Australian e-Health Research Centre

The Australian e-Health Research Centre

Annual Report 2023–2024

Traditional Owners Statement

CSIRO acknowledges the Traditional Owners of the lands, seas and waters, of the area that we live and work across Australia. We acknowledge their continuing connection to their culture and pay our respects to their Elders past and present.

CSIRO is honoured to partner and collaborate with Aboriginal and Torres Strait Islander communities across the nation and we acknowledge the contributions of all Aboriginal and Torres Strait Islander people, staff and partners towards our vision for reconciliation.

Important disclaimer

Abbreviations

ABI:	Acquired brain injury
AD:	Alzheimer's disease
ADHA:	Australian Digital Health Agency
AEHRC:	Australian e-Health Research Centre
AI	Artificial intelligence
CAD:	Coronary artery disease
CAPS:	Care assessment and support program for people after stroke or transient ischaemic attack
CSIRO:	Commonwealth Scientific and Industrial Research Organisation
CP:	Cerebral palsy
DoHAC:	Department of Aged Care and Health
ED:	Emergency department
GDM:	Gestational diabetes mellitus
LLM:	Large language models
ML:	Machine learning
NDIA:	National Disability Insurance Agency
NDIS:	National Disability Insurance Scheme
QMS:	Quality management system
SaMD:	Software as a medical device
UQ:	The University of Queensland

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The Australian e-Health Research Centre

The Australian e-Health Research Centre (AEHRC) is the largest digital health research program in Australia with over 150 scientists and engineers and a further 50 higher degree research students.

As CSIRO's national digital health research program, AEHRC has offices across Brisbane, Sydney, Melbourne, Canberra, Adelaide and Perth. AEHRC is world-wide unique in covering the full value chain in health care, from basic science all the way to delivering technology and services into the healthcare system.

Established in 2003 with initial funding from the Queensland Department of State Development and CSIRO, the partnership was extended in 2007 for a further five years with funding from CSIRO, Queensland Health and the Department of Employment, Economic Development and Innovation. In 2012 the partnership was extended for a further five years with an additional contribution of $15 million from CSIRO and Queensland Health, supplemented by in-kind contributions from the partners, as well as funding from grants, research consulting and commercialisation. The partnership was extended in 2017 and again in 2022 for an additional five years with a further contribution of $15 million from CSIRO and Queensland Health.

AEHRC is a full health and biomedical informatics research program, undertaking:

- applied research in biomedical informatics, including genomics and medical imaging
- health informatics, including clinical informatics and data interoperability
- health services research, including mobile health, tele-health and sensing technologies.

With additional investment from CSIRO and funding from state health departments and federal health agencies, the AEHRC supports the digital transformation of healthcare around Australia. Through its research program, the AEHRC develops and deploys leading edge information and communication technology innovations in healthcare to:

- improve service delivery in the Queensland and Australian health systems
- generate commercialisation revenue
- increase the pool of world-class e-health expertise in Australia.

The current AEHRC strategy engages the research capability of our five research groups – Health Data Semantics and Interoperability, Health System Analytics, Biomedical Informatics, Transformational Bioinformatics; and Digital Therapeutics and Care – to continue to tackle Australia's healthcare system challenges and expand the impact of our research. The challenges set out in this strategy are to:

- transform health with data and artificial intelligence
- transform healthcare delivery with virtual care
- enable efficiencies in healthcare systems
- innovate and develop digital technologies for precision healthcare

Our research program is informed through strong partnerships with the health industry, including clinicians, researchers, health service executives and the health IT vendor community.

Over half our staff are located in the STARS Hospital on the Herston Health Precinct in Brisbane, while in Sydney we have moved onto the Westmead Health Precinct. In Melbourne we are located at Parkville and in Perth we are located on the Kensington CSIRO site. Our locations enable us to develop strong relationships with the state-based health departments, clinicians and academics.

AEHRC continues to deliver to national programs, with key projects with the Department of Health and the Australian Digital Health Agency. As CSIRO's digital health research program, the centre works with scientists from across CSIRO, contributing to projects with the Human Health and Biosecurity programs in CSIRO Health and Biosecurity and with teams across CSIRO.

Foreword by the Chair and CEO

The past 12 months has seen AEHRC continue to increase our scientific and health service impact – delivering on a wide variety of projects with our partners and collaborators across the healthcare system. The scientists, engineers and other specialists who make up team AEHRC have shown enormous energy and commitment to ensure we have delivered on our projects.

The emergence of generative AI technologies available to the public is starting to have a significant impact in healthcare as clinicians and health services seek to use these technologies to improve healthcare delivery. This is generating opportunity for the uptake of more traditional ML technologies. As reported in previous annual reports, AEHRC uses AI technologies across our research and is well placed to contribute to the increase in AI technologies for healthcare in Australia. Indeed, over the last 12 months we have seen some of our AI based imaging technologies incorporated into Siemens MRI machine technology, while our "image to report" technology for chest X-rays continues to win international competitions and be recognised as world leading in significant reports. Meanwhile in Queensland our natural language processing technology is helping radiologists to meet new cancer reporting requirements from radiology reports.

The AEHRC has recently met a critical milestone with our quality management system (QMS) passing an audit, enabling us to be certified as meeting requirements under the ISO13485 Software as a Medical Device (SaMD) regulation. This has been a crucial piece of work over the past three years. While not all our software will need to meet this regulation, we now have the option, when needed, to ensure that our software meets the regulation ensuring clinicians can use it directly in patient care.

This year we've also delivered two national interoperability programs. The Sparked FHIR Accelerator, which got underway only in August 2023 after funding was announced in the May 2023 budget, has started with a "bang" – with close to 1000 people being involved in the workshops, design groups and connectathons that are a key component of the program. The first outputs – the Australian Core Dataset for Interoperability (AUCDI) and its associated FHIR implementation guide – are now being finalised and government and industry are planning the use of these to support national programs underway. CSIRO is working with the Commonwealth Department of Health and Aged Care, the Australian Digital Health Agency and HL7 Australia in the delivery of Sparked.

The operation of the National Clinical Terminology Service for the Australian Digital Health Agency has also been firing on all cylinders. The team has been working with industry and the Agency on the new model of the Australian Medicines Terminology – which will be released in September of this year. The team has done an amazing job in ensuring the ongoing high quality monthly releases of SNOMED CT – AU, along with moving to the SNOMED International managed service for authoring AMT and SNOMED-CT Au.

Our work with the National Disability Insurance Agency on a roadmap for implementation of AI-enabled assistive technology for disability, informed the budget announcement of the establishment of a new committee to support assistive technologies for the NDIS. This is a pivotal opportunity for appropriate technology to underpin disability support in the future.

Our teams continue to contribute to many national and international studies. The national Australian Dementia Network has received additional funding to continue while we are partnering with QIMR Berghofer, University of Queensland and Queensland Health to establish a Queensland Ageing and Dementia Study cohort. Already we have received NHMRC funding which will use this Queensland cohort for Alzheimer's disease study.

We've also partnered with the Emergency Medicine Foundation and the University of Queensland to undertake a comprehensive state-wide study of patient flow. This work was recently highlighted at the Queensland Clinical Senate with recommendations now being considered by Queensland Health.

The past 12 months has seen AEHRC scientists being part of 12 new NHRMC and MRFF grants which received funding. We are always a key partner in these grants, often providing vital technology to support trials and studies of new digital solutions for difficult medical, clinical, and health service challenges.

Our work in Indigenous health continues to flourish with new partnerships getting underway in areas such as rhematic heart disease.

Within CSIRO, AEHRC has worked with a wide variety of areas to contribute to the science across the organisation. Replace with: Within CSIRO, AEHRC has worked with a wide variety of areas to contribute to the science across the organisation. For example, we are currently working with the Australian Centre for Disease Preparedness to help transition their data and technologies to use international standards. The ACDP is starting to adopt FHIR as well as SNOVet, the veterinary extension to SNOMED-CT – the start of a real onehealth data ecosystem for Australia.

The AEHRC continues to publish impactful journal and conference publications – with a full list of our publications included at the end of this report.

This 2023-24 AEHRC Annual Report provides an overview of our research – including our research groups, platform technologies, project reports and project updates. The report this year highlights many of our successes and ongoing projects – demonstrating our ongoing central role in Australia's transition to a digitally enabled healthcare system.

Richard Royle
Chair
The AEHRC

David Hansen
Chief Executive Officer
The AEHRC

Board of Directors

Richard Royle

AEHRC Chair

Richard has over 30 years of senior executive experience in the public, for profit and not for profit private hospital sectors in Australia and is the immediate past President of the Australian Private Hospitals Association.

Richard oversaw the successful implementation of Australia's first fully integrated digital hospital in Hervey Bay as the group CEO of UnitingCare Health in 2014. In 2016, he was asked to be the startup CEO of the newly established Australian Digital Health Agency – putting into practice one of his recommendations from a landmark review he was asked to lead in 2013 for the Federal Government on digital health in Australia.

Damian Green

Damian is currently acting Deputy Director-General, Corporate Services Division in Queensland Health. Corporate Services Division works across the Department of Health and Queensland's Hospital and Health Services to provide contemporary expert advice and specialist corporate and operational support services. The Division delivers a range of services across the health system including business services, human resources, corporate enterprise solutions, finance, governance, assurance and information management and system procurement.

Damian is substantively appointed in the role of Deputy Director-General, eHealth Queensland. In this role, he has led Queensland's public health digital modernisation agenda, including Queensland's ICT response to the COVID-19 pandemic, virtual healthcare, digital hospitals and digital rural and remote services.

Damian has previously held the role of Executive Director, Digital Transformation & Chief Information Officer, Gold Coast Hospital and Health Service where he led the delivery of Gold Coast Health's two-year journey to become a fully digital hospital and was pivotal in driving continuous improvement in health service delivery and quality.

Kirsten Rose

2022 to 2024

Kirsten is Deputy Chief Executive of CSIRO and is a respected leader in technology and innovation, with a career spanning 30 years in the US, UK and Australia. Prior to joining CSIRO, she was Head of Innovation, Sustainable Operations at BHP, where she had global responsibility for bringing together innovation and technology to drive material improvements in key sustainability-related challenges.

Her previous positions include Director of the Founder Institute, an entrepreneur training and start-up launch program, State Manager for the Australian Institute of Company Directors and CEO of the Sustainable Energy Association of Australia.

Kirsten actively supports the innovation ecosystem through non-executive director and advisory board roles, as well as mentoring, and enjoys helping entrepreneurs commercialise their ideas.

Tanya Kelly

From February 2023

Dr Tanya Kelly is the Acting Chief Clinical Information Officer and Acting Executive Director, Digital Health Branch, eHealth Queensland. She has an active role in clinical leadership and clinical strategic direction for digital health across the state-wide eHealth program.

Dr Kelly is also Chair of the Queensland Clinical Senate, a body that provides strategic advice to the Queensland public health system. She is an experienced and active senior clinician (anaesthetist) who has held clinical leadership roles for the past 10 years, most recently as Director of Anaesthesia and Perioperative Medicine and Clinical Director for Digital Transformation within the Sunshine Coast Hospital and Health Service. Beyond her clinical practice, she has qualifications in clinical redesign, business and is a Certified Health Informatician (CHIA).

Dr Kelly is keen to ensure that digitally enabled healthcare in Queensland is safe, highly effective and maximises the opportunities associated with digital technology, to provide a responsive healthcare system that meets the needs of consumers.

Professor Brett Sutton

From December 2023

Professor Brett Sutton is Director of Health & Biosecurity at CSIRO, Australia's national science agency.

He is a qualified public health physician, with extensive experience and clinical expertise in public health and communicable diseases, gained through experience in government, emergency medicine and field-based international work.

Prior to CSIRO, he held the role of Victoria's Chief Health Officer together with the role of Victoria's Chief Human Biosecurity Officer. In this role, Professor Sutton played a leading role in guiding the public health response to COVID-19 in Victoria, including as statutory decision-maker and departmental spokesperson.

Professor Sutton is a Fellow of the Royal Society for Public Health, a Fellow of the Australasian College of Tropical Medicine, and a Fellow of the Australasian Faculty of Public Health Medicine (AFPHM). He is also a member of the Faculty of Travel Medicine.

Lynne Cobiac

From August 2022

Lynne Cobiac is currently the Director (Acting) of CSIRO Health and Biosecurity business unit, having been Deputy Director for 6 years and a member of CSIRO's Science Council. She has over 30 years' experience and leadership in research and management in the health sector within both research organisation and university environments. Lynne established CSIRO's Precision Health Future Science Platform in 2018 between CSIRO and research and delivery partners, which then developed CSIRO's Future of Health report. She also was the Principal Investigator in establishing the Australian Health Biobank on behalf of the Department of Health and Aged Care. Lynne is currently a Board Member for the Melbourne Genomics Health Alliance, the Australian e-Health Research Centre, and the International Life Sciences Institute (SEAR).

Richard Symons

Minutes Secretary

Robert Miotti

Finance Manager, CSIRO

Allan Caldwell

Finance Manager, CSIRO

Meetings

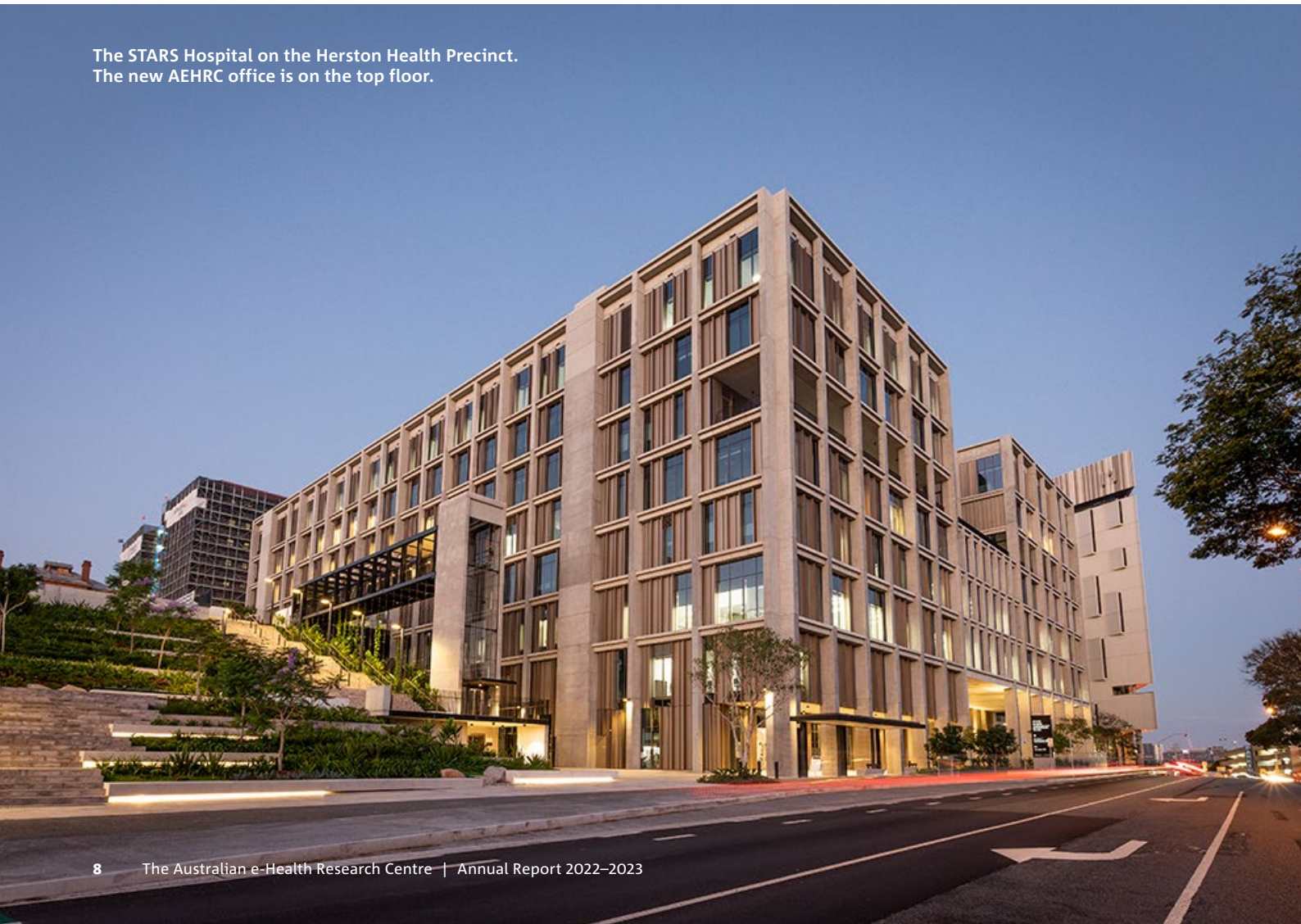
6th September 2023 | 4th December 2023 | 21st March 2024 | 27th May 2024

AEHRC around Australia

Since its formation in 2003, AEHRChas established a central role in the Australian digital health ecosystem. We continue to work closely with Queensland Health and hospital services, but our national remit means we work around Australia and internationally. Nationally we continue to work with several state and federal health agencies - including the Commonwealth Department of Health and the Australian Digital Health Agency.

Over the past 12 months CSIRO has supported our moves into new offices around Australia. In Brisbane the team have settled in well to our offices on the 7th floor of the new STARS Hospital at the Herston Health Precinct; our Melbourne and Perth staff have moved into refurbished offices in Parkville and Kensington respectively; and recently our Sydney staff enjoyed a relocation to new offices in the Westmead Innovation Precinct.

The STARS Hospital on the Herston Health Precinct. The new AEHRC office is on the top floor.



Queensland

Our AEHRC headquarters is in the new STARS Hospital on the Herston Health Precinct. We collaborate broadly across Queensland Health - including with eHealth Queensland and Clinical Excellence Queensland, as well as clinicians and hospitals in Hospital and Health Services including Metro North, Metro South, Gold Coast, Townsville, North West and Children's Health Queensland. We also collaborate with many universities - including University of Queensland, Queensland University of Technology, James Cook University, Griffith University and Sunshine Coast University.

All our research groups work with Queensland collaborators and they are acknowledged throughout this report.

New South Wales

Our NSW staff are based at the Westmead Innovation Quarter as part of the home for CSIRO Health and Biosecurity in Sydney. Sydney-based staff bring expertise across the whole program - including staff from all our Research Groups based in Sydney.

We have a number of long term collaborators - especially with the Australian Institute for Health Innovation and the applied sciences group and Faculty of Medicine and Health Science at Macquarie University, the Children's Medical Research Institute (CMRI) at Westmead and the Ingham Institute at Liverpool Hospital.

Over the past 12 months we have increased our collaboration on the Westmead campus - with new collaborations with Westmead Hospital, NSW Pathology and eHealth NSW.

Our NSW engagement is led by our Team Leaders in Sydney - Lawrence Wilson, Sarah Kong and David Silvera.

Western Australia

Our Perth based staff are on the Kensington CSIRO campus.

As part of our Digital Therapeutics and Care group, our Perth based tele-health and AI research and development team address pressing and emerging areas of healthcare delivery, particularly in respect to the provision of quality services to rural and remote populations and to high-needs groups.

The team's project reports are in our Digital Therapeutics and Care group section where we detail our collaborations with Fiona Stanley and Royal Perth Hospitals, as well as the University of Western Australia. The team also works around Australia–including leading a project in Queensland with the Northern Australian CRC.

Perth is also home to team members from other groups where work with hospitals including Fiona Stanley and Bunbury on Health System Analytics group projects and our Biomedical Informatics group has several projects with collaborators including Alzheimer's Australia and Edith Cowan University.

Our WA Health engagement is led by our Team Leaders in Perth, Shaun Frost and Jana Vignarajan.

Victoria

Our Melbourne based staff moved into refurbished offices at the CSIRO Parkville site and are part of multiple different groups - including Health System Analytics, Biomedical Informatics and Health Data Semantics and Interoperability.

The AEHRC has a number of significant long-standing collaborations in Melbourne - including with the Florey Institute and Austin Health in the Australian Imaging Biomarker Lifestyle (AIBL) Study of Ageing. The AEHRC has been CSIRO's lead partner in the Melbourne Genomics Health Alliance (MGHA). AEHRC staff are embedded within the MGHA program and at Austin Health. We also engage with Victorian Clinical Genetics Services (VCGS), Murdoch Institute, Peter MacCallum Cancer Centre (PeterMac) and Walter and Elisa Hall Institute (WEHI).

Our Victorian Health engagement is led by our Health System Analytics Group Leader Rajiv Jayasena.

AEHRC leadership

Dr David Hansen

CEO and Research Director, Australian e-Health Research Centre

Dr David Hansen is CEO and Research Director of the Australian e-Health Research Centre. David leads the research program of over 160 scientists and engineers developing information and communication technologies to improve the safety, quality and efficiency of healthcare.

David is a member of the Australian Digital Health Agency Council for Connected Care and board member of the Australasian Institute of Digital Health (AIDH).

David is passionate about the role of information and communication technologies in health care and the role of digital health in developing a safe, efficient and sustainable healthcare system in Australia.

Dr Denis Bauer

Group Leader, Transformational Bioinformatics

Dr Denis Bauer leads the Transformational Bioinformatics group and is an internationally recognised expert in machine learning and cloud-based genomics. She is an Adjunct Professor at Macquarie University and an AWS Data Hero, determined to bridge the gap between academia and industry. Denis holds a Bachelor of Science from Germany, a PhD in Bioinformatics from the University of Queensland and graduated from the Australian Institute of Company Directors (GAICD) as well as holds a Certificate in Executive Management and Development from the University of New South Wales Business School.

Her research has led to the discovery of novel disease genes for motor neuron disease and has informed the COVID-19 vaccine development. She keynotes international 10,000-attendee IT, LifeScience and Medical conferences and has attracted more than $50M in funding to further health research and digital health. Denis develops open-source bioinformatics software that has commercial impact through cloud-deployment. She was also recognised as Brilliant Women in Digital Health 2021 and Women in AI 2022 and published a senior author paper in Nature Biotechnology in 2023.

Dr Michael Lawley

Group Leader, Health Data Semantics and Interoperability

Dr Michael Lawley leads the Health Data Semantics and Interoperability group with teams in health informatics and modelling, clinical terminology and interoperability, natural language processing and information retrieval, and software engineering. The group's focus is on improving healthcare delivery and outcomes through improvements in the quality and use of digital health data during collection, exchange, and analytics.

Michael has extensive expertise in clinical terminology, specifically large-scale ontologies such as SNOMED CT and is a leading contributor to HL7's FHIR Terminology Services standard. Work developed by Michael and his team has produced technologies that have been licensed nationally and internationally by standards bodies, government organisations and SMEs. In 2018, he received the SNOMED International Award for Excellence recognising his many contributions to the evolution of SNOMED CT.

Dr Jurgen Fripp

Group Leader, Biomedical Informatics

Dr Jurgen Fripp leads the Australian e-Health Research Centre's Biomedical Informatics group, with teams covering genomics, biostatistics, medical image analysis and clinical imaging. The group's focus is on using medical imaging biomarkers, machine learning and statistical techniques for precision health (prediction, staging, prevention and treatment), including when combined with various omics, neuropsychology, smart sensing and clinical phenotypes.

Dr Marlien Varnfield

Group Leader, Digital Therapeutics and Care (DTaC) Group

Dr Marlien Varnfield is a Principal Research Scientist and leads the Digital Therapeutics and Care group, overseeing innovative approaches to improve health outcomes for older people, people living with disability, and those with chronic health conditions.

Marlien holds a Master of Science (focusing on periodontal diseases) and her PhD research at the Department of Epidemiology & Preventive Medicine, Monash University, focused on evaluating the potential for large scale implementation of health-care interventions utilising Information and Communication Technologies. The impact of Marlien's research includes translation of health research into implementable, tangible outcomes. She was key driver behind the development of AEHRC's world leading mobile health research program including the world first validation of remote delivery of cardiac rehabilitation and development of the M♡THer platform for management of gestational diabetes, which has benefited >6000 women since June 2020.

Dr Rajiv Jayasena

Group Leader, Health System Analytics and Victorian Lead

Dr Rajiv Jayasena is the Group Leader for Health System Analytics and Victorian lead for the Australian e-Health Research Centre of CSIRO. Rajiv has an Honours degree in immunology from Monash University and a PhD in Medicine from The University of Melbourne on early detection methodologies for Alzheimer's disease. Rajiv has also completed a Graduate Diploma in Business from RMIT, Certification in Operational Excellence (Lean Six Sigma Black Belt) and Safety, Quality, Informatics and Leadership Certificate Program (SQIL) from Harvard Medical School, Boston. He has held academic positions at both Monash University and The University of Melbourne and currently an Honorary Fellow at Centre for Digital Transformation of Health at The University of Melbourne.

Rajiv has established many collaborations with state and federal governments, hospitals and industry, leading to multi-million-dollar projects for CSIRO and continues his research leading the Health System Analytics group focussed on utilising health data to drive efficiency, productivity and decision-making for hospitals, patients and communities for improving quality and safe patient care.

Dr Janet Fox

Business Development Manager

Dr Janet Fox is CSIRO's Digital Health Business Development Manager and is embedded within the Australian e-Health Research Centre, where she provides commercial advice and leadership to the team. Janet especially enjoys working at the interface of discovery, implementation and business strategy to translate digital health research technologies into sustainable commercial products, delivering impact both in Australia and overseas.

Annual e-Health Research Colloquium

Over 400 people were awed by artificial intelligence and fascinated by FHIR at the Australian e-Health Research Centre's annual eHealth Research Colloquium in March 2024.

For 20 years this annual event has brought together our digital health scientists with leading industry experts, clinicians and government to showcase what's in store in the dynamic areas of AI, health data analytics, precision medicine, virtual care and more.

The focus at this year's event was unmistakably artificial intelligence and its impacts on various areas of healthcare including personalised medicine, genomics and even how people receive health information from LLMs such as ChatGPT. Another area that garnered keen attention was Sparked, the national FHIR accelerator program. AEHRC is leading the program with collaborators from HL7, the Department of Health and Aged Care and the Australian Digital Health Agency. Program Lead, Kate Ebrill, presented insights into the success of Sparked to date and what we can expect from it moving forward. She also gave a stirring call to action to the community to join Sparked and be part of the design of health standards in Australia.

The Colloquium also featured a panel on the future of digital health and talks by leaders in health and digital technology including CTO at SMILE Digital Health, James Agnew.

As is also the tradition at the Colloquium, our up and coming early and mid-career researchers took the spotlight in the afternoon session to showcase some of their innovative digital health science.

This event is a significant part of the AEHRC calendar. Not only does it give our people an opportunity to come together in one space for a day, it also celebrates our widespread partnerships and connections amongst the digital health community.


CSIRO
Australia's National Science Agency


This image was created with the assistance of DALL·E
CSIRO
Australian e-Health Research Centre
Health transformed digitally
2024
AEHRC


Sparked


Australian e-Health Research Colloquium 2024
Tuesday 19 March 2024
Australian e-Health Research Colloquium 2024
Tuesday 19 March 2024

News and Communications

This year saw an unprecedented media interest in the potential impacts of AI in healthcare. The interest was due partially to the growing awareness of AI in various settings, coupled with the awareness of our AI capability raised by AEHRC strategic comms activities.

One of the key highlights of the year was the release of the AI Trends for Healthcare Report. This report provides a much-needed snapshot of AI opportunities and challenges within the healthcare sector, as well as some poignant case studies to illustrate the breadth of application of AI from our scientists. The report was soft launched at the Annual e-Health Research colloquium and hard launched a week later with a media release and blog article. We have received on average one media associated enquiry a week on the back of the report since released in May, and we have used it to support participation and engagement at some of the key digital health events across the nation.

This year also saw the release of a series of videos dedicated to raising awareness of some of the products created and licenced by AEHRC, namely HOTspots, M♡THer and Ontoserver, as well as a unique campaign for our Centre. The 30 second format promoting a single product is unique in the comms space at CSIRO but this innovation on form was required to meet the needs of our scientific teams who wanted to promote awareness of the product "brands" amongst their potential partners and collaborators. All videos are part of a health collection of the CSIRO YouTube channel and are supported by our now expansive deep dive video collection. We also created two videos for the Sparked program to optimise community engagement and brand awareness. These have been shown enthusiastically by the team at the multiple leadership events and connectathons.

We released 18 in total news releases and articles and 6 partner releases. These captured everything from researcher profiles to our latest scientific findings to new partnerships with critical stakeholders in the health space such as Telstra Health.

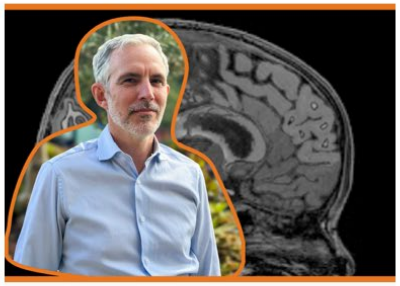
In terms of growing the media and comms capacity of scientists and students, we prepared 4 new scientists with media training and developed internships in comms for 3 interns/placements students. On top of this, most of our people now have up-to-date profile images and many of our significant events were captured by profile photography.

On the website front, we have been developing the AEHRC website with new structure and content and working with teams on research webpages for major projects.

These activities along with our BAU activities of risk management, logo approvals and pitching to industry media mean the comms team of Naomi Stekelenburg and Morgan Gilbert have barely had time to scratch themselves but it has been worth it to produce such solid outputs.

This year comms delivered seven new promotional videos

AEHRC News



AEHRC's Vincent Dore awarded prestigious de Leon Prize in Neuroimaging →

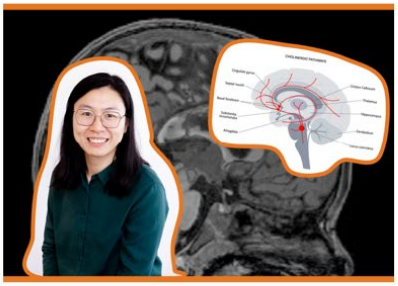
29 July 2024

The prize, which recognises 'best papers' in the field of neuroimaging of neurodegenerative processes, was awarded for his paper on standardising quantification of an Alzheimer's disease biomarker.

Kate Ebrill 'FHIR's up Talking HealthTech podcast →

29 July 2024

Interoperability is a hot topic. AEHRC's Sparked National Community Lead & Interoperability Lead joins podcast host Peter Birch to discuss information exchange in healthcare.



Tackling Alzheimer's disease with advanced imaging techniques →

22 July 2024

Ying Xia and the team are investigating an under-researched aspect of the disease to inform targeted treatment.

AI in health: CSIRO report highlights opportunities, challenges

Wednesday, 27 March, 2024

CSIRO has released a new report, AI Trends for Healthcare, highlighting the opportunities and challenges facing the continued and inevitable integration of artificial intelligence (AI) in Australia's healthcare sector — from clinical decision support to administrative tasks.

Research Director of CSIRO's Australian e-Health Research Centre (AEHRC) Dr David Hansen said that the use of AI in health care is unique because the accuracy of models could mean the difference between life and death, or ongoing health and illness.

"A key difference between the use of AI in health care compared to other industries is the use of AI in decision-making for prevention, diagnosis, monitoring and treatment," Hansen said.

"As we strive to create newer and better digital tools to harness the benefits of AI in health care, frameworks and ethical implementation along with established safety, quality and monitoring guidelines continue to be imperative."

The report also notes that the digitalisation of Australia's hospital records system — or electronic medical records (EMRs) — is rapidly expanding.

EMRs and other clinical systems are likely to provide the platform for implementing AI technologies — with uses in areas such as imaging, diagnosis and treatment, as well as tasks such as reconciliation of reports or analysis of clinical data.

Awards

Our teams were again successful in being nominated for or winning multiple awards this year.

- Bowen Xin, Aaron Nicolson, Hilda Courak, Gregg Belous and Jason Dowling achieved 7th place among around 100 participants (imaging-similarity metrics) in an international medical AI challenge (synthrad2023, co-hosted by miccai2023) synthesising CT for radiotherapy. The team was invited for an oral and poster presentation in international conference MICCAI2023. Co-authored journal paper was under review of Medical Image Analysis (Impact factor 10.9).
- Vahid Riahi, Pippa Niven, Yan Chia, Sankalp Khanna and Rajiv Jayasena selected for ON Program Commercialisation x ON Launch Camp for Outpatient prediction tools (OPAT)
- Teresa Wozniak, Majella Murphy, Aminath Shausan selected for ON Program Commercialisation x ON Launch Camp for AMR Risk Prediction
- James Doecke and Vincent Doré and co-authors (AIBL, CSIRO & ADx Neurosciences) received an award for being in the top 10% most widely read papers of 2022 in Alzheimer's and Dementia (JIF 16.655)
- Vincent Doré is on a paper in the top 10 most-cited papers published in Alzheimer's and Dementia (JIF 16.655)
- Hamed Hassanzadeh, Justin Boyle, Sankalp Khanna and FSH collaborators received a certificate of achievement from Wiley for their paper in the International Journal of Health Planning and Management being one of the most downloaded in 2022.
- Marlien Varnfield won the 2023 Research Australia 'Digital Health Technology Award'
- Jinghui Liu and Anthony Nguyen won Australasian Language Technology Association (ALTA) 2023 Best Paper award for their "Enhancing Bacterial Infection Prediction in Critically Ill Patients by Integrating Clinical Text" paper.
- Adilina Sheikh won the people choice award for her presentation at the QUT Centre for Biomedical Technologies Conference.
- Kerstin Pannek won the Best Platform Presentation Award at the annual conference of the Australia-New Zealand Chapter of the International Society for Magnetic Resonance in Medicine
- DACS team was finalist in the IoT Awards 2024 for the DACS Randomised Controlled Trial
- Aida Brankovic won the Best Paper Award at Medinfo23 (July 2023) for her lead author paper, "*Elucidating Discrepancy in Explanations of Predictive Models Developed Using EMR*". Other authors were Wenjie Huang, David Cook, Sankalp Khanna, and Konstanty Bialkowski
- The inaugural ANZCA Innovation and Technology Research Award for 2024, Dr Rachel Bourke, Dr Halia O'Shea, Dr David Evans, Professor Steven Stern, Associate Professor Paulina Stehlik, Dr Sankalp Khanna, and Dr Aida Brankovic

CSIRO recognition

- David Ireland and the and the Everyday AI Team won the CSIRO Trusted Medal for their highly successful 'CSIRO Presents: Everyday AI' podcast
- Dana Bradford and the Neurodevelopment and Plasticity Team won the CSIRO Health and Biosecurity 2023 Science and Engineering Excellence Award
- Alana Delaforce, Jessica Rahman and Moid (Members of the H&B EMCR Committee) received an H&B People Excellence Award
- Naomi Stekelenburg awarded H&B Support Excellence Award
- Teresa Wozniak, Majella Murphy, David Conlan, Aminath Shausan awarded H&B Digital Transformation Award
- Ray Mahoney, Georgina Chelberg, Sophie Wright-Pedersen Awarded H&B Aboriginal and Torres Strait Islander Engagement Impact award.
- Janet Fox, Kaley Butten, Marlien Varnfield Awarded H&B Entrepreneurship Award
- Berenice Talamantes Becerra received the Ruby Payne-Scott Award

AEHRC and Queensland Health

CSIRO and Queensland Health have enjoyed an enduring collaboration since the joint venture of the AEHRC was first established in 2003. With CSIRO and Queensland Health signing a new five-year agreement in 2022, AEHRC will continue to be an important contributor to the digital enhancement of Australia's health system into the future.

AEHRC works with Queensland Health across the program - in health data and text analytics, interoperability and connected care, mobile health and tele-health, genomics and medical imaging. Our scientists work with clinicians and service providers across the many parts of Queensland Health to ensure digital health innovation can translate to improved health care delivery, patient experience and outcomes.

Queensland Health continues to push boundaries to improve interoperability across the health system. The past year has seen eHealth Queensland's core contribution to the Sparked program that CSIRO runs nationally – and we have very much appreciated their support. eHealth Queensland is also ramping up use of their Queensland Clinical Terminology Service using our Ontoserver technology. Queensland Health is the first health system in Australia to establish its very own clinical terminology services as an enterprise service used across Queensland Health, enabling users of clinical applications to easily browse, download and create terminology and terminology related content.

To ensure our workforce are ready for the implementation of FHIR, we have further developed opportunities to align activities with Queensland Health to increase training in and adoption of FHIR and interoperability.

Working with eHealth Queensland, and key research partners including University of Queensland, Queensland University of Technology and Health Translation Queensland, we have developed a blueprint of the digital health research ecosystem in Queensland, which will include tools and resources for stakeholders navigating in the digital health research ecosystem in Queensland and support Queensland's health and medical research. These resources are designed to support health and medical researchers and industry partners navigate Queensland's digital health landscape.

Answering the call to harness data and information for sustainable health system, our scientists have been working with University of Queensland, Queensland Health, Queensland Ambulance Service, clinicians from Gold Coast and Metro South Hospital and Health Services to better understand emergency department patient flows and bed demands across Queensland's hospitals. By integrating ambulance, emergency department and inpatient data, this program adopts a system-wide view of patient flow interactions to identify access issues and design solutions to improve patient flow at a system level.

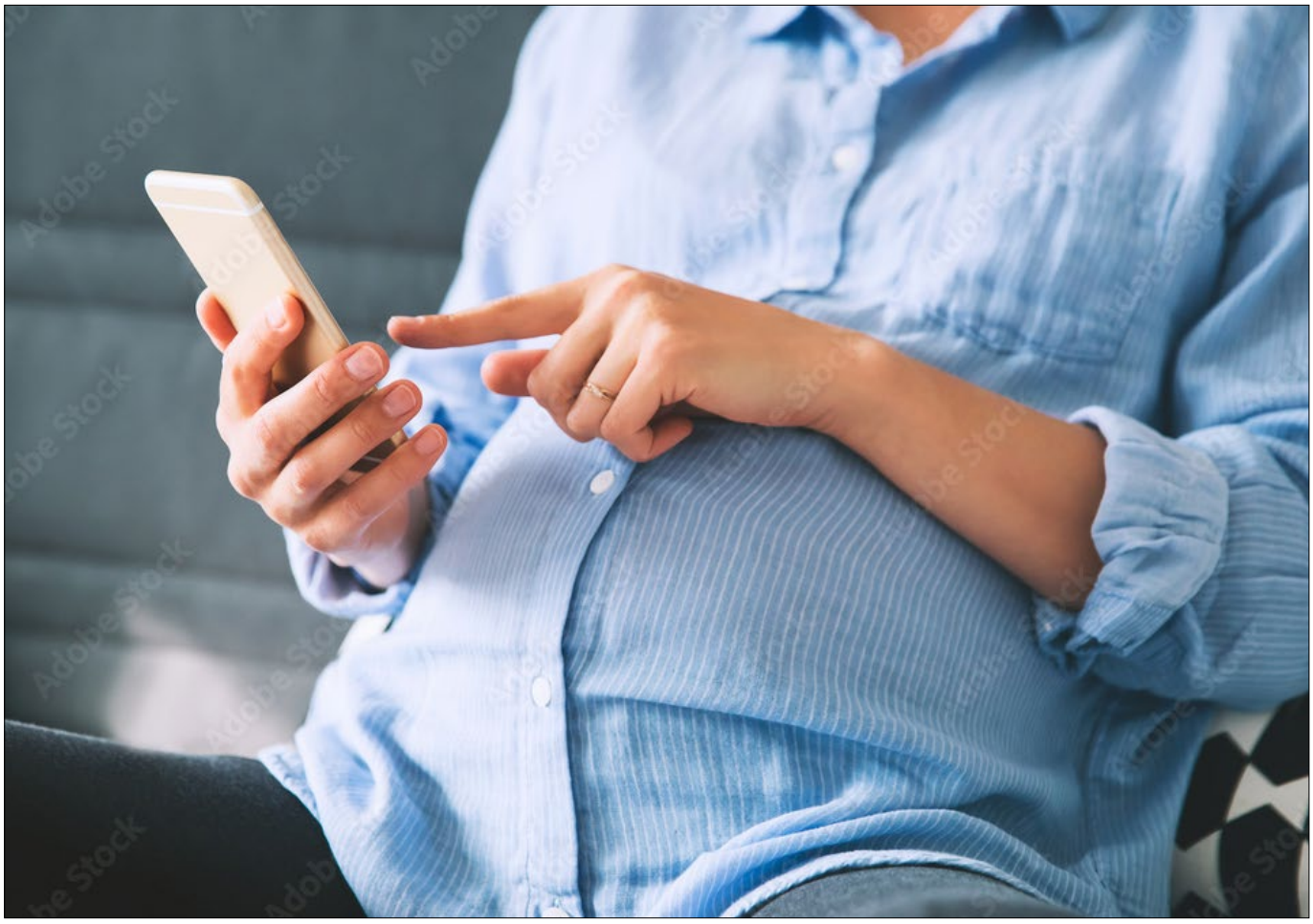
With the recent mainstreaming of AI technologies, we are in ongoing discussions around the use of AI in healthcare with Queensland Health to make certain AI capabilities are effectively and responsibly harnessed to improve patient and system outcomes. We have delivered several key projects using natural language processing techniques to enhance medical search and analytics. Among others, we have developed a precision medicine search platform at Children's Health Queensland to help clinicians identify potential treatments for children with cancers, support the notifications of cancer based on radiology reports, and utilise diagnostic test data to develop interoperable digital health antimicrobial stewardship applications to facilitate appropriate antibiotic prescription decisions.

Our teams continue to work with many areas across Queensland Health, including eHealth Queensland, Clinical Excellence Queensland, many Queensland Health and Hospital Services and Cancer Alliance Queensland. Recently, we developed several projects with these areas using data and analytics to better understand vulnerable patient groups presented to emergency departments, and improve care provided to both inpatient and outpatient cohorts connecting care to recovery. Our nationally validated M♡THer platform (developed to support women with gestational diabetes) has seen over 9000 women and their treating physicians benefiting from the solution. We have also expanded our mobile health platform for other complex care conditions such as, heart failure, colorectal cancer, COPD and stroke.

Finally, our imaging team has been working with the QIMR Berghofer Medical Research Institute, University of Queensland and Queensland Cyber Infrastructure Foundation to establish Queensland Alzheimer's disease cohort study. This study will combine patients currently enrolled in multiple studies such as the national Alzheimer's Disease Network (ADNet) and the Queensland Based PISA study to form a larger cohort study and be the basis for further grant funding. This consortium will be a critical infrastructure to support Alzheimer's research in Queensland.

With the re-establishment of our AEHRC Research and Investment Advisory Committee, with representatives from both AEHRC and Queensland Health, there will be more opportunities and conversations to ensure our digital health innovations can be translated to better care delivery and patient outcomes.

Many of the projects reported in the 2023/24 annual report highlight the way we work with Queensland Health and we continue to value their fabulous collaboration.



Artificial intelligence in healthcare at AEHRC— now in its own report

A surge in the amount of digital data in the health sector, combined with increases in compute power and the availability of new AI tools, is leading to an explosion of AI being used in healthcare, according to a new report from CSIRO, Australia's national science agency.

In May 2024 we released the AI Trends for Healthcare report, designed to reflect the centrality of AI to any discussion about healthcare and plant a flag in the ground around AEHRC's enormous and pioneering capability in this field.

The report identifies the opportunities and challenges facing the continued and inevitable integration of AI in Australia's healthcare sector, from clinical decision support to administrative tasks.

To mark the launch of the report, AEHRC CEO Dr David Hansen highlighted that the use of AI in healthcare is unique due to the critical nature of the accuracy of models, which could mean the difference between life or death, or ongoing health or illness.

It is an imperative that as we move towards more and more implementation and uptake of AI models, especially in decision making for prevention, diagnosis, monitoring and treatment of disease, we constantly monitor the bigger picture elements of opportunities, as well as challenges, within the AI space.

The purpose of the *AI Trends in Healthcare* report is to provide such a snapshot.

The report notes the need for frameworks and ethical implementation along with established safety, quality and monitoring guidelines to continue to be imperative. This is especially the case with the growth in amounts of available health and medical data, which brings data privacy and security to the fore as growing challenges.

It also notes that the digitalisation of Australia's hospital records system – or electronic medical records (EMRs) – is rapidly expanding.

EMRs and other clinical systems are likely to provide the platform for implementing AI technologies, with applications in areas such as imaging, diagnosis, and treatment, as well as tasks such as reconciliation of reports or analysis of clinical data.

