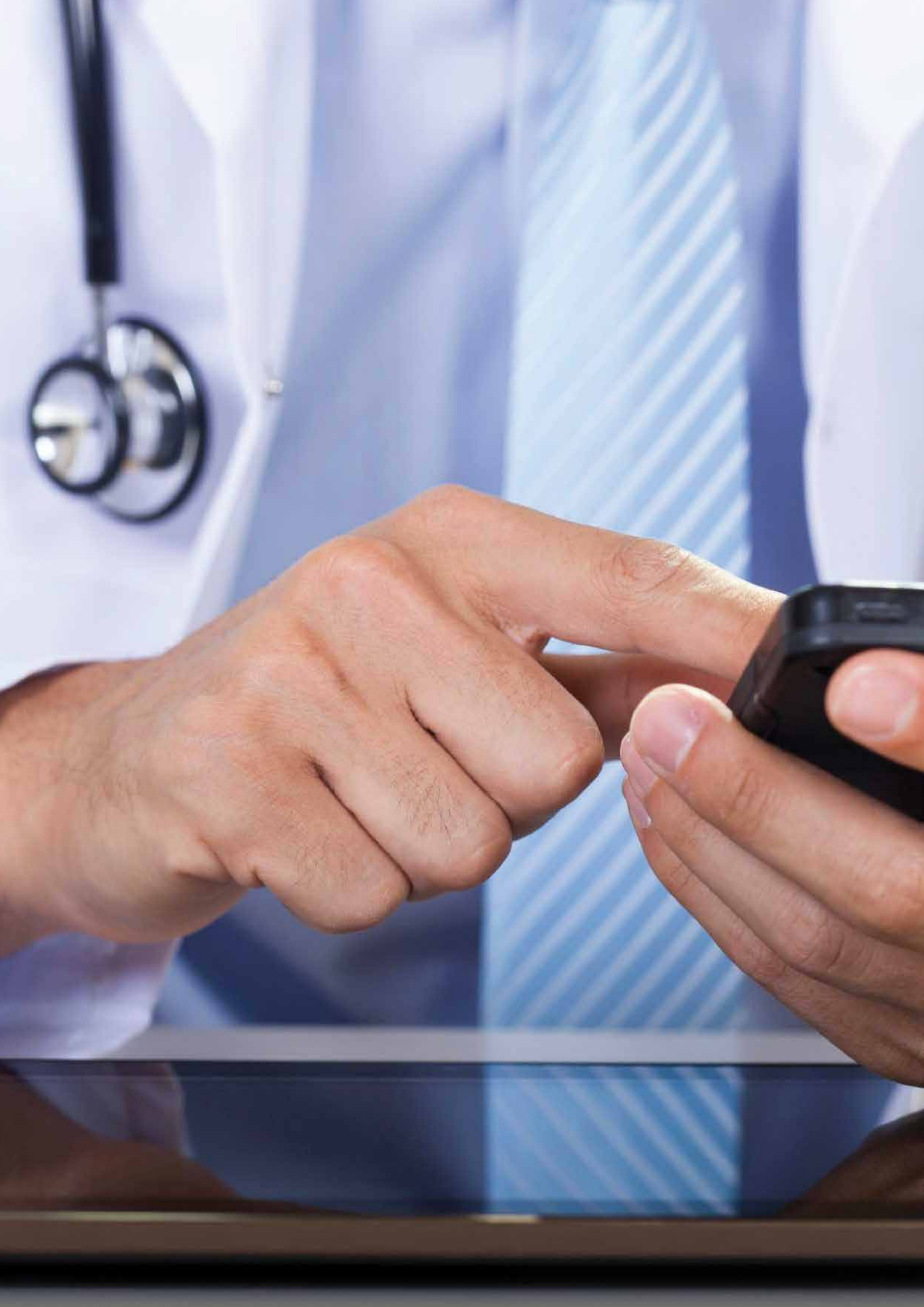
A digitally-enabled health system







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What will our healthcare system look like, once the full potential of the digital era is harnessed?



Introduction

Sarah Dods *Research Theme Leader – Health Services, CSIRO*

Australia's healthcare system is under significant and increasing pressure to change within the next twenty years.

Health is already the second largest area of government expenditure and the largest employer in Australia, with total health expenditure trebling in the last 25 years (Department of Treasury 2010: 50). Our ageing population heralds a range of exacerbated issues including a shrinking workforce, reduced tax base, and more patients. At the same time, chronic disease incidence continues to rise, as do expectations of the quality levels and breadth of treatments available to the average citizen.

All this contributes to forecasts that the national costs of healthcare will trend upwards at an exponential rate. Treasury estimates suggest that at current rates of growth, and without significant change, health expenditure will exceed the entire state and local government tax base by 2043, and require almost half of all government taxation revenue (Department of Health 2010: 53). Simply targeting administrative overheads is unlikely to deliver further substantive gains: administration only constitutes around 2 per cent of recurring health expenditure, and was the only such area to decline in amount between 2006 and 2011 (AIHW 2013).

The situation is not, however, beyond remedy. Digital technologies are powerful enablers for addressing the challenge of meeting rising demand with increasingly scarce human, capital and operational resources, at the same time delivering improvements to service quality and availability. Much of the data on which these advances rely is already available to clinicians and administrators, or will be soon.

What will our healthcare system look like, once the full potential of the digital era is harnessed?

We need to reduce the reliance on our hospitals through helping people to not become hospital patients, and making better use of the resources that we have. Digital tools will do this by moving many services to outside the hospital through broadband delivery and models of care based on rich digital information. They will improve access to services while reducing the need for hospital beds. They will help avoid errors that cause people to end up in hospital by highlighting key information and risks.

Hospital resources will be holistically managed with the aid of advanced modelling and analytics technologies, allowing administrators to predict, manage, and optimise the flows of patients and clinical staff even before the hospital day begins. Personal e-health records, coupled with evidence-based planning and analysis tools, will help clinicians make difficult diagnoses and dramatically reduce the incidence of human errors. This will help people not stay in hospital longer than they need to.

Telehealth platforms will make in-home patient monitoring the norm for those that need it, and will provide the base for an increasing range of services like specialised medical triage or rehabilitation – wherever patients are living. The use of real-time video and data streaming will make it easier to detect the early-warning signs of acute events and reduce hospitalisation rates. It will also dramatically improve the reach and efficiency of health services to remote and regional Australia, including telepresence-based staff training that promises to help alleviate many of the worker shortage issues in these areas.

Rigorous data security and privacy processes, including the ability to anonymise large swathes of population data, will enable research into national health indicators at a previously unattainable scope and depth. Common data standards will ensure that patients have access to cost/benefit analyses of different treatment options, designed according to a unique record that compiles and collates their entire medical history across diagnoses and providers.

