of major logistical barriers that can be overcome through digitalisation.

Decreases in manual and time intensive tasks improves laboratory workflow, allowing more time for pathologists to make a faster, accurate diagnosis for each patient.[154] Digital pathology also enables "telepathology" by facilitating the sharing of slides and data for remote, cross-laboratory, or cross-disciplinary analysis of patient data.[155]

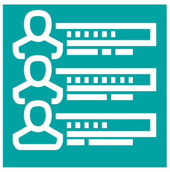
How can we best prepare the pathology workforce in harnessing digital pathology?

Elements of digital pathology have already been implemented within NSW Health Pathology (NSWHP) with the rollout of HealtheNet, which allows clinicians to remotely access pathology results.[156] Furthermore, the Digital Anatomical Pathology Workplace program has seen the shift to digital viewing and storage of tissue slides, and the use of digital workstations at various laboratories within NSW Health.[157]

Digital pathology also enables the transition to telepathology. The Royal College of Pathologists of Australia (RCPA) have identified a number of key challenges that must be addressed for successful transition. These include:

- The need to increase network bandwidth and security infrastructure to support transfer of large data files, patient privacy issues when using mobile devices and unsecure networks, and legal issues associated with the sharing of patient data security of data;
- Pathways and methodology of credentialing pathologists using digital pathology systems; and
- Workplace health and safety considerations related to the changing physical work environment afforded by digital systems. [158]

Impacts of integration of genomic medicine



Genomic medicine will see a significant increase in the quantity of information that can be extracted for higher characterisation of the patient or disease, which in turn will allow for the administration of more targeted therapies.

However, the extraction and decoding of this information will require a wider skill-set within the pathology workforce. Hence, integration of genomic medicine in diagnosis will require collaboration of a much broader team of clinical personnel.

For example, extraction of live tissue for whole genome sequencing, and assessment of sufficient tumour nuclei numbers within a sample will require biomedical scientist support.[159] Histopathologists will work with clinical scientists, biomedical scientists, and oncologists to deliver a robust report to the physician and patient.[160]

How can we best prepare the pathology workforce in harnessing genomics?

The significant impact of genomics and the collaboration required to deliver genetic data has seen increased demand for genetic pathologists who can lead laboratories across Australasia to drive genomics service delivery. However, genetic pathologists are required to attain accreditation. Further, there is a significant undersupply of genetic pathologists in the region.

To address this, NSWHP and RCPA have implemented a number of initiatives to support the pathology workforce with the adoption of genomics.

RCPA has published standards, required experience, and modules necessary to gain accreditation as a genetic pathologist. The College has also developed initiatives to recognise prior learning to accelerate the accreditation process.[161]

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NSWHP have developed the Genomics Strategic Plan 2016-2018 which has implemented initiatives that deliver genomics capability development in the NSWHP workforce. The strategic objectives include attracting and retaining quality and competent staff, and leading research and translating outcomes into practice.[162]

Implications of AI

Through research and advances in genomics, pathologists are rapidly gaining a more detailed understanding of how to characterise disease to better assist the consumer. With pathology in Australia under pressure, AI assistance is increasingly attractive. However, with AI use in pathology not yet adequate to become part of routine practice, implications for the pathology workforce including training of machine learning, and ensuring foundational knowledge for pathologists in routine cases may only be more visible in the next decade.

Considerations for NSW Health

In considering these new technologies, system managers with responsibility for the oversight of the medical workforce and the introduction of these new technologies must first assess:

The continued role NSW Health can play in increasing the workforce supply of genetic pathologists in the region through the Genomics Strategic Plan 2016-2018, including monitoring the progress on workforce capability development in genomics across the pathology workforce. A proactive and collaborative approach to increasing the workforce supply of genetic pathologists with other jurisdictions will be key to ensure that competitive practices do not exacerbate labour market shortages.

Who decides what constitutes the ethical use of data? With increased data availabilty and data sharing, the ethical use of data will become a key consideration and, in particular, who is responsible for deciding and developing guidelines on the secondary use of this data. NSW Health will need to consider what its role should be in governing the use of data, such as processes to ensure the privacy and security of information and appropriate data sharing practices between public and private pathology services. These will need to be considered in the wider context of national and international discussions regarding health data and information sharing about highly confidental clinical information.

For the publicly employed pathology workforce, NSW Health will need to consider the impacts on workplace health and safety and the changing physical work environment required to help support digital viewing and storage of tissue slides, and the changes to work practices that will be needed in bringing together multi-disciplinary teams. It is expected that the demand for genomics will rapidly increase over time and this may require additional workforce as well as greater laboratory spaces to accommodate this.