The report identifies that medical research will be a significant winner from the digitisation of healthcare and the introduction of AI algorithms, as medical research institutions invest in infrastructure to harness the power of the data being generated.

"We're at the cusp of an extraordinary era in medicine. For the first time, machines can provide efficient administrative support for clinicians and education for patients, diagnose and predict disease, and inform clinical decision making," Dr Hansen said.

"If done with care, thought, and safety, embedding AI in healthcare is an opportunity to drastically improve the work lives of medical professionals and the health and wellbeing of consumers."

The report also highlights other sectors – such as aged care or disability – as being able to benefit substantially from the improved support and vigilance offered by AI.

"Our research shows the benefits of AI's capacity for the analysis of large data sets for disease control and for clinical support in high demand areas such as medical imaging. All of this shows great promise for increasing digital health impact," Dr Hansen said.

The Health Data Semantics and Interoperability group

Group Leader: Dr Michael Lawley

Our team is answering the call for high quality real-time clinical information to be shared between individual health practitioners, healthcare provider organisations and state and territory health departments to improve patient outcomes and health system performance.

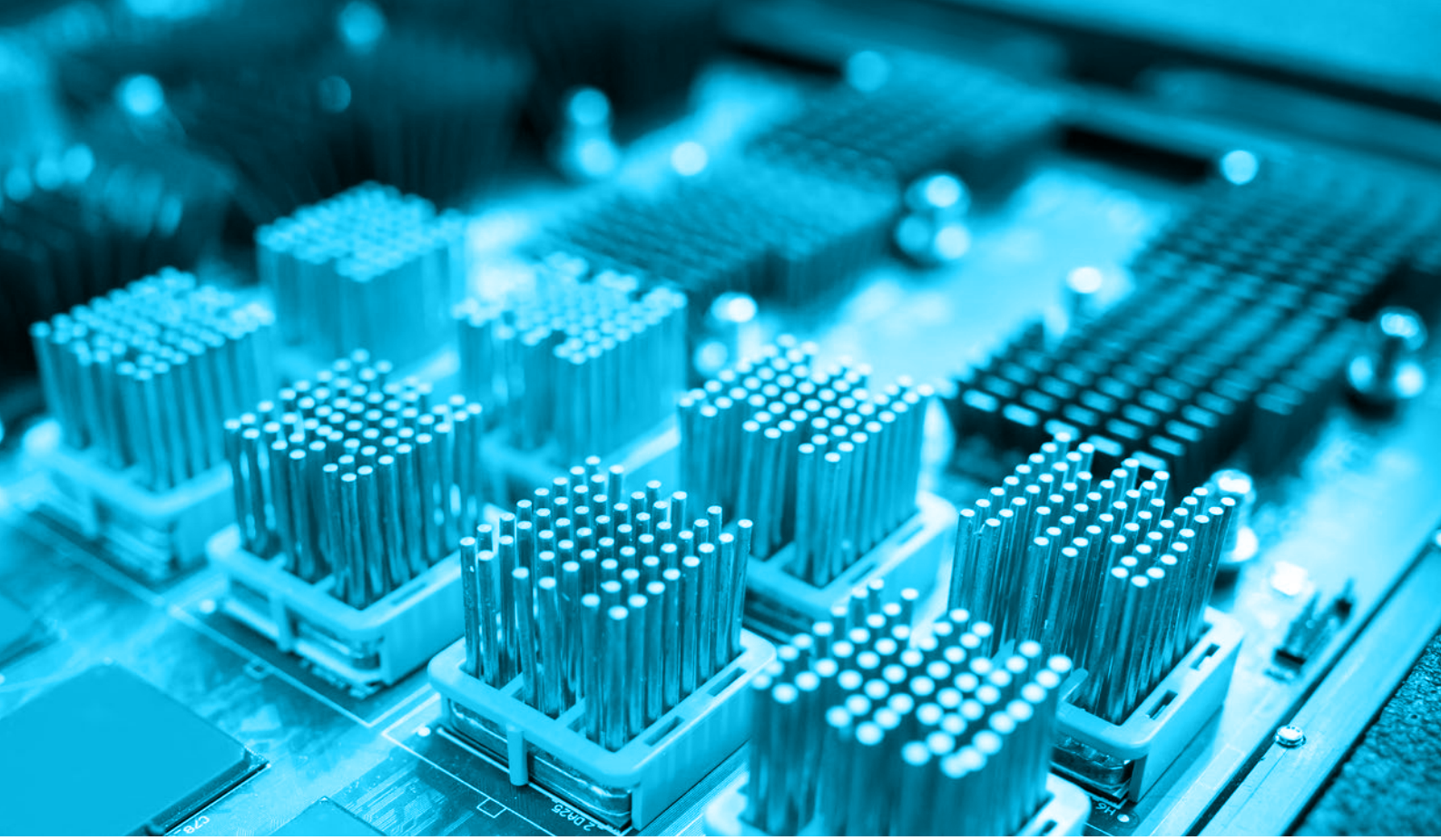
We develop and apply innovative tools and techniques for evidence-based solutions and strategies to support improved health outcomes. As catalysts in developing the maturity of Australia's digital health ecosystem, we use, promote, and enhance health IT standards to improve the quality of, and unleash the value in, health data, including electronic health records and administrative data sets.

We apply informatics, machine learning, natural language processing, and formal logic to problems involving decision support, systems modelling and integration, and reporting and analytics.

Health Data Semantics and Interoperability science and impact highlights for 2022/23

We successfully secured multi-year funding from several grant applications including the MRFF DIFFERENCE project to improve Indigenous maternal healthcare; three MRFF National Critical Research Infrastructure projects on federated learning in digital health (MRFF NINA), integrated network of platforms for brain cancer research (MRFF BCBA), an advanced learning health system for stroke care; and a national biotech incubator, CUREator, project focused on creating health-standards-based decision support tools to support antimicrobial stewardship (AMS) within the emergency department.

Following awarding of a contract by the ADHA to operate the National Clinical Terminology Service (NCTS), we are in the final phase of testing for both of the concurrent uplift projects the new AMT v4 model, and new infrastructure and tooling that will deliver a new medicine authoring tool that will work seamlessly with SNOMED International's Managed Service Authoring Platform. The final products from the uplift projects are planned to go live in September 2024. The team have been working closely with industry to provide technical support to ensure their readiness for AMT v4.



Recognising our expertise in FHIR and capability and track record in building community and consensus through work such as the Primary Care Data Quality project, we were awarded more than $9M over two years in the Federal Budget to establish a community-led specification development process that engages all stakeholders, leveraging CSIRO's expertise in community building and FHIR tooling to act as the community coordinator and deliver supporting infrastructure.

- In collaboration with the Transformational Bioinformatics group, we co-authored a *Nature Biotechnology* paper about the world's first query engine for genomic and medical data, which scales to millions of patient samples.
- Ontoserver is now the national terminology server for eleven countries: NHS England, NHS Wales, NHS Scotland, New Zealand, Belgium, Canada, Estonia, France, Sweden, Netherlands, and Australia, with additional licence holders in the United States, Canada, Germany, Switzerland, Indonesia, the ASEAN region and South America. We also have reseller and embedded licenses with Dedalus, Smile Health, and Oracle Health (Cerner).
- The Oncology Search Clinician Assistant Registry was developed for the Queensland Children's Hospital and Queensland Children's Hospital Foundation to reduce the effort of searching for targeted treatments.
- The Medtex-Rad cancer notification detector, developed in collaboration with Cancer Alliance Queensland (CAQ), was successfully trialled on-premises at a commercial medical imaging provider site. This tool automates the identification of cancer-related radiology reports that need to be notified to the Queensland Cancer Register (QCR), reducing the operational burden on imaging providers in complying with mandatory reporting requirements.

Terminology Projects team

Team Leader: Kylynn Loi

The Terminology Projects team is dedicated to improving the use and implementation of standard terminologies such as SNOMED CT to improve health data quality and data interoperability. The team does this by working with national and international groups to develop terminology content, develop and apply data analytic techniques to coded data, and provide advice around implementation and use of terminology in Australia.

FHIR Terminology and Tooling team

Team Leader: Dion McMutrie

The FHIR Terminology and Tooling team comprises engineers specialising in FHIR and clinical terminology to develop and integrate digital health systems. We create various tools to advance and facilitate the adoption of FHIR and related standards in building and integrating digital solutions within the health sector.

Data Semantics and Machine Learning team

Team Leader: Dr Bevan Koopman

Our research is about helping people find relevant and reliable health information to make health related decisions. We do this with a focus on natural language processing, search and machine learning approaches.

We tackle problems where people need to find answers and make clinical decisions in the face of overwhelming amounts of typically unstructured data. This may occur in evidence-based medicine where, for instance, clinicians need to search through vast amounts of literature and clinical trials to find a targeted treatment for a specific cancer. A solution might involve automating the processing of matching and recruiting patients to a clinical trial.

Our research is about:

- how to build models that search through, understand and generate natural language
- understanding the semantics of someone's query rather than just matching keywords
- how to inject medical domain knowledge into an AI model
- putting the human searcher in the loop so they can bring their domain knowledge to guide the model to relevant information.

Health Data and Text Analytics team

Team Leader: Dr Anthony Nguyen

The Health Data and Text Analytics team specialises in developing and applying advanced AI techniques to enable complex, automated analyses of electronic health record data. These efforts support clinical decision-making and public health surveillance. By partnering with healthcare providers, the team creates value from structured and unstructured narrative health data to deliver innovative AI technology that improves data quality, patient outcomes, and overall health system performance and productivity. Our team leverages natural language processing, machine and deep learning, including LLMsv, information retrieval and clinical terminologies. These technologies are pivotal in achieving meaningful data interoperability and analysis, facilitating decision support, analytics, modelling and reporting.

Interoperability Lead and National Community Lead Sparked

Kate Ebrill

As Interoperability Lead, Kate is dedicated to the development of the strategic direction and roadmap for the clinical terminology and data interoperability platform technologies and services. This includes ensuring program delivery, developing strategic partnerships, and furthering commercial licensing opportunities nationally and globally.

NCTS Lead

Sarah Kong

Leading the delivery of the National Clinical Terminology Service (NCTS) and projects is the NCTS Office team which is responsible for coordinating and optimising a spectrum of functions that ensure the smooth delivery of the NCTS products and services. Our team comprises seasoned industry professionals ranging from project managers, change and engagement managers and business analysts, each bringing a unique blend of skills and extensive knowledge. Together, we operationalise and execute the NCTS delivery program with the NCTS Content team and NCTS Terminology Tools team.

NCTS Content

Linda Ang

The NCTS Content team is a dedicated group of health professionals with diverse and extensive experience leveraged to deliver meaningful and useful terminology content for NCTS products: the Australian Medicines Terminology (AMT), SNOMED CT-AU (the Australian extension of SNOMED-CT), and FHIR Terminology Resources. We work with our stakeholders to support them in their terminology needs as they work towards interoperability and providing connected care for the Australian community.

NCTS Terminology Tools

Luke Swindale

The NCTS Terminology Tools team develops and maintains the software tools used to author, review, release, and integrate clinical terminologies into the NCTS. These tools also enable clinicians and external consumers to work with terminologies, such as SCT-AU, AMT, FHIR terminology resources, and third-party content. The overall goal of our team is to make it easier for end users to adopt clinical terminologies and to improve interoperability between systems. This is important because terminologies are essential for the effective communication and exchange of clinical information.

Sparked

Danielle Tavares-Rixon

The Sparked Technical team works together with the community to support the creation, standardisation and maintenance of national and international FHIR standards, to facilitate the safe and accurate exchange of digital health information across the health sector.

Michael Hosking

Michael is the Deputy National Coordinator of Australia's Sparked FHIR Accelerator, leading its engagement and strategy.

Health Data Semantics and Interoperability: platform technologies

Poor data quality and consistency resulting in a lack of, or poor, insights can compromise the quality and efficiency of care.

Our technologies enable interoperability, advanced and effective use of data captured in electronic medical records, through the development of products and services to support the use of clinical terminologies such as SNOMED CT and interoperability standards such as FHIR®

These include:

- FHIR-native terminology and classification tools: Ontoserver, Snapper, Snap2Snomed/Snapagogo, Snorocket, Shrimp, Atomio, Ontocloak, and SnoMAP
- OpenSource FHIR tools: RedMatch; Pathling
- Natural language processing tools: Medtex
- Search engines for medical reports and literature
- Chatbots to tackle a range health-focussed topics

Suite of FHIR native terminology tools

Widespread use of national terminologies by clinical systems provides considerable interoperability benefits and supports meaningful use of patient data for better health outcomes. However, rich and powerful clinical terminologies, such as SNOMED CT, are complex.

This complexity makes implementation difficult and often costly, presenting a challenge to adoption. To address this challenge, we are developing new technologies that enable the advanced use of clinical terminologies such as SNOMED CT, LOINC and any FHIR-based CodeSystems.

Ontoserver

Ontoserver is the world-leading clinical terminology server implementing FHIR terminology services and supporting syndication-based content distribution.

Over the last year Ontoserver has continued to receive many new updates including:

- Only 3rd party terminology server to be validated for use with HL7 IG Publisher and Validation infrastructure
- Significant enhancements to code validation and translation support
- Further pre-adoption of FHIR R5 features where no backward compatibility issues exist
- Extended support for new SNOMED CT expression constraint language features
- FHIR R5 support

ontoserver.csiro.au

Ontocloak

Ontocloak is an authorisation server for managing access to Ontoserver and other related services.

Atomio

Atomio is a syndication service for managing distribution content.

Snapper

Snapper: Author is a web browser-based app for authoring FHIR terminology resources and publishing them to a FHIR terminology server.

Snapper: Map is a web browser-based app that enables authoring maps from legacy terminology to standards-based terminologies. Together, these tools support migration to and use of standard terminologies, and the adoption of the national approach to interoperable digital health information.

Snap2Snomed/Snapagogo

Snap2Snomed is an opensource tool built and operated for SNOMED International to support collaborative mapping of term lists and local vocabularies to SNOMED CT. It builds on expertise developed with Snapper and leverages the automapping capabilities of Ontoserver to provide collaborative mapping to an international audience including SNOMED member countries and vendors such as Babylon Health.

Snapagogo extends the capabilities of Snap2Snomed by supporting additional target code systems hosted by Ontoserver such as LOINC, RxNorm, and ICD 10. Snapagogo is being made available to the Australian research community through a collaboration with the Australian Research Data Commons (ARDC).

SnoMAP

SnoMAP is a suite of SNOMED CT to ICD10-AM mapping products that enables diagnoses to be recorded using SNOMED CT-AU and mapped to ICD10-AM codes. We have developed two products:

- **SnoMAP Starter**: a simple SNOMED CT-AU diagnosis to ICD-10AM Codes FHIR ConceptMap, to support the use and reuse of SNOMED CT for analytics and research activities.
- **SnoMAP ED:** a mapping service for emergency department non-admitted patient reporting purposes, thus supporting the use and re-use of the standard clinical terminology for ED funding activities. This has been revamped to support mapping directly to the IHACPA ICD10-AM shortlist.

Snorocket

Snorocket is our classifier, which for the first time enabled semi-real-time authoring of very-large-scale clinical ontologies like SNOMED CT. Snorocket is available under an Apache 2.0 opensource licence and as a Protégé plugin. It has also been licensed to SNOMED International and the Australian Digital Health Agency for their ongoing maintenance of SNOMED CT. github.com/aehrc/snorocket

Shrimp

Shrimp is a widely used tool for browsing SNOMED CT, LOINC and other FHIR CodeSystems, powered by Ontoserver.

Supporting users around the world

Our clinical terminology and FHIR enabled products are used globally to support the advanced use of SNOMED CT, management of ValueSets and ConceptMaps and syndication of clinical terminologies. Shrimp and our public testbed are used worldwide.

Ontoserver is also licensed commercially by users in Australia, New Zealand, Switzerland, Germany, England, Wales, Scotland, Estonia, Sweden, France, Belgium, Indonesia, Canada, and the United States, with evaluation licences in use across the United States, ASEAN region and South America. There are also several managed-service and embedded-use reseller licences in place with vendors in Nth America and Europe.

Supporting opensource technology

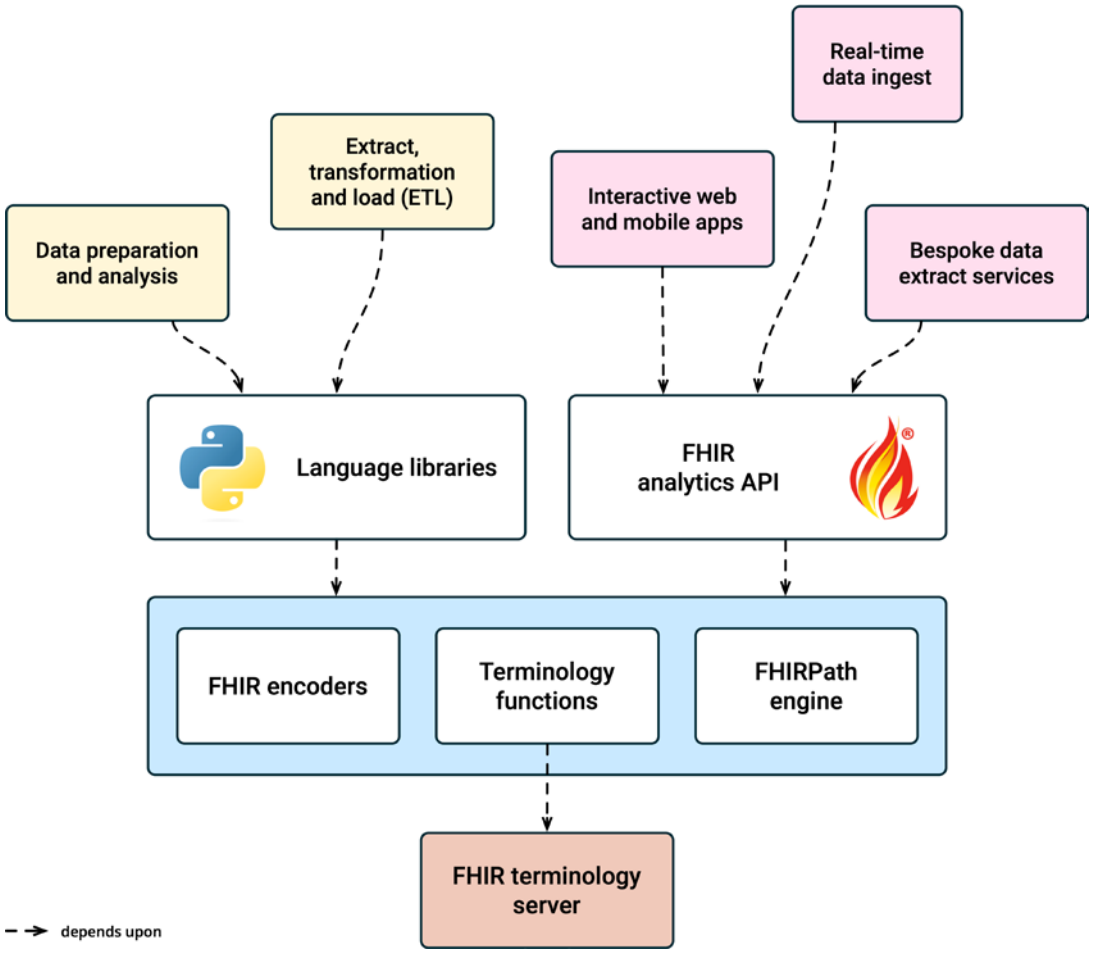
Pathling

Pathling simplifies the use of HL7® FHIR® and clinical terminology within data analytics. It is built on Apache Spark, and includes language libraries and a server implementation.

Pathling was designed to assist with these primary use cases:

- Exploratory data analysis – Exploration of hypotheses, assessment of assumptions, and selection of appropriate statistical tools and techniques.
- Patient cohort selection – Selection and retrieval of patient records based on complex inclusion and exclusion criteria.
- Data preparation – Processing and re-shaping data in preparation for use with statistical and machine learning tools.
- Pathling uses FHIRPath expressions for the aggregation and transformation of data, along with powerful and expressive search queries. This makes it easier to select and transform FHIR data as compared to a generalised query language such as SQL, and it also allows us to extend the functionality of the FHIR API to make it more capable for analytic use cases.
- Pathling also integrates with the FHIR Terminology Services API to enable advanced terminology functionality within queries, at query time and at scale. This allows users to access terminological information and join it to clinical data in arbitrary ways, including advanced support for SNOMED CT and its expression constraint language. Language libraries are available in the Python, Java and Scala languages, allowing for deep integration into existing applications and data science workflows. The server implementation provides a standard FHIR interface to analytic query operations, and is suitable for the delivery of web and mobile applications.

You can learn more about Pathling at https://pathling.csiro.au/.



Pathling: components and their corresponding use cases

Smart Forms

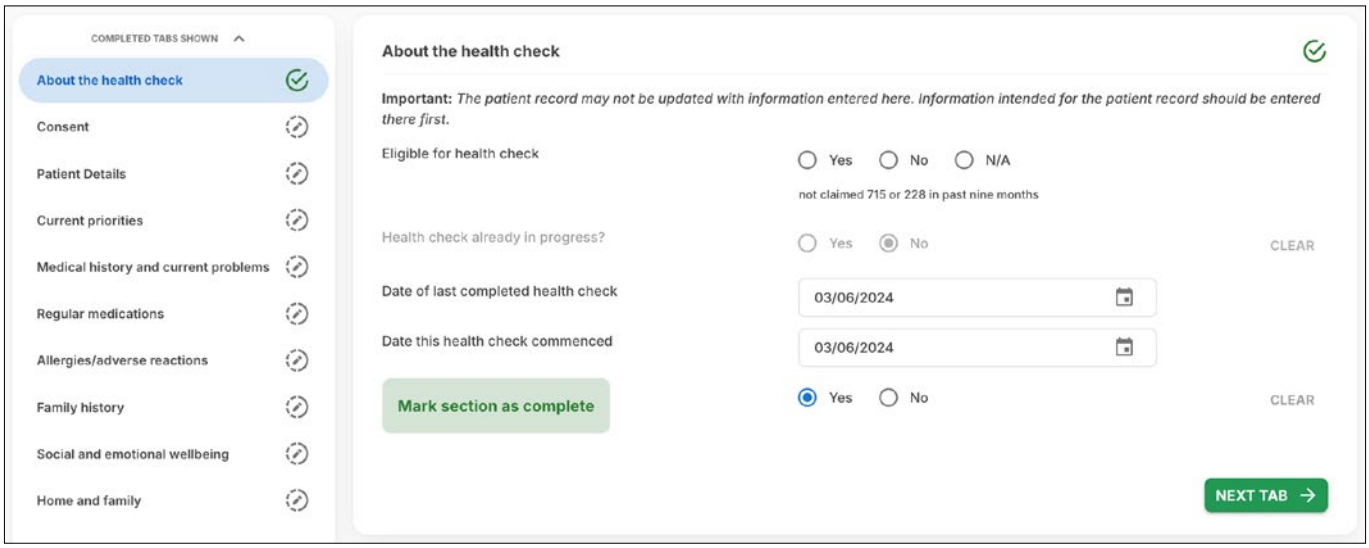
Smart Forms is an opensource web browser-based app for rendering FHIR Questionnaires. It supports clinical integration with healthcare systems for capturing standards-based health information.

Based on FHIR's structured data capture specification, it notably provides these additional capabilities for forms:

- Data pre-population – Allows re-usability of data by pre-filling data existing in the healthcare system.
- Conditional rendering – Rendering of questions based on user decisions or pre-filled data.
- Calculations – Dynamic calculation of quantitative results based on answers existing in the form.
- Terminology support – Allows use of standardised medical terminologies to represent medical concepts and data in forms.
- Smart Forms provides an open-source library for its React-based rendering engine recently adopted by a few Australian and New Zealand-based organisations in the digital health space. Other supporting libraries for data pre-population and modular assembly of sub-questionnaires are also provided.

You can check out Smart Forms at https://smartforms.csiro.au.

The development of Smart Forms has been funded by the Department of Health and Aged Care.



Smart Forms: Rendering of the Aboriginal and Torres Strait Islander Health Check.

Natural language processing

Despite the increasing adoption of EMRs and the shift towards more formalised and structured content, clinical records will invariably contain sections of narrative or free-text information. These narrative sections often hold rich, valuable insights that are important for patient care.

To use this information fully, it must be effectively queried, analysed, and reported. This presents an ongoing challenge and opportunity in healthcare, as extracting meaningful data from free text requires advanced techniques in natural language processing (NLP), deep learning, and LLMs.

Medtex

Medtex is a semantic medical text analysis software that analyses free-text clinical documents for informing clinical decision making.

Medtex learns what statements to look for and uses SNOMED CT, the internationally defined set of clinical terms, to unify and reason with the language across information sources. It incorporates domain knowledge to bridge the gap between natural language and the use of clinical terminology semantics for automatic medical text inference and reasoning.

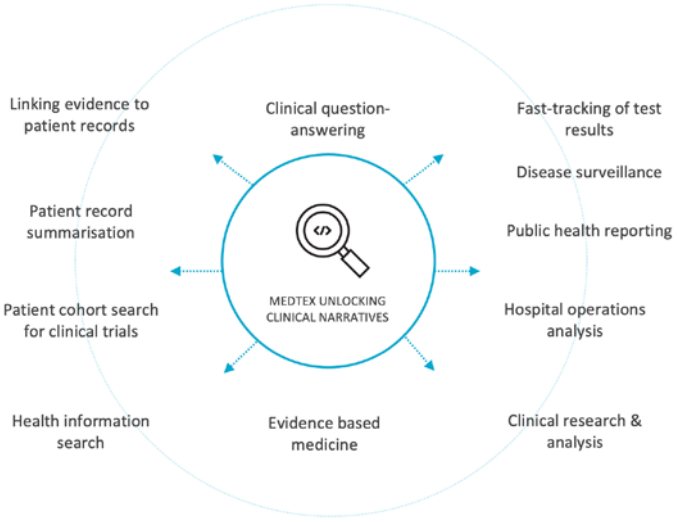
Analysis engines using the Medtex technology have been developed to:

- Standardise the free text by identifying medical concepts, abbreviations and acronyms, shorthand terms, dimensions and relevant legacy codes
- Relate key medical concepts, terms and codes using contextual information and report substructure; and
- Use formal semantics to reason with the clinical concepts, inferring complex clinical notions relevant to a health application.
- Use formal semantics to reason with the clinical concepts, inferring complex clinical notions relevant to a health application.

Medtex scales to large amounts of unstructured data and has been integrated within a highly distributed computational framework. It turns the medical narrative into structured data that can be easily stored, queried or rendered by most systems for use in their health application. Medtex is used to deliver solutions to healthcare practitioners, including cancer registries, and hospital radiology and emergency medicine departments. These solutions encompass:

- Analysing pathology and radiology reports, and death certificates, to extract cancer characteristics important for assessing cancer incidence and associated mortality rates.
- Analysing pathology and radiology test results, as well as discharge summaries, to streamline test result review management workflows in emergency departments, and to identify patients with misdiagnoses and/or those undergoing inappropriate antibiotic treatments due to drug-resistant infections.
- Analysing medical reports to provide the capability for medical record searching and advanced analytics.

Read more in Health Data Semantics and Interoperability: Project Reports.



Medtex: Unlocking clinical narratives.

Search engines for health data

With a rapid increase in health data—in all its forms—the need to search this data effectively rises. Simultaneously, much of this data is unstructured, making it difficult to search using methods tailored to structured data. Search engine technology was designed specifically for large amounts of unstructured data, making it well suited to the health domain.

We developed a suite of solutions for searching health data. Nowadays most of our work involves the training of AI models, specifically neural network models for ranking and natural language processing. These models are adept at understanding the meaning behind a user's query and the relevant information they are looking for, making them much better at finding that relevant information.

The development of our search technology is driven by the idea that people are looking for information to make important health decisions. As such, we develop solutions that support the decision making, empowering users with the information they need rather than ceding control to a black box system.

Key technologies we have developed include:

- Evidence-based search systems capable of ingesting all of PubMed and all current clinical trials and suggesting relevant evidence to support clinical decision making
- Atomated the matching of patients to clinical trials (or visa versa)
- Targeted cancer treatment recommendation for children with specific genetic findings
- Systematic analysis of human search behaviour in the health space to inform the development of better search engines

Chatbots for health

Chatbots bolster engagement in human-computer interaction. Fortunately, healthcare provides a plethora of opportunities for chatbots to support patients, carers and clinicians. A chatbot enables interactions between a knowledge base and a user in speech or text. Each chatbot is powered by a "brain" which needs to be developed and trained to support engaging dialogues. We've developed a range of chatbots for clinical and social settings. Recent examples include:

- The "What Matters 2 Kids" project uses a chatbot to engage with First Nation children that asks them to draw what matters to them. The chatbot then enquires about the drawing in order to capture the well-being of the child.
- "Dolores" a chatbot to discuss all things related to chronic pain with language suitable for the age of the user. Dolores has been piloted at pain clinics at the Royal Brisbane & Women's Hospital and Melbourne Children's Hospital.
- "Quin" a smoking cessation chatbot built from thematic analyses of Quitline counselling sessions. Quin is being designed for long-term use and support for a user wishing to cease smoking.
- "Aurora" a chatbot that administers a sleep-dependent memory test (developed at the University of Sydney) for people living with mild cognitive impairment. Aurora handles the testing within a critical time window and reschedules if the user misses the test.

AEHRC chatbots can function on mobile devices without requiring internet access and have support for:

- Smart on FHIR
- Incorporate LLMs or run entirely on a mobile device for privacy and security
- Custom user interface widgets
- Voice logging and processing

Example dialogues of Quin the smoking cessation chatbot. Here Quin is asking if anyone else lives with the user who smokes to anticipate triggers the user might be exposed to. The user may respond verbally, text or by drawing.

Health Data Semantics and Interoperability: project reports

Sparked: Australia's National FHIR Accelerator

Collaborator: Commonwealth Department of Health and Aged Care, Australian Digital Health Agency, HL7 Australia

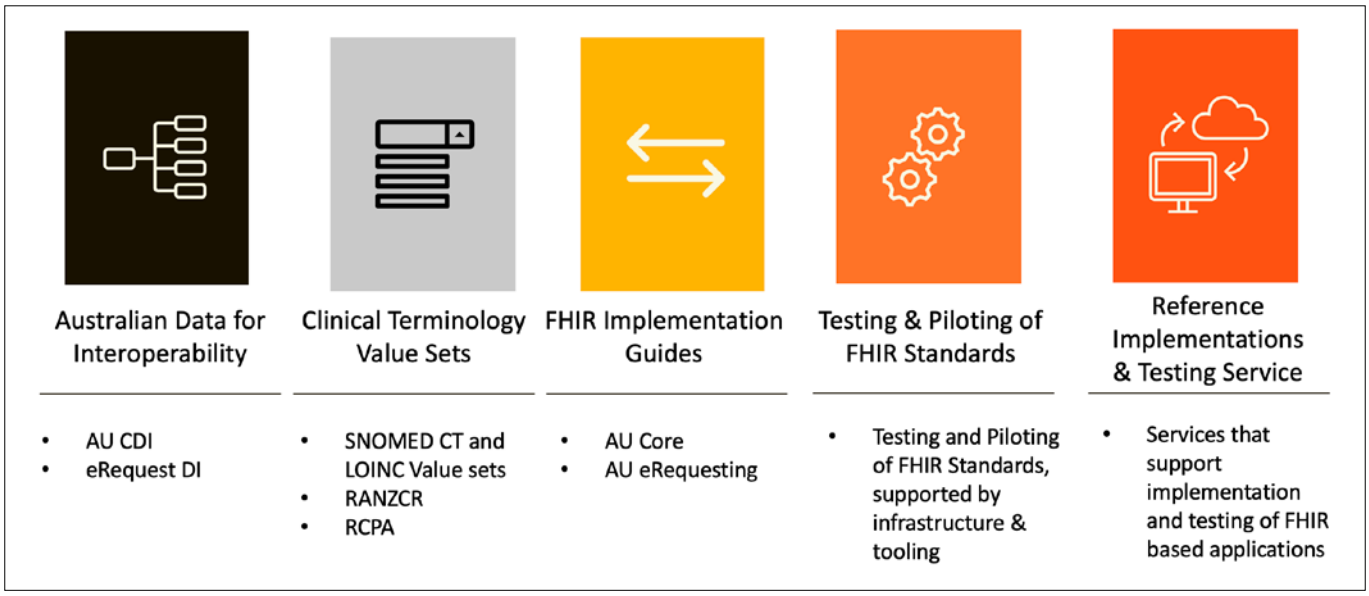
Sparked is Australia's first FHIR Accelerator, driven by a community-centric approach to accelerating the design and development of national data and FHIR standards that underpin standardised capture, storage and sharing of health information securely across Australia. The open, transparent, and consensus-driven community informing the development of these standards comprises government, technology providers and implementers, health provider organisations, peak bodies, practitioners, and domain experts.

Sparked is led by CSIRO's AEHRC in partnership with the Department of Health and Aged Care (DOHAC), the Australian Digital Health Agency (ADHA), and HL7 Australia (HL7AU).

The proposed specifications (Data for Interoperability and FHIR Implementation Guides) defined by the community have been published for public review and comments. These comments are being incorporated into the standard to ensure they are clinically and technically fit-for-purpose and scalable across Australia's implementer community. Through this process, we are conducting a scientific implementation evaluation of the approach to ensure a robust and repeatable approach is being taken based on international best practices.

Sparked has made significant progress in the last 12 months, having delivered on multiple product artefacts, including the release of the Australian Core Data for Interoperability (AUCDI) Release 1, AU Core FHIR Implementation Guide Release 1 for public comment, the first draft of the eRequesting Data for Interoperability (eReqDI). In parallel to these milestones, FHIR terminology value sets are being developed in collaboration with clinical colleges and peak bodies to implement consistent, clinically meaningful and computable language across systems. Further to the success, the DOHAC has committed further funding to support the planning of future work needing to be achieved by the accelerator.

Future projects will include supporting existing work to test the implementation of the above standards and planning to support the standardisation of concepts, including patient summaries, chronic disease management, and reason for encounter.



The National Clinical Terminology Service (NCTS)

Collaborator: The Australian Digital Health Agency

The National Clinical Terminology Service (NCTS) is governed by ADHA and operated by AEHRC. Under an initial two-year service agreement, the NCTS will drive the healthcare community's digital health needs through:

- Managing, developing, and distributing national clinical terminologies and related tools, including SNOMED CT-AU and the Australian Medicines Terminology (AMT). This responsibility includes being the Australian National Release Centre for SNOMED CT on behalf of SNOMED International.

Delivering two concurrent projects within 24 months:

- an AMT model redesign to align with the new SNOMED International medicines model
- a corresponding infrastructure and tooling uplift.

The transition phase has been completed, firmly establishing the operation of the NCTS by the AEHRC. The two concurrent projects for the new AMT model, and infrastructure and tooling uplift have made excellent progress. AMT users were invited in September 2023 to participate in the integration testing phase to test AMT v4 against their systems. The project team have been providing comprehensive support to ensure AMT users are ready to take in AMT v4 when it goes live in September 2024.

The infrastructure and tooling uplift project is completing development of a new medicine authoring module that integrates the results of our generative AI research to speed the authoring process. The testing phase for user acceptance has commenced and the tooling is on track for delivery for production use alongside the first release of AMT v4.

In the upcoming financial year, after completion of the two projects the teams will turn their focus to outreach and engagement with terminology users and implementers to support knowledge development in the community, promote adoption of standardised terminology, inform and communicate future enhancements, support implementation such as Ontoserver and extensions to the NCTS. This will be in conjunction with ongoing delivery of the monthly NCTS releases.

Snap 2 SNOMED enhancement

We have developed further functionality for a tool that we had built for SNOMED International's members and their stakeholders to collaboratively create and maintain simple maps to SNOMED CT. Maps produced by this tool are useful to support migration and adoption of SNOMED CT, identify any gaps in SNOMED CT and to support translation as part of electronic health record (EHR) implementations.

The tool was developed with an agile methodology and uses our Ontoserver to provide the real time search functionality, as well as automated mapping suggestions.

The enhancements to Snap2SNOMED were deployed in December 2023.

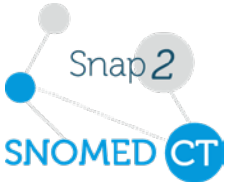
The new features of Snap2SNOMED included:

- Enhanced collaborative mapping workflow processes
  - Ability to perform a dual independent mapping and reconciliation process seamlessly within the tool
  - Ability to perform a dual review process
- Enhanced map maintenance features
  - Improved visibility in discovering inactive codes within a map
  - Automated suggestions for inactive codes
- Additional export features
  - Export to FHIR JSON
  - Additional CSV formats for comments and source columns
- Display of code properties for improved target selection

Snap2SNOMED supports a range of features including:

- Ability to create simple maps to SNOMED CT
- Online and easily accessible
- Collaborative workflow features
  - Allows teams of users to author and review a map
- Automated mapping suggestions are available as a bulk operation and for single source terms
- Intuitive UI to make browsing and mapping to SNOMED CT easy and efficient
- Ability to perform map maintenance
- Import your own code sets and maps
- Export to CSV, TSV and XLSX

Snap2SNOMED is available as an open-source codebase and also hosted by SNOMED International for its members with active users in many countries.



Snap 2 SNOMED CT mapping tool logo.

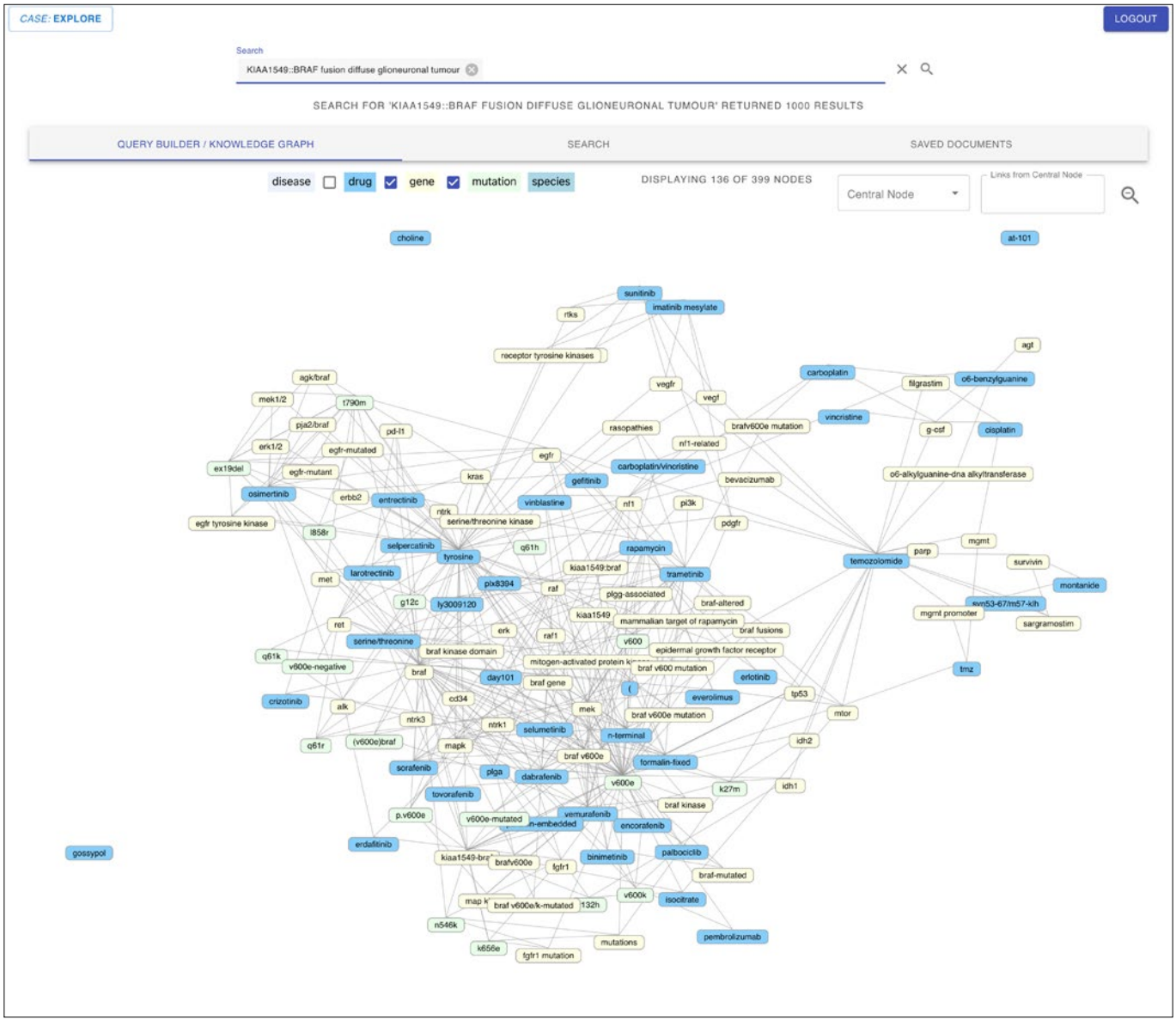
Precision medicine search engine for paediatric oncology—"Oscar"

Collaborator: The Prince Charles Hospital ED, Pathology Queensland

This project aims to create Oscar (Oncology Search Clinician Assistant Registry), a search engine for finding relevant indicative treatments for a specific child patient based on the genomic profile of their cancer.

The information being searched is: ~300,000 clinical trials from ClinicalTrials.gov; and ~25 million medical articles from PubMed. The specialised search capabilities of Oscar mean clinicians can find the right treatments for their patients with higher accuracy and less time/effort, ultimately leading to better patient outcomes for the most vulnerable patients—kids with cancer.

Oscar is capable of ingesting and tracking all medical publications and clinical trials globally. From these vast amount of data and using advanced AI algorithms, Oscar is able to extract gene, drug and cancer type information. Based on this information, Oscar locates relevant treatments tailored to individual patients. Oscar also provides tools for the effortless exploration of the treatment landscape. This provides doctors with information on the best treatments for their patients by an automated system.



Oscar provides doctors with automated information about best treatments for their patients.

Automating cancer data registries to enhance data quality and efficiency

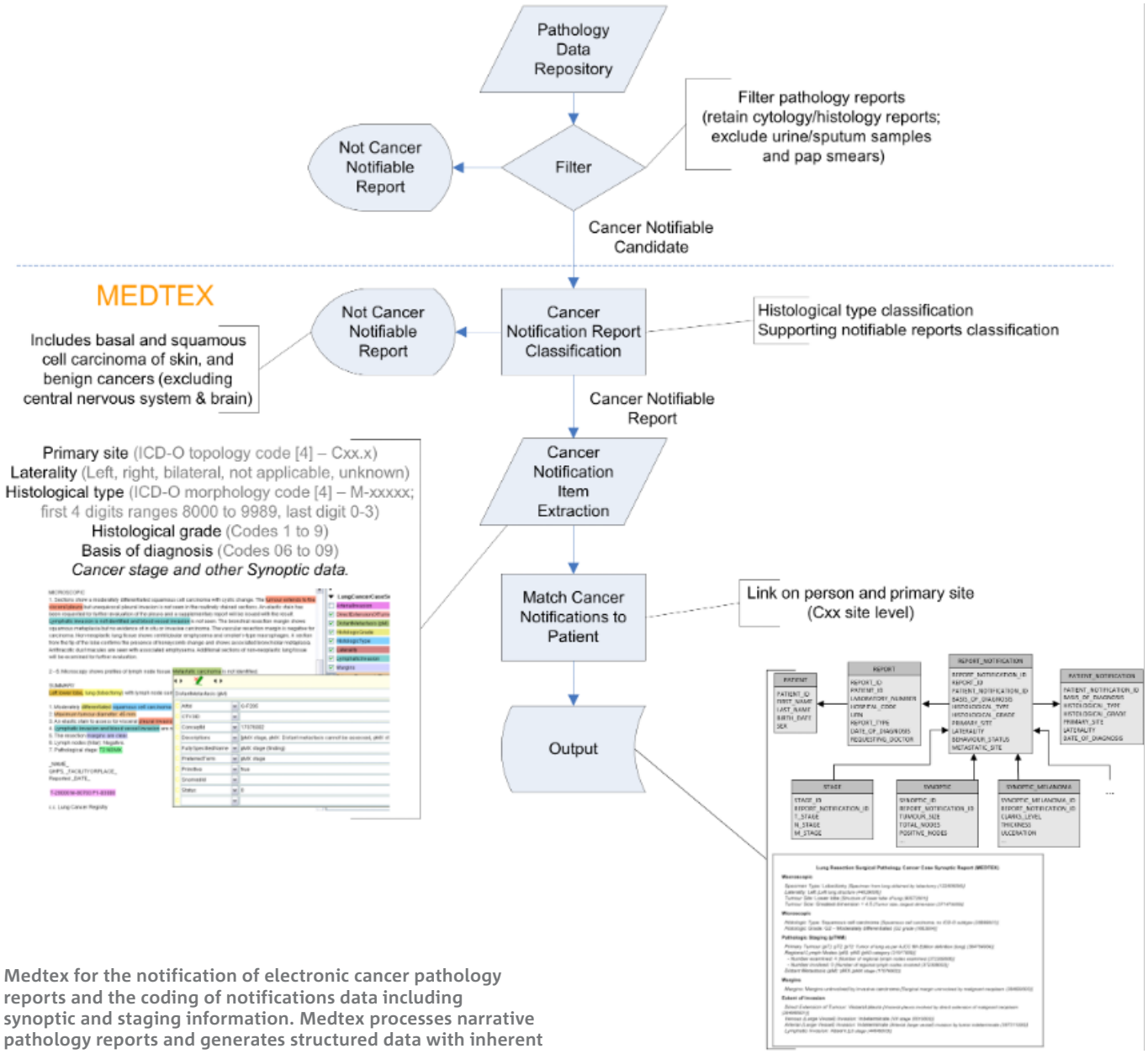
Collaborator: Cancer Alliance Queensland (CAQ), Queensland Health

The Queensland Cancer Register (QCR) is a population-based cancer register managed by Cancer Alliance Queensland (CAQ), Qld Health. In collaboration with CAQ, CSIRO has developed Medtex, a natural language processing tool designed to automate selected cancer registry tasks.