Organisations like CSIRO have been working for some time on making these possibilities a reality (Dods *et al* 2013). In this report, we outline the major issues Australian healthcare currently faces; and how digital technologies might remedy them, while ushering in new levels of service quality and patient centricity. We believe that all the scenarios described in this report are wholly achievable based on the current trajectory of research and development in this country. The challenge is that rising stresses on our healthcare system will make it increasingly difficult to invest the time and capital needed (both financial and human) to foster this type of innovation. The healthcare sector has only a limited window in which to act. The time to focus on bringing about the benefits of a digital healthcare system is now.

Digitally-enabled hospitals



Bill of Health:
Hospitals

- Hospitals are the costliest single element in Australia's health system, taking up to 40 per cent of health expenditure.
- Hospital expenditure is growing at almost 6 per cent per annum (AIHW 2012); public hospital expenditure totalled $42bn in 2011 (AIHW 2013: viii), compared to $38.9bn in 2010 (AIHW 2012: 47).
- The "bed ratio" (the number of available hospital beds for every 1,000 population) in public hospitals for people aged 65+ has declined by almost 43 per cent over the last 20 years (AMA 2014: 4).
- In 2012-2013, around 18,000 people presented at Australian emergency departments every day. The number of ED presentations increased by 16.9 per cent between 2008 and 2012. (AIHW 2013a: 7).
- The national median waiting time (time between presenting at an emergency department and receiving treatment) declined from 23 minutes to 19 minutes between 2008 and 2012, but the proportion seen on time remained relatively stagnant, only rising from 70 to 73 per cent. (AIHW 2013a: 23).
- In 2011-12, Major Metropolitan hospitals had only 54% of patients depart from emergency departments within four hours; large regional hospitals did better, with 78%. Across all hospitals types, patients that were admitted to a hospital ward spent longer in emergency than those that were discharged. (My Hospitals 2012)
- Only 31 of 122 larger hospitals around Australia reached their 2013 state targets for ED patients discharged within 4 hours (My Hospitals 2013: 1).







Patients will benefit from higher quality care with minimised waiting and hospitalisation times.

The hospital occupies a critical juncture in the overarching processes of the healthcare system. The overall quality of health services depends largely on hospitals operating quickly and efficiently to diagnose, provide immediate care for, and discharge or refer patients to other parts of the system. Yet, as the facts suggest, Australian hospitals face growing pressures on their capacity and capital resources.

As demand for hospital services rises, and resources become ever more constrained, hospitals must focus on becoming more efficient in how they triage and manage patients. Digital technology can assist operators and clinicians alike by providing greater insight into, and automatic management of, the complex patient flows that occur within and between hospitals.

Emerging digital systems are already providing increased real-time information that assists health professionals with "in the moment" decision-making. Tomorrow's digital hospital, however, will operate on a future planning basis, optimising resources ahead of time based on predictive data analysis that is accurate up to months or years in advance. Patients will benefit from higher quality care with minimised waiting and hospitalisation times. Hospital administrators and health departments will also come closer to understanding how patients move between and through the elements of the health system. This increased understanding of an extremely complex system has been impossible to map until now, and will enable care pathways and processes that are optimised across the entire system, rather than being restricted to a single, localised understanding.

Comparison chart: Number of ED patients seen within the recommended time

Metric	2012	Agreed target
30 minutes (classified as urgent)	68%	80%
4 hours (all visits)	67%	90% (by 2015)

Citation: AMA 2014. Public Hospital Report Card, p2

Patient predictions

WHAT'S NEW: Hospitals in New South Wales, South Australia, and Western Australia are already publishing real-time queue data from emergency departments. This data allows the public, GPs and ambulance staff to go where the queue is shortest– rather than simply defaulting to the closest hospital.

CSIRO's Patient Admission Prediction Tool (PAPT) uses predictive analytics to help clinicians and administrators plan for future patient presentations to individual emergency departments, their triage categories, how many will need admission into what clinical specialties, and how many beds are likely to be available. A number of Queensland hospitals already use the PAPT to accurately predict demand up to six months in advance, including during special events, such as "Schoolies" week.



WHAT'S NEXT: Tomorrow's digital hospitals will use data to anticipate and plan for future demand. Future advancements to evidence-based planning tools will provide increased levels of detail into resources needed for the anticipated patients (such as operating theatres), and optimise their allocation to manage both emergency and elective cases. The insights available from digital analytics tools will also improve planning around how patients are distributed and triaged between hospitals and departments, forming a virtuous cycle of faster care and reduced pressure on hospital staff to find urgently needed beds.

Such tools will also help staff to accurately predict and monitor an individual patient's length of stay in the hospital, and when they're most likely to be clinically ready to return home. This will allow patients (and hospital staff) to plan in advance towards an anticipated discharge date, reducing stay costs and also making an easier transition back into everyday life.

Tracking technology, timing, processes, and people



WHAT'S NEW: RFID is already being used to track key equipment in the hospital. This helps staff to find it when needed, and also helps to build understanding of how it is used, and how it could be used better.

Some hospitals also now use automated "check-in" systems for outpatients, similar to those operated by airlines. This provides administrators with new insights into their capacity utilisation in clinics, while providing real-time information to patients about their appointment.

WHAT'S NEXT: RFID tags will be used to provide continuity of care and increased safety levels for patients. They enable sharing of critical pre-admission information between "first on scene" health professionals (like ambulance workers and medics) and their in-hospital counterparts, to deliver greater consistency of diagnosis and treatment for patients, with all clinicians working off and updating a common case history for each particular presentation. The use of physical tags also ensures that this history stays with the patient no matter which ward they get transferred to; and can, for example, help avoid different wards avoid unwittingly prescribing contraindicated medications.

When integrated with a central "check-in" patient management system, wireless patient ID tags will ensure clinicians can immediately identify a patient's current location, enabling them to increase their mobility and move around the hospital more easily. They can easily be located in the event of a secondary emergency or urgent check-up or if needed for a test of consultation.

Future digital platforms will automate routine manual actions (like deployment of cleaning services to recently-freed beds, or sharing updated patient records with GPs and community health providers), giving staff and administrators increased time to focus on the quality, rather than the speed, of their decisions. In other cases, automated alerts will help ensure compliance: infection control, for example, can benefit from alerts to staff to wash their hands or send instruments for sanitising.

The "Big Data" generated by these automated systems can also offer new modes of improving hospital-wide processes. Melbourne's Austin Hospital, for example, is working with CSIRO to combine its automated check-in with simulations that help administrators optimise bed allocations based on each specialty ward's requirements. For patients, the most noticeable change will be the absence of waiting times, which should only occur for clinical reasons or when deliberating on a treatment option to pursue.

The broader role of automation will be determined according to each hospital's unique patterns, which will govern where automated systems can add value in a safe, secure manner. All automation platforms, however, will rely on shared, secure data access to earn the trust of both clinicians and patients. For this to occur, open yet robust interoperability standards must become a hallmark of how hospitals store and share their data: patients must have access to full transparency about where and how their information is being distributed at all times.