What partnerships are needed to develop these policies? NSW Health will need to work with key stakeholders such as the RCPA to set policies that reflect emerging international and national best practice in supporting genomics in health.

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05. Dermatology

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What are the emerging technologies impacting dermatology?

Skin cancer is estimated to be the fourth most commonly diagnosed cancer with over 15,000 new diagnoses as of August 2019.[163] The mortality rate of skin cancer has also increased from 4.5 deaths per 100,000 in 2016 to 5.6 deaths per 100,000 in 2019.[164] The need to support the dermatology workforce to curb this growth is increasing. Fortunately, emerging technologies are enabling rapid progress toward a more consumer centric model that yields rapid and accurate diagnoses based on data, along-side more effective and tailored treatments.

AI-based skin cancer diagnosis

There is significant progress being made in the use of automated image interpretation using AI to diagnose skin cancers with high levels of accuracy.

Computer scientists at Stanford University have created an artificially intelligent diagnosis algorithm for skin cancer.[165] The program was developed through machine learning analysis of 130,000 skin disease images to develop the ability to visually recognise potential skin abnormalities. Studies suggest this technology is more accurate than the human assessment.[166] In a non-clinical test between a group of 58 dermatologists and an AI-based system, the AI outperformed the dermatologists by identifying 89 percent of melanomas from a set of dermatoscopy images compared to 86.6 percent by the dermatologists.[167]

Although employment of AI techniques for skin cancer detection is still in the research phase with applications limited to clinical validity tests, the use of AI to assist skin cancer detection is already in use, with commercial products available for dermatology practices today.

FotoFinder, a German company specialised in skin cancer imaging and diagnostics, have created Moleanalyzer Pro.[168] This software enables real time upload and AI powered assessment of dermatoscopy images to provide a highly accurate risk score of skin lesions to support the dermatologist's assessment. Moleanalyzer Pro is in use today in Australia.[169]

Teledermatology

The clinical viability and widespread use of image processing and AI also enables the advent of remote diagnoses and more powerful telehealth capabilities.

Considering that rural and remote populations have limited physical access to dermatology services, the potential to transfer images over secure networks for AI powered clinical analysis is extremely desirable.

Non-AI teledermatology services are already available and being used in practice. Services such as MoleScope allow patients to securely send images of skin lesions through a smartphone application through an affordable dermatoscope attachment placed over the phone camera.[170] Coupled with the use of image processing software, the application allows dermatologists to efficiently and effectively diagnose patients remotely and prescribe next steps accordingly.[171] This reduces unnecessary in-clinic visits, and allows more time to deliver quality care for those who need it.

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Genomics in skin condition diagnosis

A substantial amount of genetics research has been dedicated to the characterisation of specific genes, their involvement in skin pigmentation pathways, and the pathological effect of their mutation.[172]

Definitive identification of these genes and the effects of their mutation, coupled with advances in faster and more cost effective genetic sequencing methods have seen genomics and the delivery of personalised medicine becoming increasingly relevant to dermatologists to diagnose skin conditions and cancers.[173]

Genomics in skin diagnosis is currently in clinical use and has assisted dermatologists in identifying extremely rare skin conditions in patients that have similar symptoms to more common conditions.[174] Recognising its potential in dermatology, the National Health Service (UK) is delivering education in genomics to dermatologists through professional development courses to build capacity.[175]

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How will these emerging technologies impact the NSW dermatology workforce?

Clinical workflow refinement

The advent of advancements such as teledermatology and AI assisted skin cancer diagnoses allows dermatologists to gain time in two immediately apparent ways. Firstly, the use of teledermatology and technologies such as MoleScope minimises the need for initial face-to-face appointments. Dermatologists are given the choice to schedule physical follow-up appointments if they recognise abnormalities in the images that the patient has sent through – allowing for increased time spent with patients who require additional time for care.

Further, the increasing prevalence and clinical viability of AI assisted image interpretation will allow dermatologists to spend less time analysing each image, enabling faster and more accurate diagnosis of skin features. This reduces non-patient facing workload allowing the specialist to spend more time with the patient to prescribe treatment options.

Improved access to services

Although current results find that AI and image interpretation is more accurate in diagnosing skin cancers, the possibility of such software replacing the need for the dermatology specialty is low.