Medtex identifies pathology and radiology reports that must be notified to the QCR. This tool aims to minimise the operational burden on pathology and diagnostic imaging providers by automating the process of distinguishing notifiable reports from non-notifiable ones. Medtex is unique in that it targets the full range of cancers, as opposed to tumour specific extractions used in other systems and studies. It extracts information for various reporting purposes—including cancer notifications, cancer staging and synoptic reporting—and stores it in the Queensland Oncology Repository. This supports the clinical coding workflow and improves data collection capture within the QCR.

Continual improvements and extensions to Medtex include the extraction of a broad range of cancer information such as cancer stage and recurrences across multiple cancer types, which are important determinants of cancer survival. Given that effective cancer staging depends on full access to both public and private pathology and radiology reports from across the State, CAQ and CSIRO are ensuring that Medtex solutions are generalisable, scalable, and performant across all providers and report types.

Read more about Medtex in Health Data Semantics and Interoperability: Platform Technologies.



Medtex for the notification of electronic cancer pathology reports and the coding of notifications data including synoptic and staging information. Medtex processes narrative pathology reports and generates structured data with inherent explainability, aiding clinical coders in cancer abstraction tasks.

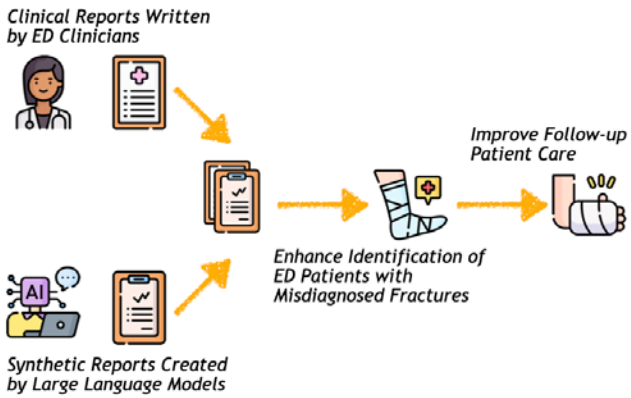
Enhancing abnormality detection from radiology reports using large language models (LLMs) to prevent missed fractures

Collaborator: Royal Brisbane and Women's Hospital ED

Patients admitted to a hospital ED with a suspected fracture are X-rayed, treated and then discharged. However, when the X-ray report is later finalised by a radiologist, ED specialists have to manually match the report from the radiologist with the patient's discharge diagnosis to ensure that subtle fractures were not missed. This manual checking process is essential but laborious, often occurring several days or more after the patient is discharged. Automating this process can help ensure abnormal findings are not missed and that patients receive appropriate follow-up care.

LLMs have demonstrated impressive capabilities in generating human-like content and hold significant potential for improving healthcare performance and efficiency. One important application of LLMs is generating synthetic clinical reports, which can alleviate the burden of annotating and collecting real-world data in training AI models. However, there are concerns and limitations regarding the use of commercial LLMs to handle sensitive clinical data.

To address this, the use of open-source LLMs was investigated as an alternative for generating synthetic radiology reports to supplement real-world annotated data. Locally hosted LLMs achieved similar performance compared to commercial models like ChatGPT and GPT-4 in augmenting training data for the downstream task of report classification to identify misdiagnosed fractures. The predictive value of using synthetic reports alone for training downstream models reached more than 90% of the performance using real-world data. The findings indicate that open-source, local LLMs can be a promising option for creating synthetic clinical reports for downstream tasks, helping to prevent missed fractures and enhance patient care.



Improving patient care: leveraging large language models to detect fractures in radiology reports.

Health Data Semantics and Interoperability: project updates

SNOMED CT in QLD digital hospital projects

Collaborator: Office of the Clinical Information Officer (OCCIO), Queensland Health

We have continued close collaboration with Queensland Health's Office of the Clinical Information Officer (OCCIO) to support the use of SNOMED CT in the Cerner ieMR product deployed in Queensland hospitals. This involves providing education and support to the team around the use of SNOMED CT in surgery, emergency departments and trauma, particularly during terminology updates, as well as support and maintenance of SNOMAP-ED.

SNOMAP-ED is a tool which takes the original SNOMED CT-encoded patient data recorded by emergency department clinicians and transforms it to qualify for activity-based funding. This is being used in Queensland digital hospitals to allow the SNOMED CT-encoded data to maintain its true value for clinical care delivery and to ensure it complies with, and qualifies for, activity-based funding. SNOMAP-ED has both SNOMED concepts and ICD-10-AM codes which are updated twice per month and Queensland digital hospitals can submit data for activity-based funding in near real time.

We are also working with Queensland Health to have this map available through to Queensland Health sites through the Queensland Clinical Terminology Service as a FHIR concept map.

SNOVet with ACDP

Collaborator: Australia Centre for Disease Preparedness

SNOMED CT has a companion veterinary extension, SNOVet, which is currently managed outside of the SNOMED International. With the increase in focus on One-Health as the intersection of human, animal and environmental health, a terminology that allows for consistent data capture across these domains will be useful.

Together with CSIRO's Australian Centre for Disease Preparedness (ACDP), we are aiming to use SNOVet as the basis of data capture across the ACDP biosecurity STARS web service, which captures data about biological samples sent to ACDP for analysis. Through this real world use we are aiming to improve One Health content coverage within the international terminologies (SCT and SNOVet) through identification of content gaps and addition of new concepts.

ACDP is now progressing to implementing new FHIR enabled codesets delivered to their systems through Ontoserver. We are continuing to deal with the labs legacy data through mapping processes and this is going well. We are also investigating alternative terminologies or taxonomies which may have greater suitability over SCT for their varying use cases.

RANZCR Project

Collaborator: Royal Australian and New Zealand College of Radiologists (RANZCR), Australian Diagnostic Imaging Association (ADIA)

RANZCR and the ADIA contracted us to assist in the development of a pilot radiology referral set (RRS) using SNOMED CT content. The primary goal of the project is to develop a standards-based set of codes to support the electronic requesting of radiology investigations.

The key deliverables were:

- A set of 20 radiology services coded using SNOMED CT
- Machine-readable artefacts to support the adoption of the terminology by software vendors. Guidance for the use of these artefacts including:
  - Starter implementation guidance for requesting and receiving systems (RRS)
  - Guiding principles for the ongoing development of the RRS after this project

This work has been absorbed into the Sparked Project. CSIRO are providing advice and assistance to RANZCR as they develop a comprehensive standards-based catalogue for use in eRequesting for radiology services. The resultant valueSet will be referenced within the Sparked eRequesting specifications.

The current draft map now covers over 1000 procedures, with over 400 equivalent maps accepted for use. The remaining procedures generally require qualification with laterality to provide left/right/bilateral variants.

ACDC+ Project

Collaborator: Digital Health CRC, University of Queensland, Regis Aged Care, AutumnCare

The Aged Care Data Compare Plus project will implement and evaluate the use of data standards and technologies to support quality of care benchmarking and quality indicator reporting. An Aged Care Quality Indicator (ACQI) app that leverages Smart Forms technology and FHIR data exchange standards will be trialled as a solution to ease the burden of quality indicator reporting requirements, while providing a standard data representation that can be used for further analytics and risk adjustment.

Development of the ACQI App is nearing completion. This includes a Smart Forms app for the display and completion of quality indicator information. CSIRO has also developed a FHIR facade component that can be deployed in an aged care clinical system to support the exchange of FHIR compliant data structures between the clinical system, Smart Forms app and data analytics server. Working closely with project partner, AutumnCare, they have developed components necessary for the integration of the ACQI App. The next phase of the project will see the ACQI App piloted in a real-world setting covering two quality indicator reporting periods.

Automation of AMT Modelling

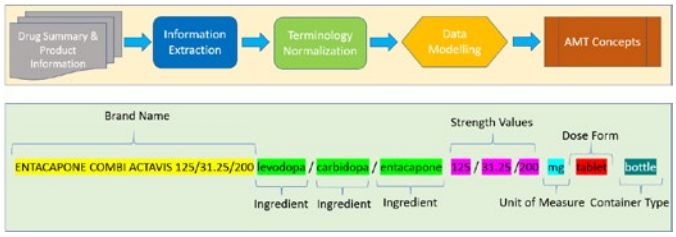
Collaborator: Australian Digital Health Agency

The Australian Medicines Terminology (AMT) is the national standard terminology for describing medicines and is a key enabler of medicines interoperability. AMT is authored manually by a team of pharmacists and released monthly by the ADHA. The aim of this project was to develop algorithms to automatically produce AMT from drug registration information in the Australian Register of Therapeutic Goods to support the ADHA in creating efficiencies in maintaining the AMT.

We have proposed algorithms to detect ingredients and their unit measures as well as strength values from the ARTG drug summary. The experimental evaluations showed that the accuracy performance was significantly improved from the baseline method to our proposed method. These results indicate the viability of developing a complete system to extract all necessary information to convert a drug summary into AMT data model with a high degree of accuracy.

This work has now been expanded to explore the feasibility of using LLMs to generate fully specified names and preferred terms for concepts in the new AMT specification version 4. At this stage, we have fine-tuned GPT-3.5 for the task of name generation. The evaluation results on the test dataset are promising, and it has been integrated as a generative AI component in the new AMT automation system.

We are now looking at further improvements to cover automation of other modelling aspects of AMT v4.



Semantic search for clinical terminology

Collaborator: InterSystem

Finding concepts in large clinical terminology systems can be challenging when queries use different vocabularies. A search algorithm that overcomes this problem is useful in applications such as data annotation or concept normalisation, where concepts can be referred to in different ways, using different synonyms. However, current search algorithms only use standard string matching without understanding the meaning of the queries, so they only work well when the queries and their expected results share many words in common.

To overcome this limitation, we propose a deep learning-based approach to build a semantic search system that understands the queries and search results by their meaning. Particularly, an ML model has been trained to encode concepts' labels into high-dimensional semantic embedding vectors, thus they can be indexed in a distributed vector database for quick approximate nearest search.

The main deliverables included:

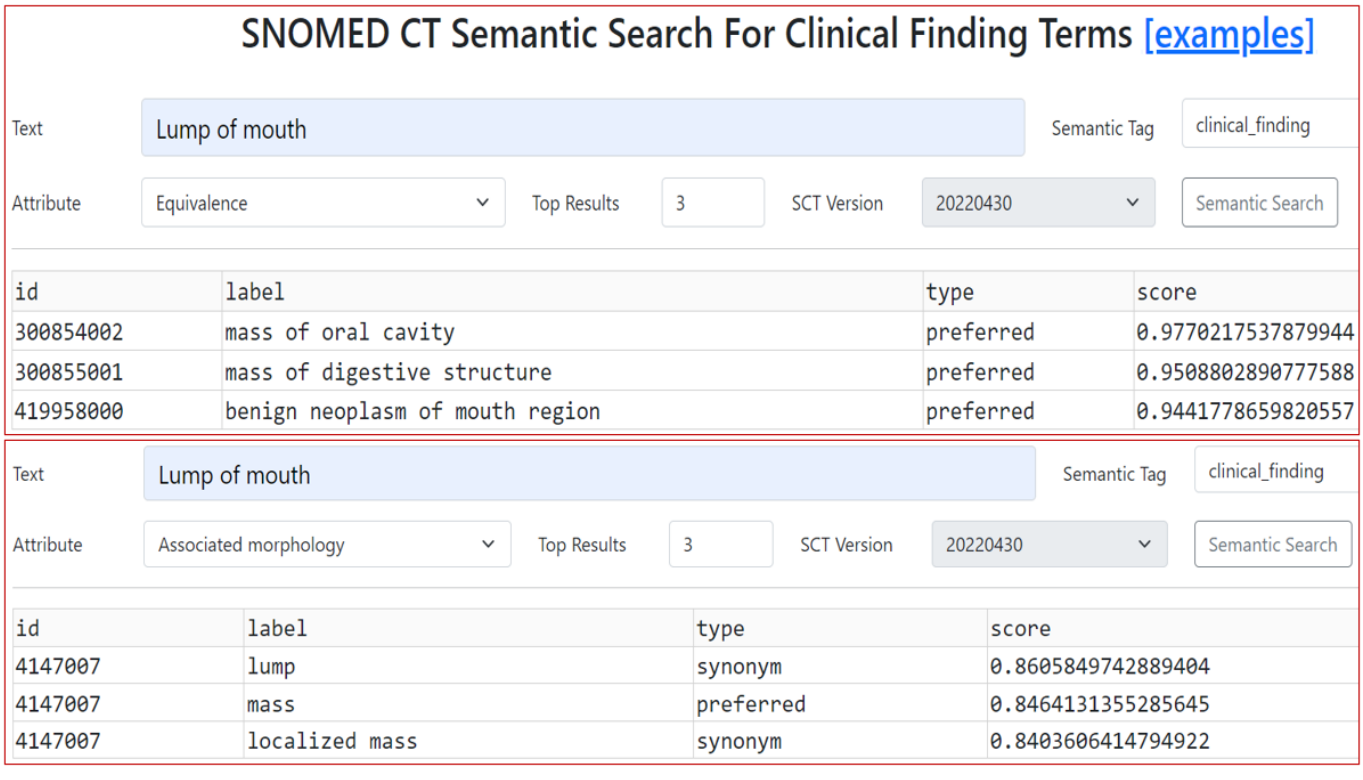
- A research paper published and presented in the Ontology Matching ISWC 2022
- A research paper published and presented in the AMIA 2022 Annual Symposium
- An abstract paper published and presented in the SNOMED Expo 2023
- A poster displayed at the MEDInfo23 conference

Digital health software project course with the University of Queensland

Collaborator: University of Queensland

We again partnered with the University of Queensland (UQ) to offer a health informatics on FHIR course to third- and fourth-year IT/software engineering students in the second semester of 2023. The course was led by Dr Chelsea Dobbins, lecturer at the UQ School of Information Technology and Electrical Engineering, and CSIRO Distinguished Visitor Professor Mark Braunstein. This year's cohort of students was significantly larger than previous years, up to 73 students.

The students worked with a group of clinical stakeholders including researchers from AEHRC, with student groups building SMART-on-FHIR apps. Professor Braunstein's Health Informatics on FHIR online course was further expanded to include more videos and exercises covering the Australian digital health landscape. Once again, we had an impressive series of guest lectures from local, interstate and international experts, including presenters from AEHRC talking about FHIR, SMART apps, and clinical terminology.



ARDC HeSANDA Project

Collaborator: Australian Research Data Commons, Health Translation Queensland, Queensland Cyber Infrastructure Foundation

The HeSANDA (Health Studies Australian National Data Asset) program is a strategic partnership with the Australian health research community to build a distributed national data asset from the outputs of health studies to support health data sharing and secondary use. HeSANDA will make health and medical research data easier to find, access, share and reuse, resulting in a reduction in research waste and improved researcher collaboration. It will increase Australia's return on health and medical research investment by reusing existing data to inform new research questions, initiate new research collaborations and lead to improved health outcomes for patients.

The AEHRC, along with its partners, is one of nine nodes who was successfully awarded $300k in funding to join this initiative in September 2021. The Queensland node implemented a Dataverse instance, as its operational platform, to facilitate the collection of the clinical trial metadata.

One of the outcomes of HeSANDA is the HDA platform, which launched in July 2023. Following the launch, a community connect project was initiated, in July 2023, to inform and educate the clinical trial community in Queensland about HeSANDA and the Queensland Node. This initiative has instigated a series of virtual and in-person workshops and the design of a suite of videos to better inform the clinical research community in Australia on four topics:

- Benefits of data sharing
- What is Health Data Australia
- How to setup your clinical trial up for sharing
- Why is metadata important for research

The HDA platform was launched in July 2023.

The community connect project culminated in the official launch of the HeSANDA Queensland Node in November 2023. The Queensland node has been successfully awarded an additional $200k in funding in April 2024 to extend the activities of the HeSANDA project until May 2026. The next phase of the project will expand the HeSANDA catalogue to include cohort studies and registries.

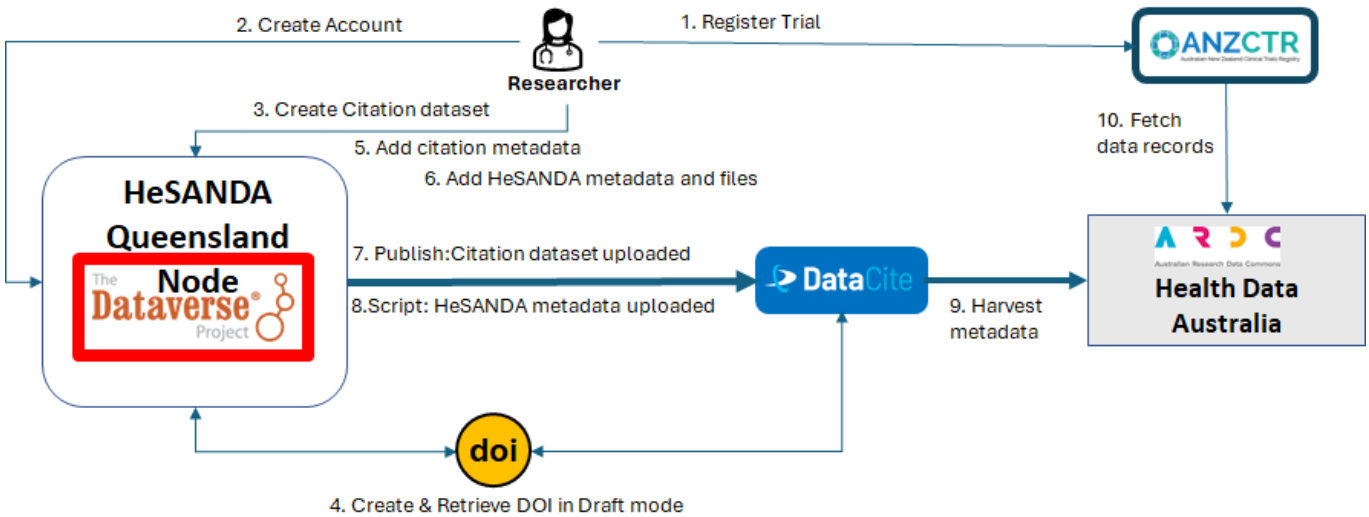
The 3,000 Genomes project: using machine learning and artificial intelligence for robust culture-independent susceptibility testing

Collaborator: Pathology Queensland, University of Queensland, AMR Mission

AMR is a growing threat with newly emerging resistance genes rapidly spreading in our hospital system.

However, while species level identification from genomic data is relatively straightforward, detection of the presence of AMR genes is not always reliably predictive of phenotypic susceptibility. For rapid genomics-based diagnostics to be fully realised in clinical practice, we need predictive algorithms to robustly guide safe and effective antibiotic therapy. The prediction of resistance in bacteria is challenging because of complex underlying mechanisms and high rates of acquisition of resistance determinants via horizontal gene transfer.

In collaboration with Pathology Queensland and UQ, this project develops bespoke reliable machine learning analysis workflow to optimise rapid resistance prediction of antibiotic susceptibility from whole genome data for common bacterial pathogens. Two established machine-learning models were used to obtain the AMR contributory genotypic and *k-mer* frequency-based features. The features were individually evaluated for the classification performance with scores exceeding 90% observed on both the training and the validation datasets.



Pathology and clinical data integration for infectious disease monitoring in a hospital setting

Collaborator: Queensland Genomics, Pathology Queensland, University of Queensland, AMR Mission

Hospital-acquired infections (HAI) particularly those resistant to antibiotics, are a common and costly issue for modern health care globally, and can be a significant risk to hospital patients. However, while laboratory reporting is an inherently manual process, prompt responses are often necessary, and automation and integration of HAI processes save time and improve data quality.

We have extended our collaboration with Pathology Queensland and UQ to also include Metro North Hospital and Health Services to implement a FHIR-based bioinformatics pipeline. This pipeline provides seamless integration of non-standardised data from the pathology laboratory and emergency department to a FHIR server, enabling a platform to build SMART-on-FHIR apps and a standardised API for accessing the data. This is enabling easier access to data forward visualisation, dynamic analysis and reporting of outbreaks within a hospital setting.

This pipeline has been integrated into the QLD One Health AMR Hub platform to showcase antibiotic sensitivity testing apps for the AMR mission. We are, presently, formalising the pipeline to adhere to the FHIR AU-CORE specifications, which will give rise to a FHIR *Implementation Guide*.

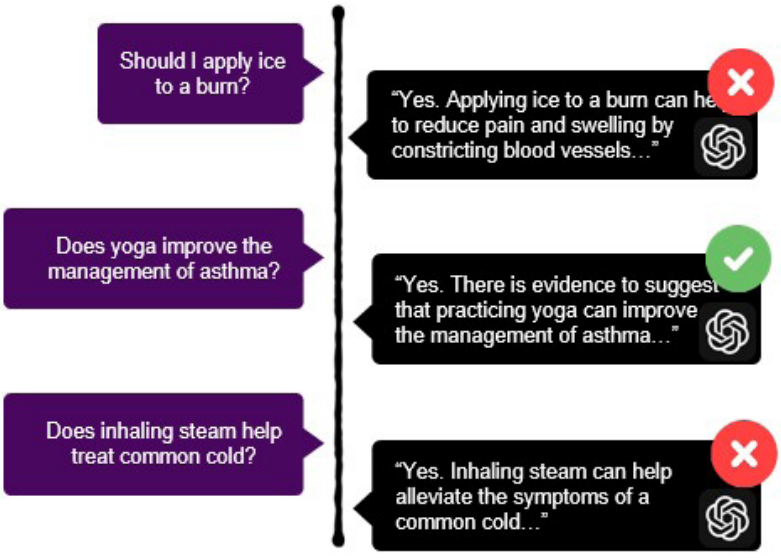
How effective are large language models like ChatGPT at answering health related questions?

Collaborators: Queensland Digital Health Centre (QHDeC), University of Queensland

As people depend more and more on generative LLMs like ChatGPT, it is critical to understand model behaviour under different conditions, especially for domains where incorrect answers can have serious consequences such as health.

We empirically evaluate ChatGPT to show not just its effectiveness but reveal that knowledge passed in the prompt can bias the model to the detriment of answer correctness.

While AI tools like ChatGPT have exploded onto the scene of late, there is very little rigorous evaluation of both their effectiveness and how different conditions impact their answers. In this preliminary study, we hope to shed some light on these important concerns about using such systems. In addition, this work can help in the development of more robust and transparent question-answering systems based on generative LLMs. Indeed, based on our findings we are now developing new LLMs that provide answers backed by reliable evidence sources.



Examples of common health questions asked of LLMs and the accuracy of answers.

Towards personalising hospital antibiograms: Enhancing antimicrobial stewardship through patient-centric resistance data

Collaborator: Metro North Hospital and Health Service (The Prince Charles Hospital)

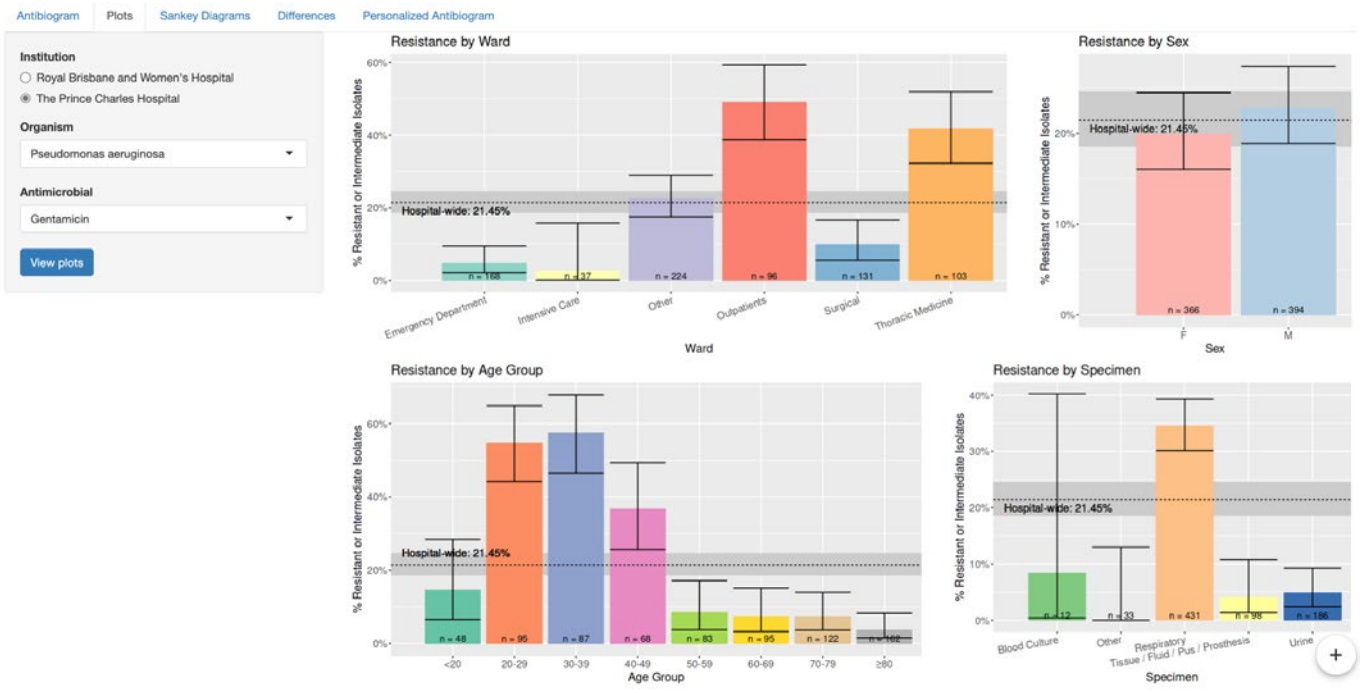
Hospital antibiograms play a pivotal role in antimicrobial stewardship efforts, serving as a data-driven tool to understanding institutional AMR rates and guide prescribing decisions.

Clinical studies have revealed that hospital antibiograms may misrepresent resistance rates for certain patient subgroups. This discrepancy has led to research aimed at personalising antibiograms to offer more targeted resistance data based on individual patient characteristics.

While ML approaches to predicting resistance continue to evolve, an alternative method seeks to inform clinicians of significant associations between resistance and patient characteristics, providing transparent insights for antibiotic prescribing.

This study investigates the extraction of patient subgroups with significant differences in resistance patterns from hospital AMR data. The clinical implications of personalising resistance data were considerable, with analyses revealing numerous encounters at major hospitals from January to August 2022 where the suitability of antibiotics for treatment were affected. These differences were attributed to patient characteristics, highlighting the limitations of antibiograms stratified by single characteristics such as ward or specimen type.

Such stratifications, commonly recommended in clinical studies and antibiogram specifications, do not fully capture the variations in AMR within an institution's patient population and lack sufficient levels of personalisation.



Hospital-wide AMR rates (grey bands with their 95% confidence interval) are masking patterns or group effects in certain patient subpopulations

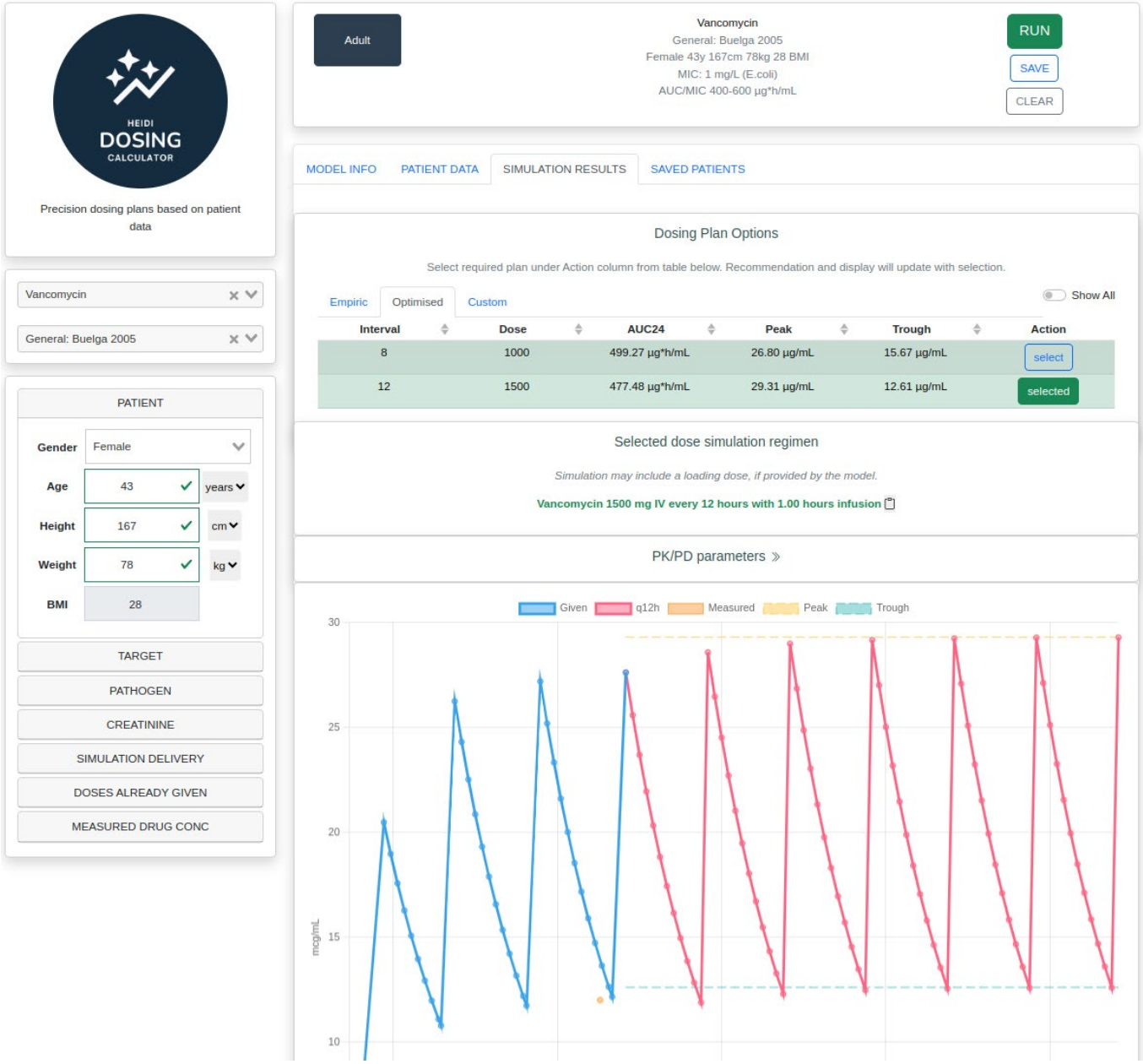
Improving antimicrobial dosing in critically ill patients

Collaborator: Metro North Hospital and Health Service (MNHHS; Royal Brisbane and Women's Hospital, The Prince Charles Hospital, Redcliffe Hospital), The University of Queensland

Difficult-to-treat infections are those caused by multi-drug resistant organisms, requiring prolonged antimicrobial therapy and often leading to patients being acutely unwell and in need of life-saving interventions. These patients are prevalent throughout the hospital system and are at high risk of poor outcomes, including death. A significant proportion of the morbidity and mortality associated with these infections can be attributed to suboptimal antimicrobial therapy, including ineffective dosing, which may also lead to the emergence of AMR.

A potential game-changer to address these profound antimicrobial dosing challenges is precision dosing, where dosing is personalised for the patient by considering all available data, including pathogen susceptibility and measured antimicrobial concentrations.

The project aims to collaborate with key groups and develop and validate via end-user (i.e., clinicians) assessments, a proof-of-principle dosing software solution feasible for MNHHS, Queensland, and beyond.



HeIDI-CSIRO Precision Dosing Calculator: A proof-of-principle software solution.

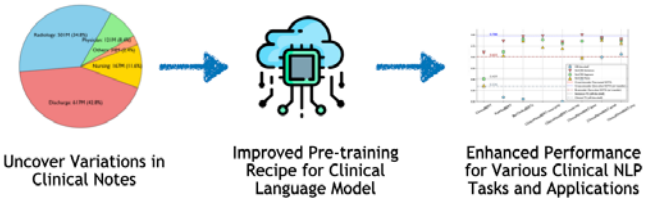
Pre-training recipes for language models - Uncovering variations in clinical notes for NLP modelling

Collaborator: The University of Melbourne; RMIT University

LLMs pre-trained on large amounts of text have become the backbone of many NLP systems and applications. Typically, LLMs are based on transformer neural networks, with architectural variations in encoder, decoder, and encoder-decoder configurations.

These different types of models present numerous opportunities to create value in healthcare. While decoder-based generative chatbots like ChatGPT are widely popular, fine-tuned encoder-based LLMs remain state-of-the-art in the clinical context.

Our series of highly performant and efficient 'ClinicalNoteBERT' encoder models achieve better results than baseline models of similar or larger sizes on various clinical NLP tasks and datasets, demonstrating the benefits of our pre-training recipes. Different choices made during pre-training can lead to improvements for the downstream tasks. Notably, our small and tiny versions of ClinicalNoteBERT maintain over 96% and 91% of the best performance with less than 61% and 14% of the parameters, respectively.



Unlocking insights. Exploring clinical note variations for NLP modelling

What Matters 2 Kids

Collaborator: UQ

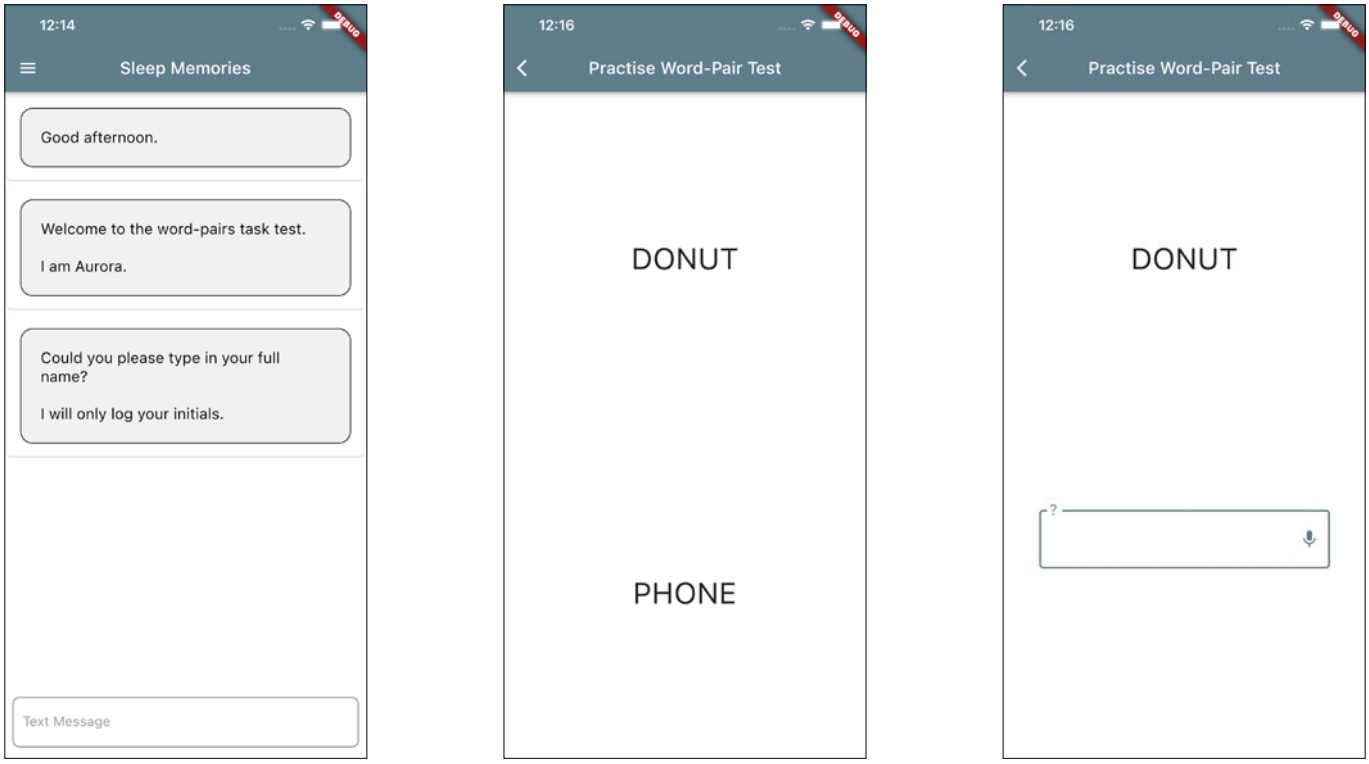
The What Matters 2 Kids (WM2K) project is co-designing a nationally relevant, strengths-based well-being measure for Aboriginal and Torres Strait Islander children. To that end a collaboration between CSIRO and the University of Queensland has combined art and technology into a new chatbot app. The WM2K app mimics art and yarning sessions by inviting the child to draw on a tablet and then asking them to describe their art and its importance to them. Rather than settling for an AI generated voice, the spirited young voice of First Nations child, Stevie Fagan was used to engage with users as the app captured their data.

Aurora: Sleep dependent memory chatbot

Collaborator: University of Sydney

A body of evidence supports the notion that sleep contributes to memory consolidation. Despite these findings, sleep-dependent memory is not routinely studied particularly in people living with mild cognitive impairment. Aurora is a chatbot that administers a sleep-dependent word-pair memory test developed at the University of Sydney for people living with mild cognitive impairment.

Aurora sets up a user profile, provides instructions to the user, and display the word-pairs widget within the valid time window. It also coordinates scheduling of notifications and procedures when a missed appointment has occurred. Aurora is now being deployed in several pilot studies by the University of Sydney.



Screenshots of the Aurora chatbot introducing itself and example word pairs that the user is asked to memorise and recall before and after sleeping.

Health Data Semantics and Interoperability: postdoc and student highlights

Postdoctoral fellow

Yutong Wu, CSIRO Research+ Postdoctoral Fellowship

CSIRO Research+ Postdoctoral Fellowship

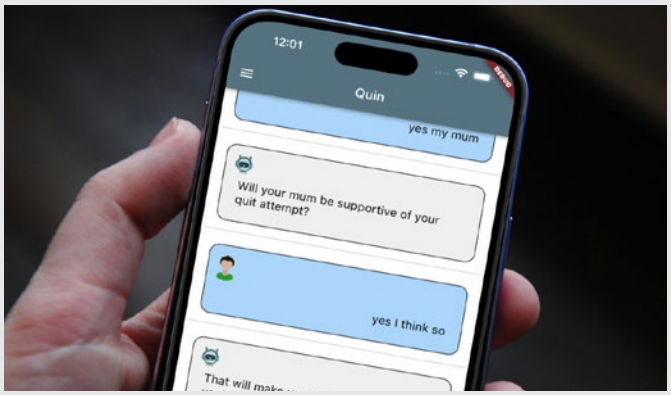
Most health data is recorded in free-text unstructured documents. This data contains valuable information for clinical decision making and secondary use. However, its clinical importance and large volume hinders manual analysis – undermining effective clinical decision support and population health monitoring and reporting.

In this research, interpretable deep learning algorithms, including LLMs, have been developed to automatically extract and classify clinical information from both unstructured clinical notes and structured data sources. These approaches scale to large amounts of data and have been integrated within a highly distributed computational framework. Challenges include the meaningful interpretation of noisy free text from different report types across disparate sources and coping with rare diseases for which only few samples are available for computational learning.

AI-driven search engine technology

Shengyao Zhuang, CSIRO Research+ Postdoctoral Fellowship

LLMs like ChatGPT stand to have a huge impact on how people seek and consume information. Shengyao's is developing novel models and applications of LLMs in the health space. He has shown how these general purpose, foundational models can be tailored to answering clinical questions, without the need for vast amounts of training data required for previous approaches. While making core scientific contributions to search engine research, he also aims to achieve real impact by translating his research to working systems. In particular, on a project to build a search engine to help doctors at Queensland Children's Hospital find targeted treatment for kids cancer.

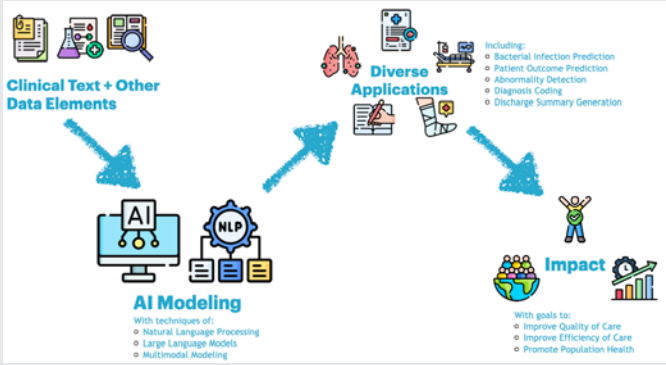


Screenshot of the chatbot 'Quin' asking the user whether they will have family support when quitting smoking.

Jinghui Liu, CSIRO 'Impossible Without You' Postdoctoral Fellowship

The research investigates the application of NLP and LLMs to analyse and interpret diverse healthcare data to improve clinical decision-making. A primary challenge being addressed is how to integrate different types of clinical data, encompassing both measurements and clinical text, through multimodal modelling and innovative LLM applications. By examining clinical notes and other sources, the research seeks to offer valuable clinical insights to enhance care decisions.

One key focus area is developing data-driven approaches to understand and minimise AMR. This involves creating an analysis platform for electronic health records that leverages the power of LLMs to support clinical decision-making regarding prescriptions, promote antimicrobial stewardship, and analyse AMR patterns.



Leveraging AI to transform clinical data into healthcare solutions.

PhD students

Conversational AI to support smoking cessation: The co-design development of Quin, a smartphone application-based smoking cessation chatbot

Hollie Bendotti

Tobacco smoking continues to be a public health challenge as a top contributor to global and national burden of disease. Whilst there are effective, evidence-based treatments to assist smoking cessation, many people choose to quit unaided. Conversational AI, such as chatbots, have the potential to bridge the divide between professional and population-level interventions, by providing in-pocket access to a highly tailorable and interactive smoking cessation counsellor. This project aims to assist in addressing these gaps via the development of a smoking cessation chatbot called Quin, with the novelty of the research being a multi-phase, co-design approach with embedded agile mobile health development processes.