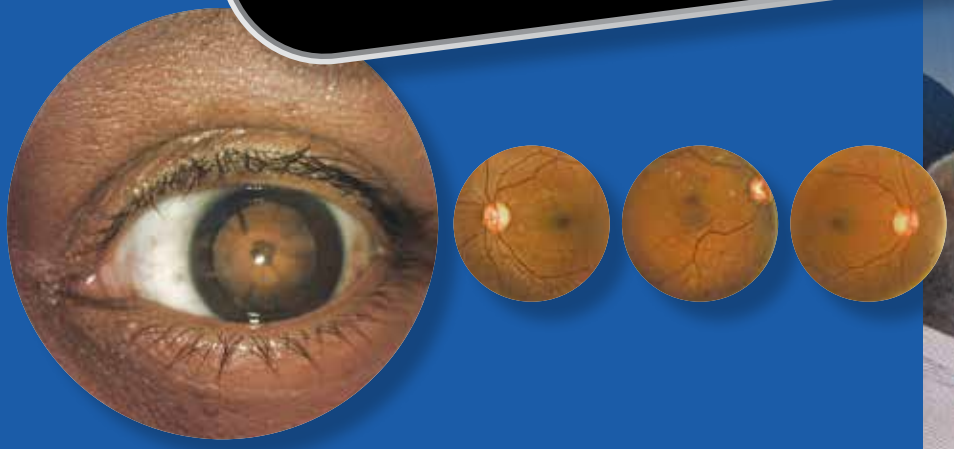
From hospital to home – the rise of telehealth



Bill of Health:

Chronic disease and regional health

- In 2004, almost 23 per cent of Australians aged 65+ had three or more chronic diseases (AIHW 2005). In 2007, more than 80 per cent of people in that age group had three or more long-term health conditions (Department of Health 2012).
- In 2008, $65.1bn was spent on chronic disease (AIHW 2013b: 7), comprising more than half of all health expenditure in Australia that year (AIHW 2010a: ix).
- Each Australian hospital admission that results from acute chronic disease costs around $6,000 on average (Department of Human Services Victoria 2003: 11).
- Spending on cancer increases by more than 20 per cent per annum (AIHW 2010: ix), increasing by 56% between 2000 and 2008 (AIHW 2013b: 27).
- Spending on cardiovascular disease alone cost almost $8bn in 2008, up 48% from 2000 (AIHW 2014: 27).
- The combined costs of chronic diseases and an ageing population are expected to exceed $200bn by 2045 (Department of Treasury 2010: 51).
- The hospitalisation rate from chronic diseases in remote areas of Australia is more than double that of for major cities (AIHW 2010b: 251).
- In remote Australia, there are only 589 nurses and 58 GPs per 100 000 residents, compared to almost 1000 nurses and nearly 200 GPs for major cities (Department of Health and Ageing 2012: 9).

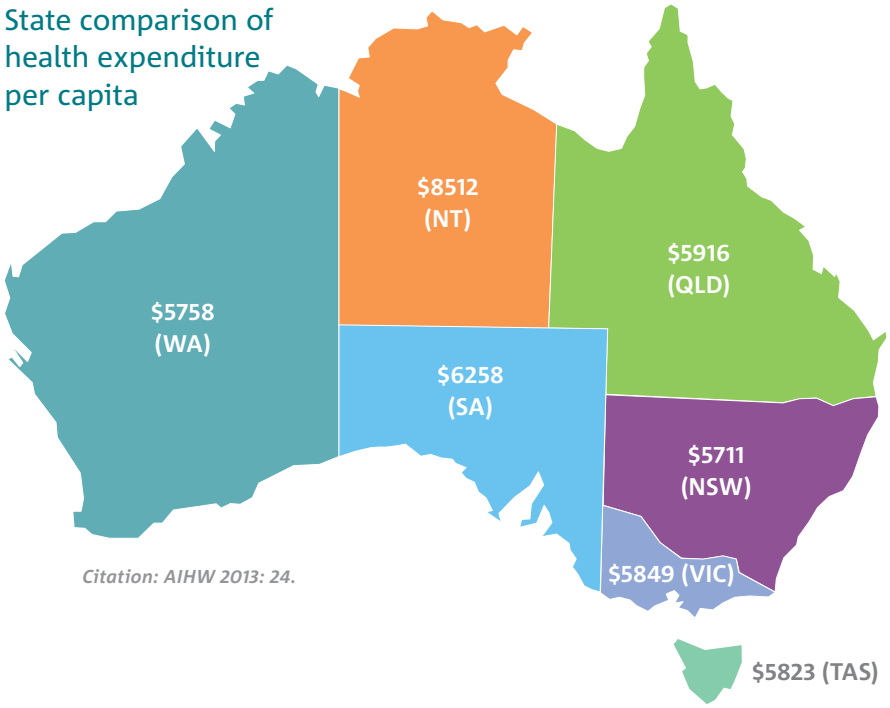




The predicted increases in rates of chronic diseases like cancer, cardiovascular disease, and diabetes cannot be tackled through hospitals alone. Primary and community health providers will be required to play a different and increased role in delivering ongoing care in a cost-effective manner that is focussed on patient outcomes. Their impact will be felt most acutely by those in regional and remote Australia, where rates of hospitalisations due to chronic disease already far outstrip those in metropolitan areas. At the same time, the health workforce faces human resource shortages which are only set to increase over the coming years – another area where the impact will be amplified for remote and regional Australians.

Telehealth – the delivery of health services via telepresence services like high-definition video streaming – is already being trialled locally and internationally as a means to actively manage chronic disease. For Australia's rural and remote communities, telehealth could not only dramatically improve chronic disease management, but also address underlying issues of staff training and timely access to health services – which, in turn, should translate into lower hospitalisation and mortality rates. With ubiquitous access to superfast broadband now only a matter of time, health service providers are in a prime position to explore the opportunities that telehealth processes and infrastructure offer.

State comparison of health expenditure per capita



Citation: AIHW 2013: 24.

Bring your own diagnostics

WHAT'S NEW: Some clinicians are trialling "guided self-monitoring" of chronic disease, where patients digitally take their own measurements that are reported back to their GP or community health professional daily. Studies suggest that using telehealth platforms to manage chronic diseases can reduce emergency department admissions by between 20 and 60 per cent (Meyers *et al* 2002), while others estimate that patient-directed telehealth can reduce chronic disease management costs per patient to $8 a day per patient (less than $3000 a year) (Thaker *et al* 2013).

WHAT'S NEXT: More affordable and user-friendly measurement devices will make self-monitoring and telehealth consultations the norm. Predictive algorithms will monitor reported readings, and provide managed alerts for developing trends as well as abnormal readings. Clinical staff will use decision support systems to review the patient-collected data, respond to alerts and alarms with suggestions for self-care, or arrange subsequent onsite action if required – anything from a primary care consult to rapid hospitalisation. Patients with long term health conditions will only need to physically present to doctors in exceptional circumstances, dramatically reducing time spent on medical visits, while nursing caseloads can increase without raising workloads (Seto 2008). GPs and specialists will only act on tasks requiring clinical expertise, and be able to make more informed diagnoses thanks to richer and more frequent data collection than ever before.