Technology should be seen as another tool for dermatologists rather than replacing them. It should be noted that the majority of "AI versus human dermatologist" studies in which the software outperformed the dermatologist were conducted outside a real-world clinical setting. The result of clinical studies with current progress will likely show inferior performance of AI against experienced dermatologists.[176] Further, patients want to see doctors, not computers. Hence, the most likely and ideal future sees dermatologists use such technologies as a tool within their extensive ecosystem of services to provide better care to more people.[177]

The Department of Health (the Department) in 2017 found that with the (then) current intake of dermatology specialists, there will be a significant national undersupply by 2030.[178] The recommendation put forward by the Department was to facilitate specialist dermatologists to manage complex, rare or severe skin conditions and support specialist nurses and GPs to manage patients with common or more straightforward conditions.[179]

The powerful advances in telehealth technologies and AI powered skin cancer diagnoses software can not only assist dermatologists, but also specialist nurses and GPs. This enables more efficient and wider access to dermatology services, ensuring that the future demands of Australian consumers are met.

How can we best prepare the dermatology workforce in harnessing new technologies to improve patient experience/outcomes?

The Australasian College of Dermatologists (ACD) is the peak medical college for the specialty of dermatology.[180] The ACD recognises the importance and benefits of telehealth and e-learning in up-skilling trainee dermatologists. Developments in virtual learning have enhanced communication within the discipline and allowed for distance education.[181] These avenues must be further explored and utilised to develop learning activities that are proactive rather than reactive to allow capability development of dermatologists, specialist nurses and GPs in the adoption and use of technologies such as teledermatology.[182]

There are also several medico-legal and financial barriers to adoption of teledermatology. Dermatologists are not formally trained to analyse digital images and there are concerns about the reliability of data sent by patients, and whether the image can be trusted. Clinicians are not confident in providing a diagnosis through these mediums, as there is a lack of clarity about the legal implications, and whether insurance would cover diagnosis and advice from patient generated data.

There are also concerns about privacy in the transfer of this data. Questions about the level of encryption in commercial teledermatology technologies, and protocols of management and

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transfer of patient identifiable data between clinicians are yet to be answered.

Further, currently there is no Medicare reimbursement for store-and-forward services within teledermatology. This reduces the likelihood of adoption as dermatologists are currently providing these services in their own time.

These issues must be explored and policies must be developed to legally and financially support and accelerate, the implementation of teledermatology services in practice, so that the benefits of this technology can be realised.

The Topol Review recommends adequate governance structures to ensure responsibility for the safe and effective adoption of digital healthcare technologies at scale, which may be more applicable to the public health system.[183]

The ACD has taken a number of steps to support and advance the use of emerging technologies within the speciality. It has added significantly to *"Artificial Intelligence: Australia's Ethics Framework"* where it welcomes the use of AI as a tool to assist dermatologists and establishes a solid foundation of ethical principles on which the technology can be adopted safely and effectively.[184] As thought leaders in dermatology in Australia, the ACD is ideally placed to accept this responsibility and foster discussion for the safe and effective adoption on emerging technologies in dermatology.

Considerations for NSW Health

In considering these new technologies, system managers with responsibility for the oversight of the medical workforce and the introduction of these new technologies must first assess:

How the use of AI and other technologies may asisst in addressing the shortages within the dermatology workforce. While dermatologists work across both the public and private sector, NSW Health will need to monitor the workforce shortages expected, noting that there may be some workforce efficiencies found through the adoption of AI, particularly in the diagnosis of skin cancers.

What systems are in place to support the use of patient-generated data? With the growing use of patient-generated data, policies will be required to support the use and quality of this data, for example, through setting minimum standards. This will need to be considered in the context of discussions occuring internationally and nationally across health care.

How is NSW Health supporting the introduction of this new technology to realise consumer benefits? The opportunity to leverage technology to increase access to services is a key role for NSW Health to support the targeting of services to the patients who need it most. In rural and regional parts of NSW the increased use of teledermatology services could significantly improve patient access to dermatology and improve early diagnosis of skin cancers and skin conditions.

Who does NSW Health need to work with to implement new technology? Bodies like the Therapeutic Goods Administration and the Colleges will play key roles in ensuring the quality of technology and associated data and its uptake amongst the workforce. Building strong relationships with stakeholders such as these will ensure that NSW Health is aligned with the direction of key stakeholders and the work already being progressed by the ACD.

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> Patients can confidently expect surgery to become gradually less invasive, more accurate, have more predictable outcomes, faster recovery times and lower risk of harm.
>
> The current unique relationship between the patient and the surgical team will become even more important, as technology allows greater access to information.
>
> *- Future of Surgery, Royal College of Surgeons (UK)*

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