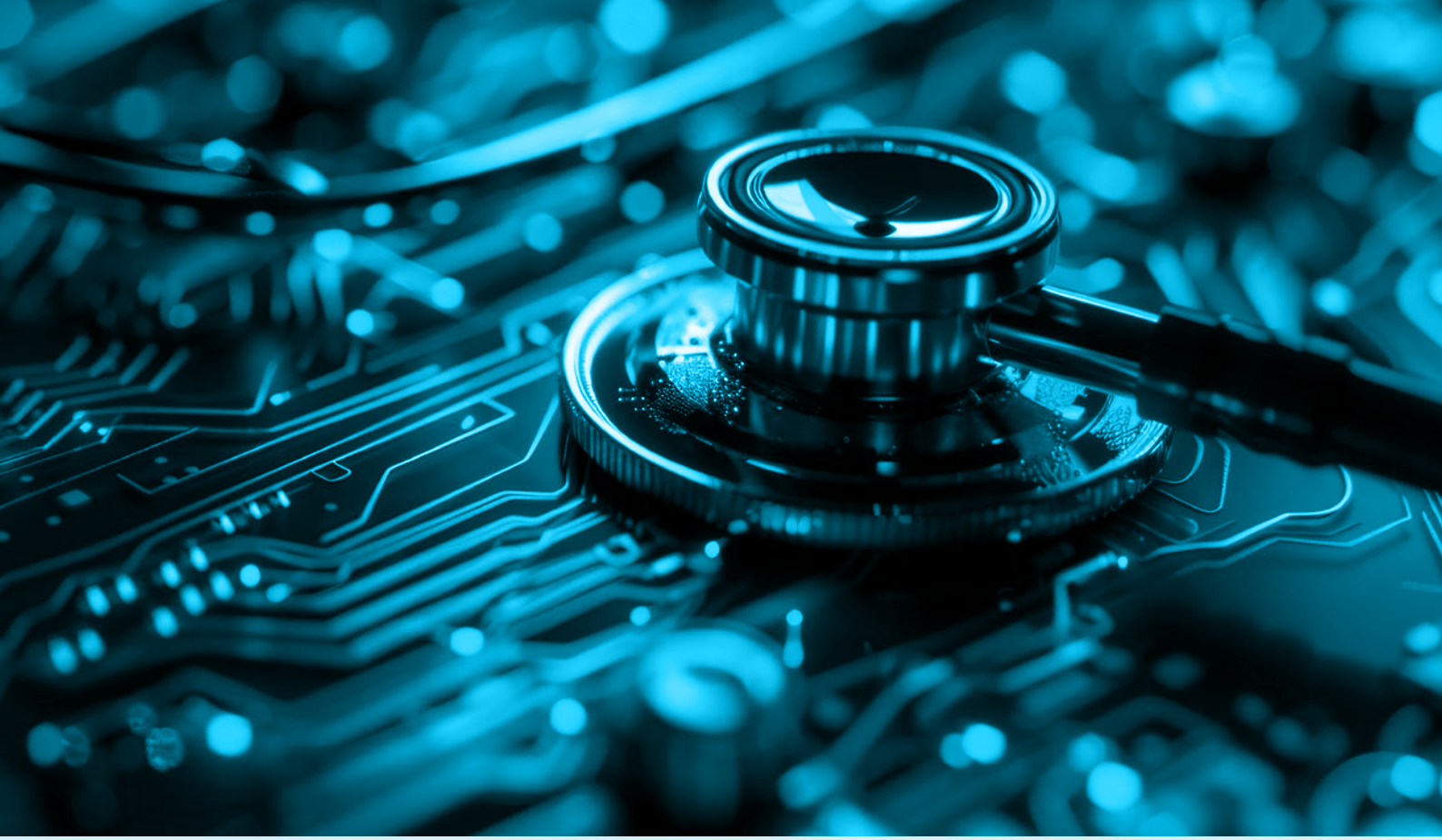
The Transformational Bioinformatics group

Group Leader: Dr Denis Bauer

The Transformational Bioinformatics group enables scientists and industry partners to scale their research output using cloud-computing and machine learning. The group delivers impact in two areas: human health and biosecurity.

Transformational Bioinformatics science and impact highlights for 2023/24

- We led the publication on the future of genomic data management and dynamic consent, with co-authors across 10 research organisations and universities, emphasising the need for putting the individual at the top of decision-making process (GigaScience, Impact Factor 9.238)
- Together with the Australian Centre for Disease Preparedness, we secured two contacts with the US Food and Drug Administration investigating the impact of infectious diseases on host systems
- We continue to collaborate with external researchers and organisations, developing novel bioinformatic solutions for newborn screening as well as ribonucleic acid therapeutics and vaccine development with additional successful grant applications
- Denis Bauer graduated from the Australian Institute of Company directors
- Letitia Sng was selected for Science Meets Parliament
- Natalie Twine and Laurence Wilson prepared and embarked on their international leg of the Julius Award



Genome Insights team

Team Leader: Dr Natalie Twine

Acting Team Leader (Jan 2023 – Oct 2023): Dr Letitia Sng

The Genome Insights team generates knowledge into genome-trait relations by analysing population-scale 'omics (genomics, transcriptomics, proteomics) and integrating with observational data. Our aim is to discover the genetic origins of disease and ultimately improve and personalise diagnostics and identify new therapeutic targets. Our software solutions also facilitate the incorporation of genomic information into clinical practice via genetic risk score predictions or synthetic data generation.

Digital Genome Engineering team

Team Leader: Dr Laurence Wilson

The Digital Genome Engineering team develops analytics and web-services to improve genome technology applications in the health and biosecurity spaces. By computationally guiding editing machinery, such as CRISPR-Cas9, we improve accuracy and efficiency for precision therapy and biosecurity applications (such as genetic control of invasive and dangerous species). We also apply our technologies in the RNA therapeutics and vaccine space and advance our understanding of pathogen-host interactions.

Bioinformatics Products team

Team Leader: Yatish Jain

The Bioinformatics Products team leverages cloud technologies and machine learning approaches to develop innovative bioinformatics platforms and novel algorithms in the health and biosecurity domain. Sustainable software development not only facilitates reproducible research but also creates commercialisation possibilities. The team builds sustainable bioinformatics solutions and distributes them using various delivery vehicles such as infrastructure as a code, web interfaces, cloud marketplaces and federated APIs to reach broader bioinformatics communities.

Transformational Bioinformatics: platform technologies

VariantSpark

Collaborators: Seoul Clinical Laboratories (SCL), SAHMRI, UKBiobank, DNAnexus

Our genomes hold information that can substantially improve clinical care. However, finding the actionable information in the 3 billion letters of the human genome is challenging. While genome wide association studies (GWAS) have identified individual genetic contributors to diseases and traits (biomarkers), and polygenic risk scores (PRS) capture the overall genetic disease risk, there is no methodology able to identify the set of specific biomarkers that capture contributions from individual genes as well as the interaction between genes to predict overall disease risk. VariantSpark provides this capability, thereby improving clinical care while also increasing knowledge of the molecular mechanisms of disease.

VariantSpark is a ML approach implemented using distributed computing (Apache Spark) that is scalable to cohorts of 100,000+ whole genome sequences. Enhancing interpretability of results, we developed a novel statistical approach to control for false positives (*Computational and Structural Biotechnology Journal*, 2023). We demonstrated the power of VariantSpark by analysing Alzheimer's disease (SciRep, 2023) and COVID-19 viral data (Computational and Structural Biotechnology Journal, 2022), finding disease markers that were independently validated in Alzheimer's Disease Neuroimaging Initiative cohorts and laboratory experiments. An active community of developers and researchers is now involved in the VariantSpark project to improve the code base and explain its application within health. VariantSpark is available for high-performance compute clusters, as well as for cloud computing, through services such as RONIN, AWS, Azure, and TerraBio.

Over the last 12 months, we analysed the world's largest genomic data repository (UKBiobank) using cardiovascular disease (CVD) phenotypes, being the first to process the whole genome sequencing data of 500,000 individuals.

We subsequently performed validation analysis using the NIH TopMed datasets (CVD) cohorts. Our research in Alzheimer's disease yielded the ground-breaking finding that VariantSpark captured more genetic variance in the UKBiobank and ADNI cohorts than is possible with traditional logistic regression methodology (PLINK).

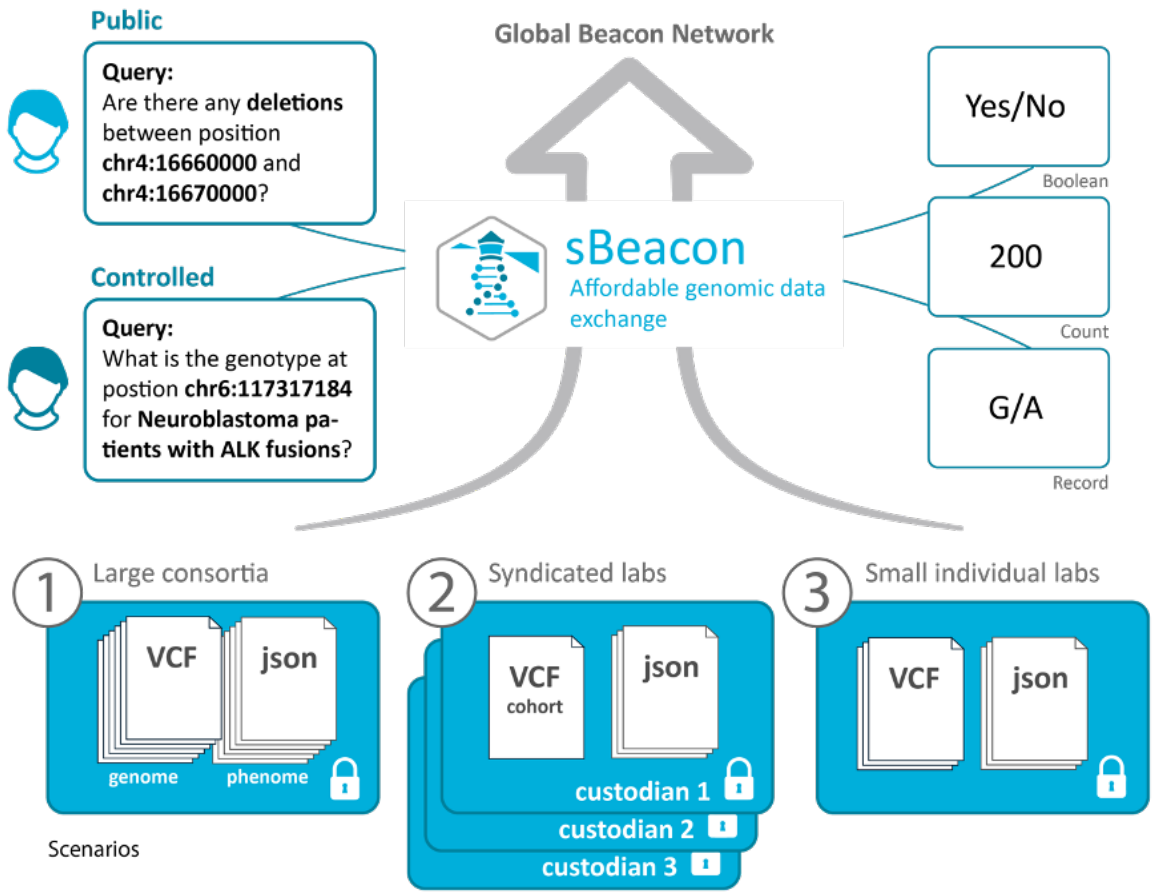
We further developed an ecosystem of open-source software around VariantSpark, such as BitEpi (SciRep, 2021) which uncovers the interacting genes from the VariantSpark output and visualises them in their biological context, as well as PEPS (MEDInfo23) to create realistic synthetic phenotypes datasets. Speaking to the application agnostic capability of VariantSpark, we have investigated applications for VariantSpark in the minerals and mining domain.

Serverless Beacon

Collaborators: Alliance for Genomics in Health (GA4GH), UMCCR, MGHA, DFAT, and GISlab, Indonesia, Australian BioCommons

Data sharing in genomics is a crucial yet challenging task. The sheer volume of genomic data increases every day with application for researchers, clinicians, and pharmaceutical organisations, e.g. cohort studies, diagnostics, and drug discovery. sBeacon is a cloud-native federated data exchange platform published at *Nature Biotechnology* (impact factor 68). It implements Beacon v2 protocol by GA4GH, the internationally accepted standard for genomic querying. sBeacon also incorporates the international standard for clinical metadata handling, FHIR, through CSIRO's Ontoserver. This enables complex queries across genomic and phenotypic data.

VariantSpark can process both big and 'wide' genomic data to drive biological insights.



Serverless Beacon allows fast and economical exchange of genomic and metadata while enabling data custodians to regulate data access.

sBeacon is implemented on top of high performing AWS technologies such as AWS Lambda, DynamoDB, S3, and Athena, achieving real-time query time and scale to millions of samples. It caters to the vision for even a small organisation to stand up a Beacon and contribute the knowledge in their data to the world by eliminating idle time costs and automating infrastructure maintenance. The data storage architecture enables operation directly on the source data, which avoids data-duplications and supports direct control by participants through dynamic consent.

This year, we worked with GSIlab, Indonesia's second-largest sequencing facility, to adapt sBeacon for the pathogen space, achieving great scalability for continuous pathogen monitoring. We are currently developing sBeacon's pathogen domain further into PathsBeacon, which enables the rapid detection and tracking of specific pathogen strains. We also work closely with GA4GH on the release of the Beacon V3 standard.

Further, we're contributing to CSIRO's OneHealth initiative by standing up PathsBeacon for AAHL's avian influenza sequencing laboratories to allow researchers to query their sequenced genome and generate insights.

GT-Scan Suite

Collaborators: JCSMR, ANU, Gene Therapy Unit, CMRI, Westmead; Translational Vectorology Group, CMRI, Westmead

GT-scan is a platform solution that improves the accuracy of genome engineering applications (on-target scoring, SNP-aware off-target search) to enable novel high-precision applications such as human health. Finding a suitable genome editing spot is like finding a specific grain of sand on the beach; it needs to have the right shape and colour (properties for CRISPR to bind) and also be unique compared to all other grains on the beach (for CRISPR not to accidentally bind to another gene).

This is a very expensive task computationally. We reduced the overall runtime for this task from weeks to seconds by massively parallelising the individual search tasks using a revolutionary new compute approach called function-as-a-service or serverless.

We continue to expand the capability of the platform, working with collaborators at the University of Adelaide to develop analysis pipelines for new and emerging gene editing technologies (such as our PETAL tool for designing prime-editing applications) and targeting diverse populations (e.g. our VARSCOT2.0 pipeline).

Over the past years, we established a cloud-based computational framework for designing a wide range of CRISPR-based experiments. This platform comprises of several published tools including GOANA (evaluation framework for gene-editing experiments), TUSCAN (CRISPR-Cas9 on-target efficiency predictor), CUNE (efficiency and effect predictor for HDR-based editing) and VARSCOT (SNP-aware off-target finder).

Our work led to a review on CRISPR-Cas9 predictive tools (cited over 90 times) and has been presented at many international conferences. Read more in Transformational Bioinformatics: Project Updates.

This year we updated our webservers further by engaging with RMIT and UNSW students to improve the user experience of independent applications on GT-scan suite.

Specifically, GT-scan suite now follows a coherent template along with dedicated improvements to Goana and sInsider. We are continuing to expand the capabilities of the GT-Scan models, expanding to alternative CRISPR-Cas9 enzymes (such as Cas13) and developing models for predicting mutation-resistant guides for use in rapidly evolving populations (such as viral pathogens).

Genomator

Collaborators: Royal College of Pathologists of Australasia

Data powers our insights economy. But data is also hard to extract and transport due to data privacy and regulations. We are creating digital representations of data which can protect privacy while preserving statistical relationships to enable analytics. However, current statistical and deep learning methods for creating synthetic data struggle with large data dimensionality and volumes, are prone to hallucinating scenarios incompatible with reality, and seldom quantify privacy meaningfully. We developed Genomator, a patent-pending algorithm that is based on logic solving approaches (SAT solving), which efficiently produces private and realistic representations of the original data.

In the last 12 months, we have demonstrated Genomator on genomic data, which is the most complex and private information.

We generated synthetic data from a cohort of 1000 whole genome data and benchmarked against GenAI approaches, showing better utility and higher privacy protection.

Genomator is the only production-ready implementation scalable to whole genomes and capable of handling population-specific pharmacogenomic markers. It can be run in the data owner's trust environment (on-prem) with minimal compute resource needs.

We also developed Reverse Genomator, which can controllably re-link synthetic data samples to their real-world counterparts, enabling discovery projects which require re-identification upon discovering a patient-notifiable indication.

Transformational Bioinformatics: project reports

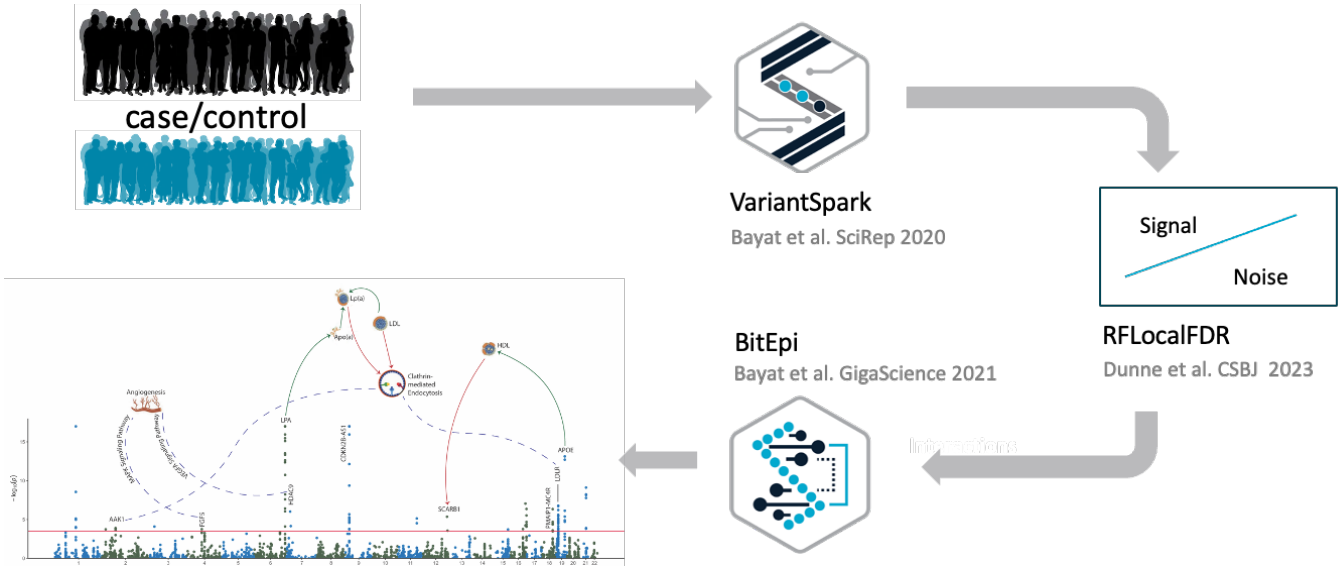
Identifying potential drivers for Alzheimer's and coronary artery disease inside the genome's dark matter

Collaborators: Johan Verjans (SAHMRI), Sydney University, UKBiobank, NIH TopMed, ADNI

Gene by gene interactions, or epistasis, are proposed as part of the solution to the missing heritability problem in genomics. For example, the cumulative heritability of known genetic variants for coronary artery disease is 28%. VariantSpark is a cloud-based machine learning platform that accounts for both marginal and epistatic effects of genotype associations to complex phenotypes. In conjunction with RFlocalFDR and BitEpi, we can identify statistically significant higher-order epistatic interactions, creating a complete genome-wide association study and epistasis analysis pipeline.

We have applied our pipeline to identify novel genes and genetic variants associated with two complex diseases, AD and CAD using the UKBiobank, which contains genotype and phenotype information from up to 500,000 samples. Validating our results for the AD phenotype with the Alzheimer's Disease Neuroimaging Initiative cohort, we identified two novel genes, SH3BP4 and SASH1, associated with AD through epistatic interactions with the well-known pathogenic APOE allele. The calculated variance explained for the UKBiobank cohort was shown to increase 10% with the inclusion of BitEpi interactions indicating that epistasis does indeed play a role in AD. We also demonstrate that VariantSpark detects disease associations with 80% fewer controls than traditional logistic regression, unlocking discoveries in well annotated but smaller cohorts.

This work was published in Scientific Reports (Lundberg et al., 2023). Similarly, we have validated well-known CAD loci, in the NIH Trans-omics for Precision Medicine (TOPMed) cohort using VariantSpark. Using BitEpi, there is evidence of epistasis between the CAD loci and a lncRNA, suggesting that this lncRNA may act as a disease modifier through a regulatory mechanism. VariantSpark also replicated another known CAD-associated gene which logistic regression on the same datasets failed to identify, reaffirming the increased sensitivity of VariantSpark to find signal in smaller but well annotated cohorts.



Workflow showcasing our full tool suite for VariantSpark platform, incorporating RFLocalFDR and BitEpi to identify disease associated genetic variants and epistatic interactions in CAD.

Uplifting population health capability for Indonesia and Malaysia

Collaborators: DFAT, and GSIlab, MoH Indonesia, Australian BioCommons

Spreadstopper is a $1M dollar project funded by the Australia Indonesia Health Security Partnership (AIHSP) originally tasked to increase the genomics tracking capability for COVID19. With the Indonesian Ministry of Health's involvement, its scope expanded into genomics analytics for various diseases, aimed to boost precision medicine capability in Indonesia. In collaboration with the Malaysia Genome and Vaccine Institute (MGVI), it also expanded into vaccine design. We are wrapping up the project with CSIRO's first Nature Biotechnology paper and with robust research and industry relationships.

The collaboration with GSIlab involved deploying and adapting the PathsBeacon tool, tailored to GSIlab's specific data management and analytical needs, enabling real-time genomic data analysis and visualization. This groundbreaking platform opens exciting possibilities for researchers, as it enables faster and more cost-effective complex queries.

Developing capability for precision medicine, we built capacity in analysing biobanks, specifically, the UK Biobank, which holds the world's largest publicly available genomic data. We developed RAPpoet, which is optimised to run bioinformatic pipelines across multiple files on their research analysis platform, achieving a 44% cost reduction and a 40% runtime speed-up. This framework can be leveraged and applied to other populations, such as Indonesia, when such datasets become available.

As part of the Vaccine Access and Health Security Initiative, CSIRO received funding from DFAT to support vaccine development in Malaysia. A 3-day event including seminars and workshops was conducted with cloud partners at MGVI in Selangor, Malaysia. Through this hands-on workshop, the attendees launched personalised compute infrastructure to analyse their data, increasing their bioinformatics capabilities and enhancing their skills in genomic analysis of pathogens.

This work has substantially improved the precision medicine capability in the Asia Pacific region and fostered strong R&D partnerships. Indeed, a follow-on funding request to the Indonesian government of $2.5M with GSIlab and Xapiens has been made. This project aims to deliver the analytics capability for Indonesia's genomics project of sequencing 10,000 individuals and discovering population-specific biomarkers for population health intervention.

Identifying genomic biomarkers for early diagnostics of metabolic diseases in Korean population

Collaborators: Seoul Clinical Laboratories (SCL)

In 2023 the Transformational Bioinformatics group initiated a consulting contract with Seoul Clinical Laboratories (SCL), the first nationwide reference laboratory in South Korea, to analyse Korean genomes with our flagship tool, VariantSpark. The patient samples have rich clinical information associated with them, such as cholesterol levels, which enhance the power of the study. The analysis is powered by Amazon Web Services (AWS) enabling our SCL clients to retain data ownership by bringing VariantSpark to their data in their own cloud environment.

We have worked with SCL in using VariantSpark to identify multiple novel genomic variants which are associated with metabolic disease but are specific to the Korean population. These genomic variants have not been previously identified in previous Eurocentric genome wide association studies, highlighting the importance of performing genome analysis in non-Caucasian populations due to the poor portability of results found in distinct populations.

This analysis will facilitate the development of novel biomarkers for early diagnosis of metabolic diseases and to guide the development of therapeutics that would be particular to the Korean population, building a truly personalised approach to healthcare. Furthermore, as the Korean researchers applied VariantSpark with our guidance, SCL now have the capability to apply VariantSpark to other diseases and datasets that they have access to, allowing them to continue to find novel biomarkers and therapeutics for other complex diseases that will be specific to the Korean population.

Dynamic and informed consent for genomic data management

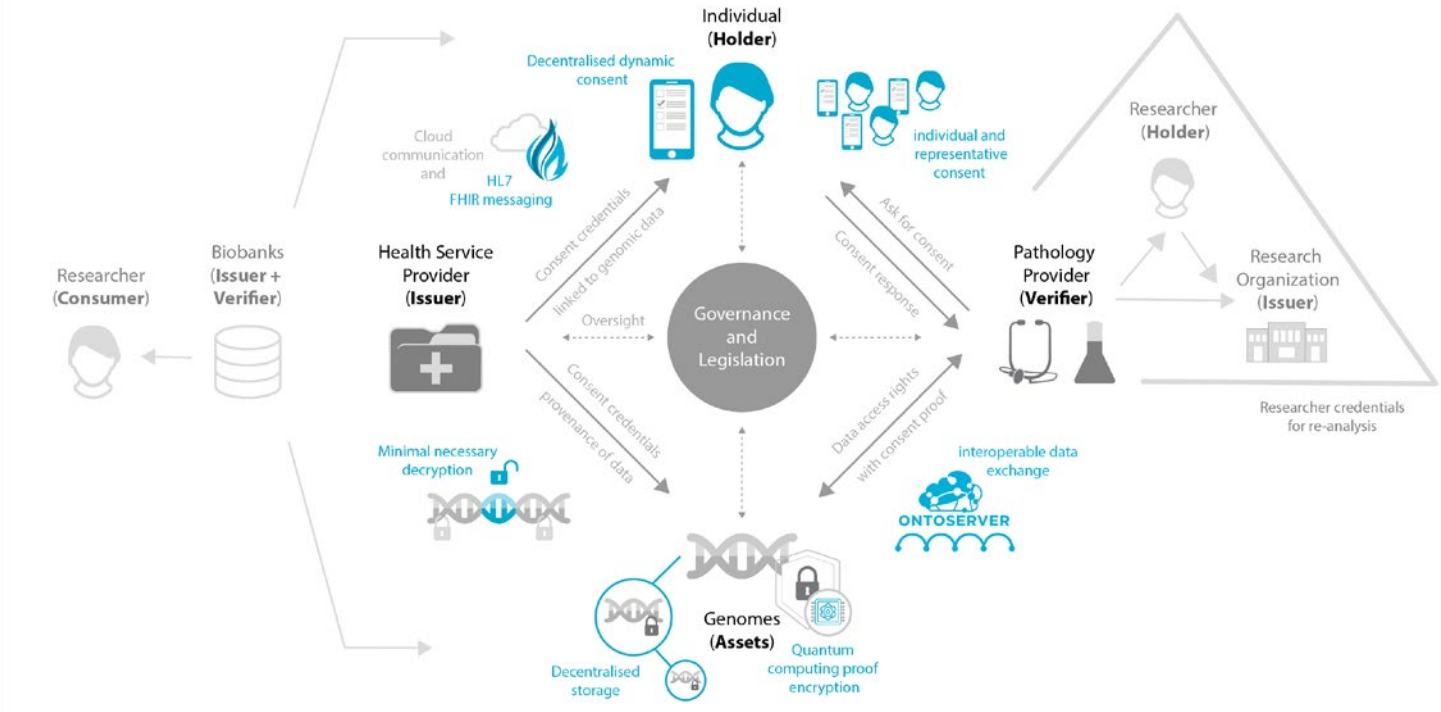
Collaborators: Sydney Children Hospital, NSW Health. NSW Pathology, Telethon Kids Institute, National Centre for Indigenous Studies

The dynamic informed consent model is an innovative approach in genomics and healthcare, focusing on continuous engagement and flexible participation while respecting cultural values. It is particularly beneficial for Indigenous communities, where the connection to genetic heritage differs from Western views. This model empowers individuals by giving them control over their genomic information, supported by recent studies [Yuwan et al., 2023], which emphasise individual authority over data access.

In collaboration with Sydney Children's Hospital Network and NSW Health Pathology, we are exploring a dynamic consent management system using infrastructure-as-code for the TRAIL newborn screening project, funded by the Medical Research Future Fund. We plan to use CSIRO's MacroKey digital wallet for managing volunteers' identities and credentials, implementing a password-less decentralised approach. Our backend leverages AWS services like S3, AWS Quantum Ledger Database, AWS Cognito, and AWS Lambda. This decentralised approach enhances trust and participation in genomics and health studies, empowering participants for better research engagement.

We first conducted a comprehensive review of available technologies for the platform, and published it in GigaScience [Oliva, Kaphle et al., 2024]. This review helped us evaluate and select the optimal set of solutions for the platform, based on our proposed trust model based on self-sovereign identity (SSI) principles. SSI allows users to control their digital identity and interactions with verifiable credentials.

The dynamic consent model we are developing is participant-centric. Participants' identity information is stored as verifiable credentials in a digital wallet on their mobile devices, enabling interaction with the consent platform. This wallet allows sharing information and digitally signing transactions, providing cryptographic proof of ownership. The wallet also stores consent states, reflecting participants' preferences for using their genomic and health data in various scenarios. An immutable ledger also stores these consent states, ensuring tamper-evident recording of changes for data governance. Participants maintain control over their data, with the ability to change or revoke consent in real-time via the platform's consent CRUD services.



A trust model using the self-sovereign identity framework to enable participant-controlled consent management in genomics.

Food & Drug Administration (FDA) project with Australian Centre for Disease Preparedness (ACDP) on strengthening COVID-19 animal models and regulatory science using a systems biology approach

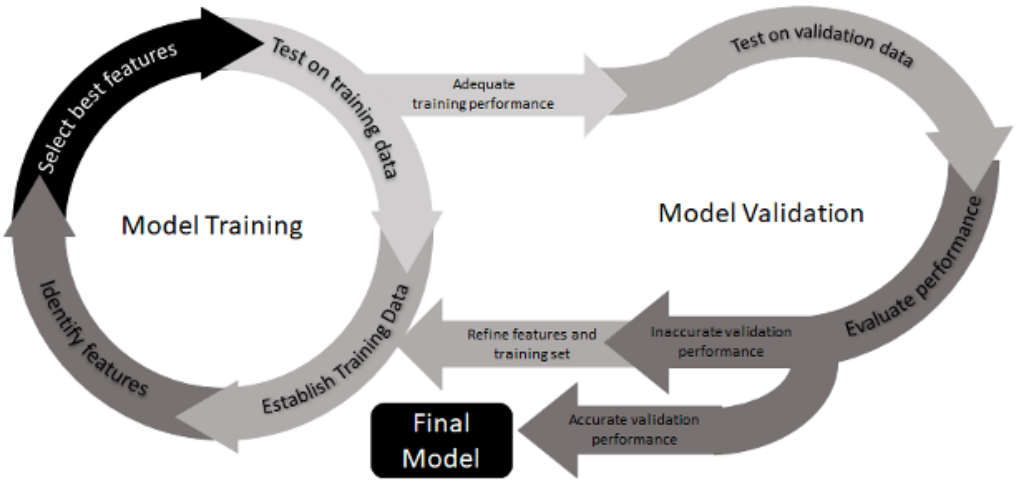
Collaborators: CSIRO's Australian Centre for Disease Preparedness; Manufacturing; Land & Water, Deakin University/Barwon Health, Coalition for Epidemic Preparedness Innovations (CEPI), James Cook University, The Peter Doherty Institution, University of Texas Medical Branch

Since 2020, the COVID-19 pandemic has been a global health concern with over 700 million worldwide cases and 7 million deaths. Vaccines cannot prevent all infections and the emergence of new COVID-19 variants of concern has complicated vaccine development. Safe, effective, and affordable COVID-19 treatment is vital in the pandemic response, especially for 'long-COVID'.

To identify important biomarkers involved in neutralising COVID-19 infection, we used a combination of ML approaches and multi-omics data. Using random forest, we identified a multi-omics signature involving 12 biomarkers that are important for distinguishing the vaccination status of ferret models. Several of these have been previously identified to be up- or down-regulated during COVID-19 infection and potentially countered with the test vaccines. We have also identified at least three synergistic interactions between four biomarkers involving three different -omics that are associated with higher or lower neutralisation titres for COVID-19. The outcomes of this project will allow us to identify important biomarkers involved in neutralising infection and better understand complex mechanisms involved in vaccine response to diseases.

Additionally, analyses on various tissue model infections found over 200 genes up-regulated during COVID-19 infection compared to controls and a majority of these are involved in immune response pathways and COVID-19 specific infection pathways. Feature selection in the ML pipeline also identified the top-ranking genes to be involved in distinguishing between infected and non-infected tissues are inflammatory, immune or cell differentiation/adhesion genes. Current work to assess the temporal response of tissue models to drug treatment is undergoing. This will provide insight to what biomarkers are associated with successful treatment and can be used to identify new drug candidates or repurposing existing FDA-approved drugs.

This project is funded by the Australian Government's Medical Research Future Fund, Food & Drug Administration, and internal CSIRO funding.



ML method to identify treatment progression and efficacy

Gene drive platform

Collaborators: Australian Pest Genome Alliance, Australian Centre for Disease Preparedness

Gene drives are an emerging technology that may lead to genetic biocontrol of pest species by manipulating their genome to prevent spread. However, the technology is still in its beginning stages with numerous challenges to overcome. Chiefly, the challenge of ensuring genomic diversity. To successfully target a wild population, the gene drive must be fashioned in a way that makes it robust against the natural diversity within the population. This means accounting for the natural variations among genomes, a computationally intensive process.

We have developed platforms that can analyse diverse populations to design complex and targeted intervention strategies. Our platform, VARSCOT2.0, builds upon our original VARSCOT pipeline which was the first tool for designing gene editing approaches that account for an individual's unique genomic profile.

We have now expanded the pipeline to handle population level information in a high-throughput manner using AWS cloud computing. In addition to identifying drives common within a target population, the platform can also analyse the genome of bystander populations reducing the risk of the drive spreading beyond its intended targets.

The platform will integrate with the GUARD pipeline (being developed by the Australian Pest Genome Alliance), which is used to model the effectiveness of potential guides, providing researchers and policy makers with an end-to-end platform for the design and evaluation of targeted drives. The work has led to developments in designing robust strategies for interventions resistant to genetic change, meaning guides can be used to target rapidly evolving populations. This has formed the basis of a new project being conducted in collaboration with ACDP to develop evolution-resistant intervention plans.

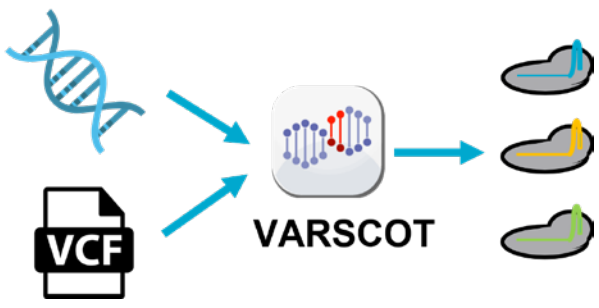
Using these new tools, we have begun working with other researchers within CSIRO to design targeted intervention strategies to tackle the problem of invasive species and AMR.

Variant prioritisation for pathogen labs using ML

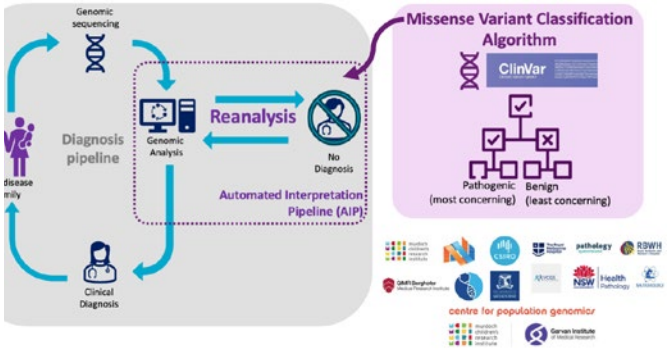
Collaborators: Centre for Population Genomics, Garvan Institute of Medical Research and Murdoch Children's Research Institute, Australian Genomics Health Alliance, Melbourne Genomics Health Alliance, QIMR Berghofer Medical Research Institute, University of Melbourne

Advancements in whole genomic sequencing (WGS) techniques have significantly improved genetic disease diagnoses. However, the substantial volume of data generated by WGS presents challenges in efficient interpretation. Reassessing previously analysed genetic data, especially non-diagnostic cases, has shown promise in enhancing diagnostic rates. Yet, this process is typically conducted case-by-case and is constrained by the manual labour, clinical expertise, and time required. To address these challenges, a multi-institutional collaboration led by The Centre of Population Genomics received MRFF funding to develop and evaluate a national program for the systematic reanalysis of genomic data. As part of this grant, our collaborators developed the Automated Interpretation Pipeline (AIP), a variant prioritisation tool for the reanalysis of undiagnosed clinical cohorts.

The AIP uses logical approaches to analyse whole genome data, identifying strong candidates for new diagnoses and returning only highly plausible diagnostic variants. While effective in capturing confident deleterious variants like stop codons, the AIP struggles with missense variants due to their complex impact on protein structure and function. We addressed this by developing an ML algorithm to support the AIP that targets missense variants, classifying them as pathogenic or benign. For this work, missense variants from the ClinVar database were used to train and test the ML model. Features were annotated with Variant Effect Predictor (VEP) using the dbNSFP plugin. Pathogenicity scores were key predictors, with ensemble and Bayesian models like ClinPred, BayesDel, REVEL, and VEST4 outperforming scores commonly used in clinical software, such as CADD and SIFT. This AI approach could help support the AIP in streamlining variant interpretation, novel gene discovery, and increasing diagnostic cases.



Our new gene drive platform builds upon our VARSCOT platform to analyse the genetic variance within a population (stored in a VCF file) to identify strategies to target the entire population.



Our ML algorithm targets missense variants, classifying them as pathogenic or benign.

Transformational Bioinformatics: project updates

Indigenous genomics data management

Collaborators: Telethon Kids, ALIGN, Indigenous Genomics ANU

We continued our engagement with Telethon Kids, Australian Alliance for Indigenous Genomics (ALIGN) and ANU Indigenous genomics groups. Engagement included product introductions and demonstrations of sBeacon, VariantSpark, BitEpi and Genomator to evaluate avenues for efficient delivery of CSIRO expertise in genomics-driven Indigenous health and wellbeing.

We further showcased the capability of dynamic consent platforms and use of AI-assisted informed consent education to consult with ALIGN on suitable technologies to advance Indigenous health projects. As the next steps, a suitable bioinformatics solution will be evaluated in the Indigenous domain to identify specific use-cases and develop them into a live, ongoing and production solution.

Pangenomes and their application

Collaborators: Mayo Clinic, Minnesota, USA (Now Clemson University)

CAD is a significant health concern among Somali populations, yet genetic studies in these groups remain limited. Existing linear references inadequately represent the unique ancestral genetic components of Somalis and other Eastern Africans, hindering reliable genetic research. To address this, a collaboration between researchers has led to the creation of a pangenome, aiming to develop a more suitable reference for these individuals.

The Mozabite population from North Africa exhibits the highest ancestral contributions to Somali populations among non-East African groups, making it a promising choice for building the variation-graph. The Bedouin population served as an appropriate control due to their minimal genetic divergence and strong ancestral affinity with the Mozabites. This inclusive approach facilitates large-scale genetic research, enabling a comprehensive understanding of CAD mutations and paving the way for personalised medicine tailored to their genetic profiles.

Polygenic risk and UKBB

Collaborators: UQ, UCLA

A polygenic risk score (PRS) is an individual's genetic predisposition to a particular complex disease which, when integrated with other risk factors such as gender and age, can improve overall disease prediction, inform prevention strategies, and be used to develop personalised treatment plans.

ML algorithms can improve upon current PRS prediction models by accounting for non-linearity and interactions between genes, but is hindered by their need for large-scale data and significant computational power.

Leveraging our experience and capability in cloud computing, ML, and population-scale genomics, we aim to develop and evaluate new advanced PRS tools. Additionally, we plan to harness AEHRC's expertise in privacy, federated learning, and otology to ensure clinical applicability. We are also forming collaborations with experts on admixed populations from UQ (A/ Prof Loic Yengo) and UCLA (Prof Bogdan), we will also address the Eurocentric bias in genomic datasets to ensure that clinical PRS benefits all Australians.

Newborn screening and neonatal testing

Collaborators: NSW Health, UNSW, GenePath

Newborn screening (NBS) is one of the most successful population health programs providing benefit through early diagnosis of serious health conditions, enabling early intervention. Currently NBS screens around 30 conditions through independent biochemical tests.

The number of diseases that will benefit from screening will continue to grow and genome sequencing, both targeted and whole genome sequencing, can provide a universal platform for effective NBS at scale. Using genome sequencing for NBS would enable the number of diseases screened for by an order of magnitude.

We are part of a $3million MRFF grant with NSW Health, called TRAIL, to investigate the use of genome sequencing in NBS, where our team's contribution focuses on developing a dynamic consent platform for genomic data management, which ensures the user has control over their own genomic data. Furthermore, the grant also explores the use of individual's genome sequencing in whole of life care. We are also part of another $3 million MRFF grant with UNSW and GenePath, expanding on our previous projects published last year in clinical chemistry (IF = 9,3) and prenatal diagnosis.

SynerOmics - an ML approach to identifying cross-omic interactions

Collaborators: ProCan

Use of proteomic data for the discovery of biomarkers which predict cancer treatment efficacy is a promising field.

Recent studies have identified single proteins in cancer cell-line derived proteomic data which correlate with drug susceptibility. However, due to computational demand and lack of suitable algorithms, identifying pairwise (doublet), and higher-order (triplet and quadruplet) combinations of proteins that synergistically modulate drug susceptibility of cancer cells are beyond the scope of current methods. In our study, we modify an existing ML approach to capture these interactions.

By incorporating AlphaFold in our approach, we can speculate putative interactions between our significant hits. Furthermore, our versatile methodology can identify cross-omic higher-order signatures in any multi-omic dataset.

Our method uncovers “global” baseline signatures predicting drug susceptibility that recurrently appear across all drug classes, and “local” signatures that exclusively predict susceptibility to specific drug classes.

emCells - novel approach to biodiversity analysis

Collaborators: Cross-BU collaboration with the National Collections and Marine Infrastructure business unit, Environomics FSP

This cross-BU project focuses on developing a bioinformatic pipeline to support the novel environmental cell sequencing method, emCell-Seq.

While eDNA has proved promising for genomic analysis of wild aquatic species, it can determine only species presence due to the fragmented nature of the genetic material. EmCell-Seq, a novel method for isolating individual metazoan cells from water samples, overcomes this limitation by enabling the use of single-cell sequencing to characterise nuclear DNA genotypes, allowing for comprehensive genomic analyses.

This project included a proof-of-concept study where we tested the ability to identify replicated individuals with emCell-seq, demonstrating its potential use for a genomic mark and recapture approach to species abundance estimation.

The pipeline demonstrated high accuracy, identifying the correct individual zebrafish 95%. This method could enhance non-invasive monitoring and management of wild aquatic species for conservation, biosecurity, and fisheries.