Such an approach is very well suited for chronic disease management, where the frequency of health checks directly correlates with the minimisation of acute and potentially harmful episodes. The longitudinal nature of these ongoing data samples will be sustained by lower non-compliance rates, as a result of more convenient and mobile self-monitoring devices. This data will help clinicians identify potential issues far in advance, preventing acute episodes and minimising longer-term healthcare costs as a result (Linden 2006; Britton 2008). As this new mode of health service delivery develops and the associated costs decrease, it will become cost-effective for a growing number of conditions. In the distant future, this may play out to become a semi-automated monitoring system in every home, moving our health system to a population health management footing.

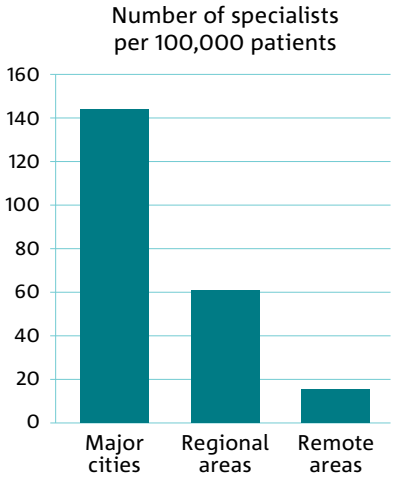
A self-monitoring, telehealth-based service delivery system will also create a vast and extensible de-identified data resource, containing national patient trends that could transform how the health sector develops new methods of disease prevention and cure (see over).



Telepresence
treatment and training

WHAT'S NEW: The Federal Government's Medicare Telehealth rebate offers financial incentives to support a range of health professionals conducting video consultations with their patients. The eligibility of this rebate is determined based on patients' and health professionals' location being outside of major cities.

CSIRO's Remote-I project focuses on the provision of ophthalmology assessments to regional Australia. Currently in trial phases, Remote-I platform includes a telemedicine 'dashboard' system that records and archives an eye examination, allowing specialists and experts to review and analyse the entire session remotely.



WHAT'S NEXT: Video-streaming consultations will become the norm for regional and remote consultations, reducing the need for specialist fly-ins that can cost in the thousands per visit. Telehealth will also substantially reduce the "health divide" between Indigenous communities and the rest of Australia, which is in large part caused by a lack of access to healthcare resources for otherwise preventable diseases.

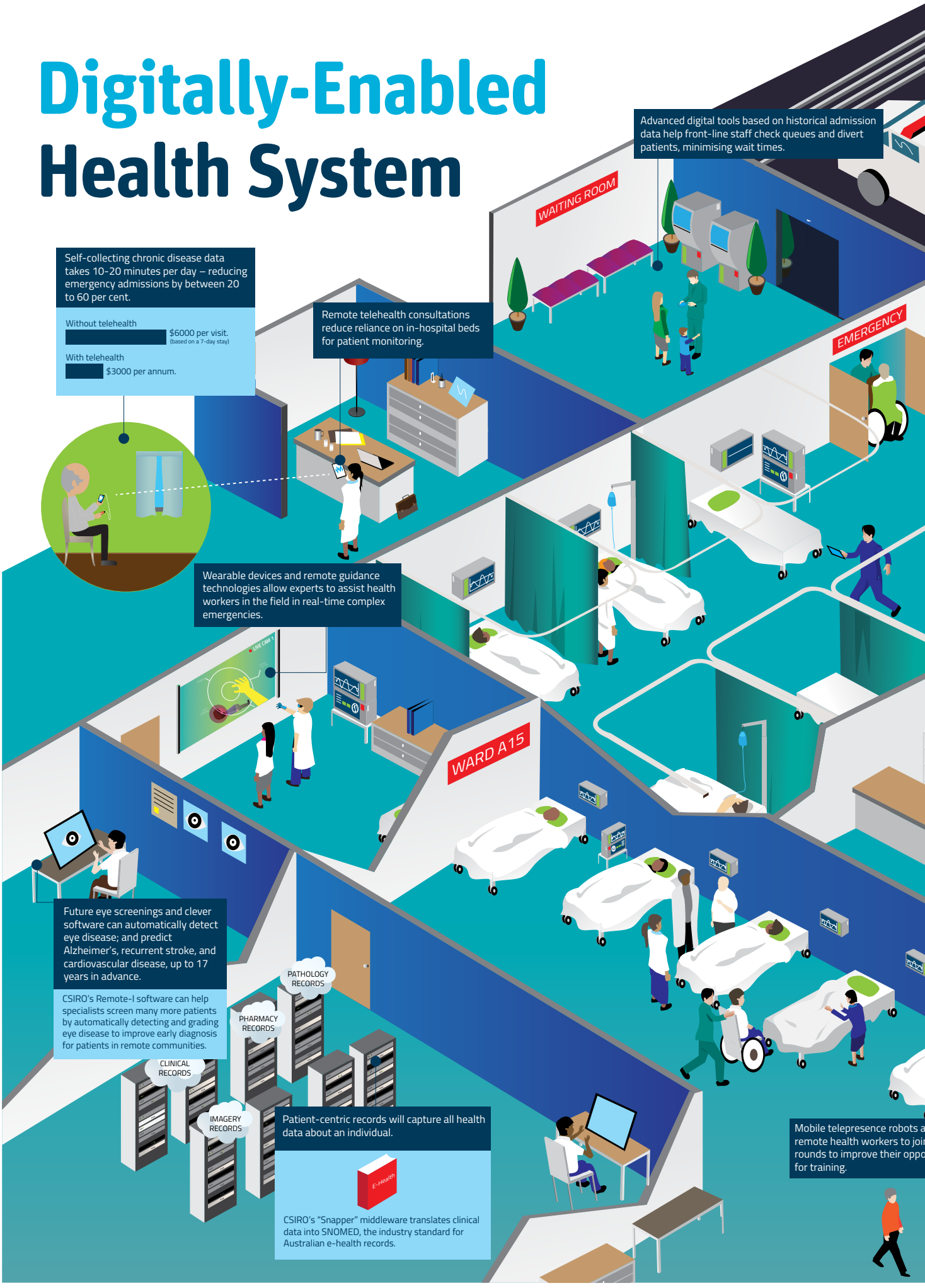
Eventually, digitally-enabled remote health clinics, connected via superfast broadband, will provide for the most part, equivalent comprehensive diagnostic and treatment options to remote communities as experienced in major cities. Specialists and clinicians will assist remote health workers in treatment using increasingly intuitive telepresence robots, and unobtrusive wearable computer systems, allowing each clinic to meet the majority of health needs of their communities without putting pressure on relatively low numbers of staff.

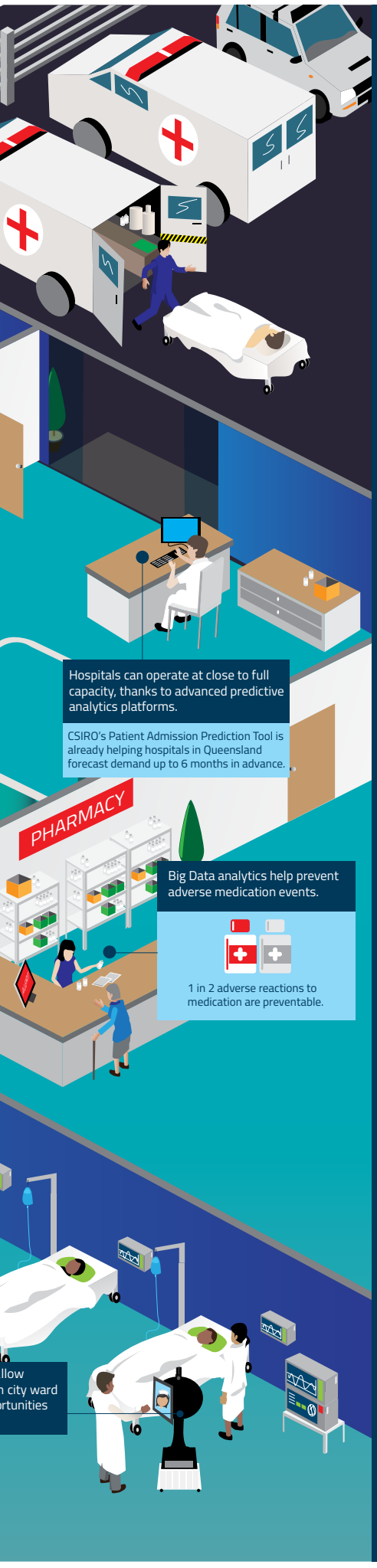
CSIRO is currently exploring the use of wearable devices that allow remote experts to direct a health worker's movements based on the specialist's gestures, as well as two way immersive audio and video, to deliver more effective training and real-time advice to remote healthcare providers. We are also working on real-time haptic feedback for clinical training and remote case review, which could dramatically impact the quality and availability of endoscopy, ultrasound, physiotherapy, and other health services that cannot be easily translated by images or audiovisual consultations (Huang *et al* 2011).

In a similar vein, telepresence robots will help train and support staff in remote areas of Australia: CSIRO's Mobile Telepresence Robots, for example, could enable far greater professional development opportunities for remote clinicians than are currently available, allowing them to participate in ward rounds in major hospitals via a high-speed broadband connection.



Digitally-Enabled Health System





Hospitals can operate at close to full capacity, thanks to advanced predictive analytics platforms.

CSIRO's Patient Admission Prediction Tool is already helping hospitals in Queensland forecast demand up to 6 months in advance.

Big Data analytics help prevent adverse medication events.

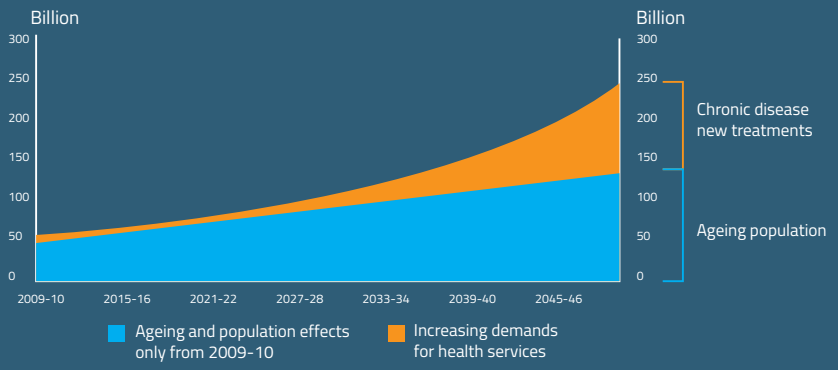
1 in 2 adverse reactions to medication are preventable.

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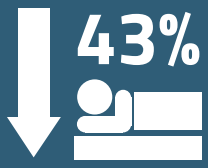
REFERENCE: Department of Health 2010. A National Health and Hospitals Network for Australia's Future. Page 51.

Rising health costs



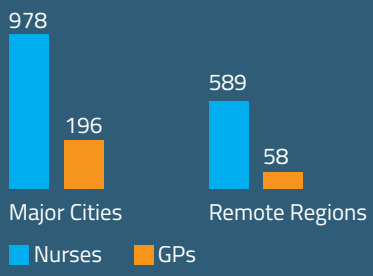
Ageing population

The "bed ratio" (the number of available hospital beds for every 1,000 population) in public hospitals for people aged 65+ has declined by almost 43 per cent over the last 20 years .



REFERENCE: AMA 2014. Public Hospital Rate Card 2014. Page 4.

Fewer health workers in remote areas



Health professionals per 100 000 residents.

REFERENCE: Department of Health and Ageing 2012. National Strategic Framework for Rural and Remote Health. Page 9.

What's Next?



Monitoring and rehabilitation services at home



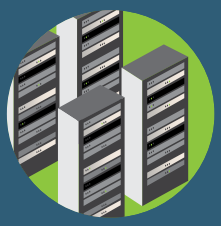
Patient admission and discharge forecasting improves bed usage.



Systems automatically pre-empt adverse drug reactions.



Remote guiding of health workers using telepresence



Patient-centric records that help health workers collaborate better



Mobile telepresence robots for remote ward rounds and training

Diagnosis from a distance

WHAT'S NEW: CSIRO has shown that eye screenings can detect the onset of diseases such as diabetes, Alzheimer's, and recurrent stroke, up to 17 years in advance of other symptoms (Frost *et al* 2010). However, the current process, still in the lab, would typically require health workers to both scan and manually analyse the resulting images of the eye – a time-consuming and resource-intensive process. A new diabetic retinopathy system is under development, to provide clinical decision support and prioritise patients to see a specialist according to the severity and urgency of their case.

WHAT'S NEXT: Future digital diagnostic systems will use simple, non-invasive screenings to allow clinicians to diagnose multiple chronic diseases from simple, non-invasive screenings. CSIRO's diabetic retinopathy system is being designed to eventually screen a far broader range of chronic diseases, including those like macular degeneration where the



> **The next generation of diagnostic platforms will be fast enough that patients can be referred at the time of screening.**

effectiveness of treatment depends largely on the speed of diagnosis.