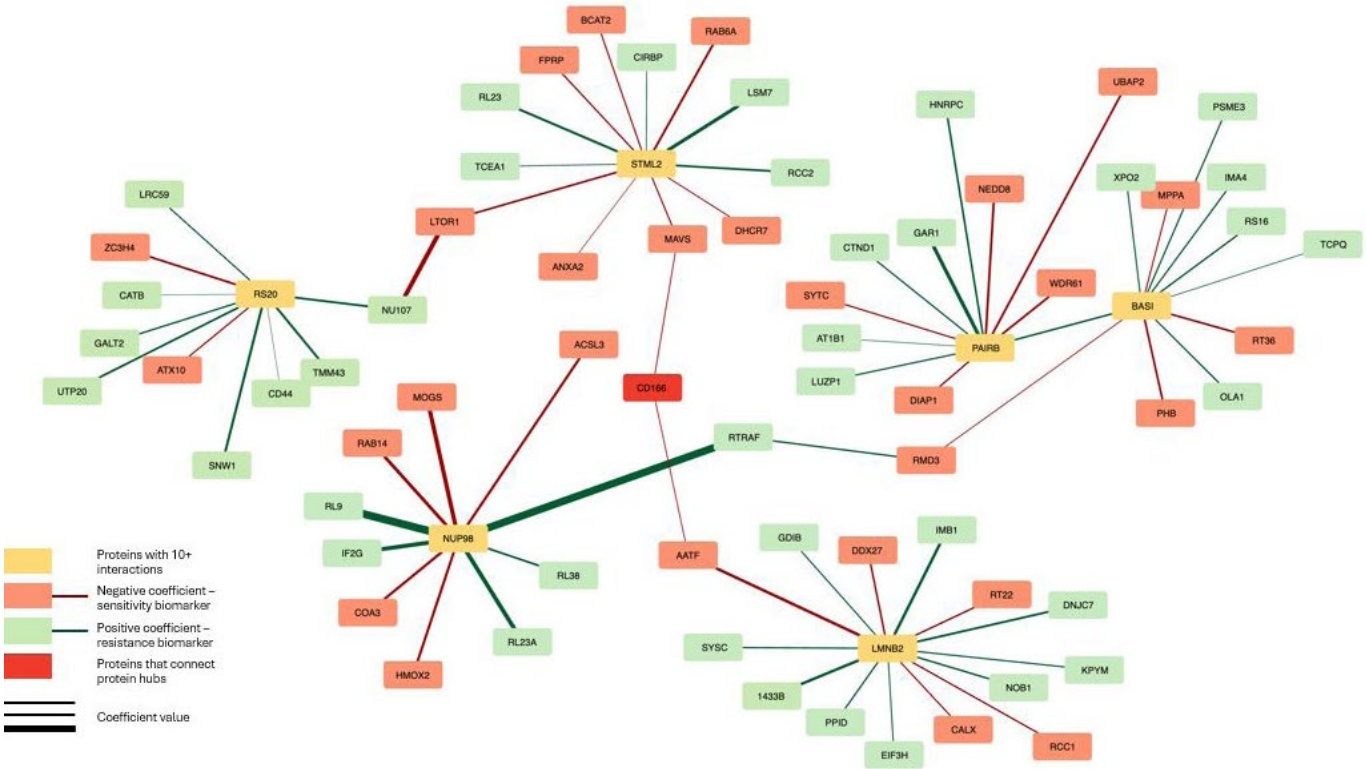


Figure: Local interconnected “hubs” of synergistic markers in the microtubule inhibitor drug class. Yellow rectangles represent hub proteins with 10 or more interactions. Light red rectangles represent sensitivity biomarkers, and green rectangles represent resistance biomarkers. Width of the adjoining lines are proportional to the strength of the association between protein expression and drug susceptibility.

Using genomics and ML to optimise the cattle breeding process

Collaborators: CSIRO A&F

Using genomic approaches to selectively bread beef cattle has demonstrated impact on the sustainability of livestock production.

Genomic estimated breeding values (GEBV) have been employed to predict traits including bull fertility, cattle immune competence and carcass characteristics. However, current accuracies of the GEBV models remain at 28-62%, indicating room for improvement.

Our grant from the genomics cross-cutting capability allows us to engage with Toni-Reverter Gomez's team in the Agriculture and Food program to use our ML toolkit, VariantSpark-BitEpi, to improve on existing linear modelling approaches for GEBV.

We have demonstrated in human disease phenotypes that we can capture 10% more phenotypic variance by using genetic variants and interactions identified by VariantSpark-BitEpi than those identified by linear regression. Based on this, we hypothesise that we can improve GEBV accuracy for livestock in a similar way. We will apply our approach on existing genetic datasets for bull fertility (n=8000), cattle immune competence (n=5500) and carcass characteristics/marbling(n=8316).

Furthermore, VariantSpark's explainable ML will be able to identify QTLs, which, for example, can aid in pinpointing therapeutic and gene-editing targets for immune competence phenotypes, as well as contribute to our understanding of the molecular processes underlying marbling in cattle carcasses

Rabbit project

Collaborators: H&B

The T-locus is a region of the mouse genome that exhibits gene-drive-like behaviour, where the gametes that contain the selected allele effectively poison those that do not, leading to skewed inheritance.

This project has been initiated to search for a similar locus in the rabbit genome, which could be used as part of a genetic control regime.

The process involved obtaining short-read single cell sequence data from individual sperm cells collected from a selection of rabbits. This sequence data was then analysed to determine if there were any transcripts that displayed an uneven pattern of abundance, such as a bimodal distribution. In addition, individual single nucleotide polymorphisms (SNP) have been characterised between the sperm cells and rabbits and these are currently being examined to identify systemic bias in the allele read numbers across multiple cells and rabbits.

PathsBeacon for avian influenza surveillance

Collaborators: CSIRO's AAHL, CSIRO's Data61

Recent avian influenza outbreak further reinforces the urgency to do real-time analytics on quickly sequenced genomic samples. Under the One Health initiative, we started working with the Australian Animal Health Laboratory (AAHL), responsible for sequencing avian influenza samples. These samples are being stored in a private storage space in Bowen cloud. We were able to set-up PathsBeacon instance hosted on AWS cloud with secure access via API to Bowen storage.

PathsBeacon allows users to securely query genomic data along with the associated metadata in real-time. Once appropriate permissions to access AAHL's genomic sequences are received, the PathsBeacon instance will allow AAHL researchers to quickly check for pathogenic segments by checking for insertions. By setting up publicly available datasets researchers can also find if some of the avian flu segments were encountered earlier either in Australia or internationally.

Climate project ACS

Collaborators: Australian Climate Service

Climate change can induce mutations in pathogens, affecting pathogen survival, replication, and virulence. Conducting analyses to predict pathogen sensitivity to climate variables is valuable for understanding how pathogens and the diseases they cause might change under different climate scenarios.

We used ML and statistical methods to analyse genome sequence alignments of pathogen species from various climates over time. By identifying correlations between pathogen mutations and climate changes, we aim to understand their effects on pathogen survival, replication, and virulence in Australia, focusing on species, samples, and climate variables relevant to the Australian context.

We identified 340 mutations in the dengue virus associated with increased temperature, mainly in a gene linked to temperature sensitivity in labs.

Similar analysis was conducted for salmonella but challenges in collecting the correct data limited the power of the analysis. This underscores the importance of real-world data for accurately identifying mutations and tracking heat resistance, as laboratory results may differ from real-world observations.

The work is continuing as a broader collaboration across CSIRO, incorporating more fine-grained real-world data allowing us to investigate further the link between climate change and pathogen evolution.

Teamsport CRISPR immunity

Collaborators: Immune Resilience FSP

This project is part of the larger project "Arming food production animals with a novel anti-viral defence".

Collaborating with a team of postdocs, our primary objective is to fortify the immune system of livestock and aquaculture species against viral threats. More specifically, our role, sub-project C, is to develop a sophisticated predictive model for CRISPR/Cas13 efficacy using AI. By harnessing advanced ML techniques and deep learning, this model will serve as the backbone for the design of optimised CRISPR/Cas13 guides that can effectively combat infectious pathogens.

Additionally, recognising the rapid evolution of viruses, we aim also to devise methodologies for modelling the evolution of orthomyxoviruses and predicting potential escape mutants. These methodologies will be validated using diverse viral datasets and experimental results obtained from sub-projects A and B.

A successful outcome of this project holds the promise of extending our findings to benefit other species, thereby contributing to the advancement of RNA therapies.

Viral capsid modelling

Collaborators: The Translational Vectorology Group, Children's Medical Research Institute (CRMI), Westmead

Gene therapies are transformative technologies that enable treatment of previously untreatable diseases. Most approaches use viral capsids, protein shells derived from viruses such as adeno-associated virus (AAV), as delivery methods for the therapeutic DNA cargo. The size and volume of these capsids provide strict limits on what can be packaged inside them.

To improve packaging, we are exploring two complementary approaches: increasing the volume of the capsid through targeted mutations and reducing the effective volume of the DNA cargo through more efficient folding (Figure below).

By using new developments in protein and molecular modelling, such as AlphaFold, we can model how the viral capsid and DNA interact in 3-dimensions and test how specific changes influence packaging effectiveness.

We have also developed an ML model to predict packaging efficiency. This model is currently undergoing laboratory testing to evaluate the accuracy and effectiveness of our predictions.

We are collaborating with Associate Professor Leszek Lisowski, leader of the Translational Vectorology Group at the CMRI, Westmead, a world leader in the design and manufacturing of gene therapy capsids.

National vaccine design platform with TechCentral

Collaborators: UTS and ANU

In the post-COVID era, the development and popularisation of mRNA vaccines and RNA therapeutics have become urgent.

Traditional laboratory methods are often time-consuming and costly due to the instability of mRNA and the large number of downstream experiments.

To address these challenges, we employ high-throughput phylogenetic methodologies, genome-scale reverse vaccinology, and immunobiological approaches for novel epitope selection from genomic data.

Our project involves the design and deployment of cloud-based workflows and pipelines for reverse translation modalities targeting proteins. We leverage ML and AI techniques to enhance these processes.

In collaboration with UTS, which is developing pipelines for RNA therapeutics, we are focusing on the cloud infrastructure. By using AWS cloud resources, we perform large-scale analysis of genomic data to identify novel potential mRNA sequences, simulate their stability and function, and thereby reduce the vaccine design lifecycle.

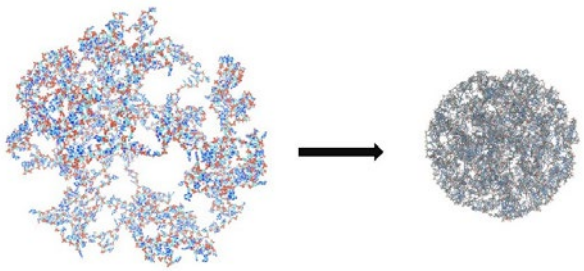


Figure: Modelling how a nucleotide sequence fits within a specific volume involves first modelling the three-dimensional structure of the molecule (left) and then compressing it to the desired volume to determine the stability of the final compacted structure.

Vaccine design for UTS

Collaborators: Minimising Antimicrobial Resistance Mission, UTS

Designing new vaccines is a complex, time consuming and expensive process, typically taking 10-15 years from initiation to clinical application.

We are working with collaborators within CSIRO and externally to develop new computational methods to streamline the process, helping researchers predict the best vaccine targets for effective intervention.

This project uses ML and protein structure modelling to simulate how pathogen antigens interact with the immune receptors and predict the antigen sequences most likely to elicit a strong immune response.

In addition to developing these new methods, we are also working to apply these methods to assist in the development of new vaccines for biosecurity threats including African swine fever and drug resistant bacteria.

Genomical

Collaborators: Genomical, Melbourne Genomics Health Alliance, Royal Melbourne Hospital, Monash University

sBeacon was integrated into the Genomical Genomic Orchestration Service (GOS) using an adapter architecture to enhance its functionality for clinical applications.

Key use cases were devised in consultation with Genomical's customers, focusing on expanding the Beacon UI's analytics capabilities.

To address clinicians' need to filter variants of interest, the results of sVEP, a quick variant prioritisation tool, were integrated into Beacon analytics, enabling precise variant querying. A critical component of the Beacon analytics implementation was the ability to compute correlations between variants of interest and phenotypic features, significantly enhancing its utility for clinical use cases.

The entire sBeacon suite was deployed into Genomical's AWS account, enabling them to securely handle their data within their own infrastructure. This integration and development effort aimed to provide clinicians with a robust tool for genomic analysis, ensuring accurate and meaningful insights into patient data.

AskBeacon

Collaborators: Global Alliance for Genomics in Health, CSIRO Science Digital (Sigma8)

We initiated AskBeacon, the revolutionary enhancement to the Beacon UI that transforms the way users interact with complex biomedical data. AskBeacon adds a sophisticated layer of natural language abstraction to the traditional Beacon interface, seamlessly connecting with the robust sBeacon backend hosted on AWS serverless infrastructure.

The primary goal of AskBeacon is to improve accessibility by humanising the intricate world of ontology terms, complex query conditions, and the stringent Beacon V2 schema. By distilling these elements into a natural and conversational query experience, AskBeacon empowers users to interact with data effortlessly.

AskBeacon masks the struggle of multiple ontologies like HPO and SNOMED CT behind simple natural language. AskBeacon achieves this by allowing users to describe phenotypic traits in plain language, eliminating the need for manual lookups. This ensures that even those without extensive beacon knowledge can discover valuable data insights.

Using the cutting-edge GPT-4 Turbo JSON and Text APIs, AskBeacon compiles and executes queries with precision, seamlessly populating the Beacon UI to maintain transparency and validity. The future of AskBeacon plans to enable natural language-driven beacon analytics. Users will soon be able to perform ETL operations followed by code execution in sandboxed environments, unlocking deeper and more powerful analytics capabilities.

Transformational Bioinformatics: postdoc and student highlights

Postdoctoral highlight

Mitchell O'Brien

Clinicians can diagnose and treat illnesses more effectively using genomic insights. As genomic data grows, a transition to scalable workflows is essential. Leveraging ML and cloud infrastructure, Mitchell has developed and supported novel pipelines, applying his skills in clinical genomics, whole genome analysis, and synthetic data generation. Notably, he was part of a team that conducted the first association study on the world's largest genomic cohort, developing a scalable orchestration engine (RAPpoet) to support clinical research and advance open-access science.

Engineering highlight

Mark Burgess

Generating privacy-preserving and hallucination resistance genomic synthetic data has been an ongoing challenge in the field of genomics. Mark developed a logic-solving algorithm for the creation of synthetic genome data from a real dataset, which has been scaled to generate whole human genomes, analysed for accuracy in reproducing features of real genome data, and evaluated for privacy potential in obscuring individuals from the real dataset. A scientific publication has been submitted, a provisional patent lodged, and we are currently in CSIRO's ONprime program to evaluate market potential for this technology.

Master's student highlight

Valentina Galeone

The rapid evolution of influenza poses a significant challenge for combating the seasonal pandemics. Using associated rule mining, we investigate the co-evolution of mutations in influenza and identified potential rules of evolution. These include, identify mutations that always co-occur, or act as stepping-stones to further mutations and in some cases, mutually exclusive mutations. By understanding these rules, we will be able to identify what current strains are precursor to future strains and develop new monitoring strategies based on this knowledge. The work is currently being prepared for submission and has formed the basis of a successful funding application to the US-FDA to further study influenza evolution.

The Biomedical Informatics group

Group Leader: Dr Jurgen Fripp

The combination of precision medicine and AI will revolutionise healthcare. The Biomedical Informatics group works at this exciting interface, leveraging AI's ability to generate insights that empower clinical decisions (prediction, staging, prevention and treatment). Our precision medicine focus is on discovery and validation of novel medical imaging biomarkers (from MRI, PET, CT, US, and X-ray), with AI guided insights integrating -omics, neuropsychology, smart sensing and clinical phenotypes. The imaging, statistical and AI/ML techniques developed on our informatics platform enable both reproducible and scalable cloud and standalone software deployment. These are applied within in a wide range of (NHMRC, NIH funded) large observational and randomised control trials across the human lifespan and disease spectrum (including osteoarthritis, cerebral palsy, cancer and dementia). Where required we are developing our technology as SaMD.

The group is a key partner in many clinical trials and studies in Australia and internationally where we contribute to the collection and analysis of data and interventions with our clinical and research partners.

- Dementia is the second leading cause of death of Australians and is likely in future to become the leading cause as our society ages. The hallmarks of dementia can be characterised by a range of fluid and imaging biomarkers, including amyloid and tau PET. Our group is as a key partner in the Australia Dementia Network (15 institutions nationwide) and the Australian Imaging Biomarker Study of Aging (AIBL), providing advanced image analysis and biostatistical expertise. This is highlighted by our role in over 20 journal papers in the last 12 months.
- Each year in Australia, more than 20,000 infants are born premature and/or with low birthweight. This puts them at risk of neurodevelopmental conditions, such as cerebral palsy, where they potentially face a range of adverse cognitive, behavioural, educational and motor outcomes. In a large collaborative effort, including with the University of Queensland, Monash Health and the Cerebral Palsy Alliance, we are currently contributing to 11 projects which allow us to track brain development and investigate functional brain networks. These studies, conducted across the childhood period from preterm infancy to adolescence, provide insight into neuroplasticity following insult or intervention, and can be used to improve clinical reporting and to tailor the most effective therapy to enhance quality of life for the children and their families.

Biomedical Informatics science and impact highlights for 2023/24

- Using a rodent model of foetal growth restriction in collaboration with the Queensland Brain Institute, we were able to identify one brain biomarker and three placental biomarkers that we can now investigate in our human FGR study with Monash University.
- Together with the Cerebral Palsy Alliance, research partners with lived experience and Miroma Project Factory, we have developed a prototype mHealth aide for the selection of effective interventions for cerebral palsy.
- Our team led by Aaron Nicolson came first in the 2024 Shared task on Large-Scale Radiology Report Generation @BioNLP ACL'24.
- A team of our postdocs participated in the MICCAI SynthRad challenge (an international challenge for synthetic CT generation from MRI) and finished 6th from around 100 participants.
- Co-editors of new international standard ISO/IEC 3253-2 (Segmentation for medical image-based modelling for 3D printing).

Medical Image Analysis team

Team Leader: Jason Dowling

The focus of the Medical Image Analysis team is the development of novel AI technology to obtain precision medical imaging (from MRI, PET, CT, US, and X-ray). This is achieved through close collaboration with clinicians, industry, and patients to understand needs and then develop, validate and translate precision imaging AI and ML technologies to improve disease diagnosis, treatment planning and treatment delivery. This involves the development of AI and ML methods for the extraction, quantification, and modelling of information from 2D and 3D medical images and sensors; mapping data across imaging modalities and individuals/populations and performing image reconstruction and synthesis. Clinical applications include radiation oncology, cardiology, respiratory physiology, orthopaedic surgery and musculoskeletal image analysis.

Neurodevelopment and Plasticity team

Team Leader: Dana Bradford

The focus of this team is to develop advanced neuroimaging technology (from MRI) to accurately localise and measure the extent of neuroplasticity for use in research and the development of precision medicine technologies. The outcome of this research is to provide earlier detection and improved diagnosis for childhood neurodevelopmental disorders and other brain trauma. Clinical applications include cerebral palsy and epilepsy.

Neuroimaging team

Team Leader: Vincent Doré

Our team focus is on developing advance neuroimaging technology and ML algorithms to extract clinically meaningful metrics from medical images, such as MRI and PET scans, for use in precision medicine applications. These metrics include diagnostic tools and disease staging applied to a range of clinical challenges.

In particular, we are developing a range of precision medicine SaMD applications related to AD. Our suite of precision medicine biomarkers encompasses metrics related to metabolism, amyloid, tau, neuroinflammation, cholinergic system to neurodegeneration.

These neuroimaging techniques are essential for discovering and validating fluid biomarkers, characterising at-risk group' for developing dementia groups and allow early interventions, such as lifestyle improvement.

Biostatistics team

Team Leader: James Doecke

The Biostatistics team work on various projects with the aim to elucidate the complex relationships between fluid and imaging biomarkers, genes, lifestyle, environment, cognition and disease pathology.

We have specialists in bioinformaticians and statisticians who apply their knowledge to biomedical data to identify disease-specific relationships. Our bioinformaticians develop software to process raw genomics data into usable summary information, while our biostatisticians develop online and publicly available statistical applications and provide reproducible reports for projects and collaborators. Our research partners rely on our specialist analytical expertise to move their research from the bench to the bedside, from collecting data through publishing results in high impact journals.

Biomedical Informatics: platform technologies

Milx: Medical image processing platform

The medical image analysis platform supports the analysis of a suite of medical imaging modalities (MRI, PET, CT and US) used within our clinical research projects or trials. This platform leverages open-source image analysis libraries such as ITK and VTK, and includes algorithms such as image enhancement, feature detection, tissue segmentation, registration, shape modelling and classification.

The platform provides the core of a range of applications that extract imaging biomarkers for use in neuroimaging, musculoskeletal image analysis and MR-alone radiation therapy. These applications are generally fully automatic and incorporate a range of supervised and unsupervised AI and ML techniques that extract clinically relevant information or knowledge from the medical images.

Read more in Biomedical Informatics: Project Reports and Project Updates.

Zendaya: Intelligent medical image analysis platform

This project will deliver a standardised, easy to use, platform to enable the clinical and research deployment of medical image analysis pipelines. This includes the development of a browser based open-source graphical user interface which can be deployed into secure cloud and clinical environments to generate research results, validate methods, or gain clinical feedback on prototype software.

The platform uses an extensible architecture which enables the integration of modules with protected IP (closed source) and the integration of difference containerised AI/ML models with clinical or research data storage environments (PACS).

The platform will also provide a pathway for ISO13485 compliance or regulatory evidence through TGA Clinical Trial Notifications for software as a medical device.

MilxCloud: Cloud based image analytics

The MilxCloud web application is used to access our workflows that perform automated quantification and extract imaging biomarkers from medical imaging data. This has been implemented in the Galaxy framework (galaxyproject.org) to provide scalable access to the cloud. Typically, this involves the medical images (MRI, PET, CT) being uploaded to a cloud-based platform where they are analysed. The user is then provided with a PDF analysis report containing quantitative measurements. A version of MilxCloud with our most popular workflows can be evaluated at milxcloud.csiro.au.

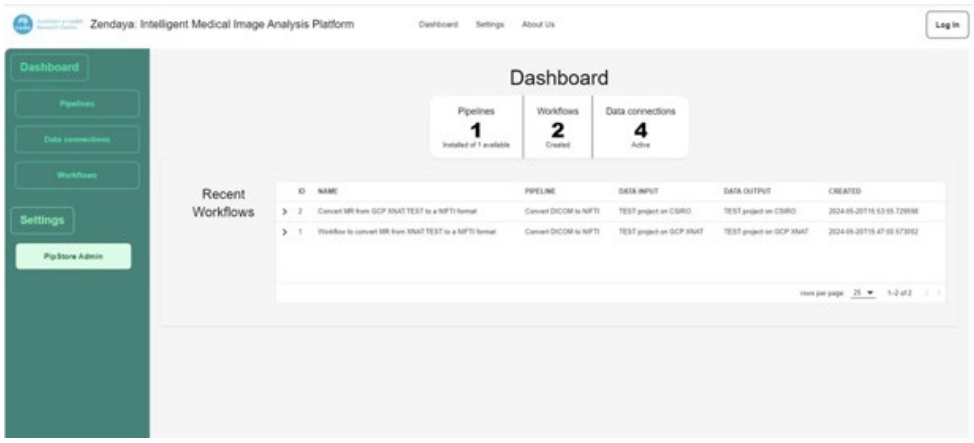
MilxCloud applications: CapAIBL

Recent developments in medical imaging have allowed the in-vivo examination of brain pathology associated with AD, such as Aβ plaques, glucose metabolism, cortical atrophy and more recently, tau tangles.

PETimaging is a sensitive technique for the detection of the key pathological hallmarks of AD which occur many decades before the onset of clinical symptoms. PET provides invaluable insight into the future development of this disease, while MRI provides useful clinical information on neurodegeneration. Thus, in-vivo brain imaging has an increasingly important role in therapeutic trials.

The computational analysis of PET by AIBL (CapAIBL) is a web-based implementation of our automated PET reporting tool. These reports include a Z-score display which allows a universal visualisation and comparison of tau and Aβ imaging PET scans. It allows the report to be sent to, and reviewed by, a specialist not specifically trained for the tracer used for scanning. It will reduce the cost of analysing PET scans and will provide wider access to tau and Aβ imaging scans, including in Australia's remote areas.

We have been working on a new harmonisation technique for amyloid PET quantification as well as the quantification of all tau tracers, which will be available in a forthcoming version. A trial version of CapAIBL is available on MilxCloud, our web platform (milxcloud.csiro.au); read more in Biomedical Informatics: Project Reports and Project Updates.



Zendaya dashboard screen showing recently completed medical imaging AI pipelines (alpha release, June 2024).

MilxCloud applications: AssessCP

AssessCP is a web-based tool to support the assessment of paediatric brain MRI by providing quantitative information of brain structure (including anatomical volumes and cortical shape) relative to a typically developing cohort as a Z-score, and a visualisation of brain lesions. It utilises a range of AI and ML techniques designed to be robust to potentially severe brain injury, making it able to quantitatively assess children with CP and ABI. To support clinical translation, these quantitative measures are then provided in an automatically generated PDF report to clinicians, to illustrate where the patient sits relative to an age-matched typically developing cohort.

This software has been used in a number of projects to find cross-section associations between brain structure and childhood function in collaboration with Queensland Cerebral Palsy and Rehabilitation Research Centre (QCPRRC), elucidate subtle differences in brain structure associated with genetic markers associated with CP (with collaborators in Monash University, Phoenix Children's Hospital), and is currently being used to process existing clinical data from multiple European sites as part of the AInCP Horizons grant (Fondazione Stella Maris, University of Pisa). It is being validated on a large paediatric cohort (combined n=366) of children born preterm or with CP, after which a trial version will be available on MilxCloud.

Health research data: CSIRO AWS REDCap

The collection of data (personal and medical) is one of the most important steps in any clinical study or trial concerning human health. We developed a secure CSIRO managed Amazon Web Services (AWS) cloud platform using a collection of open source and in-house software systems that follow CSIRO governance controls and standards. Electronic data capture is handled using:

- REDCap, which is a web application used to manage and capture basic clinical research data
- XNAT, which is an imaging informatics platform used to capture imaging data, and
- Dashboard, an in-house web application that allows for a seamless experience in dealing with data entry, collecting summary data and completing study specific tasks.

The XNAT platform is used in several large multi-site neuroimaging studies (ADNeT and PISA), read more in Biomedical Informatics project reports and project updates.

FORTE: Workflows in FHIR

Workflows are the basic building blocks of clinical tasks. While there may be several platforms in the clinic such as the hospital information system, the radiological information system and the patient management system, these are used to collect information rather than track and guide a clinical workflow. It is therefore up to clinicians and hospital staff to make sure that their interactions with these systems are as per their best practices, guidelines and standard operating procedures.

FHIR is a new standard for storing and querying health care data which is being rapidly adopted into the clinic. The concept of workflows is modelled in FHIR which can allow us to track and guide the completion of tasks as part of workflows independent of clinician input.

Our FORTE platform allows for the definition and execution of clinical workflows using FHIR. These workflows can be used to embed automated tools (including AI systems) and decision support systems directly into the clinical workflow. Based on this platform, we have now developed a prototype RIS that allows us to showcase our tools and workflows including several AI tools that have been developed in the lab.

We are collaborating with the Royal Australian and New Zealand College of Radiologists (RANZCR) to further develop our platform and explore alternate clinical workflows, as well as the possibility of using this platform in other areas of medicine that also involve imaging such as histopathology.

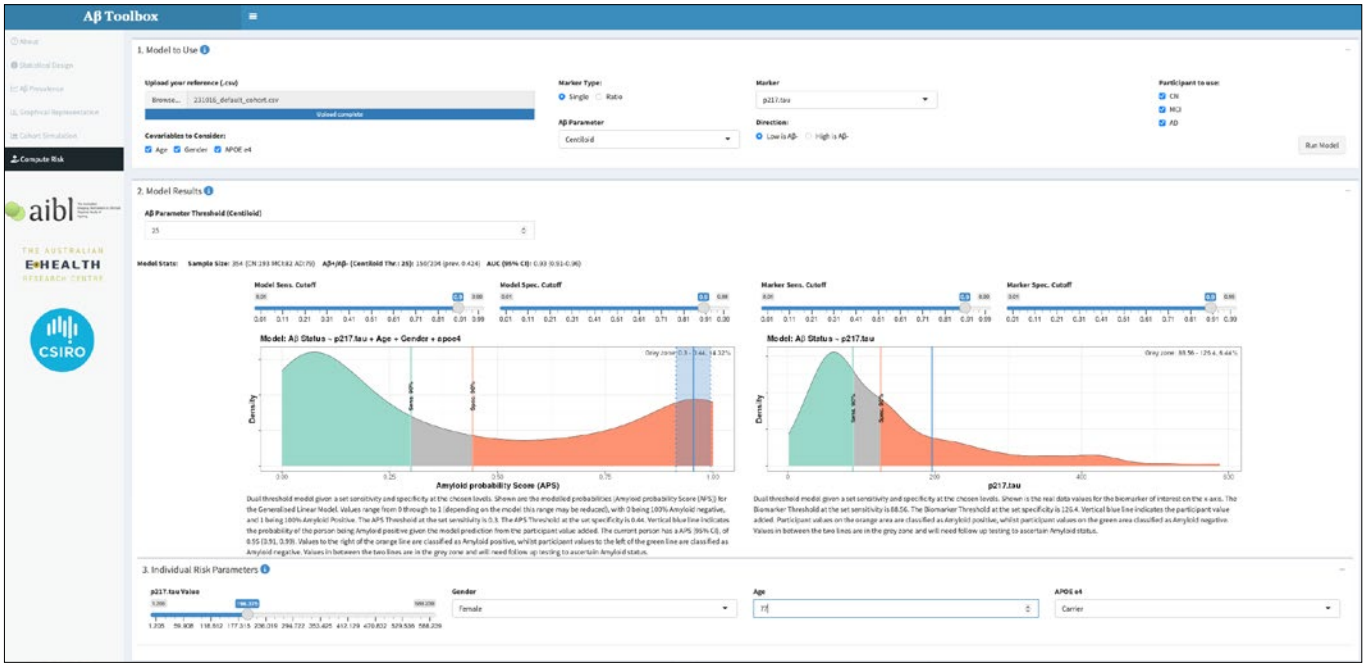
Biostatistics and bioinformatics with ML and AI

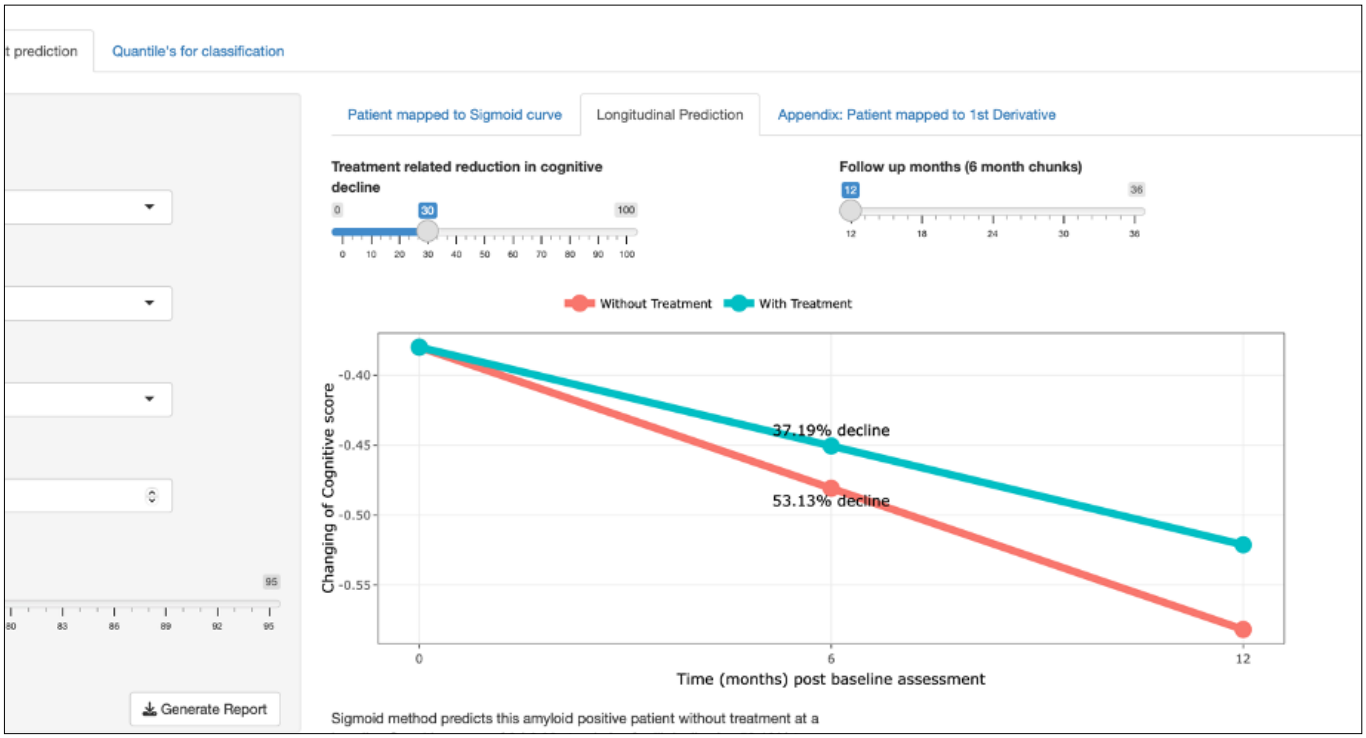
Our team develops biostatistical workflows (reproducible workflows with R Markdown) and applications (R Shiny Apps) for clinical, pharmaceutical and industry partners. Applications are created for internal and external use given project requirements. Collaborators and team members design statistical analyses plans (SAPs) to investigate data as per collaborator research priorities. Once the SAPs are agreed upon, team members design, produce and deliver reproducible reports using ML and AI methods to comb through the data and investigate the collaborator research questions.

Team members use programming platforms such as R-Studio (with the R statistical environment) and Python (iPython) to design the statistical/bioinformatics workflow. When the data becomes too large for standard processing, certain packets of analyses are passed to the HPC, with results sent back to either Python or R (statistical packages). Typical ML/AI technologies used include Bayesian or Frequentist methods such as Bayesian Graphical Network (BGN), the Least Absolute Shrinkage and Selection Operator (LASSO), Random Forests, Mixture modelling and Generalised Boosted Trees.

The team's focus is to develop and use novel methodologies to assess longitudinal trajectories of Alzheimer's disease biomarker data. We work with researchers and scientists within the Australian Imaging, Biomarkers and Lifestyle (AIBL) study of ageing on many projects, with collaborators involved in the development and investigation of benchmark blood-based biomarkers to detect Alzheimer's disease pathology.

Shown below are two examples: (left) an application called the Amyloid Toolbox: this application is designed to assess biomarkers for the prediction of PET amyloid, and (right) an application called the patient prediction tool, this application defines a participant's predicted cognitive decline based upon a set of mathematical models.





Data visualisation through R Shiny.

Biomedical Informatics: full project reports

Automated chest X-ray reporting

Collaborators: University of Melbourne, University of New South Wales, Monash University, Edith Cowan University, Flinders University, South Australia Health and Medical Research Institute (SAHMRI), University of Sydney, Neuroscience Research Australia, Macquarie University, QIMR Berghofer, University of Tasmania

This project addresses the important area of radiology reporting, aiming to enhance the accuracy and efficiency of chest X-ray (CXR) interpretations through advanced computational models.

The primary goal of our recent Artificial Intelligence in Medicine (Nicholson, et al. 2023) paper was to augment the diagnostic accuracy of CXR report generation by employing a technique known as "warm starting," where pre-trained models are fine-tuned to improve performance on specific tasks.

The investigation has highlighted significant enhancements in report generation metrics, with models initialised via warm starting outperforming traditional methods. This approach demonstrated an improvement in capturing detailed diagnostics akin to expert radiologists' analyses.

By improving the accuracy and reliability of CXR reports, this project has potential implications for clinical practices, aiming to reduce radiologists' workloads and enhance patient outcomes through more precise and consistent reporting.

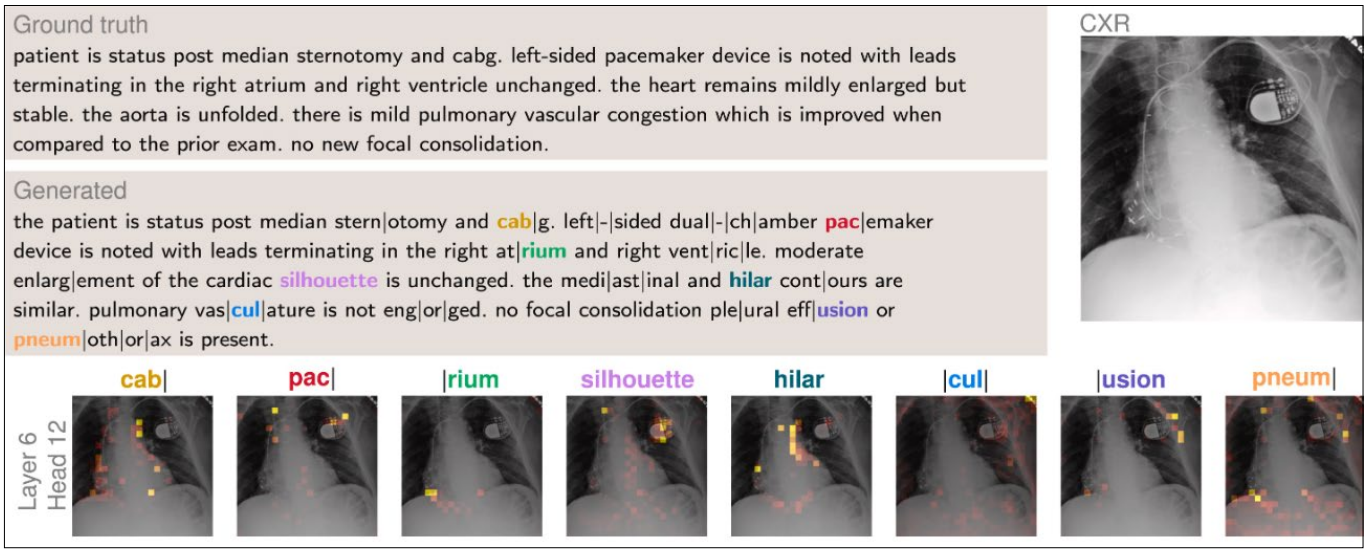


Figure 1. Case study of sample chest X-ray from the MIMIC-CXR test set. The 'ground-truth' report was produced by a radiologist, while the 'generated' report was produced by our model. The X-ray displayed has been pre-processed for testing. Subwords produced by our model (DistilGPT2) are separated by a vertical bar. Areas of attention from each word are highlight on the chest X-ray, providing explainable results for the clinician.

Source: Nicolson A, Dowling J, Koopman B. Improving chest X-ray report generation by leveraging warm starting. Artificial Intelligence in Medicine 2023 Oct;144:102633. doi: 10.1016/j.artmed.2023.102633. PMID: 37783533.

Prediction of neurodevelopmental outcomes from newborn MRI

Collaborators: The University of Queensland, Monash Health, Mater Mother's Hospital

Very premature birth (before 32 weeks completed gestation) is a risk factor for later adverse neurodevelopmental outcomes. Early, accurate prediction of outcomes is required to commence targeted early intervention. As part of a large, multi-site prospective cohort study, more than 270 babies born very preterm were recruited at 3 hospitals (Royal Brisbane and Women's Hospital, Mater Mother's Hospital, and Monash Health). Babies underwent brain MRI in the first few weeks of life, and again around term equivalent age (i.e. around the baby's due date) and were followed up with neurodevelopmental assessments at 2 years, with a 6-year follow-up currently underway.

As part of this study, we optimised MRI acquisition protocols to increase the success rate of newborn MRI, developed automated quality assurance and processing pipelines, and conducted statistical analyses to relate newborn brain biomarkers with later outcomes.

Our findings indicate that advanced brain biomarkers obtained from diffusion and structural MRI are correlated with and even predictive of neurodevelopmental outcomes at up to 2 years old (published work: PMID29868441, PMID32663645, PMID32278897, PMID36529204), with ongoing work indicating correlations and predictions at up to 6 years old. This work was essential in securing a UQ-led NHMRC Synergy grant, which will expand recruitment to other high-risk infant populations.

Our work has received several awards, most recently the First Prize Platform Presentation at the 2023 ISMRM ANZ Chapter meeting, and the 2023 Health and Biosecurity Science and Engineering Excellence award.

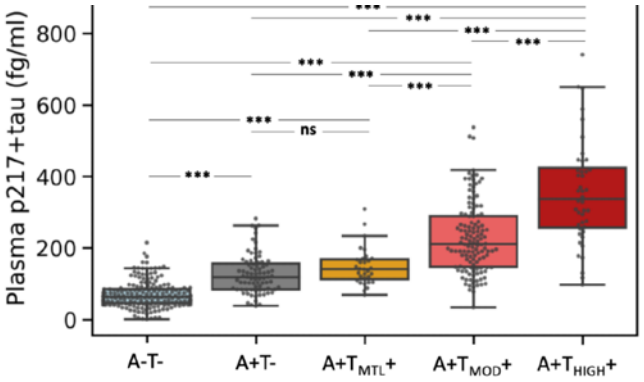
Alzheimer's disease biological PET staging using plasma1 p217+tau

Collaborator: AIBL, Janssen

Plasma phospho-tau biomarkers, particularly p217+tau excels at identifying AD neuropathology, and our study explored its capacity to inform AD biological PET stages both at the group and individual levels. We examined data from 475 participants, including cognitively unimpaired and impaired individuals, using the Janssen plasma p217+tau Simoa® assay alongside 18F-NAV4694 Aβ PET and 18F-MK6240 tau PET scans.

The results demonstrated that plasma p217+tau concentrations increased across various AD stages, with significant differences observed between stages. At the group level, p217+tau showed excellent discrimination between stages, with area under the curve (AUC) values ranging from 0.91 to 0.93.

At the individual level, logistic regression analysis confirmed the biomarker's ability to distinguish between early and advanced stages of AD. These findings highlight the potential of p217+tau to not only screen for AD but also to provide prognostic information and improve patient selection for clinical trials and disease-modifying therapies. This research aligns with our commitment to advancing precision medicine and enhancing diagnostic tools to better combat neurodegenerative diseases.



Plasma p217+tau levels in the different PET stages. The error bars in the boxplots represent 1.5 times the interquartile range (IQR) above and below the upper (75 t h percentile) and lower (25 t h percentile) quartiles. Plasma p217+tau concentrations exhibited a clear incremental trend across these stages, with significant differences between all, except for the Initial and Early stages. A-T- amyloid negative and tau negative; A+T- amyloid positive and tau negative; A+TMT L + amyloid positive with tau uptake limited to medial temporal region; A+TMOD+ amyloid positive with moderate tau uptake in temporo-parietal region; A+THIGH + amyloid positive with high tau uptake in temporo-parietal region. *** p<0.001 (corrected for multiple comparisons); ns non-significant.