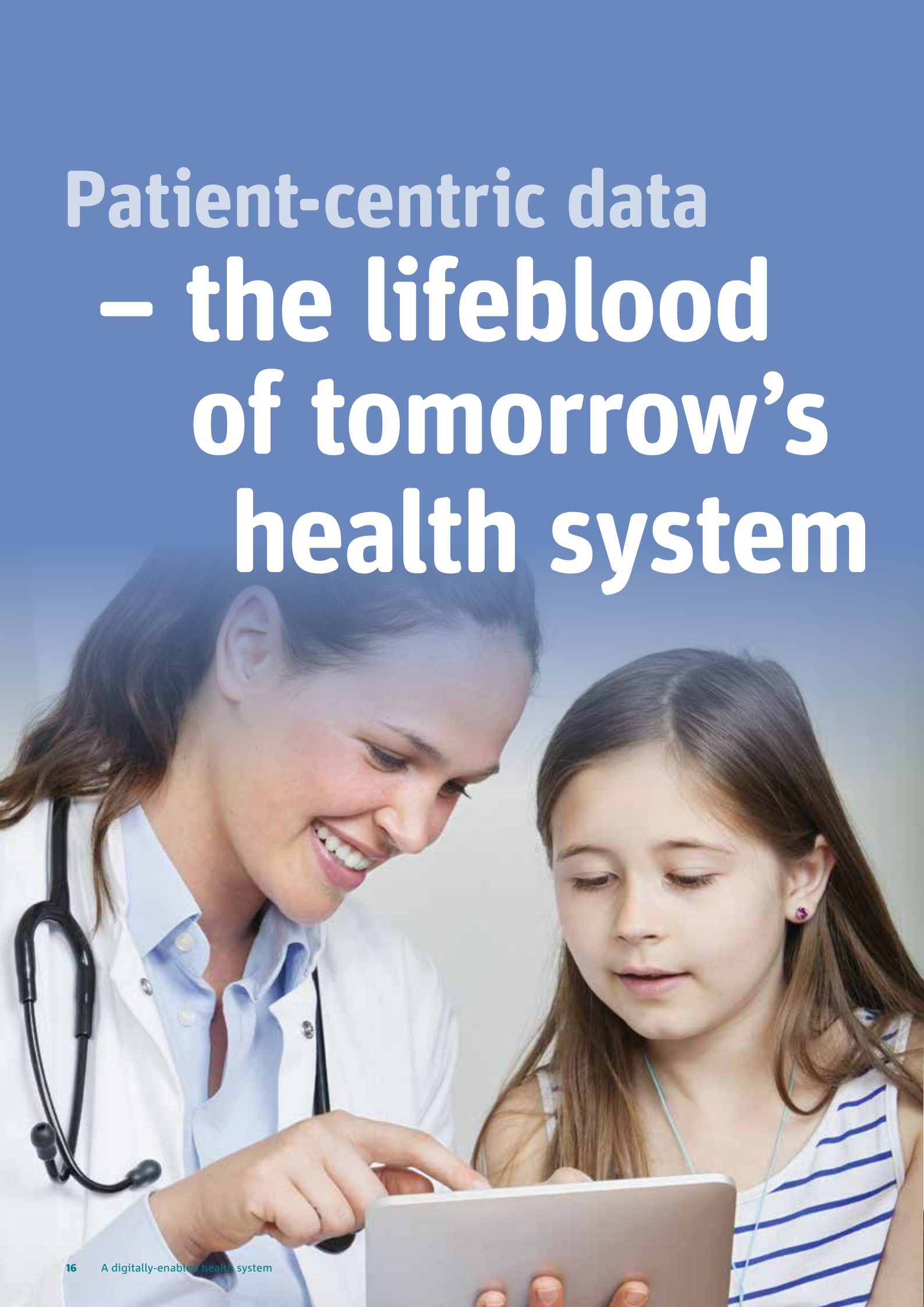
Currently, specialist referrals are by letter, and urgency is indicated by each referring doctor. In the future, referrals to specialists will be digital and include the screening images and outcomes. This will enable each new case to be compared with the existing waiting list; and to be prioritised using an objective, evidence based comparison on patient needs.

The next generation of diagnostic platforms will be fast enough that patients can be referred at the time of screening. Some diagnostic tools may operate on a standard smartphone, allowing almost any health worker to conduct screenings on the fly and in remote areas where access to traditional infrastructure may be limited. By reducing the waiting time between diagnosis and treatment, chronic disease patients will be at less risk of their conditions deteriorating in what can often be an irreversible manner, both improving their quality-of-life outcomes and mitigating the future burden of acute incidents on hospitals and clinicians.



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Patient-centric data – the lifeblood of tomorrow's health system



Bill of Health:

Patient data and medications management

- In 2010, around 65 per cent of GPs used electronic records exclusively, 85 per cent produced prescriptions electronically, and 72 per cent received pathology results online (Britt et al 2010).
- Adverse medication reactions account for about 3 per cent of all hospital admissions, around 50 per cent of which are preventable (Runciman et al 2003).
- Medication-related hospital admissions cost around $660m nationally each year (Roughead & Semple 2009). At least one in six patients may have clinically significant discrepancies in medication records when transferred within a hospital (Duguid 2012).
- Around half of hospital medication errors occur on admission, transfer and discharge of the patient, of which 30 per cent have the potential to cause harm (Duguid 2012).







Once all patient information moves off paper and is digitised, health professionals will be able to analyse and draw insights with unprecedented breadth and depth. Rigorous analysis of data will determine the competitiveness of Australian healthcare in a global economy for patients and their revenues.

At present, however, patient data is fragmented, staying within each health service provider. This has ongoing implications for all elements of the healthcare sector, where high-quality and highly accessible data is a necessary (yet often overlooked) precursor to optimal quality of service. Clinicians use data to guide their diagnoses and avoid potentially-harmful decisions, including the prescription of medications that may interact adversely. Health agencies look to compare the efficacy of alternative treatment paths, and to understand the causes of different outcomes. Researchers tap into broader data sets to identify and analyse population-wide trends, or inform the development of promising new treatments. Organising patient data according to consistent and meaningful criteria will deliver sizable advantages to all of these.

Australia's national Personally Controlled Electronic Health Record (PCEHR) system, launched in 2012, provides a basic platform for storing and sharing patient-centric data. The next generation of advances will focus on consistent access and seamless connectivity between different departments, divisions, and organisations in the healthcare system, improving the quality of collaborative decisions and helping ensure ongoing innovation in Australia's healthcare sector.

Much data, one language

WHAT'S NEW: SNOMED CT has been developed as an international standard for clinical terminology, enabling the digital capture, analysis and sharing of clinical health concepts across different record systems, and has been selected by NEHTA for use in the PCEHR. CSIRO has developed a suite of software tools that function as middleware to translate clinical terminology in different health software into SNOMED terms, helping ensure the integrity and interoperability of patient data no matter its source.

WHAT'S NEXT: Future iterations of the PCEHR will rely on common terminology standards to consolidate historical health data about each individual, capturing information from a range of systems and sources including smartphones and telehealth applications. Clinicians and other health workers will have access to each patient's central record at every presentation, allowing them to personalise, track, and coordinate their efforts with far more visibility than ever before. Patient-centric records will be particularly critical to the acute care sector, where comprehensive evidence-based decisions are required to make urgent choices on how to treat a patient without inadvertently causing harm.



More accurate medications management

WHAT'S NEW: Emerging medication management systems can already analyse the active ingredients in each potential treatment drug against all current diagnoses for a patient. Such systems then flag adverse medication interactions that may result from each treatment option, helping clinicians lower the incidence of "adverse medical events" (which occur when a prescribed medication interacts harmfully with one that's been previously administered). The final outcome can then be captured and stored as part of sector-wide data logs, helping improve the efficacy of future analysis and treatments.

WHAT'S NEXT: The impact of analysing patient-centric data is not limited to reducing adverse medical events. Radiology and pathology reports will also be automatically reconciled with records of treatment, highlighting any incidences that fall outside standard procedures. Future analytics systems will use the same principles to assist clinicians in matching up seemingly-disparate symptoms which occur over time, in order to deliver more accurate diagnoses for chronic conditions like diabetes. This broader overview of a patient's medical state, spanning multiple healthcare providers and the individual's entire lifespan, will positively impact the fundamental principles of how clinicians diagnose and treat each individual.



Data privacy protection

WHAT'S NEW: CSIRO research has developed privacy and confidentiality standards that allow approved researchers to securely access individual health information. These standards enable researchers to analyse data for large-population studies through the Population Health Research Network, while "blinding" or separating out personal identifiers like name and address (O'Keefe *et al* 2005). These standards support research studies of unprecedented scale, while adhering to the basic tenets of patient privacy.

WHAT'S NEXT: A nation-wide database of patient information will offer researchers new kinds of opportunities to develop population scale rigorous analyses of national health trends, particularly the spread of contagious or chronic diseases; and chart the correlations between disease incidence, treatments, and cure rates over far more socio-economic indicators than ever before. On an individual scale, analysis of genetic traits and lifestyle information will allow clinicians to personalise treatments that account for the patient's unique scenario and preferences, including whether to deliver care over a smart phone or a surgery visit (Hansen *et al* 2011).

Future versions of tools like CSIRO's Health Data Integration (HDI) tool, which draws together and securitises patient records from disparate data sets, will enable improved reporting and correlation of health trends. Other platforms will enable real-time analysis and prediction of population health phenomena, including the spread of contagious disease outbreaks and the identification of chronic disease clusters. These insights will improve on, and result in new, treatments as our population varies in size and composition over time. They will also directly inform day-to-day responses and strategies – such as in the event of an epidemic – that sustain the health and wellbeing of all Australians.



A day in the future health system

It's mid-morning, February 2020, and it's already hot outside the hospital emergency department, where staff gear up for a busy day. Increased average temperatures have led to rising dehydration and heat-stroke incidents in our ageing population.

Staff are also prepared for a large state-wide annual athletics carnival being held at a nearby recreational reserve. From patient admission modelling, emergency staff are expecting seven extra incidences of sprains and broken bones to come into emergency during the day, one of which will require admission. The hospital's Patient Flow tools have helped it predict the additional emergency admissions and devise a plan well ahead of time.

Through automated rostering, staff numbers are distributed across the hospital effectively. Two triage nurses are shift-sharing, and an orthopaedic surgeon with an hour to spare in another state will staff the ED telehealth consultation line to provide additional support to the in-house registrar.

An ambulance arrives with 13-year-old Lee, whose arm has been broken after a fall. Lee is the third of twelve broken limbs expected this morning. En-route the ambulance officer has accessed Lee's e-health records, delivered a quick injection of painkiller (his history automatically checked before the right dose is prepared), and used a mobile x-ray unit to scan the boy's arm. All this information is transmitted as a medical summary to the ER after checking which of three possible hospitals had the shortest queue.

As Lee arrives, his mother accompanying him, the triage nurse checks the information to date on his portable screen. The nurse cross-links a pre-printed radio-ID tag to Lee's medical recorded, and then clips it to Lee's wrist; the tag starts recording Lee's heart-rate, blood pressure and temperature. The image from the ambulance has been assessed in advance, and an orderly is waiting to whisk Lee and his mother through to radiology for a detailed image of the injury.

After Lee's arm is scanned, the decision support system analyses the image, highlights the areas that show the serious nature of the break and provides input to help the radiologist quickly generate the radiology report. The system also triages the case to an orthopaedic surgeon; the first available is across the other side of the hospital. Within minutes the surgeon's face appears on a nearby screen and he briefs a registrar in the ED on the less-than-fortunate news: surgery is necessary to pin the bones into place.

The registrar delivers the news to Lee and his mother in person. The hospital's patient flow system had already predicted that a bed would be needed for someone like Lee. The registrar consults the system to find a bed, and sees that several patients are currently being discharged – one in a suitable ward. An orderly is summoned and within half an hour, Lee is admitted, waiting to see the surgeon. Meanwhile, the clinical flow system has processed the diagnosis and determined that Lee is most likely to be ready for discharge by noon the following day.

The break is painful and Lee is administered painkillers and monitored overnight. A nurse regularly checks in on Lee's status, while his digitally recorded vital signs are monitored in real time to check for worrying trends.

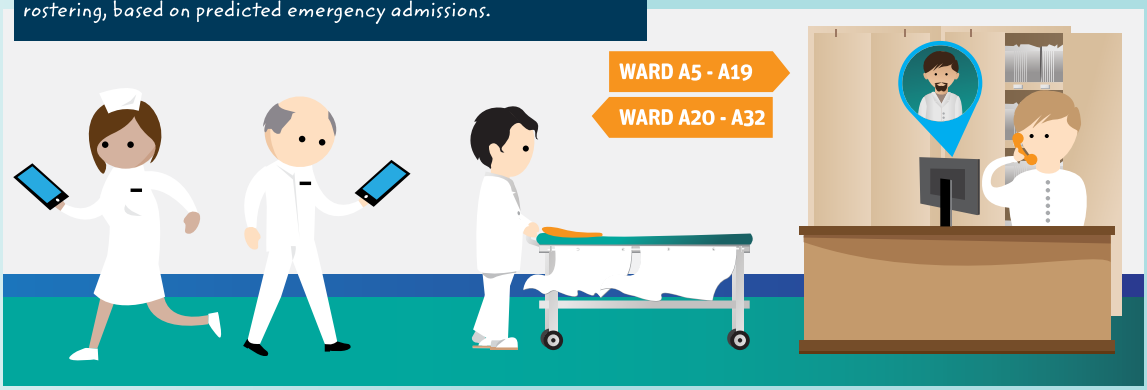
Surgery is scheduled for first thing and by noon, Lee is ready to leave – just as predicted by the clinical flow system the day before. The orthopaedic surgeon has a chat with Lee and his mother via telepresence about Lee's plans to play sport in future, and to answer any more technical questions.

Lee is discharged at noon, arm in a cast and sling. His GP has received a discharge summary, and a follow-up appointment has been scheduled via video conference for within 24 hours to check on Lee's progress. An appointment has also been scheduled for Lee to return to hospital to have his cast removed, and with a local physiotherapist to commence visits.