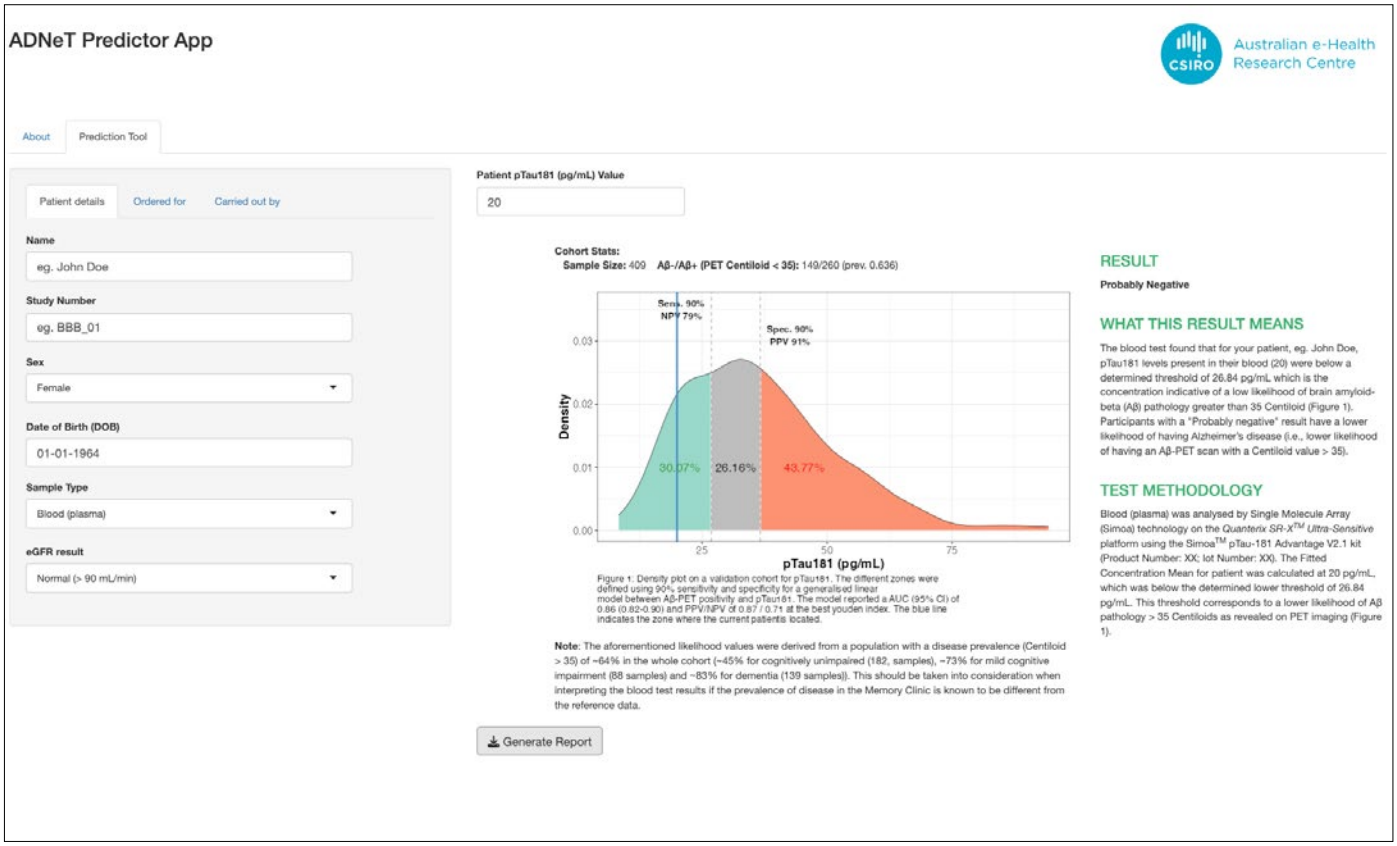
Fluid based biomarkers to predict Alzheimer's disease

Collaborator: AIBL, Biogen, Roche, Eisai, Biogen, Abbvie, Janssen, Labcorp

Identifying biomarkers for the early prediction of AD pathology and the cognitive trajectory of the disease are important for the increasing number of pharmaceutical treatments for prevention. In collaboration with several pharmaceutical companies, we are assessing a range of potential biomarkers for predicting AD pathology and progression.

Our research focusses on changes in cognition, blood and CSF-based biomarkers and pathological proteins via PET imaging. Along with collaborators from world-leading laboratories, our team members are instrumental in round table discussions to discuss the best way forward in conducting research across multiple countries.

Our work with Biogen was used as background for their FDA application for the first treatment for AD. We are working with the world's largest pharma and industry partners to define an optimal blood test for AD which can be brought into Australian memory clinics. Shown below is an example of an online tool for the clinic using a blood-based biomarker to predict the AD pathology amyloid beta as measured via PET imaging.



Example online tool for the identification of amyloid beta in the brain via a blood-based biomarker test. The tool is designed for use in the clinic and will generate a report for the neurologist regarding the likelihood the patient has amyloid in the brain.

Biomedical Informatics: project updates

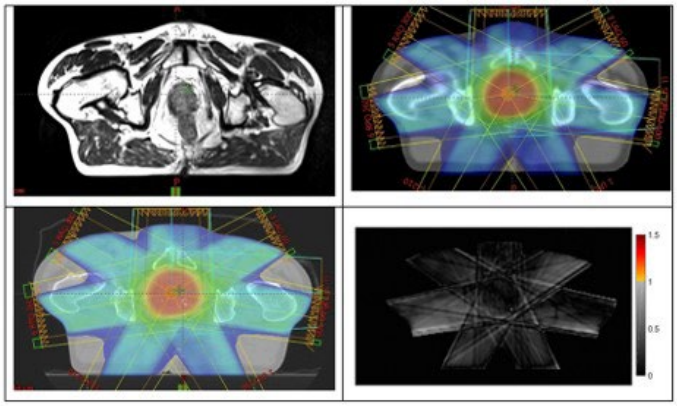
NINJA multi-centre clinical trial

Collaborators: Trans-Tasman Radiation Oncology Group, Ingham Institute, Liverpool Hospital, Calvary Newcastle Mater Hospital

The novel integration of new prostate radiation therapy schedules with adjuvant androgen deprivation (NINJA) clinical trial compares two emerging schedules of radiotherapy in the treatment of intermediate or high-risk prostate cancer. The trial is supported by funding from Cancer Australia (APP1158455).

Participants are randomly assigned to one of two radiotherapy schedules as part of this study. In schedule 1 (called Stereotactic Body Radiotherapy) participants receive 5 radiotherapy treatments over 2 weeks. In schedule 2, (called Virtual High Dose Rate Boost), participants receive stereotactic body radiotherapy delivered in 2 treatments over 1 week followed by 12 treatments of conventional external beam radiotherapy over 2 and a half weeks.

This research has potential to improve the accuracy and quality of radiotherapy treatment in prostate cancer. An important component of the study includes validation of MRI-only radiation therapy treatment at eligible sites. This involves the generation of synthetic CT from patient MRI scans to enable dose delivery planning using CSIRO's sCTGen software. To date over 150 men at five hospitals have been treated during this trial using the sCTGen software (TGA: CT-2020-CTN-03318-1; ACTRN12618001806257; Protocol: https://bmjopen.bmj.com/content/9/8/e030731).



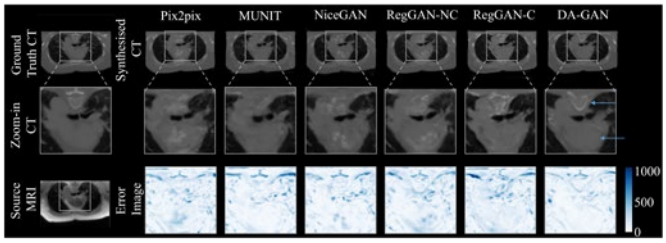
An axial slice from a patient's MRI scan (top left) and matching MRI generated synthetic CT with dose plan (top right). A comparison CT is shown bottom left and dosimetry quality assurance (bottom right).

MRI-based paediatric lung structure and function assessment

Collaborators: Queensland Children's Hospital, Siemens Healthineers, Herston Imaging Research Facility

This project aims to improve health outcomes for children with cystic fibrosis (CF) and ataxia-telangiectasia (AT) by using MRI to provide information on lung status. Currently the most informative method for lung imaging in these children is computed tomography (CT) scanning which increases a child's cancer risk due to the radiation dose delivered. To address this issue, we are developing acquisition methods and software to extract quantitative information from MRI. This work is supported by external funding from the AT Children's Project, the US CF Foundation, and a 2020 NHMRC MRFF grant.

The progress over the past 12 months has involved developing a synthetic lung CT algorithm to address the pairwise spatial misalignment issue (presented at MIDL2024, July 2024, Paris). The team also participated in the international MICCAI SynthRad medical AI challenge, ranking top10 (https://doi.org/10.1016/j.media.2024.103276).



The synthetic CT from lung MRI generated by our method, DA-GAN, outperformed all comparison methods. Particularly, the blue arrows indicate our improved qualitative results at spine and heart (Xin, et al., 2024, Deformation-aware GAN for Medical Image Synthesis with Substantially Misaligned Pairs, Medical Imaging with Deep Learning, Paris: July 2024).

Examining the association between epicardial adipose tissue and incident heart failure

Collaborators: UNSW, St Vincent's Private Hospital, Liverpool Hospital, and the Lundquist Institute

Epicardial adipose tissue (EAT) is located between the myocardium and the visceral pericardium of the heart. While previous studies have identified associations between pericardial fat (the composite of epicardial and paracardial fat) and adverse cardiovascular events, the direct role of EAT in incident heart failure remains unclear.

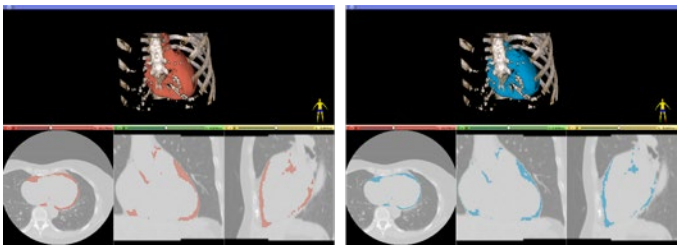
We have developed a novel segmentation model using deep contrastive learning to detect EAT in both non-contrast and contrast-enhanced CT scans. In collaboration with the Lundquist Institute (California, USA), we will further evaluate our technique using Multi-Ethnic Study of Atherosclerosis dataset to determine if EAT is a significant predictor of incident heart failure.

MRI radiogenomics and breast cancer outcomes in a neo-adjuvant treatment setting

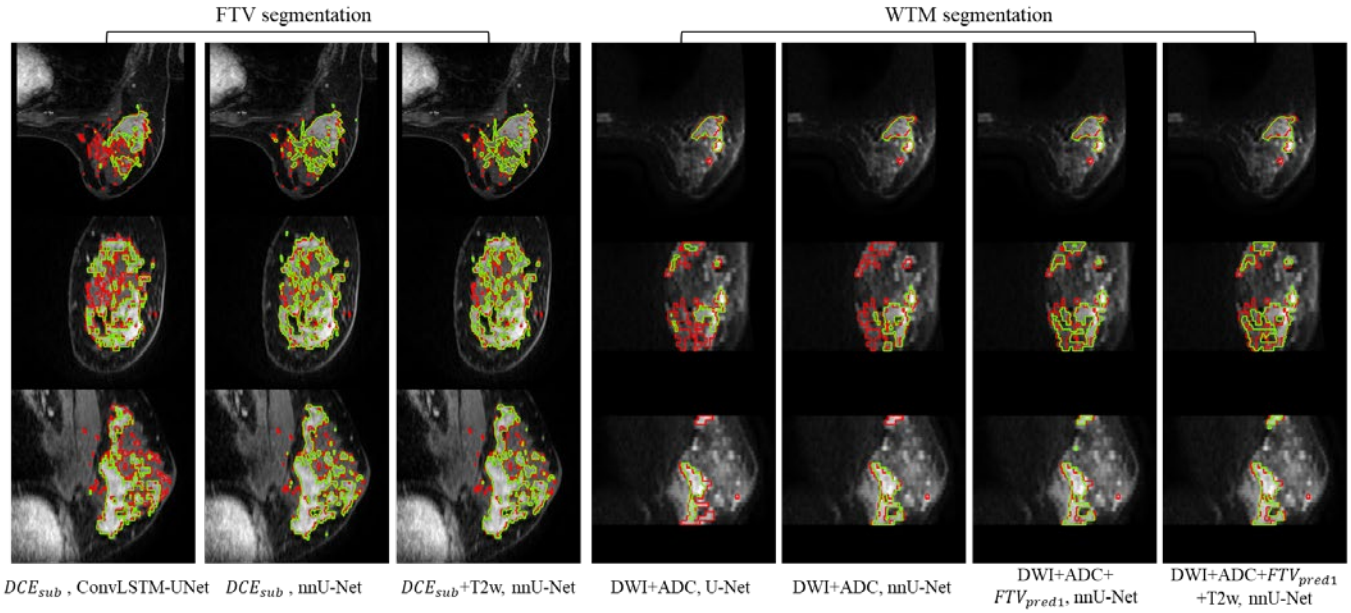
Collaborators: PA Hospital, University of Queensland and QIMR

This project aims to predict breast cancer patients' response to neoadjuvant chemotherapy using radiomics data from multiparametric MRI (mpMRI) and genomic profiles. To extract radiomics data, the cancerous regions need to be identified on mpMRI.

A study exploring the impact of sequence combinations on segmentation performance has been carried out on a multicentre breast mpMRI dataset using nnU-Net. The nnU-Net model using dynamic contrast enhanced (DCE) sequences achieved a Dice similarity coefficient (DSC) of 0.69 ± 0.18 for functional tumour volume (FTV) segmentation. For the whole tumour mask segmentation, adding the predicted FTV to MRI DWI and ADC maps improved the DSC from 0.57 ± 0.24 to 0.60 ± 0.21. Adding T2-weighted imaging did not yield significant improvement, which requires further investigation under a more standardized imaging protocol. This study serves as a foundation for future work on predicting breast cancer treatment response using mpMRI.



Epicardial adipose tissue segmentation using proposed deep contrastive network (left) versus ground-truth segmentation (right).



FTV and WTM segmentation comparison across various networks and sequence combinations.

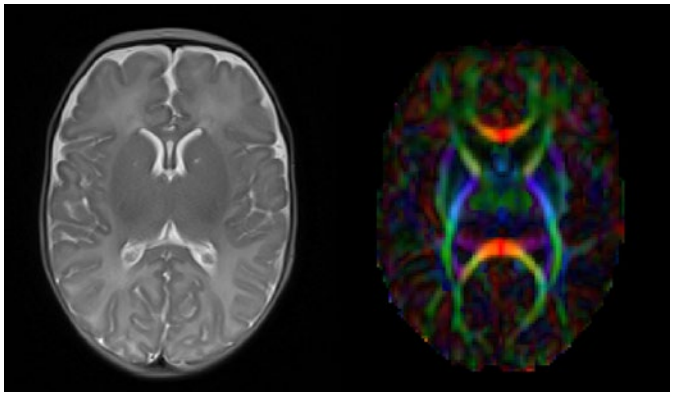
Identifying biomarkers in mothers and mice for foetal growth restriction

Collaborators: Monash Health, Hudson Institute of Medical Research, Queensland Brain Institute

In Australia, 1 in 16 babies are born with a low birthweight, often caused by foetal growth restriction (FGR). FGR can result in stillbirth or adverse outcomes such as CP. The challenge with FGR is its detection and diagnosis to enable timely delivery and minimise stillbirth, while preventing impaired neurodevelopmental outcomes associated with preterm birth.

Together with our partners at Monash Health and the Hudson Institute, we are collecting blood from mums, and at delivery placenta, as well as cord blood. We also obtain scans of the baby's brain. We hope to develop a simple blood test to monitor placental function and baby brain health to give clinicians greater confidence in diagnosing FGR and timing delivery. Such a test would provide anxious parents with peace of mind and inspire hope for the best possible start in life for their child.

To further explore, and potentially manipulate, FGR biomarkers, we are looking at a rodent model of FGR with our partners at the Queensland Brain Institute.



Structural (left) and diffusion (right) images at 40 weeks can be used to measure brain health in babies.

Neurodevelopment and developmental disorders - the DRIVE CP Centre for Research Excellence

Collaborators: Cerebral Palsy Alliance Research Institute, University of Sydney, The University of Queensland, Monash Medical Centre, Murdoch Children's Research Institute, Deakin University

CP is the most common childhood physical disability globally, highlighting the vital need for early intervention to improve long-term outcomes.

People with CP and their families have identified severity reduction, early diagnosis and enhanced participation as their highest research priorities. Together with our collaborators, the Directing Research In Very Early Cerebral Palsy Centre for Research Excellence (DRIVE CP CRE) leverages earlier work from our Australian CP clinical trials network CRE to further reduce the severity of CP towards full participation in society.

Our role is to contribute to the creation of new knowledge for children at high risk of CP to be detected at <3 months old and fast-tracked to receive early, evidence-based intervention. Our neonate projects include wearable sensors and automated reporting of brain scans.

TRANSMIT: A multifaceted knowledge TRANslation Strategy iMprovIng funcTion in children and youth with cerebral palsy

Collaborators: University of Sydney, The University of Queensland, Monash Medical Centre, John Hunter Children's Hospital, Miroma Project Factory

Lifelong with no known cure, 43% of people with CP do not receive known effective interventions, and 20% receive harmful or ineffective care; resulting in lost opportunity that decreases the likelihood of long-term independent living and employment.

Together with six of the topmost published CP researchers in the world, we are developing a mobile health (mHealth) aide that streamlines and filters established evidenced-based interventions for children living with CP. The aide reflects five knowledge translation (KT) strategies, and overcomes the need to understand complex health information, supporting consumers to choose, clinicians to provide, and policymakers to reimburse effective treatments.

Co-designed by our research partners with lived experience, our collaborators and Miroma Project Factory, the mHealth aide will be trialled with people with CP up to 18 years of age. We aim to determine change in function compared to the CP population that did not receive our KT strategy during the same 12-month period in the waitlist control states, extracted from the NDIS population database and matched for severity, regional-remote status, and socio-economic status.

Protect-Me

Collaborators: Monash Health

Protect Me is a clinical trial of maternal melatonin supplementation to improve neurodevelopmental outcomes of babies with foetal growth restriction, led by collaborators at Monash Health. As part of this study, babies with foetal growth restriction undergo brain MRI at term equivalent age (around the baby's due date). Our team perform advanced MRI analysis to determine whether newborn MRI biomarkers:

- correlate with or are predictive of outcomes at 2 years
- differ between intervention and placebo groups.

This project has recruited more than 100 babies from whom MRI data were acquired, with recruitment expected to be completed in late 2024 and outcome data collection continuing until late 2026.

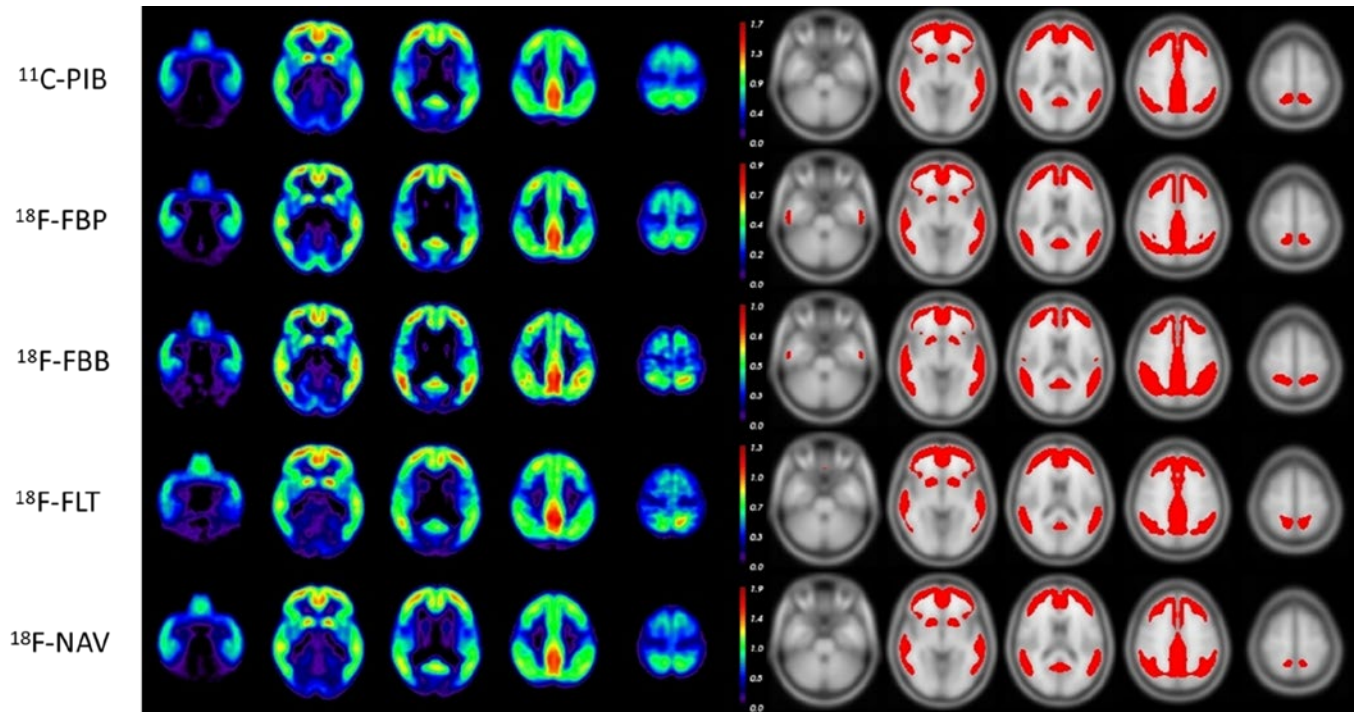
Universal neocortical mask for centiloid quantification

Collaborator: ADOPIC/NIH grant with Melbourne University, Washington University, ADNI, AIBL, ADNeT

The centiloid (CL) project was developed to harmonise the quantification of Aβ-PET scans to a unified scale. The CL neocortical mask was defined using 11C-PiB, overlooking potential differences in regional distribution among Aβ tracers.

We created a universal mask using an independent dataset of 5 Aβ tracers, and investigated its impact on inter-tracer agreement, tracer variability and group separation. For each Aβ PET tracer, we computed a new mask based on the difference between the PET scans of typical AD patients and aged-matched healthy controls. We found that the masks for each tracer were in good agreement.

A universal mask was defined as the intersection of all masks. The universal CL mask led to a small increase in inter-tracer agreement. It also improved group separation in the ADOPIC dataset. Those differences were however relatively small. This indicates that the existing Standard CL mask is already suitable for the quantification of all Aβ tracers.



Difference images (Alzheimer's disease healthy controls) for all 5 tracers and their corresponding masks.

Neuroimaging advancements in Parkinson's disease monitoring

Collaborator: Austin Hospital, Melbourne University

Our team tackled the critical challenge of monitoring disease progression in Parkinson's disease (PD) by assessing the sensitivity of 18F-AV-133 VMAT2 PET imaging. With limited validated biomarkers available, our research demonstrated that VMAT2 PET imaging not only enhances diagnostic accuracy but also detects early neurodegenerative changes associated with prodromal PD.

The study involved participants with PD, REM sleep behaviour disorder (RBD), and neurological controls (NC), who were scanned twice over a 26-month period. Significant declines in PET signal were observed in key brain regions of PD and RBD participants, indicating ongoing neurodegeneration. Notably, our imaging trajectory calculations suggest that neurodegeneration in PD can span approximately 33 years, with significant changes occurring years before clinical symptoms and diagnosis.

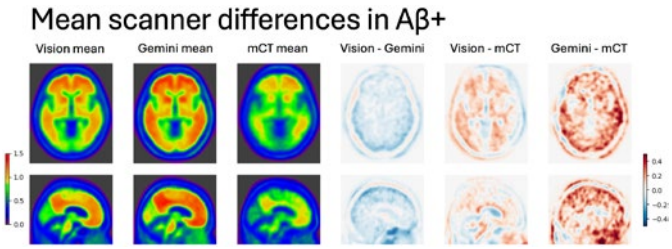
These findings underscore the potential of VMAT2 PET as a powerful tool for early detection and monitoring of PD, which is pivotal for improving patient stratification and the efficacy of disease-modifying treatments in clinical trials. This breakthrough aligns with our commitment to advancing precision medicine and enhancing patient outcomes through cutting-edge neuroimaging technologies.

Harmonisation of amyloid PET imaging across scanner hardware

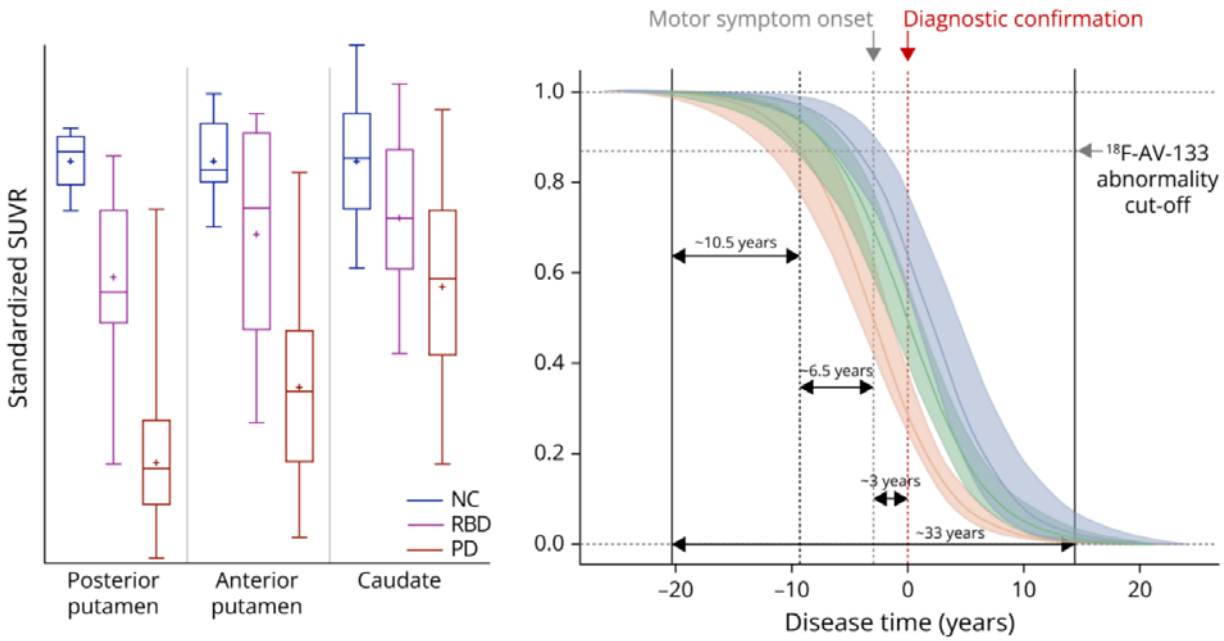
Collaborator: Machine Learning and Artificial Intelligence Future Science Platform, Austin Hospital, AIBL, ADNet

PET enables the precise quantification in the brain of levels of beta amyloid, a protein that accumulates in the brain and is a hallmark of AD. However, we recently demonstrated that images acquired on different types of scanners, as is common in large clinical trials, lead to different measurements. This is due to improvements in newer scanners as well as due to nuances of how different manufacturers process imaging data.

In this new project funded via the Machine Learning and Artificial Intelligence Future Science Platform, we are applying deep learning techniques to learn to minimise the differences between different scanners.



A comparison of beta amyloid PET images acquired on the Siemens Vision, Philips Gemini and Siemens mCT scanners. Left show the mean scans on each scanner, and right show the mean of paired scanner differences.



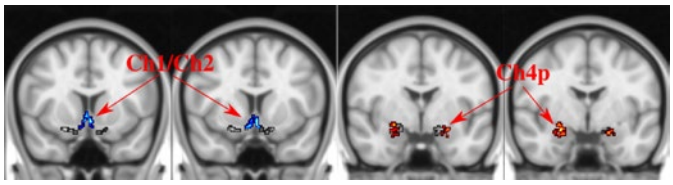
Standardised VMAT2 18F-AV-133 SUVR plots and trajectory curves along the Parkinson's disease continuum. Boxplot horizontal lines represent the median, whiskers reflect minimum and maximum values, plus sign represents the mean. Perforated red line represents the average point of clinical diagnosis (time 0), perforated green line represents the average point of motor symptom onset; shaded portion represents CI.

Longitudinal cholinergic degeneration in aging and Alzheimer's disease

Collaborator: AIBL, ADNeT, University of Queensland

Dysfunction of the cholinergic basal forebrain (BF) system begins during the preclinical stage of AD and persists throughout the disease's progression. This dysfunction interacts with other biological changes in AD, substantially contributing to cognitive impairment.

This study characterises the nature of BF volume loss and the extent to which BF atrophy manifests as cognitive decline in early AD. Our findings indicate that individuals with abnormal levels of amyloid-β burden (Aβ+) showed faster volume loss in BF and hippocampus, as well as faster decline in memory and attention. Notably, hippocampal atrophy primarily influenced memory decline, and atrophy in the predominantly cholinergic subregion of BF (Ch4p) affected attention decline.



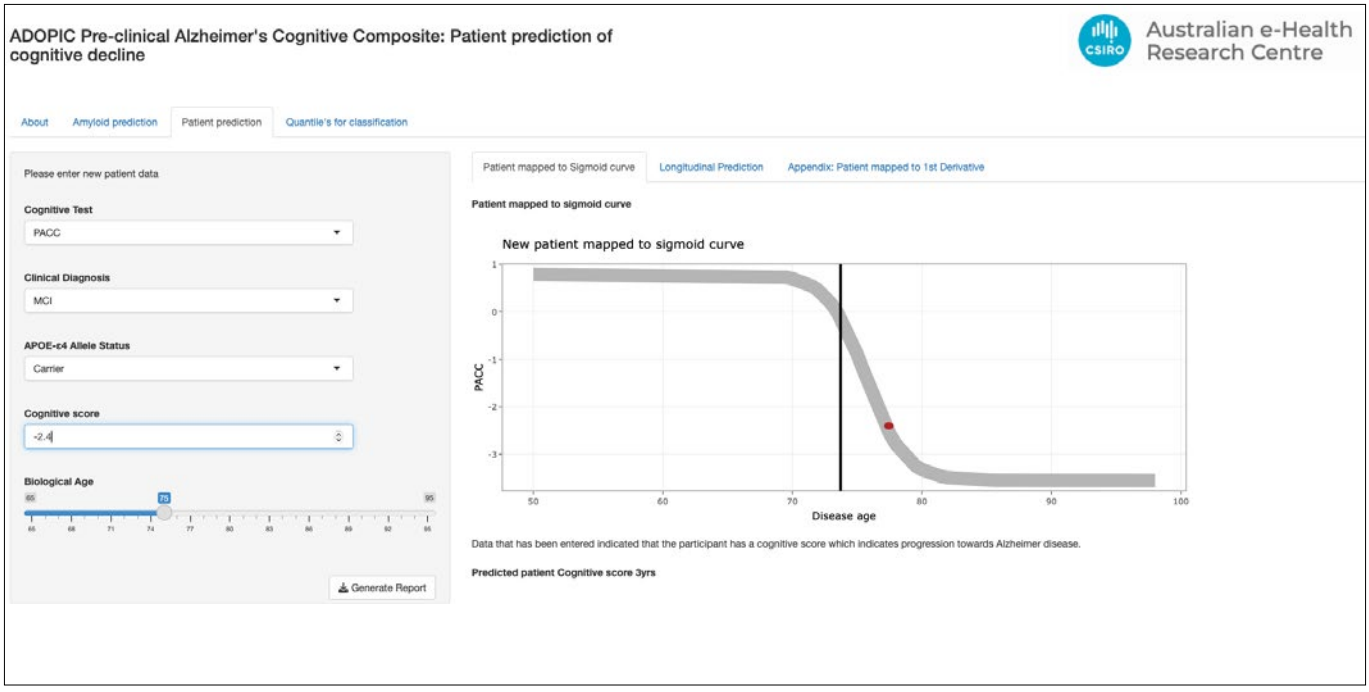
Mask of the cholinergic basal forebrain subregions overlaid on a human brain template. (Red) Ch4p: the posterior subdivision of the nucleus basalis of Meynert, (Blue) Ch1/Ch2: the medial septal nucleus and vertical limb of the diagonal band of Broca.

Biostatistics for Alzheimer's disease biomarker identification

Collaborators: Australian Imaging, Biomarkers and Lifestyle Study, Biogen

AD has a long lag period between the onset of pathological changes and clinical symptoms. The Australian Imaging, Biomarkers and Lifestyle (AIBL) study of ageing focusses on identifying biomarkers to detect disease pathology prior to the onset of clinical symptoms.

Working with Biogen, the Biostatistics team designed and produced a multi panel online application using disease trajectory models to identify patients with cognitive decline patterns consistent with AD. Below is a screenshot of the application that shows the participant being aligned to a point on the disease trajectory by statistically mapping their cross-sectional information to data from a large international cohort.



R Shiny application to define where on the AD trajectory a patient lies and if they are likely to experience cognitive decline consistent with AD.

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Biomedical Informatics: postdoc and student highlights

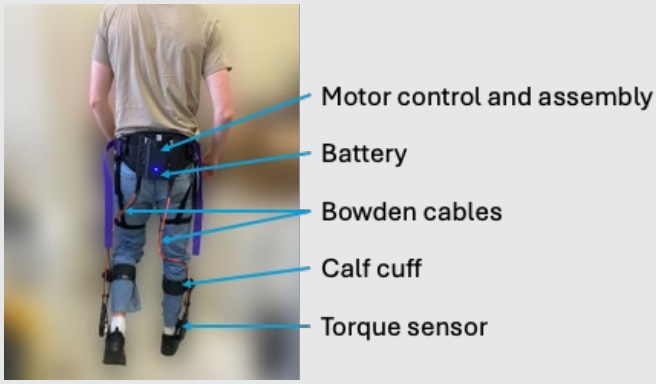
Postdoctoral fellow

One step closer: measuring muscle-plasticity following an ankle exoskeleton intervention in people with mobility disorders

Jess Bugeja

Collaborators: University of Queensland, Children's Health Queensland Hospital and Health Service, Metro South

Jess is a postdoctoral researcher in the neurodevelopment and plasticity team working across MRI, mHealth and biomechanics projects. This project aims to investigate the influence of longitudinal exoskeleton-based interventions on lower-limb muscle plasticity. This will allow us to assess the effectiveness of ankle exoskeleton interventions in people with mobility disorders. Through consumer engagement, we are currently assessing the feasibility and acceptability of exoskeleton-based interventions for people with mobility disorders.



The Biomotum robotic ankle exoskeleton used in our project.

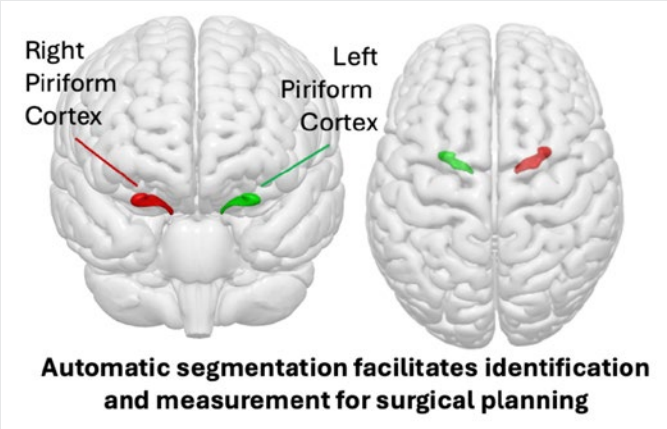
Advancing epilepsy surgery through automated piriform cortex segmentation

Javier Urriola, CSIRO Early Research Career Fellow

Collaborators: Monash University, Austin Hospital, Data61

This project leverages deep learning techniques to automate the segmentation of the piriform cortex (PC) from MRI scans, aiming to improve surgical outcomes for temporal lobe epilepsy patients.

Precise PC segmentation is essential for personalised treatment, as it informs tailored resections by revealing how the PC is involved in seizure spread in the brain. We aim to predict surgical outcomes and identify patients who would benefit from extended resection. Validation includes expert neuroradiologist comparisons and performance against traditional segmentation methods.



Our initial results show promising high concordance with manual segmentations, potentially providing clinicians with faster, accurate measurements for surgical planning. We are testing different deep learning architectures, including state-of-the-art models (nn-Unet) and newer transformer-based deep learning models (MedNeXt).

Automated wearable imaging platform for continuous imaging

Maria Antico, CSIRO Early Research Career Fellow

Collaborators: Queensland University of Technology, Technician Training Australia, Ontogo, CSIRO's Space Research Program

This project is developing a fully automated wearable imaging platform capable of continuous volumetric and real-time monitoring of internal body structures during everyday activities. This technology integrates arrays of transducers, such as capacitive micromachined ultrasound transducers, distributed on a flexible patch that users can easily position on the target anatomical area following simple instructions.

This year, we focused on advancing this solution for two specific clinical applications:

- automated haemorrhage detection for remote applications (figure below), in collaboration with the industrial partner Ontogo and
- automated thrombosis detection for astronauts during space flights with CSIRO's Space Research Program.

Additionally, we developed advanced image analysis algorithms using transformer-based deep learning for comprehensive anatomical visualisation.

Our findings were presented at national and international conferences and meetings, such as IEEE EMBC 2023, Acoustics 2023, ASUM 2023, and ESA/EAC Australian delegation 2024.

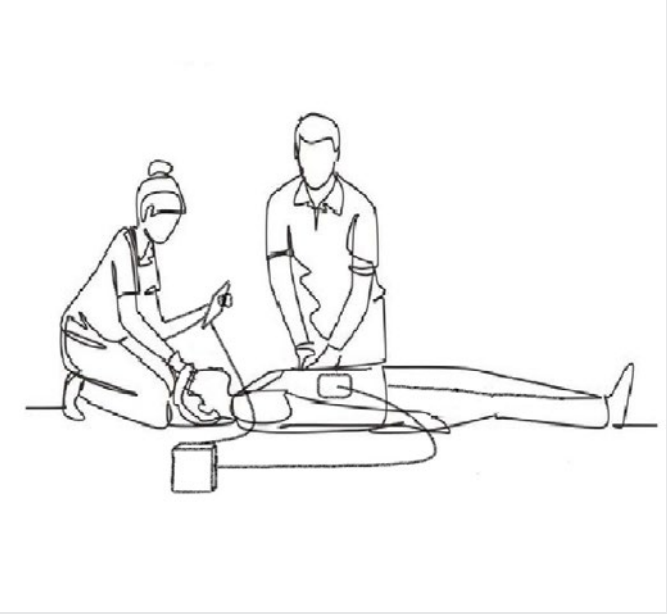


Figure: Graphical representation of the proposed system for the specific use case of automated detection of haemorrhage, with the wearable ultrasound patch positioned on the right flank of the patient, connected to hardware for ultrasound signal generation and control.

PhD

Internal organ motion prediction in radiation therapy

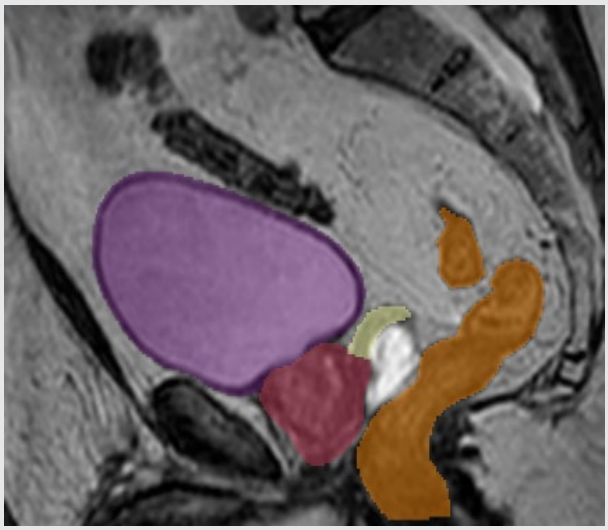
Febrio Lunardo, CSIRO supervisors: Ashley Gillman and Jason Dowling

Collaborators: James Cook University and Townsville Health and Hospital Services

External beam radiation therapy (EBRT) is an effective treatment of prostate cancer; however, internal organ motion introduces uncertainty during administration of radiation beam, which can lead to accidental irradiation of healthy cells. In collaboration with the Townsville Health and Hospital services (THHS), our work investigates the specifics of how internal organ motion occurs for prostate cancer patients during EBRT.

We have found that the bladder and its expansion during treatment to be influential in causing motion. However, its effect can be mitigated by ensuring the patient's bladder is moderately full (at 200mL) prior to treatment to minimise expansion. This knowledge can assist radiation oncologists and therapists in better planning and managing of treatment sessions, leading to more efficient and effective radiotherapy for prostate cancer.

a.



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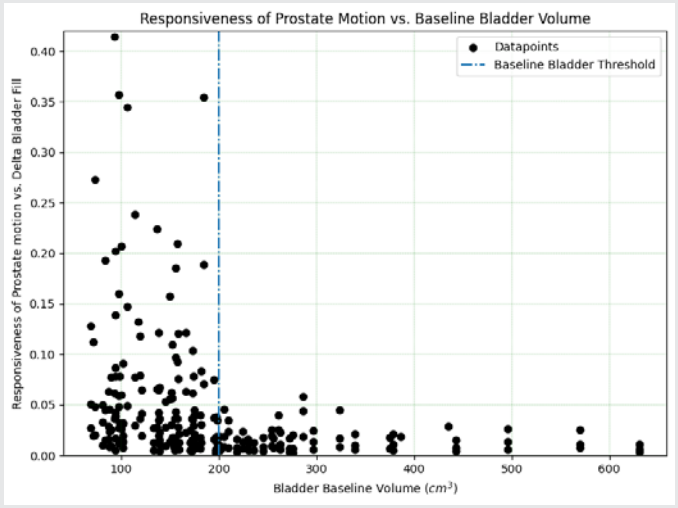


Inset a: Sagittal view of a labelled pelvic MRI captured for the project. Note: bladder (purple), prostate (dark pink), rectum (brown), seminal vesicles (yellow). Inset b: Relationship between prostate motion during treatment vs. bladder volume at start of treatment. **Inset a: Sagittal view of a labelled pelvic MRI captured for the project. Note: bladder (purple), prostate (dark pink), rectum (brown), seminal vesicles (yellow). Inset b: Relationship between prostate motion during treatment vs. bladder volume at start of treatment.**

The Digital Therapeutics and Care (DTAC) group

Group Leader: Marlien Varnfield

Our team of research scientists, technicians, and engineers in the Digital Therapeutics and Care group is dedicated to enhancing care services for older adults, individuals with disabilities, and those with chronic health conditions. By leveraging advanced digital platforms, we provide evidence-based interventions that are co-designed with consumers to improve health outcomes.

We harness the potential of cutting-edge sensor systems, smart devices, and digital technologies to gather personalised physiological data, as well as behavioural and social patterns, from diverse sources. This comprehensive data collection allows us to monitor individual progress and identify potential health issues before they become serious concerns.

The integration of technology in healthcare optimises the delivery of care, which extends to the improved overall well-being of our target populations.

Science and impact highlights for 2023/24

- Built new and maintained key relationships across the aged care and disability sectors. These include over 20 aged care providers, and government departments such as Department of Health and Aged Care, Department of Social Services and Department of Industry, Science and Resources.
- A new relationship with the NDIA which informed government policy for the $45m NDIS Evidence Advisory Committee
- Our mHealth platform, originally designed to assist in managing chronic conditions like cardiovascular disease, diabetes, kidney disease, and mental illness, has recently been expanded to include support for hypertension, heart failure, stroke, and post-colorectal cancer surgery follow-up.
- The award-winning M♡THer platform for the management of gestational diabetes has benefited >9000 women since June 2020. A randomised study to evaluate the effectiveness of using the platform to manage women with hypertension in pregnancy in multiple NSW hospitals has completed recruitment with 265 participants. We have also extended the M♡THer platform to include a diet diary component which is being trailed in QLD hospitals.

Artificial Intelligence in DTaC team

Team Leader: Shaun Frost

The Artificial Intelligence in DTaC team develops diagnostic and decision support systems for remote delivery of health services. The multi-disciplinary team combines expertise in clinical research, telemedicine systems and artificial intelligence for medical image and data analysis. The team works with key stakeholders and collaborators to develop and trial these solutions to demonstrate improved health outcomes and health service delivery.

Emerging Technologies in DTaC team

Team Leader: David Silvera

With wireless sensors, mobile technologies and health technologies pervasive in everyday use, new and rich sources of data are now available to determine the influence of lifestyle on health and wellbeing. The DTaC Emerging Technologies team uses internet-connected sensors, robots, and smart devices to facilitate improved outcomes for health, aged care, and disability, support people to live longer in their homes, and also support carers and service providers.

DTaC Project Support Team

Team Leader: Liesel Higgins

The DTaC Project Support team supports the wider group with project governance, research design development and the practical implementation of projects. The group consists of research technicians, project managers, and research scientists, all with clinical backgrounds. The team uses their multi-disciplinary knowledge and experience in stakeholder liaison and management, interpretation of health and social care related research problems and projects, and strategic development of research projects. Collectively the team contributes to research design and development, project evaluation, research analysis, data management, application to ethics and privacy governing bodies, project timelines and accountability of project deliverables.

DTaC Insights team

Team Leader: Janardhan Vignarajan

Our DTaC Indigenous Research team addresses the health disparities between Indigenous and non-Indigenous people in Australia. We partner with Aboriginal and Torres Strait Islander community-controlled organisations to co-design and co-develop ehealth solutions to complement existing successful models of care for some of the most significant health issues in these communities.

DTaC Insights Team

Team Leader: Pennie Taylor

The DTaC Insights team comprises of scientists and engineers with expertise in public health, clinical and health services, software engineering and ML. The team works with key stakeholders and collaborators (commercial and academic) to develop, trial and validate new models of care in mobile health, tele-health and virtual care settings, to optimise accessibility and consistency of care in a range of health discipline areas.