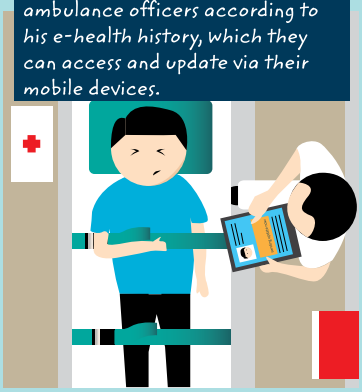
Lee's physiotherapist provides the boy with a smartphone app, which offers video demonstrations and progress tracking of how Lee performs with his rehabilitation exercises. The App is multilingual so Lee's family can also understand and support his rehabilitation. Some of Lee's follow up visits with his physio are via phone or video call to check on progress. His patient records, updated along the way, become part of the national dataset, accessed by researchers looking into a variety of fields from sports injury to medication management to assess alternative treatment pathways and patient responses.

A day in the future health system

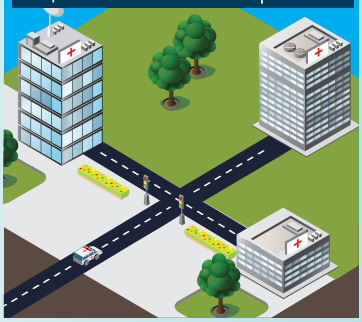
Before the sun rises, staff take up their stations based on automated rostering, based on predicted emergency admissions.



Lee's broken arm is being treated by ambulance officers according to his e-health history, which they can access and update via their mobile devices.



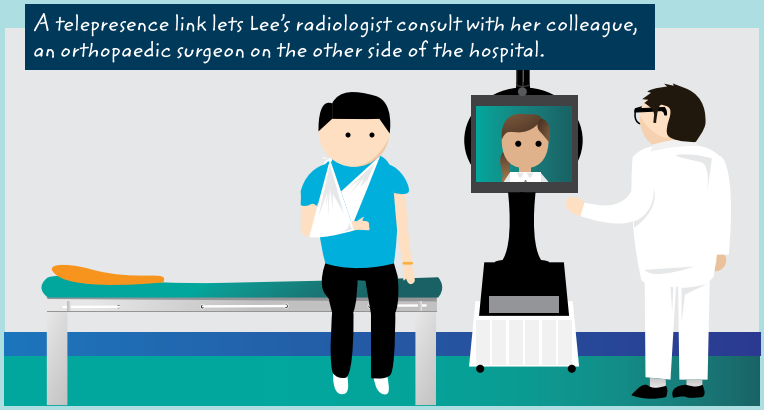
Lee's ambulance crew check admissions data, and pick the local hospital with the shortest queue.



The radio ID tag waiting for Lee at the hospital will record his heart-rate, blood pressure, temperature as well as his ID.



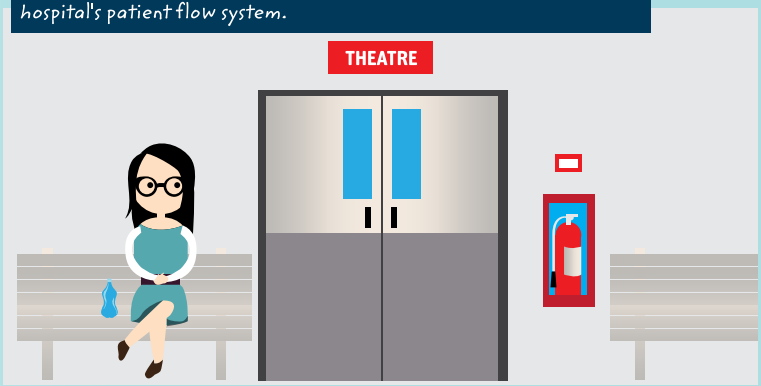
A telepresence link lets Lee's radiologist consult with her colleague, an orthopaedic surgeon on the other side of the hospital.



The break is serious, but Lee's overnight stay in hospital is helped by robot aides and regular nurse check-ins.



After surgery, Lee is ready to be discharged - just as predicted by the hospital's patient flow system.



Lee and his mother are presented with several options that take into account his current sporting ambitions and lifestyle pattern.



The hospital's data management platform has already added Lee's X-ray to his e-health file, and will also help researchers improve treatments for sports injuries in the future.



A smartphone app 'coaches' Lee so he can go through rehabilitation at home. The only time he'll have to visit the hospital is to have his cast off and to say "thanks!" to his friends.



Conclusion

Each generation of Australians rightly expects better quality of healthcare than the last. Our health system has consistently delivered these advances over the past decades: diagnoses become more accurate, prevention mechanisms more timely, treatments more effective yet less invasive.

Australia's health sector has a responsibility to itself, and future generations of Australians, to continue this upward trend in quality-of-life and economic wellbeing that healthcare advances bring.

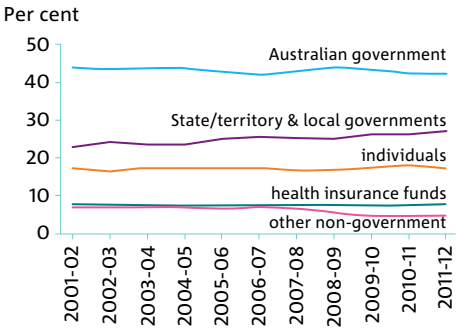
We can only do so if we recognise, and address well ahead of time, the economic limitations that are fast approaching for Australian healthcare. This can only be done by increasing funding into the system, or by improving what is achieved with current levels of funding and resourcing. Of the two the latter is the more sustainable, but also more complex to achieve.

A digital healthcare system offers us promising new ways through which to do more with what we currently have. The health profession's move from paper to electronic, digitised records is only one part of a broader trend towards generation of massive quantities of operational data – all of which can be analysed to produce unprecedented insights into how the health system works. Once we truly understand the way in which patients and health workers actually use the health system, with the ability to track how this changes over time, we can identify how best to go about improving it.

Digital data plays a key role in almost every innovation outlined in this report. Big Data and predictive analytics are helping hospitals move from reactive to proactive planning models that promise to minimise wait times, improve bed availability, and forecast likely discharge times – all of which make for a far less stressful experience for patients and staff alike. Telehealth care relies on the ability to collect and share complex health data in a simple and cost-effective way, whether that be through patient self-monitoring or collaboration between health practitioners who are thousands of kilometres apart. To enhance our understanding of Australia's overall health patterns and trends – in order to prevent and treat them better – researchers will require secure access to standardised data sets from patients across the nation.

Australia is rightfully proud of our record of medical research achievements. There is enormous potential for Big Data, analytics, and decision support systems to help continue this record. Finding cures for diseases has long been the focus of the healthcare profession. Finding new ways to deliver higher-quality care, at an affordable national cost, needs to be one too.

Who's funding the health system?



Total health expenditure, by source of funds as a proportion of total health expenditure, 2001-02 to 2011-12.

Citation: AIHW 2013: 32.



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