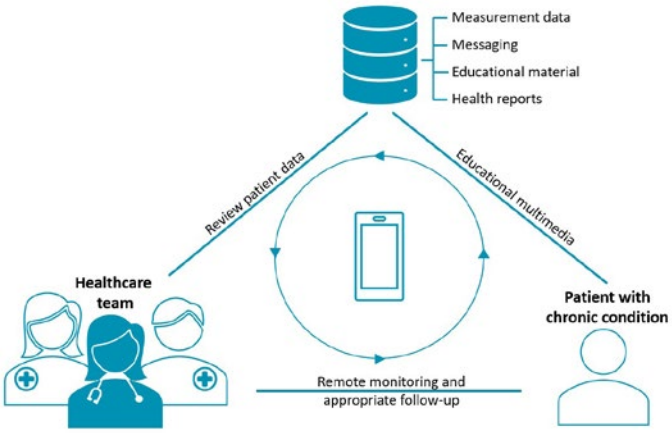
Digital Therapeutics and Care: platform technologies

Mobile health platforms

Our mHealth platform, developed to support the management of chronic conditions such as cardiovascular disease, diabetes, kidney disease and mental illness, has recently been extended to the management of hypertension, heart failure and stroke as well as post colorectal cancer surgery follow up.

The digital solution, which uses smartphone apps and the internet for ambulatory monitoring of health and wellness measures, was re-engineered and improved to integrate new wearable technologies such as a variety of activity and sleep-tracking devices.

Applications of the mHealth platform for various medical conditions are being evaluated in collaboration with our health service and industry partners. In addition to using the platform for self-management of existing health conditions, we have also developed a preventive smartphone application risk profiling matrix for chronic diseases.



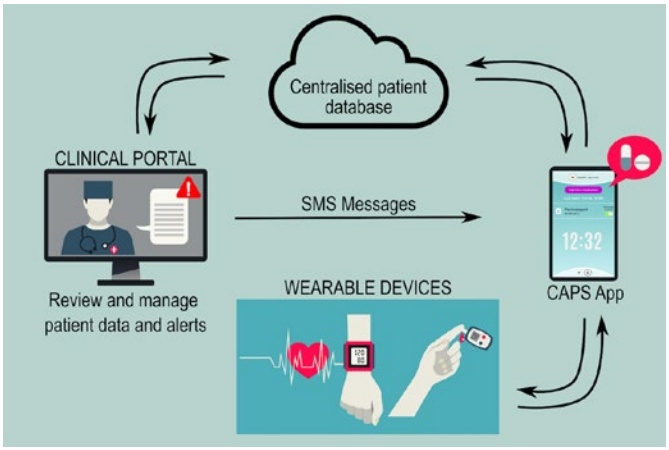
Components of the mHealth platform and data communication.

The platform design has personally controlled health information and interoperability concepts at its core. The FHIR based architecture attempts to solve the issues around 3rd party FHIR server integration and correlation of existing patient identity while maintaining the patients' control over where their data goes, be it a primary care system, hospital system or other FHIR server like a Health Data Exchange.

Our first proof-of-concept is ready for piloting in a Victorian public hospital and will be used for monitoring people with gestational diabetes with a redesigned interface informed by clinician focus groups and the M♡THer trial. A simulated hospital information system is being used for the pilot, but we have begun investigating integration into the hospital's electronic medical record system.

CAPS Stroke

The Care Assistant and support Program for people after Stroke (CAPS) or transient ischaemic attack (TIA) is a clinician-led program designed to improve the secondary prevention of stroke. The program combines person-centred goal setting and risk-factor monitoring through a web-based clinician portal, SMS goal-aligned messages, a mobile application (app), and a wearable device. The feasibility of the program was tested this year among people living with stroke or TIA, and clinicians who would deliver the program in future. The program was accepted by people living with stroke or TIA and clinicians who saw the value of CAPS for secondary prevention.

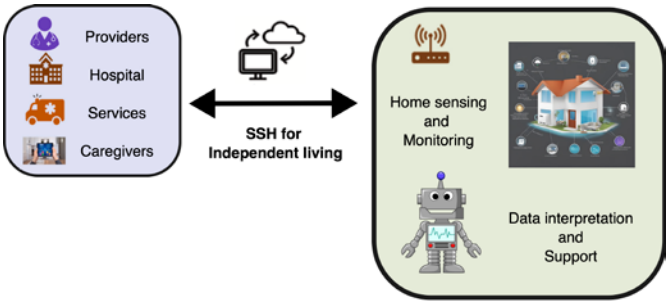


Integration of the CAPS program.

Smarter Safer Homes platform

Smarter Safer Homes (SSH) is an in-home health monitoring platform designed to support older people living independently in their own homes. The platform features a novel metric that determines an individual's functional independence, indexed through objective measurements of "activities of daily living". It was designed with consumers and industry partners to establish features that would enable them to self-manage and engage support from formal and informal care providers. The SSH platform includes a sensor-based in-home monitoring system (data collection), data analysis, and a client module with a tablet app, a family portal and a care provider portal. The SSH platform has been licensed to an Australian ASX listed company, and currently being integrated within a commercialised aged care platform and service offering.

In the last two years, the platform evolved into the Internet of Robotic Things space, where supporting intervention is incorporated in addition to data monitoring. Hence, the platform underwent a redesign to improve sensing, communication and computation in AI-enabled smart environments. This includes a new network architecture in which the centralised cloud processing is combined with edge-distributed processing (including AI analytics at the edge), to address trade-offs between the network of static (ambient sensors) and mobile (robots) nodes, including privacy, energy efficiency, network resources (latency, reliability, scalability) and distributed processing (task offloading).



The SSH platform supports people to live independently.

Medical Image Communication and Exchange (MICE) platform

Maintaining well-managed medical image communication and storage systems is a major problem hospitals face. In collaboration with South Metropolitan Health Service (WA), we developed the MICE platform, a secure and safe mobile health platform which assists clinicians to manage patient-related images and consent forms securely.

The MICE platform does not store any information on the clinician's smartphone, and automatically sends the records to the hospital's electronic medical record system, helping to protect patient confidentiality and privacy through a controlled process.

The platform has now transitioned to "business as usual" technology within the WA Health infrastructure and has been deployed in different clinical settings, such as burns ward rounds, plastics, emergency cases, radiology consent forms and home-based patient visits by nurses.

We are also further exploring collaborations to expand the technology in rural and remote regions in the general practitioner setting and Aboriginal health workforce. As part of the WA Minister's "Challenge" initiative, CSIRO is working with SMHS to expand the platform into rural health care.

The MICE app image review.

SIANNO: Simple Image ANNOtation Platform

CSIRO has developed an easy-to-use image labelling and annotation platform (SIANNO) which manages the workflow of labelling, annotating and inferring medical images.

The platform handles common 2D medical image formats and allows the user to use a handful of imaging tools (including rectangles, labels, custom labelling forms and polygons) in generating large amount of image dataset with a unified workflow.

Once the AI model is trained, the output of the AI detection can be integrated into the platform for managing patient imaging workflow in a clinical environment. The platform has been made open-sourced in GitHub and is being used for various projects including dental AI, foot and chest X-ray AI, and diabetic foot infection detection.

AI detection integrated into SIANNO tool to detect foot bones in X-ray images.

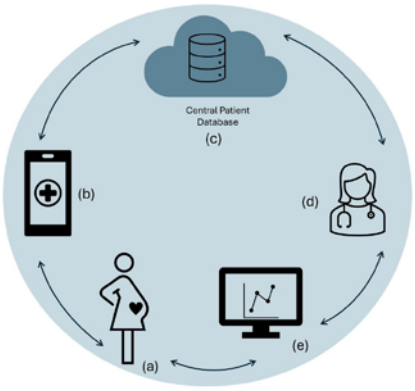
Digital Therapeutics and Care: full project reports

M♡THer studies

Collaborators: Metro South Hospital and Health Service, Metro North Hospital and Health Service, Mater Mothers' Hospital, Cairns Hinterland and Hospital Health Service, South Western Sydney Local Health District, Western Health and Monash Health Melbourne

GDM and hypertension are two of the most common conditions of pregnancy with the incidence and prevalence of both conditions increasing over recent years due to changing diagnostic thresholds and an increased cardiometabolic risk profile amongst the population. The conditions are resource intensive, placing considerable demands on both the mother and health system due to their chronic nature and multidisciplinary management requirements.

In 2017 we co-developed the 'M♡THer platform' with the Redland Hospital to address some of their challenges providing GDM management to a growing population.

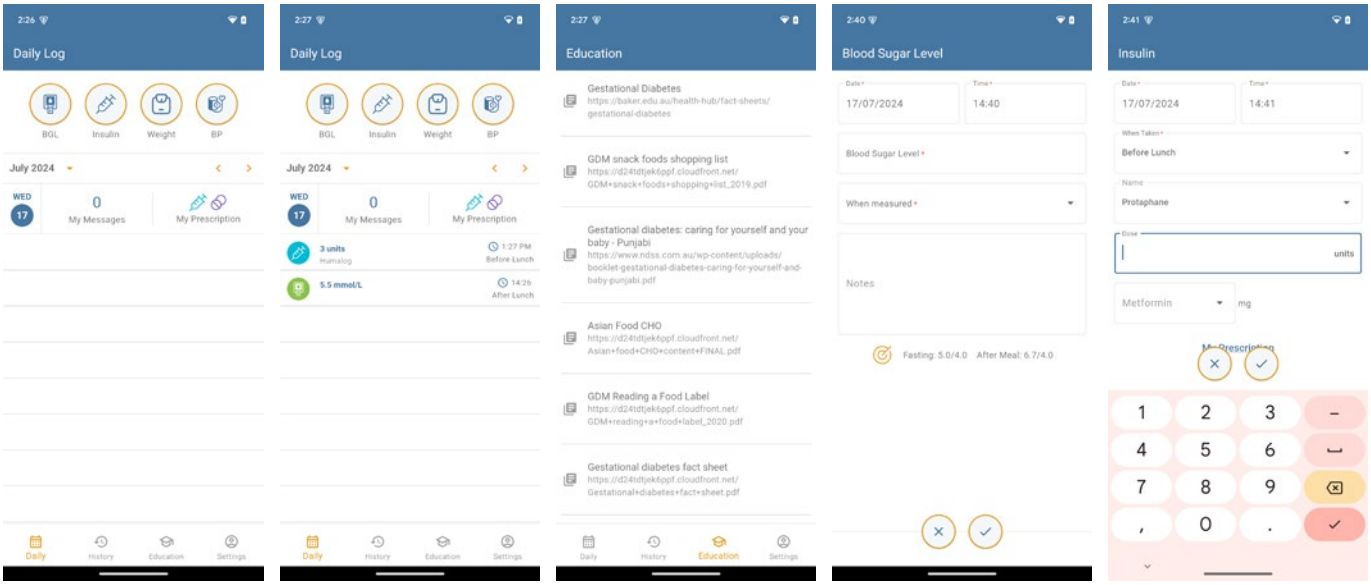


In collaboration with the maternal diabetes clinic, we developed a platform that could support an individual to log and track their health data (blood glucose, blood pressure, steps, stress, sleep etc) and facilitate remote monitoring by the multidisciplinary team. The platform consists of a patient facing app and a web-based clinician platform. A successful feasibility study led to a multisite implementation study, buoyed by the demand for remote-monitoring during the COVID-19 pandemic.

Since mid-2020, the GDM platform has supported over 9000 women and their health care team, with studies operating across Redland, Logan, Mater, Royal Brisbane and Women's Hospital and Ipswich Hospital. Additional feasibility studies have also been undertaken in regional and remote areas, including a past study at Mt Isa Base Hospital and an active study at Cairns Hinterland and Hospital Health Service (inclusive of Innisfail Hospital, Mareeba Hospital, and Mossman Hospital). The continued demand for the platform suggests mHealth supported GDM management is an effective tool for women and their health providers in managing GDM. A randomised control trial is commencing with a Melbourne health service to explore if and how the mHealth supported model of care for GDM can positively affect clinical outcomes.

Inspired by the opportunity to provide quality care remotely, easing the resource burden associated with frequent face to face appointments for hypertension in pregnancy, South Western Sydney Local Health District sought to augment the platform to manage hypertensive disorders in pregnancy. A randomised control trial has completed recruitment (n=265) across three hospitals in Sydney. The preliminary feedback suggests the platform was well accepted by users, further analysis will provide insight into the safety, user-satisfaction, cost-effectiveness and impact on healthcare utilisation.

Schematic illustration of the M♡THer platform. A woman with GDM (a) installs the M♡THer app on their smartphone (b). The M♡THer app is used for data input such as blood glucose levels, weight, exercise and symptoms, and delivery of motivational prompts and educational media. Patient data is uploaded to a secure centralised patient database (c), that can be accessed by the GDM care team (d) via a clinician web portal (e). Data can be reviewed via the web portal by healthcare practitioners, aiding in discussions and management decisions.



Patients can record blood glucose levels and other key readings in the M♡THer app

Diet diary app extension

Collaborators: Redlands and Logan Hospitals, Adelaide University (PhD Student evaluation support - Amy Myles)

A new diet diary feature was implemented after interviews with clinical collaborators and the M♡THer survey where end-users indicated a desire for greater functionality within the M♡THer app to support nutrition data.

At present, the team is conducting an evaluation of the tool including surveys, interviews and analysing data from the app. Preliminary data indicates that the diet diary improves the quality of the dietetic consults and allows the diabetes educator to provide more explicit feedback to women on the carbohydrate load and medication titration needs.

Women also report to have found it beneficial to capture their diet, especially carbohydrate portions in the tool; to help learn how their dietary intake affects their blood glucose levels. Once the study is complete, the findings will be published, and the feature progressed to other sites for wider implementation testing and adoption.

GDM postpartum care: a national survey

Collaborators: Diabetes Australia, Deakin University (Institute for Health Transformation) and the Australian Centre for Behavioural Research in Diabetes (Victoria), Metro South Hospital and Health Service, NDSS, Logan Hospital and Redlands Hospital

GDM is one of the most common complications of pregnancy in Australia affecting >17% of pregnant women. Despite the compelling evidence that consistent, and patient-centred, management of GDM can improve the uptake of blood glucose management recommendations, there remain inconsistencies in the implementation of clinical guidelines, both at a service level, and across the country. Digitally supported models of care, such as apps to log blood glucose, have also increased in the last 5 years and little is known about how these tools are or could be used within the scope of GDM self-care.

This study qualitatively explored the contemporary experiences of individuals with GDM in a large cross-sectional Australian survey, with a secondary aim to identify opportunities to use digital solutions to better support GDM management. Although the original target was for 400-700 respondents, 1474 respondents were recruited, of which 815 (55%) also provided a meaningful response to at least one of the 3 opened-ended questions.

Drawing on the data collected in this cross-sectional online survey which explored respondents' experiences of GDM and the healthcare system, including digital health usage during this time, findings suggest demand for more supportive, person-centred GDM care. Respondents indicated a desire for improved information provision and individualised application of the clinical guidelines, considerate of their unique health experience. More person-centric approaches are proposed to reduce access barriers as well the negative phycological impacts of GDM, such as the stigma associated with it. Though not central to the identified experiences, digital health tools may be able to assist with the delivery of more tailored care and reduce reported barriers. The study was conducted by a multi-disciplinary research team including professional experience in dietetics, diabetes education, health promotion and health psychology as well as lived experience of GDM.

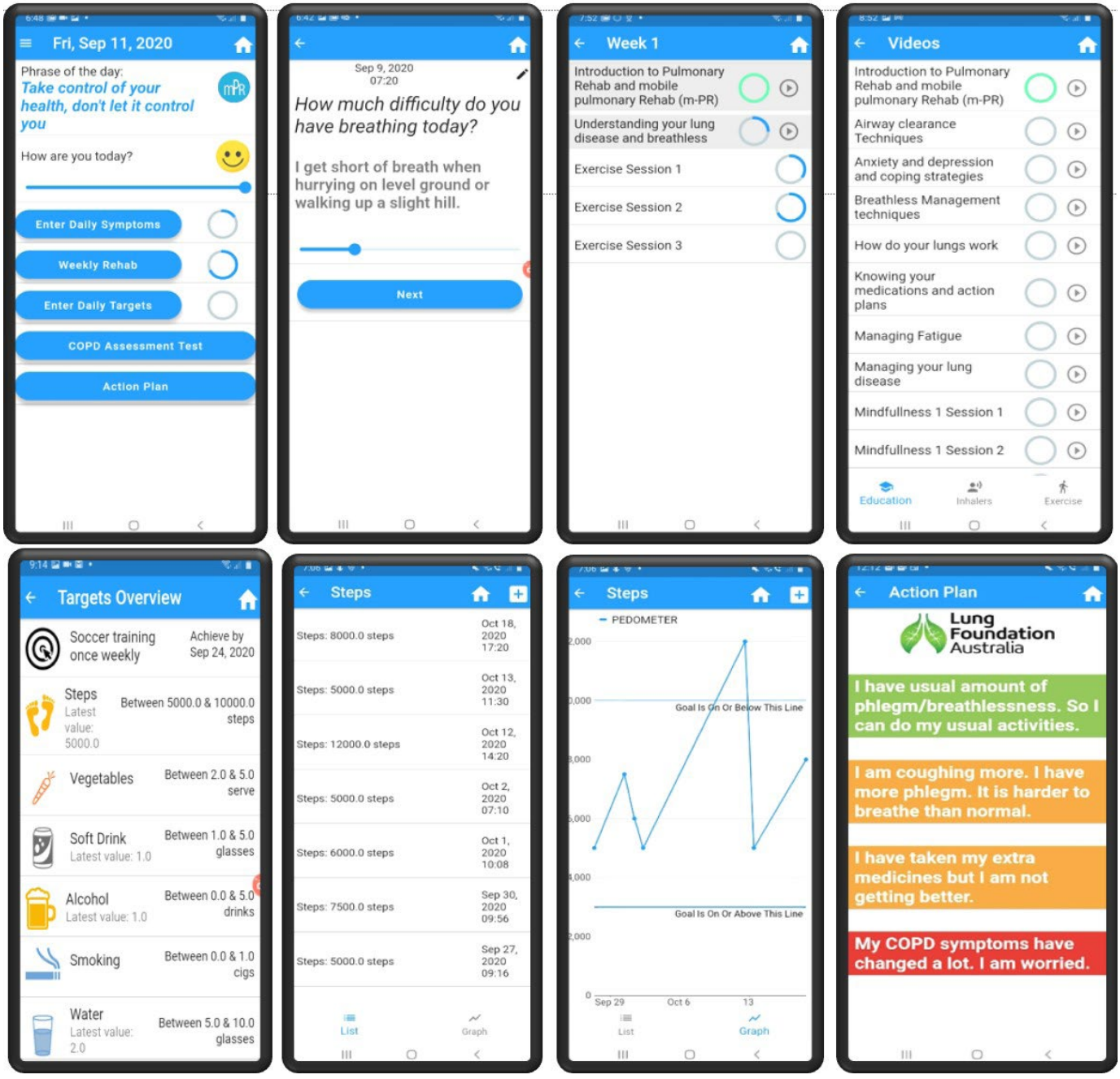
Rehabilitation for pulmonary disease (m-PR)

Collaborators: Northern Sydney Local Health District, University of Sydney, Better Breathing Foundation, Lung Foundation Australia

mHealth offers a novel method of delivering pulmonary rehabilitation (PR). A mHealth PR platform, the mobile Pulmonary Rehabilitation (m-PR™) app was developed with our collaborators. m-PR™ allows participants to complete endurance and resistance exercises, watch informational videos, track daily health goals, monitor symptoms, view a medication action plan and receive motivational notifications.

The m-PR platform is being evaluated through three research projects. The first evaluated the messages used to provide support for improved pulmonary disease self-management. The second project was user testing with results demonstrating excellent overall usability of the app, 91% enjoyed using the app and found it easy to use.

A randomised controlled clinical trial (RCT) is now underway (n=90) to evaluate the effectiveness of m-PR™ compared to centre-based PR. A single-arm preliminary analysis of the RCT intervention group was conducted to evaluate engagement and adherence to the m-PR™ app. Thirty-three participants (mean age 74 [SD 7] years, 47% female) completed the study. Overall engagement was high with all sections of the m-PR™ app. The findings from this study suggest that people with COPD will be engaged and adherent to tasks when participating in evidence-based PR through the m-PR™ app.

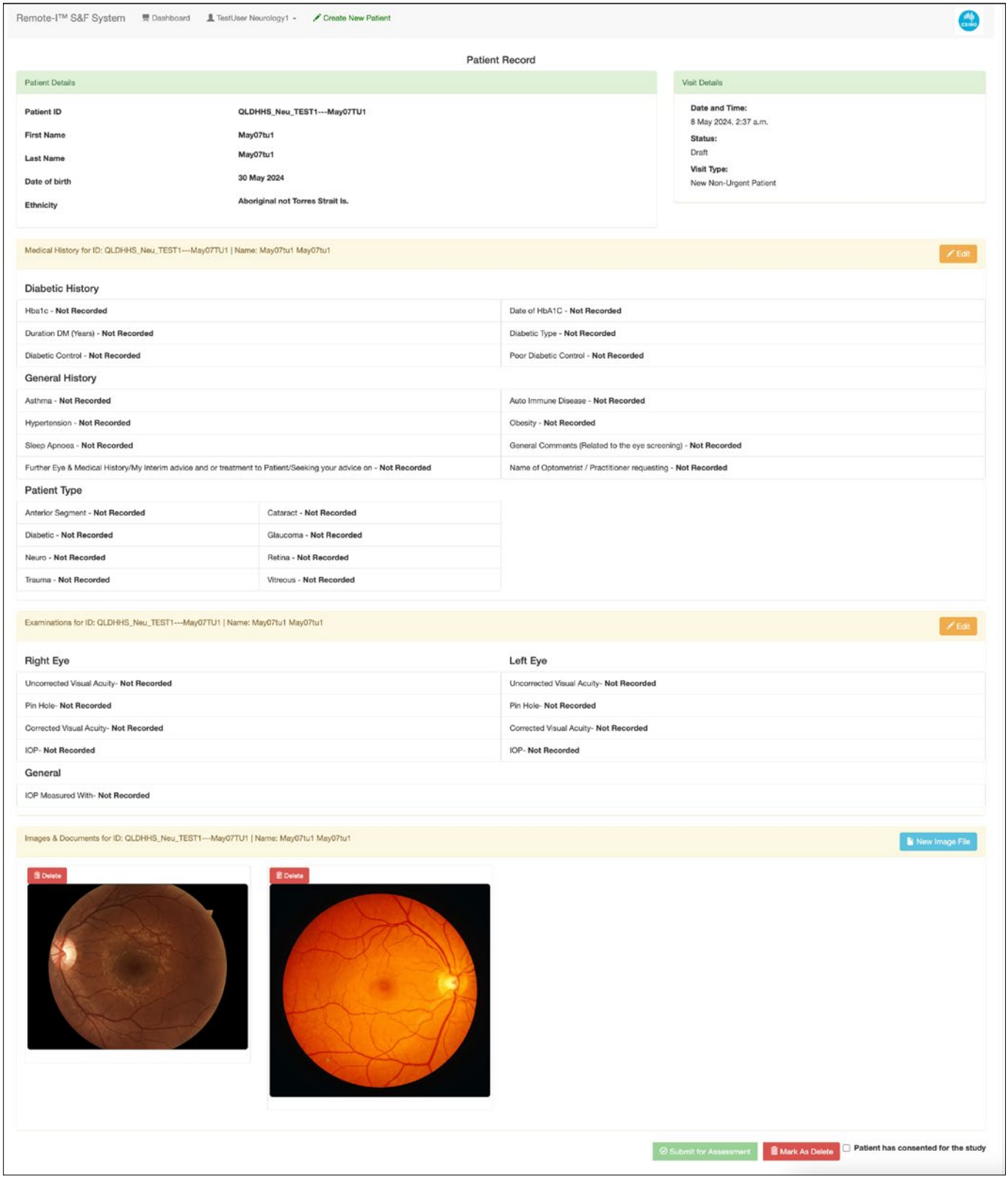

Fri, Sep 11, 2020
Phrase of the day:
Take control of your health, don't let it control you
How are you today?
Enter Daily Symptoms
Weekly Rehab
Enter Daily Targets
COPD Assessment Test
Action Plan
Sep 9, 2020
07:20
How much difficulty do you have breathing today?
I get short of breath when hurrying on level ground or walking up a slight hill.
Next
Week 1
Introduction to Pulmonary Rehab and mobile pulmonary Rehab (m-PR)
Understanding your lung disease and breathless
Exercise Session 1
Exercise Session 2
Exercise Session 3
Videos
Introduction to Pulmonary Rehab and mobile pulmonary Rehab (m-PR)
Airway clearance Techniques
Anxiety and depression and coping strategies
Breathless Management techniques
How do your lungs work
Knowing your medications and action plans
Managing Fatigue
Managing your lung disease
Mindfullness 1 Session 1
Mindfullness 1 Session 2
Education
Inhalers
Exercise
Targets Overview
Soccer training once weekly
Achieve by Sep 24, 2020
Steps
Latest value: 5000.0
Between 5000.0 & 10000.0 steps
Vegetables
Between 2.0 & 5.0 serve
Soft Drink
Latest value: 1.0
Between 1.0 & 5.0 glasses
Alcohol
Latest value: 1.0
Between 0.0 & 5.0 drinks
Smoking
Between 0.0 & 1.0 cigs
Water
Latest value: 2.0
Between 5.0 & 10.0 glasses
Steps
Steps: 8000.0 steps
Oct 18, 2020 17:20
Steps: 5000.0 steps
Oct 13, 2020 11:30
Steps: 12000.0 steps
Oct 12, 2020 14:20
Steps: 5000.0 steps
Oct 2, 2020 07:10
Steps: 6000.0 steps
Oct 1, 2020 10:08
Steps: 7500.0 steps
Sep 30, 2020 09:56
Steps: 5000.0 steps
Sep 27, 2020 09:16
List
Graph
Steps
PEDOMETER
Goal Is On Or Below This Line
Goal Is On Or Above This Line
Sep 29
Oct 6
13
List
Graph
Action Plan
Lung Foundation Australia
I have usual amount of phlegm/breathlessness. So I can do my usual activities.
I am coughing more. I have more phlegm. It is harder to breathe than normal.
I have taken my extra medicines but I am not getting better.
My COPD symptoms have changed a lot. I am worried.

The m-PR app.

Redefining eye-health delivery in underserved population

Over several years, the team has developed a telehealth platform that provides secure store and forward capability for remote health service delivery, mainly ophthalmology, but also including items such as dentistry, pain and burns.

The platform underpinned a 4-year project delivered for the CRC for Developing Northern Australia connecting metropolitan-based specialists with remote communities in northern Australia. One of the partners in that project was Queensland Health who requested additional functionality to allow the system to be used within the Queensland correctional system, and to cover other eye diseases. Since project completion, the system has continued to be used by Queensland Health, a testament to the effort invested to ensure everything is encrypted and complies with Queensland Health's strict cybersecurity policies.



CSIRO's eye health platform used in IIH cohort - patient record page

In 2023-24, the team liaised with Queensland Health's telehealth support unit and outreach optometry team. The team indicated that not only was the platform desired as a BAU component to support existing use cases, there was a new interest from the neurology team, keen to manage their bigger cohort of idiopathic intracranial hypertension patients via the platform.

A wish list of enhancements was delivered and appropriate procedures were established to enable the platform to be used to reduce inflow of IIH patients to outpatient departments. Some of the modifications were to enable neurology staff to view the journey of records with clear audit trails without affecting the record trail itself.

Testing of the platform was successful, and following onboarding of optometrists, the system went live in June 2024.

Digital yarning using interoperable computer integration for sharing medical records and photographs to close the gap

Collaborators: South Metropolitan Health Services, Department of Health

We were one of the ten recipients of the Minister's Innovation Challenge in Western Australia to work towards a proof-of-concept project showcasing the capabilities of integrated digital health, especially focussed on the remote region of Pilbara, Western Australia. With our project partner South Metropolitan Health Service in Western Australia we will collaborate with local Aboriginal health service stakeholders to produce a long-term interoperable proof of concept solution to connect various service providers through open health standards. Following from this we will demonstrate the implementation the solution.

This project is supported by the Western Australian Department of Health through the Future Health Research and Innovation Fund and keystone partners Rio Tinto and BHP.

EEG in depression: Default mode network detection using EEG in real-time

Collaborators: Resonait

In Australia, one in seven adults are expected to experience depression. The burden of this disease in Australia is now the third highest, as measured by financial cost, mortality and morbidity.

Through a kickstart grant, we are collaborating with Resonait, an exciting Australian startup, to validate their technology and support their vision of developing a new medical device to manage and treat depression in the home. By using wearable sensors on the scalp (electroencephalogram) this device uses AI algorithms to identify brain activity (resting state networks) closely associated with depression. The prevalence of these networks, specifically the default mode network, could potentially be used to monitor and support recovery from depression.

In the last year, through this collaboration, we have investigated the real-time processing requirements, coordinated a pilot pre-clinical study with the Black Dog Institute, and evaluated the performance of numerous commercial wearable EEG devices (for example Muse and Emotiv) when applying Resonait's software platform. Our efforts have recently seen a conference paper accepted detailing the ability of the Resonait platform to achieve real-time detection of the default mode network using a public dataset.

Resonait are developing technology to detect and modulate the default-mode-network, particularly relevant to depression as it is often a brain state associated with rumination.

Patient record view for remote health practitioner which combines and integrates all the records from hospital in one view.

Smart Footprint - Diabetes-related foot ulcer risk detection device

Collaborators: Queensland University of Technology, Queensland Metro-South, and Translational Research Institute

Diabetes-related foot ulcers (DFUs) are a major, but frequently under-appreciated, complication estimated to affect approximately 30% of people with diabetes. Over half of DFUs develop infection, of which, 17% result in amputation.

The 5-year mortality rate for people with a major lower extremity amputation due to DFU is greater than 50%. Proper surveillance and early identification are therefore essential to prevent possible ulcer formation and the associated morbidity and complex healthcare management challenges.

Via a Translational Research Institute grant, the team developed a prototype which is currently undergoing functional testing. Furthermore, the project is preparing documentation, ethics, and a research plan to conduct a proof-of-concept trial.

In the last year we conducted a survey on potential patients to better understand user requirements for better design. Results were presented at the Preventative Health Conference in Darwin and will contribute towards a future design paper. Functional testing of the design has begun, where a pre-clinical study in regional and metro sites is scheduled to begin later this year.

Through an iterative design process, the design of the device (as imagined by DALL-E, top right) and wireframes (bottom) of the prototype continue to be developed.

Digital Therapeutics and Care: short project updates

The SSH solution to support older people living in their own homes: Randomised controlled trial

This study investigated the impact of smart home monitoring on the Adult Social Care Outcomes Toolkit (ASCOT), EuroQol-5 Dimensions-5 Levels (EQ-5D-5L), Katz Index of Independence in Activities of Daily Living (Katz ADL), Lawton Instrumental Activities of Daily Living Scale (IADL), and Geriatric Depression Scale (GDS) among older people living in their own homes over a 12-month period.

The data from 130 participants were used in the analysis, with no significant differences in baseline characteristics between the control group (n = 61) and the intervention group (n = 69). In comparison to the control group, the intervention group had a higher ASCOT score at the 6-month assessment (mean difference: 0.045; 95% CI: 0.001 to 0.089; Cohen d: 0.377). However, this difference did not persist at the 12-month assessment (mean difference: 0.031; 95% CI: -0.014 to 0.076; Cohen d: 0.259). There were no significant differences in EQ-5D-5L, Katz ADL, IADL, and GDS observed between the intervention and control groups at the 6-month and 12-month assessments.

HAPPI MIND

Collaborator: Monash University

While there is currently no cure for dementia, there is evidence that some health conditions and lifestyles may increase the risk of developing dementia.

With our collaborators at Monash University, we are conducting a cluster randomised trial to evaluate a new approach for assessing and reducing dementia risk factors in middle-aged adults. By June 2023, 394 patients were recruited from primary care practices/ clinics to participate in this multi-domain, primary care, nurse-led and smartphone assisted intervention. The primary outcome measure for the study is the Australian National University Alzheimer's Disease Risk Index (ANU-ADRI) score. To date, Overall, n=330 have completed the primary outcome at 12months.

MoTER-HF Heart Failure Platform

Collaborator: The Prince Charles Hospital

We have developed an interactive digital platform to support patients with heart failure in managing their chronic condition. This platform was developed collaboratively with clinicians from the Prince Charles Hospital (TPCH) using AEHRC's mHealth technology. It comprises a smartphone app for patients and a web-based portal for clinicians.

A feasibility study of the platform commenced in April 2024. Patients with primary or secondary diagnosis of heart failure are being recruited from the heart failure services at TPCH. Each patient participant uses the MoTER-HF app and two study devices (blood pressure monitor and digital weight scale) daily for a period of 12 weeks. Clinicians at the heart failure services monitor patients' app data, including daily diaries, clinical measurements, symptoms, and exercise logs, and review this data during the patients' clinic visits.

The study is using mixed-method design aims to evaluate the uptake and acceptability of the app and platform among patients and clinicians, assess the potential impact of using the platform, and explore the experiences and recommendations of both patients and clinicians regarding the integration of the digital platform into clinical practice.

Design and evaluation of a clinical decision support system for managing COPD

Collaborators: The Prince Charles Hospital, Lung Foundation Australia, University of Melbourne

Through co-design with our collaborators, we are designing and evaluating an innovative digital platform aimed at supporting efficient decision-making for clinicians in managing COPD. The platform will feature an easily accessible and interactive digital interface to translate national COPD guidelines effectively, within hospital settings.

A systematic review on clinical decision support systems, completed by the project team in 2024, highlighted the importance of a user-centred design approach and alignment with interoperability standards in the platform's development.

Co-design workshops involving hospital clinicians and patients with COPD will commence soon. Following the platform's development, a clinical trial in emergency departments will be conducted, leveraging principles from implementation science. This approach aims to ensure the effective integration of the digital intervention, and to enhance the adoption of guidelines in the clinical practice for COPD management.

CAPS – Feasibility study, qual work with GPs

Collaborator: Monash University

Feasibility testing of the 12-week multicomponent digital care assessment and support program for people after stroke or transient ischaemic attack (CAPS) was completed with 33 participants. End-user participant and clinician feedback suggested the need for some minor modifications in preparation for a randomised controlled trial. This year we completed the modifications to the app and clinical portal, reviewed the SMS educational messages, and a qualitative study with general practitioners to gather their feedback on the program implementation. The qualitative interview study, funded by the STOPStroke program, was conducted with eight GPs from four states and three program managers of the Stroke Foundation between April and June 2024. The results highlighted the potential benefits of supporting stroke patients' self-management, identified challenges in integrating the CAPS program with existing workflow and data monitoring practices, and generated suggestions for a clinical trial and future CAPS program implementation. The program is now ready for a pilot randomised controlled trial.

TERRACOTTA

Collaborators: Monash University

Targeting Treatable Traits in COPD to Prevent Hospitalisations (TERRACOTTA) will focus on a national roll-out of the interdisciplinary model of care, to inform its scale-up as a routine service. The current study's aim is to demonstrate the efficacy of a practice nurse-coordinated intervention targeting treatable traits in moderate-severe COPD in general practice for improving health-related quality of life and reducing hospitalisations/emergency department visits. As a part of this intervention, we developed a consumer facing mobile application to provide guided health information and a digitised version of the COPD action plan, which allows the research team to collect engagement and real time COPD status information.

Geriatric evaluation and management - outcome measures that are automated, timely, interoperable and consolidated (GEM-OMATIC)

Outcome measurement tools (OMTs) are used in aged care to support clinical decision making, plan care, determine funding requirements and report against quality indicators.

The current use of OMTs in aged care is fragmented (hindering a collaborative team approach), and burdensome (repetitive and inefficient).

Interoperable OMTs have the potential to reduce administrative burden, and if used as part of a unified "comprehensive geriatric assessment", also have the potential to improve health outcomes. The project has mapped the stakeholders involved in the collection and use of OMTs in Australia have:

- mapped the OMTs currently mandated by the Government
- identified the data-items that make up the mandatory tools and
- mapped duplicate data-items.

We are preparing to conduct surveys and interviews with a range of health professionals to allow us to map the broader landscape of OMTs. The project aims to form the foundations of an open-source library of "building-blocks" to support interoperability across the continuum of care between different OMTs.

Wearable sensors for energy expenditure measurement in patients with burn injury

Collaborator: Royal Brisbane and Women's Hospital

Severe burns cause a profound pathophysiological stress response and a radical increase in metabolic rate. The gold standard method (indirect calorimetry) for determining energy expenditure (EE) in patients with burns only provides a short snapshot of resting EE and is not practical to be used throughout the day.

This project will identify the primary physiological indicators of EE and explore how they can be measured throughout the day non-invasively using wearable devices. A literature review, market research, and consultation with relevant stakeholders was undertaken to identify promising wearable technologies capable of measuring physiological indicators of EE. A feasibility trial has been planned, and will be conducted to evaluate these sensors. These devices will gather physiological data, enabling the estimation of total EE through standard estimation equations and iterative algorithms, which will be compared against the gold standard measurement for EE in a clinical setting (indirect calorimetry). This research will provide valuable data to improve our understanding of the potential use of wearable devices to monitor EE to guide nutrition decisions.

Human identification using mmWave radar

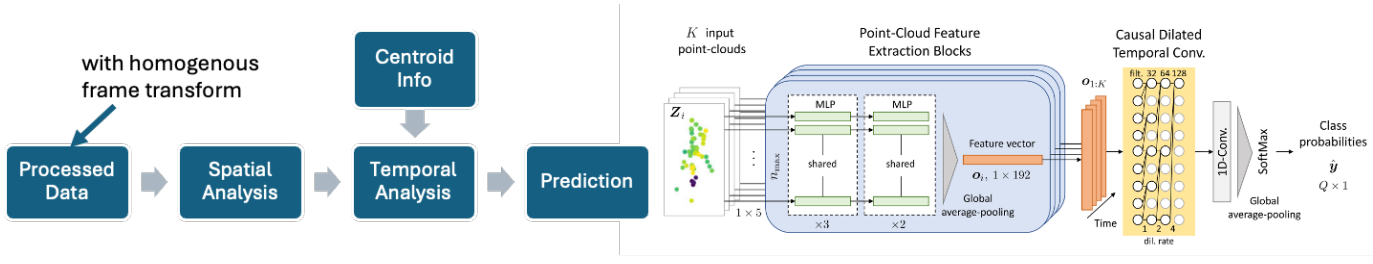
This project focuses on developing the signal processing and machine learning techniques for human identification using mmWave radars.

We introduced novel homogeneous frame transformation and centroid compensation units to a benchmark model for mmWave human identification[1]. The improved model was evaluated on a public mmWave dataset, demonstrating a 12% increase in testing accuracy compared to the benchmark model.

Fall prevention in residential home via distributed sensors - BEST CARE project

In March 2023, we were awarded an Aged Care Research and Industry Innovation Australia (ARIIA) grant in a collaboration with Talius, to understand if distributed ambient sensors can be used to successfully predict falls, before they occur, within a residential aged care home environment. The long-term objective is to use a combination of sensors placed around the residential aged care home with settings adjusted to individual risks to identify factors that can lead to a fall.

This study explores the acceptability of these autonomous sensors and the use of an individual's "sensor story" to understand a person's wellbeing. The study will also identify any barriers to adoption and the impact of this technology on the aged care organisation's operations. Ethics was obtained in August 2023 and data collection is currently taking place. This project is due to be finished by December 2024.



Signal processing and ML techniques for human identification model.

1 Pegoraro, Jacopo, and Michele Rossi. "Real-time people tracking and identification from sparse mm-wave radar point-clouds."IEEE Access 9 (2021): 78504-78520.

AgeWell mHealth insight of ageing Australians

Collaborators: Sax Institute, UNSW

This collaboration between CSIRO, UNSW, and the Sax Institute leverages on advanced digital tools, including ambient and wearable sensors, to establish an Australian repository of longitudinal health and lifestyle data from ageing Australians.

Specifically, the project will complete a proof-of-concept by collecting data from 100-200 participants using surveys, interviews, and distributed wearable and ambient sensors to investigate the relationships between behaviour, demographics and health outcomes in ageing Australians, with particular interest on social isolation, loneliness, mental health, and anxiety.

By examining how health issues manifest and are managed in the 45 and over age groups, this project will provide valuable insights to inform targeted public health interventions to promote healthy ageing.

Through the integration of these data sources and analytical techniques, the project will inform strategies to improve health outcomes, prevent diseases, track population health trends, and optimise the efficiency and effectiveness of public health programs and services.

Internet of robotic things to support independent living

This project leverages the IoT to monitor the health and activities of older adults and individuals with disabilities, utilising robotic systems to provide autonomous and real-time assistance. The project will promote independence and enable individuals to age in place. Currently, we are employing various distributed wearable and ambient sensors to collect clinically relevant data on an individual's activities.

This data will be used to develop an index to help identify early signs of physical or cognitive decline to enable timely clinical intervention. Additionally, the project is exploring privacy-preserving mechanisms for data processing, such as edge computing and federated learning. We have developed an architecture for hierarchical federated learning in environments where users have multiple data-generating devices (e.g., smartphones, smartwatches, smart rings). This architecture enhances activity recognition performance, reduces the energy consumption of sensing devices, and minimises delays in providing support and intervention.

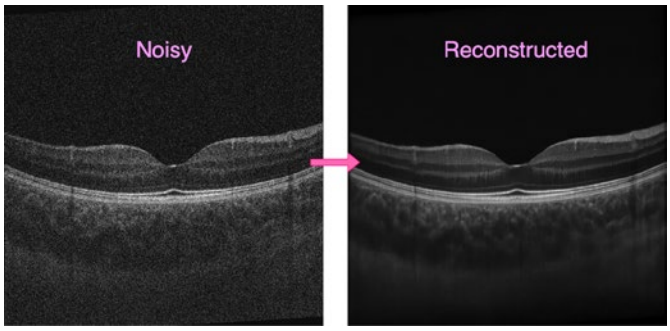
Retinal image reconstruction in optical coherence tomography

Collaborator: Queensland University of Technology (QUT), QUT Contact Lens and Visual Optics Laboratory (CLVOL)

Speckle noise, an inherent limitation of optical coherence tomography (OCT) images, makes clinical interpretation challenging. The recent emergence of deep learning techniques could offer a reliable method to reduce noise in OCT images.

We investigated the application of OCT image reconstruction/denoising employing generative adversarial networks (GAN). We looked at the problem of OCT image denoising as a neural style transfer (NST) which is the process of using convolutional neural networks (CNNs) to render a content image in various styles. Specifically, in the problem of OCT image reconstruction, the aim is to render the noisy OCT image with the style of the averaged gold standard OCT image. The network training and results are completed, expert feedback from our collaborators is gathered.

Published (April 2024) in Biomedical Optics Express, a paper titled: "Employing texture loss to denoise OCT images using generative adversarial networks"



A noisy image and a reconstructed image using our technology.

AI in dental images and radiographs

Funder: WA Health Research and Innovation Office

We have developed a suite of AI models to detect dental caries and tooth numbers from dental radiographs (bitewing and panoramic X-ray images) and colour dental photographs. Data for the project was collected from various clinics across Perth.

Several deep learning-based artificial intelligent feature detection models were developed and tested against the dataset. Calibrated dental specialists were involved in labelling the data. Our deep-learning based detection model was developed to detect tooth caries in colour dental images has reached an accuracy of 79% using the Inception-v3 network. Further validation of such models in large datasets is being explored.

Artificial intelligence and smartphone-based system for assessment and monitoring of glaucoma at home

Glaucoma stands as the foremost cause of irreversible blindness on a global scale. Routine screening, particularly for individuals at heightened risk, is essential to prevent vision loss due to glaucoma. Nevertheless, the provision of screening services poses significant challenges in remote areas and for those with limited mobility. This project seeks to mitigate these challenges by enabling in-home eye screening, through the development and validation of an artificial intelligence and smartphone-based system designed for the assessment and monitoring of glaucoma.

We have developed a fully automated, AI based glaucoma detection system tailored for resource-limited devices. The system achieves an accuracy rate of 97.4% and an F1 score of 97.3%, with sensitivity, specificity, and an AUC of 97.5%, 97.2%, and 99.3%, respectively. The system not only matches or surpasses the performance of existing methods but also delivers significantly faster decision-making while drastically reducing resource requirements.

The results were published in Nature Scientific Reports - Saha S, Vignarajan J, Frost S. A fast and fully automated system for glaucoma detection using colour fundus photographs. Scientific Reports. 2023 Oct 27;13(1):18408.

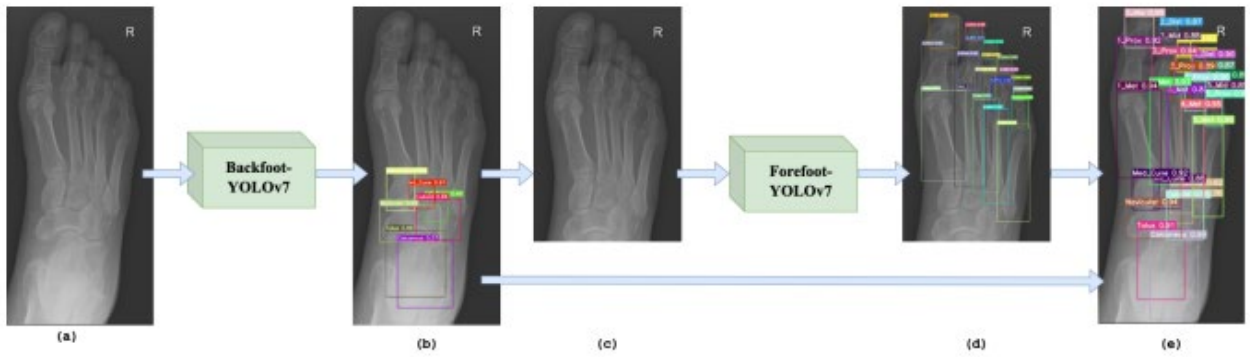
Detection of osteomyelitis and toe amputations and patient management through AI in X-ray imaging

Collaborator: South Metropolitan Health Service, Western Australia

X-ray imaging of the foot is frequently employed to diagnose diabetic foot infections. Assessing osteomyelitis infections and their progression using X-rays presents a significant challenge, even for experts. In collaboration with Edith Cowan University and South Metropolitan Health Services, this project aims to analyse over 13,000 radiographs of diabetic feet and develop a deep learning-based AI model for determining the presence of osteomyelitis and toe amputations.

A model has been developed to detect toe bone numbers from radiographs, and it is currently integrated with the osteomyelitis detection algorithm developed by ECU for ongoing validation. Additionally, a CNN-based system capable of detecting longitudinal changes in radiographs has been developed. Funded by the Department of Health, WA, the project focusses on assisting automated X-ray reporting through images and textual reports.

A paper was submitted to EMBC (Annual International conference of the IEEE Engineering in Medicine and Biology Society) but was not accepted. Further improvement of the models and validation of models is being explored.



Foot X-rays using AI detection of osteomyelitis.

Late-onset Alzheimer's disease: a functional test for neurovascular health status

Collaborators: AIBL, The University of Melbourne, Centre for Eye Research Australia

Healthy brain function needs responsive blood-flow to deliver oxygen and nutrients following brain activity (neurovascular response). Damage to this neurovascular response can occur in late-onset Alzheimer's disease, making it a potential biomarker for predicting progression from mild cognitive impairment to dementia.

Although the neurovascular response is technically difficult and expensive to measure in the brain, it is relatively easy to measure in the retina, which can be imaged non-invasively. This project developed a way to image a person's neurovascular response in the smallest blood vessels (Figure 2, pink overlay, showing increased blood flow). This protocol was then tested in participants recruited from the AIBL study, with results showing an altered and reduced neurovascular response in participants with mild cognitive impairment in comparison to their healthy counterparts.

(left) Standard retinal image (colour) with overlaid image of blood flow in the smallest vessels (black and white inset) at baseline (right) Pink overlay indicates regions with increased blood flow following neural stimulation (neurovascular response).

Ocular biomarkers: testing deep learning algorithms in a hypertensive cohort

Collaborator: Dobney Hypertension Centre, Royal Perth Hospital

The study explored the potential to detect clinically useful incidental ocular biomarkers by screening fundus photographs of hypertensive adults using commercial diabetic deep learning algorithms.

Of the 29 non-diabetic participants misclassified as positive for diabetic retinopathy, 28 (97%) had clinically useful retinal biomarkers.

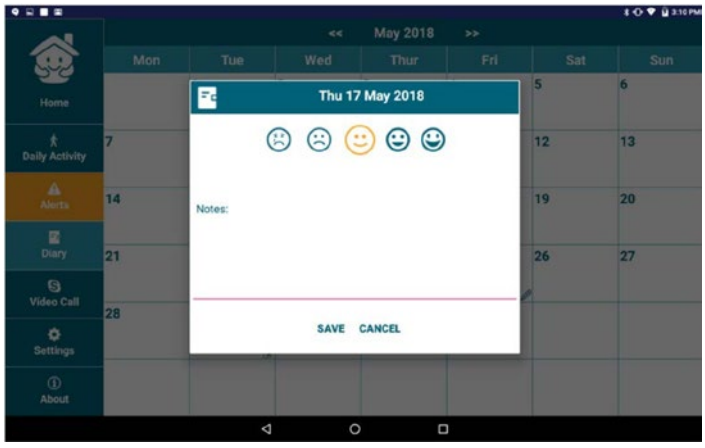
The results suggest that diabetic deep learning models may be responsive to hypertensive and other clinically useful retinal biomarkers within an at-risk, hypertensive cohort. Observing that models trained for fewer diseases captured more incidental pathology suggests that self-supervised learning has potential for developing autonomous comprehensive screening. Meanwhile, non-referable and false-positive outputs of other deep learning screening models could be explored for immediate clinical use in other populations.

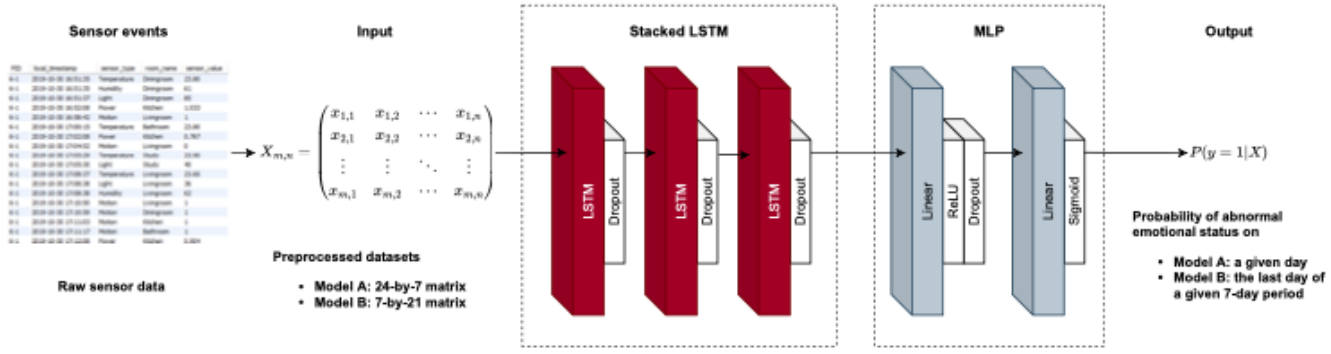
Unobtrusive emotional well-being assessment for independent-living older adults

This project aims to develop a smart home system integrating a deep learning model to predict the daily emotional well-being for independent-living older adults.

The predictive model was built on the data from a trial involving 10 older adults who lived independently in an unobtrusive smart home environment over 9-12 months.

We compared two model variants based on long short-term memory neural network, each taking the sensor data aggregated over a different time interval as input. The model with the best performance achieved a Matthews Correlation Coefficient of 0.67 with high sensitivity (0.80) and specificity (0.96).





Digital Therapeutics and Care: postdoc and student highlights

Postdoctoral fellows

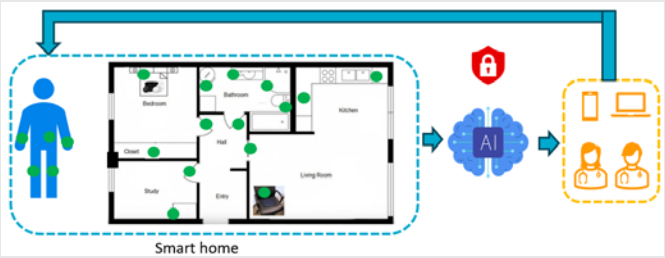
Dr Anna Roesler

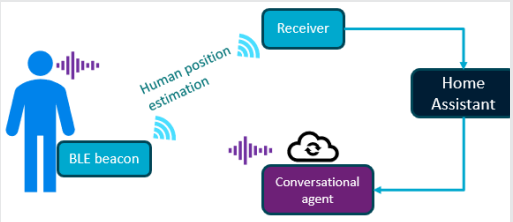
With a focus on pregnancy, maternal health post-birth is often overlooked. Anna is exploring the needs and values of women and their health providers in the context of GDM post-birth. Her work aims to gain an understanding of, if and how, digital health can support women and their providers in the 'fourth' trimester.

Dr Moid Sandhu

Moid is developing a 'smart home' system to promote independent living for older adults and individuals with disabilities. His work uses various wearable and ambient internet of things (IoT) sensors to monitor residents' well-being and daily activities within their homes. Currently, he is employing various IoT sensors to collect data related to activities of daily living to develop AI algorithms for reliable and real-time activity and functional monitoring.

Additionally, he is exploring advanced assistive technologies to provide autonomous, real-time support, aiming to enhance overall quality of life and well-being. He also developed a smart home prototype for individuals after a traumatic brain injury, which employs a conversational agent to deliver daily reminders for tasks such as medication, meals, and hydration, thereby improving their independence and quality of life.





Deepa Prabhu

Deepa is using data from wearable and ambient sensors to understand lifestyle, activities, and health behaviours in older people. This is to help develop methods to effectively manage acute and chronic health conditions (including mental health risks such as social isolation, loneliness, depression, anxiety) and maintain functional and cognitive well-being. Deepa analysed the data from the DACS trial to understand correlations between in-home movement patterns (measured using sensors) and depression among older adults living independently in the community. She is also working on an ARIIA-funded project aimed at early identification of falls risks using ambient sensors for proactive prevention in older adults living in residential aged care settings.

Dr Andrew Bayor

Andy currently supports the chronic obstructive pulmonary disease (COPD) project, contributing to the design of a clinical decision support system for effective COPD care and management. Andy is also exploring emerging technologies to enhance the self-determination of people with disabilities, including work on the NDIA project, which focuses on developing an accessible framework for assistive technology design and implementation. Additionally, Andy provides user interface design support and guidance for the Western Australia challenge project, which focuses on enhancing medical image interoperability and accessibility for clinical use in Aboriginal communities. Recently, Andy has been supporting a research collaboration to conduct a user experience study of an mHealth intervention for supporting the wellbeing of neurodivergent children.

The image illustrates an integrated environment where computing systems leverage metrics from the human lungs and knowledge stored in their databases to make decisions in support of lung health.

Dr Syed Qasim Abbas

Syed is augmenting X-ray clinicians with AI technology for improved outcomes in fracture diagnosis in emergency settings. Together with specialists from Fiona Stanley Hospital and WA Health, and made possible by access to unique datasets and clinical expertise, this project aims to develop and validate a revolutionary AI system that can leverage bone analytics to support clinical decision making and improve health outcomes for fracture patients.

Post-graduate Students

Yashodhya Vachila Vijesinghe, Queensland University of Technology (Masters)

This study aims to predict falls among the elderly patients using data mining techniques. A feature selection model is proposed to select a set of discriminative features to represent falls and no falls from clinical notes. From this a question and answer based on automated frailty index calculation will be proposed. The research also focuses on determining the relationship between frailty and falls by applying deep learning techniques.

Erin Downs (Masters)

Erin's Masters research seeks to investigate the benefits of digital health technologies for persons with gastrointestinal cancer and gain insights from patients, caregivers, and healthcare professionals.

Results from the study consolidates current insights on cancer apps, and compellingly advocates for real-time monitoring through apps, particularly in patients who experience high symptom burden, as these patients have more to gain and benefit from such an app. This unique perspective enriches existing knowledge and lays the groundwork for more effective digital health solutions tailored to these specific patient needs.

Liam Allan, Monash University (PhD)

Liam is a final year PhD student based in Melbourne. His work focusses on the feasibility, effectiveness, and potential delivery costs of mHealth programs for secondary prevention of stroke. Liam's program of work began with publishing a review exploring the translation of mHealth interventions for secondary prevention of stroke into real-world use to the journal Stroke (American Heart Association).

Over the past two years, he has been involved in all aspects of the feasibility evaluation of the Care Assistant and support Program for people after Stroke or transient ischaemc attack (CAPS), including trial preparation, coordination, and quantitative and qualitative analysis. Preliminary findings of this work have been presented on international platforms, including at the Stroke 2023 conference, European Stroke Organisation Conference 2024, and European Society of Cardiology Congress 2024. As part of his PhD, he is also involved in evaluating an eHealth program for people after stroke which has recently completed a phase III RCT (2024) and will be involved in preparing the economic evaluation for cost-effectiveness.

Daniella Di Benedetto, University of Adelaide (PhD)

Daniella's work examines the utility of continuous glucose monitoring systems for the management of post-prandial hyperinsulinemia hypoglycaemia (PPHH) post weight loss surgery. In the past year Daniella has been preparing a review of the literature exploring the prevalence and implications and nutritional management of post-prandial hyperinsulemic hypoglycaemia in bariatric metabolic surgery recipients. This review is to inform a pilot study to explore the utility of CGMS in determining potential detection of PPHH and treatment strategies for improved health outcomes of this population. Currently ethics is being prepared with Ramsay Health Care.

Sonia Farhana Nimmy, University of New South Wales (PhD)

Sonia's work studied the application and potential impacts of explainable AI techniques in AI-based glaucoma assessment. She explored state-of-the-art XAI techniques applied in glaucoma assessment, identified gaps in the literature, and developed ideas to address these gaps. She has one journal article under review and another is in drafting stage.

Lucas Cardoso, University of Queensland (PhD, Industry Placement)

The main objective of this project was to develop a dynamic background subtraction method tailored to a ceiling-mounted ultra-wideband (UWB) for automatic fall detection. This method enables precise isolation of objects and motion from background noise, addressing a key limitation of the existing system published by AEHRC.

As a secondary goal, Lucas investigated the efficacy of various ML techniques, such as long short-term memory and transformer models, to distinguish falls and daily activities using UWB signals. The proposed classification model with the dynamic background subtraction method achieved 84.94% testing accuracy.

Christopher Bird, University of Queensland (PhD)

This project proposes the development, evaluation, and application of ultra-wideband (UWB) radar as a novel technology to indirectly estimate muscle force output and fatigue. As the electromagnetic properties of a material change, so too does the propagation of an electromagnetic wave of UWB radars through that material. It is hypothesised that the physiological changes that occur during muscle force generation and in the presence of fatigue will impact the electromagnetic properties of the muscle, in a way which can be measured from the UWB radar signal. This would allow a practical method to estimate muscle forces, that can account for changes in force with muscle fatigue and is compatible with FES.

Chris will:

- use UWB radar scans of muscle to non-invasively estimate joint torque;
- investigate the changes to a muscle's electromagnetic properties that occur during contraction and fatigue and determine potential physiological mechanisms responsible for these changes;
- determine the effectiveness of the technology to non-invasively estimate joint torque under various conditions.

Abdullah Al-Mamun Bulbul, University of Queensland (PhD, Industry Placement)

Abdullah is supporting the development of a 'smart home' system to monitor the health and activities of older adults, promoting their independent living.

The primary goal of this project is to create a prototype that collects real-time data from distributed wearable and ambient sensors and processes it locally on devices like smartphones, instead of relying on a remote server. This approach addresses the issues of unreliable network connectivity and limited bandwidth, which are significant obstacles in implementing smart home systems in remote and regional areas. Additionally, he is working on collecting data related to an individual's daily living activities to develop algorithms that detect early signs of physical and cognitive decline.

HIGHLIGHT

AEHRC and Indigenous Health

Acknowledgement

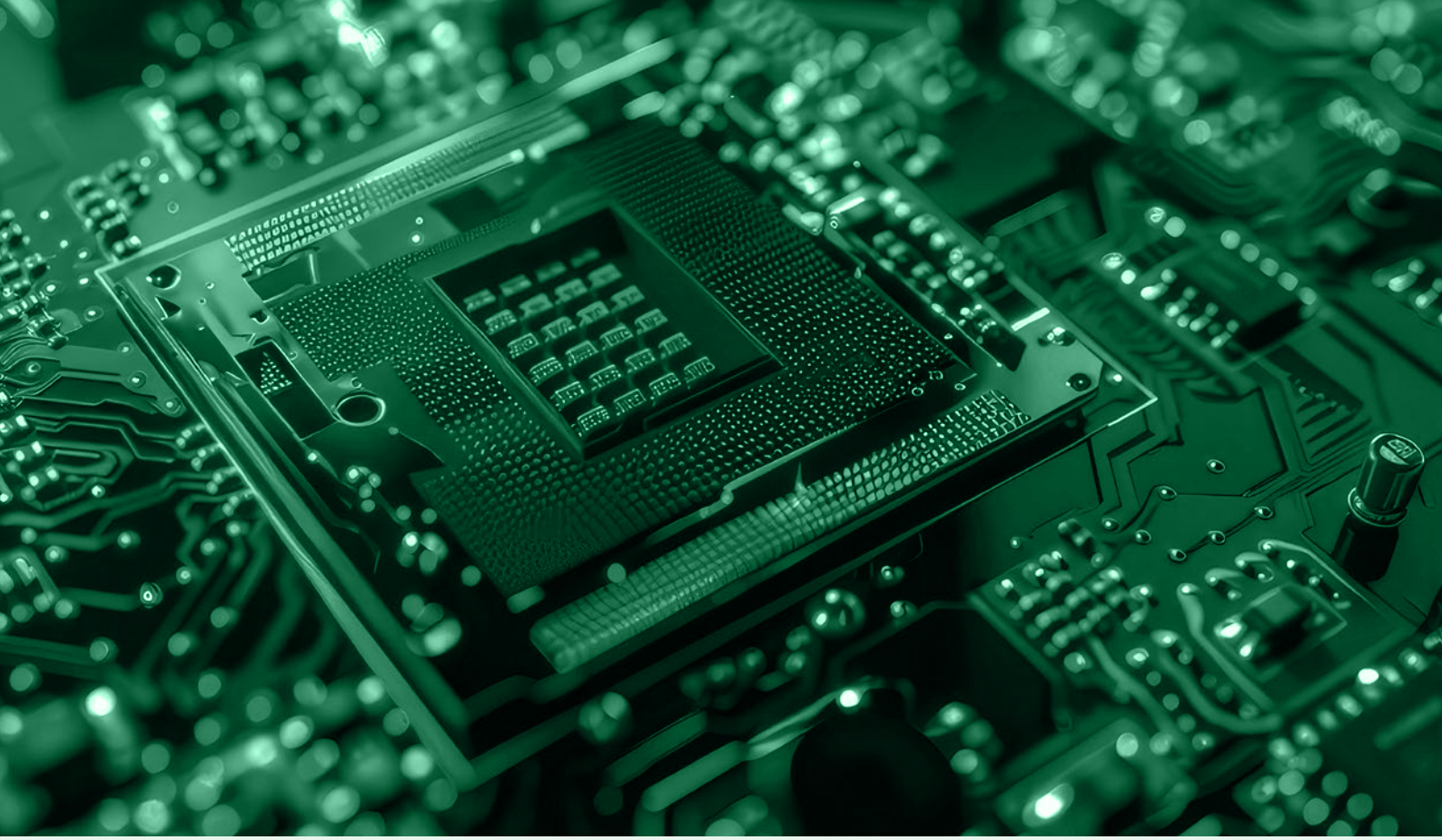
The AEHRC Indigenous Health Team acknowledge and pay our respects to the Traditional Owners and ongoing custodians of the lands, skies, waterways and knowledge systems on which our learning and research takes place.

We acknowledge that Aboriginal and Torres Strait Islander peoples are Australia's first scientists, our first educators, and our first healers of illness. We acknowledge our elders who have and continue to pave the path for all Aboriginal and Torres Strait Islander communities of today. Finally, we celebrate our emerging leaders, who are the decision makers of tomorrow.

About Indigenous research at AEHRC

Committed to increasing our contribution to addressing the health disparities between Indigenous and non-Indigenous people in Australia, we partner with Aboriginal and Torres Strait Islander community-controlled organisations to co-design and co-develop ehealth solutions to complement existing successful models of care for some of the most significant health issues in their communities.

Central to the vision and research activities of the Indigenous Health team is an understanding that Indigenous people conceptualise health as holistic, dynamic and interconnected, as opposed to dominant individualistic and siloed models on which many health interventions are based. In 2023-2024 the Indigenous Health Team has established new projects as well as continued the work of several existing projects. These projects leverage CSIRO technology to challenge the health disparities faced by Indigenous peoples within Australia.



The Team

Janardhan Vignarajan, Team Leader

A passionate and enthusiastic team leader, software engineer, developer and a student with 17+ years of professional experience in healthcare industry. Jana transforms research ideas into usable software products in the real-world healthcare environment and is the recipient of multiple awards for the projects. Jana leads the Indigenous Health Research team at AEHRC with great minded researchers and engineers working towards improving healthcare with digital solutions that use state of the art, science and research methodology.

Professor Ray Mahoney, Principal Research Scientist

Ray Mahoney is a Bidjara man with family ties to Central West Queensland. Ray has worked extensively to co-design, develop, implement and evaluate best practice public health and prevention programs to close the gap in health and wellbeing between Indigenous and non-Indigenous people. Ray currently leads a range of research projects with Indigenous community-controlled organisation partners. Since joining H&B's Australian e-Health Research Centre in 2018 Ray established the Indigenous Health Research Team.

Dr Andrew Goodman: CSIRO Early Research Career (CERC) Postdoctoral Fellow

Andrew is an Aboriginal man from Iningai Country in Central West of Queensland. Prior to his PhD journey (commenced in 2019) Andrew spent more than 14 years as an Indigenous Healthcare Worker in Queensland alongside rural and remote Aboriginal and Torres Strait Islander peoples in the discipline of cardiac and healthcare services. His PhD (co-hosted by AEHRC and The University of Queensland, 2023) was a strengths-based exploration and assessment of mobile health (mHealth) for the management of hypertension within an Aboriginal and Torres Strait Islander healthcare setting. Andrew's current research seeks to explore novel approaches and/or solutions to improve Aboriginal and Torres Strait Islander peoples' health and wellbeing using electronic health (eHealth). These solutions may offer an opportunity to challenge the health disparities within Australia and Andrew loves that his research is driven by partnership with Aboriginal and Torres Strait Islander people and organisations.

Tiana Thorne: PhD Student JCU and Research Technician

Tiana is a proud Gamilaraay and Kuku Yalanji woman living in Townsville. Tiana has completed a Bachelor of Exercise Physiology (Clinical) Honours at JCU and is undertaking a PhD at JCU through CSIRO's Research Fellowship Indigenous Graduate Program. The project aims to explore cardiovascular disease (CVD) experiences of Aboriginal and Torres Strait Islander people living in North Queensland. This project will integrate into existing CVD projects and build on relationships with Mulungu, Wuchopperen and Apunipima Community Controlled Health Services.

Melissa Kilburn: PhD Candidate (JCU and HART)

Melissa is a clinical dietitian living in Cairns. Melissa completed a Bachelor of Nutrition and Dietetics (Hons Class I) at QUT and is undertaking a PhD at JCU within the Healthy Ageing Research Team (HART), supported by CSIRO's PhD Top-up scholarship.

The PhD project aims to develop and validate for use, diet and physical activity web-based e-tools for Aboriginal and Torres Strait Islander peoples living within the Torres Strait region of Far North Queensland. The tools have been developed with comprehensive community consultation and collaboration with Torres Strait Islander co-researchers, are delivered in local language and provide point-of-care feedback based on national healthy living guidelines.

These tools will support primary health care clinicians in the region to provide tailored and culturally relevant healthy lifestyle advice for community members. Melissa has completed her Confirmation of Candidature and data collection is currently underway for the validation phase of the project. Melissa also recently presented the progress of the project so far at the International Congress of Nutrition and Dietetics in Canada.

Dr Hannah Law (Research Scientist)

Hannah joined the Indigenous Health Team at AEHRC in March 2024, and holds a PhD in immunology and bioinformatics from the Kirby Institute, UNSW Sydney. Her PhD focussed on the interrogation of human lymph node T follicular helper cell responses to influenza vaccination, utilising a range of proteomic and genomic sequencing technologies, and bioinformatic analysis of high dimensional health analytics data. Hannah has expertise in quantitative research methodologies including laboratory-based research, public health interventions, infrastructure services and management, and diagnostic technologies. Her research interests focus on working with and learning from vulnerable communities that experience significant health disparities to co-design and deliver effective health solutions.

Lucinda Jones (Research Officer)

Lucinda began her journey with the AEHRC in October 2023 after completing a Bachelor of Arts and Bachelor of Science at the University of Queensland. Working with the Indigenous health team has given Lucinda valuable experience in a range of research methodologies and deepened her passion for and understanding of public health. Lucinda hopes to continue her time at AEHRC applying science in creative ways to improve health outcomes for community.

Charankarthi Musuwadi (Research Assistant)

Charankarthi holds a Bachelor of Science (Public Health) and is currently a Medical Student at the University of Queensland. Charankarthi has been a contributor to the development of the best practice framework for eHealth with Aboriginal and Torres Strait Islander peoples exploring the scientific literature to identify the factors important to Aboriginal and Torres Strait Islander peoples in the implementation and adoption of eHealth interventions.

Sophie Wright-Pedersen (Research Scientist)

Sophie holds a Bachelor Degree of Nutrition and Dietetics (Hons) and is a current PhD candidate within QUT's School of Exercise and Nutrition Sciences. Sophie's PhD garners children's first-hand perspectives on what influences the food they eat and how they get or make food. Research was conducted in participatory ways through children's drawing, photos and videos accompanied by interviews with children. The intent of this research was to inform ways in which public health strategies aimed at improving child food and nutrition outcomes may become more meaningful for children to improve their engagement and subsequent impacts. Prior to commencing the PhD, Sophie worked for charitable, non-government and government organisations as a public health dietitian in regional and remote areas of New South Wales and the Northern Territory.

Team highlights 2023-2024:

- Dr Andrew Goodman completed his doctoral studies and was conferred by the University of Queensland in November 2024. His thesis is titled 'Can an integrated mHealth platform assist in the management of hypertension for Aboriginal and Torres Strait Islander people?'.
- Prof. Ray Mahoney, Sophie Wright-Pedersen and Dr Georgina Chelberg received the H&B Aboriginal and Torres Strait Islander Engagement Impact Award for their strong, ongoing three-year relationship and partnership with Tangentyere Council Aboriginal Corporation to co-deliver the Residential Thermal Comfort project for improved remote Indigenous housing conditions.
- Dr Andrew Goodman was successful in securing an Indigenous Research Grant for project titled 'Exploring the relevance of Artificial Intelligence (AI) for Healthcare Applications in Australian Indigenous Communities: Scoping Project' (ISEP-ID 64).
- Dr Hannah Law was successful in securing a Research Scientist role with the Indigenous Health Team and commenced in March 2024.
- PhD Candidate Melissa Kilburn awarded best presentation at the Cairns and Hinterland Hospital and Health Service (CHHHS) 2023 Research Symposium for abstract titled: 'Exploring self-report physical activity assessment methods validated with Indigenous populations globally'.

St George community wellbeing centre research and evaluation co-design

Collaborators: Goondir Health Services, Southern Queensland Rural Health, University of Queensland's Centre for Online Health & Rural Medical School, and Indigenous Land and Sea Corporation

Goondir Health Service has established the collaborative St George Community Wellbeing Centre (SGCWC) to address health and social needs identified by the local Indigenous community. This Indigenous-led intervention aims to reduce community-wide chronic disease incidence and risk factors by proactively addressing physical, social, emotional, and cultural wellbeing through wrap-around, place-based prevention and community building programs and support services. The SGCWC activities target all life stages from pre-conception, early childhood, children and young people, new parents, adults and older people.

Activities span across health and social emotional wellbeing services, social support, cultural development, youth engagement and empowerment, women empowerment, training and education, exercise and fitness, food security, nutrition and healthy lifestyle interventions and enterprise.

Building upon previous work to co-design the SGCWC Research and Evaluation Framework, the Indigenous Health Team is involved co-designing and co-delivering the implementation of this framework. Funding for this work was secured via the Ingenious Research Grants scheme. The SGCWC evaluation plan incorporates process and impact measures to assess delivery and effectiveness of programs and the centre as a whole. Part of this work has been conducting scoping reviews of the peer-reviewed and grey literature to investigate wellbeing indicators and methodologies to guide best-practice SGCWC data collection procedures.

Preventing Rheumatic Heart Disease (RHD)

Collaborators: Apunipima Cape York Health Council, Mulungu Aboriginal Corporation Primary Healthcare Service, Roche Diagnostics, Aboriginal Investment Group

Acute rheumatic fever (ARF) is an inflammatory disease that follows untreated or recurrent Group A Streptococcus (GAS) infection. Untreated ARF is known to permanently damage the heart valves in a condition called rheumatic heart disease (RHD). Although ARF and RHD are entirely preventable diseases they persist almost exclusively in Aboriginal and Torres Strait Islander communities due to continued high rates of GAS exposure. Through a combination of activities funded via H&B Indigenous Appropriation, one primordial and one primary prevention, this project aims to reduce GAS exposure, untreated infections and subsequently ARF and RHD in remote Indigenous communities.

The primary prevention 'proof-of-concept' activity will implement and test the Roche Diagnostics point-of-care test (PoCT) for GAS whilst concurrently exploring the cultural acceptability of the technology's deployment in partner Aboriginal community-controlled health organisations (ACCHO's). Diagnosis of GAS can be done through swab and culture via a lab service; however, this process is time and infrastructure onerous and is rarely utilised for patient management. Instead, PoCT for GAS can be undertaken on site in 10 to 15 minutes allowing for more efficient, responsive and pragmatic health care delivery.

Remote Laundries Project was launched in 2019 by the Aboriginal Investment Group (AIG) in response to community identified health issues associated with overcrowding and a lack of washing facilities in remote Aboriginal communities in the Northern Territory. Forming the primordial activity, a mixed-methods evaluation of Remote Laundries will assist in building evidence of the project's impact on preventing ARF and RHD. Scabies infestation affects 80% of Aboriginal babies in remote communities before their first birthday and infection of scabies skin sores with Streptococcus bacterium leads to more complex diseases including the development of ARF and RHD. In partnership with AIG and the Remote Laundries team, CSIRO has been invited to evaluate the impact of the Remote Laundries on community outcomes through implementing the Social Impact Framework (pictured).

Figure 1: AIG Remote Laundry Project Social Impact Framework

The AEHRC and Indigenous Health: Project Reports and Updates

eHealth Research Collaboration

Collaborators: The Queensland Aboriginal and Islander Health Council (QAIHC), the University of Queensland, the Queensland University of Technology, Flinders University, the University of Canberra and Queensland Health.

In 2019 CSIRO AEHRC established an Indigenous lead eHealth Research Collaboration for Aboriginal and Torres Strait Islander Health (The eHealth Collaboration). Membership includes Indigenous and non-Indigenous eHealth engaged stakeholders across the science, academic, health and Indigenous community-controlled sectors. The group is focused on establishing an evidence base for technology in health care specific to the interests and needs of Aboriginal and Torres Strait Islander peoples. The eHealth collaboration meets bi-monthly and is led by Indigenous researchers and scientists (namely Professor Mahoney, Dr Goodman, and Assoc Professor Ryder) who guide the ethos of research activities and responsibilities.

Development of a best practice framework for eHealth with Aboriginal and Torres Strait Islander peoples: a Delphi study

Collaborators: eHealth Collaboration

This study is a part of a larger program of work by the research team and the eHealth Research Collaboration for Aboriginal and Torres Strait Islander Health (the Collaboration) to establish a best practice framework for the development and deployment of eHealth with Aboriginal and Torres Strait Islander people (Chelberg et al. 2022). There is increased evidence for the benefits of eHealth interventions with Aboriginal and Torres Strait Islander people. While there has been emerging evidence for the implementation of eHealth, there is no established framework that clearly guides culturally safe eHealth with Aboriginal and Torres Strait Islander people.

The objective of this research process is to determine the factors most important to the implementation, adoption, and evaluation of eHealth with Aboriginal and Torres Strait Islander people using the Delphi method. Three Delphi consensus activities have been completed with a broad range of experts and knowledge holders. This Delphi process is novel in that it utilises the views and expert consensus of three distinct, but interrelated cohorts: leaders in eHealth, experts in eHealth, and members of the Aboriginal Community Controlled Health sector. This project was funded through H&B Appropriation and granted ethical approval via CHMHREC in February 2024 (ref: 2024_001_LR).

InReach Kids Project Evaluation

InReach Kids is an integration model developed between Goondir Health Services (GHS; primary health care) and Darling Downs Hospital and Health Service (DDH) to provide patient-centric seamless flow of journey for Indigenous patients across two systems, and to streamline services, ensuring less duplication of services, identification of service gaps and improved health outcomes. The InReach intervention focussed particularly on improving health service usage and health outcomes for children, young people, and antenatal, perinatal, and postnatal women.

CSIRO has conducted a mixed-methods evaluation to assess the appropriateness and effectiveness of the InReach Kids project through process, impact, and outcome evaluations. To compliment the qualitative evaluation delivered in the 2022-2023 year, a quantitative report has been delivered to Goondir Health Services and Darling Downs Health analysing health service access and usage across the two health services.

Key outcomes from quantitative data showed that the InReach Kids project improved access to certain health care services which were above national and state averages including:

- increased access to key services such as MBS Item 715 health checks and ear, nose and throat specialist appointments
- increased engagement in sexual and reproductive health services including antenatal appointments
- decrease in “failure to attend” rates at Darling Downs Health.

However, some health measures did not meet national and state averages, with some measures unable to be further interrogated due to data limitations. Overall, these results are promising, indicating that small changes towards improving health user access and engagement are occurring and have the potential to greatly improve long-term health if continually supported.

Thermal Comfort and Housing Suitability

Collaborators: Tangentyere Council, CSIRO Energy (Building Energy Efficiency Team)

This project is contributing toward a broader climate change adaption and heat mitigation project in partnership with the Aboriginal Community Controlled Organisation Tangentyere Council in Alice Springs. In the Alice Springs region, poor housing suitability, energy insecurity and climate change exacerbating poor health outcomes were identified by the community as key issues for investigation. Access to empirical evidence (environmental, housing, and social factors) will facilitate Tangentyere Council to advocate for policy changes and decision making to improve housing suitability and other underlying determinants whilst also providing evidence to address Target 9b of the National Agreement on Closing the Gap.

This project has been split into two phases. In Phase 1 a feasibility study determined the acceptability of collecting real-time sensor data on temperature and humidity. Data for this phase has been collected with analysis showing that temperatures and relative humidity in Town Camp residences were rarely within the nationally recognised comfort range.

Phase 2 extends this quantitative data collection whilst also exploring via mixed methods the effects of thermal comfort on residents’ physical, cultural, social, and emotional wellbeing. This aims to provide evidence to support Tangentyere’s advocacy work regarding the social and cultural determinants of health that disproportionately impact Aboriginal and Torres Strait Islander people. In May 2024, environmental quality devices and Sigfox Access Station Micro Gateways were procured for the establishment of an Internet of Things network in the Alice Springs region. This enabled the installation of the first group of devices into six Town Camp community centres to understand the network and device capabilities. Devices will be deployed into Town Camp residences across Alice Springs in September 2024.

IMAGE (L-R): Laura Stephensen, Dr Andrew Goodman, Dr Andrea McKivett, Jeremy Rigney, Prof. Louise Cullen, Dr Gregory Starmer, Dr Sean Nguyen, Prof. Ray Mahoney, Dr Katrina Starmer, Prof. William Parsonage, Virginia Campbell.

The Powerful Pictures Study: A new model of care for tackling heart attacks with Indigenous Australians

Collaborators: Apunipima Cape York Health Council, Mulungu Aboriginal Corporation Primary Healthcare Service, Wuchopperen Health Service, Northern Aboriginal & Torres Strait Islander Health Alliance (NATSIHA), Queensland University of Technology, Metro North Hospital and Health Service, University of Sydney, Cairns and Hinterland Hospital and Health Service, Torres and Cape Hospital and Health Service, South Metropolitan Health Service (WA), and East Metropolitan Health Service (WA).

The Powerful Pictures study aims to develop a new model of care with Aboriginal and Torres Strait Islander people to improve the way heart disease is detected and managed through computed tomography coronary angiography as a form of imaging of the heart to detect coronary heart disease (CHD). Chief investigators Mahoney and Goodman (MRFF 2022 Cardiovascular Health grant) along with Tiana Thorne are leading the co-design phase of this study to ensure it is both tailored to the needs of local Aboriginal and Torres Strait Islander people and acceptable to the clinical community.

In 2017/2018 CHD was the leading cause of hospital admission in Australian patients >50 years, which resulted in 5% of all ED admissions. For Aboriginal and Torres Strait Islander people, heart disease is occurring at a younger age (>45 years) compared to non-Indigenous Australians. This study's objectives are to co-design and implement the Powerful Pictures model of care for the assessment of Aboriginal and Torres Strait Islander people with suspected CHD and to evaluate the model of care using a hybrid effectiveness-implementation study. Our approach aims to ensure Aboriginal and Torres Strait Islander people with lived experience of CHD and their preferred health service providers have a say in how this new model of care is hosted and delivered.

Centre of Excellence for Aboriginal Digital in Health (CEADH)

CSIRO is collaborating with the Centre of Excellence for Aboriginal Digital in Health (CEADH; auspiced by Victorian Aboriginal Community Controlled Health Organisation (VACCHO)). CEADH was established in February 2024 and is a first of its kind entity that seeks to strengthen and unite Aboriginal and Torres Strait Islander peoples from across Australia to provide an Aboriginal led, governed, and designed voice and opinion for Digital in Health initiatives. The CEADH membership includes peak body organisations which represent the Aboriginal Community Controlled Health (ACCHO) sector (AHSCA, AH&MRC, AMSANT, AHCWA, QAIHC, TACINC, Winnunga, and VACCHO), as well as representation from the Indigenous health team at the AEHRC. A steering committee comprised of peak body state/territory member-based ACCHO representatives has been established to ensure a diversity of knowledge and expertise, and representation from across Aboriginal and Torres Strait Islander health sectors.

AEHRC supported the first National workshop for CEADH, which was hosted face-to-face in Canberra in June 2024. AEHRC Indigenous Health Team utilised this opportunity to gain valuable insight from ACCHO sector to facilitate the progression of two ongoing projects:

- Best Practice Framework for eHealth and Indigenous Health: Delphi Study and
- AI an Indigenous Healthcare Sector: Scoping Study.

Exploring the relevance of artificial intelligence for healthcare applications in Australian Indigenous Communities: Scoping project

Collaborators: Victorian Aboriginal Community Controlled Health Organisation Inc. (VACCHO), The Aboriginal and Torres Strait Islander Community Health Service (ATSICHS) Brisbane, Centre of Excellence for Aboriginal Digital in Health (CEADH).

There is a gap in the inclusion and priority of Aboriginal and Torres Strait Islander peoples' voices in the fast-developing world of AI. Yet, due to the national policy and protocol infancy of this resource in healthcare applications, the relevance and priority AI plays in Aboriginal and Torres Strait Islander healthcare is unknown.

This project has implemented a consultation methodology approach through conducting independent workshops with key stakeholders to identify priorities and unanswered questions relevant to AI applications in Aboriginal and Torres Strait Islander healthcare. By building an evidence base, the project seeks to clarify the relevance of AI to Aboriginal and Torres Strait Islander healthcare and identify any concerns and opportunities associated with its use and deployment in healthcare.

Strong Communities, Strong Health: chronic disease prevention in the Torres Strait

The Strong Communities, Strong Health project is a 3-year project being managed by the Healthy Ageing Research Team (HART) at James Cook University, Cairns. The project is a multi-methods project combining, lifestyle behaviour trends and desk-based asset mapping with qualitative data through yarning to comprehensively explore and report community specific strengths that can be harnessed for health promotion within the Torres Strait. The project culminates with co-design workshops between researchers, community members and relevant stakeholders, utilising this information to design strength-based health promotions strategies tailored for communities by communities.

The Health System Analytics group

Group Leader: Dr Rajiv Jayasena

The Health System Analytics group harnesses health data to drive efficiency, productivity and decision-making for hospitals, patients and communities to support quality and safe patient care.

The group's research agenda is focused on developing safe and effective tools for generating insights, informing operational planning and policy making through modelling and simulation, surveillance systems and clinical decision support using artificial intelligence. These tools are developed using our quality management system (QMS) and deployed with the support of implementation science, resulting in scalable and commercial ready products that drive the uptake of sustainable health services.

Our research includes building analytics, prediction, optimisation, and operational and clinical decision support tools that can help hospitals and clinicians obtain a better understanding of where they can optimise delivery of health services. It also provides them with solutions that can help improve and streamline the delivery of care and improve patient outcomes.

The group focuses broadly on three areas of research – artificial intelligence, statistics and operations research to increase productivity and patient safety, evaluation of health service interventions and disease surveillance and response.

The group also has two programs of activity supporting research undertaken at AEHRC, health data engineering and QMS. These two programs contribute by embedding industrial standards, interoperable software engineering and uplifting the regulatory compliance of AEHRC's software tools and solutions to be scalable-ready when we commercialise or offer products for routine use.

Health System Analytics team science and impact highlights for 2023/24

- Successfully led the Emergency Medicine Foundation commissioned "Study on Patient Flow in Queensland's Public Hospitals". This high impact multi-institutional study investigated contributing factors to increased patient waiting times creating "access block" in public hospital emergency departments in Queensland, providing several evidence-backed recommendations to address this issue. These recommendations when implemented are targeted at impacting the access block issue to improve the patient journey in the public hospital system.
- Successful in several competitively awarded grants, including from the Medical Research Future Fund (MRFF), Heart Foundation, Australia-Indonesia KONEKSI program, Australian and New Zealand College of Anaesthetists (ANZCA) and Australian Research Council (ARC).
- Insights from HOTspots surveillance system has led to the collaboration with the antimicrobial stewardship (AMS) Academy and National Aboriginal Community Controlled Health Organisation (NACCHO), to support training in stewardship and capacity building of the Aboriginal and Torres Strait Islander workforce and those working in community-controlled organisations.
- Invited to represent the scientific evaluation panel for a global collaborative to curb AMR with a One Health approach--the Joint Programme Initiative in AMR (JPIAMR).
- Received a certificate of achievement from Wiley for the paper "A discrete event simulation for improving operating theatre efficiency" in the *International Journal of Health Planning and Management*, being one of the most downloaded during its first 12 months of publication in 2022.
- Delivered phase one of the Sparked FHIR Accelerator Implementation Evaluation, a co-design workshop informed by interview data and theory-informed implementation recommendations.
- Successful delivery of the DFAT disease surveillance workshop Malaysia on health data analytics for data-driven decision making and response. The workshop had a wide range of Malaysian government organisations with attendees from National Institutes of Health (Ministry of Health, Kementerian Kesihatan Malaysia), 2 research institutes (Kuala Lumpur Institute for Medical Research, Malaysia Genome and Vaccine Institute) 4 universities (Universiti Kebangsaan Malaysia, Universiti Putra Malaysia, Universiti Malaysia Sabah, Universiti Sains Malaysia) and MH Nexus, digital health industry partner in Malaysia.
- QMS stage one audit was completed successfully without any major or minor non-conformances.

Health Implementation Science team

Team Leader: Dr Alana Delaforce

The Health Implementation Science team is 'making it real' by moving innovation from the benchtop to bedside and beyond. Our team develops and promotes the use of implementation science methods to ensure sustainable uptake of digital health solutions that enhance health outcomes at patient, provider, service and national levels. The team's research focuses heavily on co-design and capacity building through implementation enhancement plans to drive the uptake of evidence into practice. The team also undertakes evaluations of health services to demonstrate effectiveness and/or efficacy of their services through hybrid-effectiveness trials.

Health Intelligence team

Team Leader: Dr Sankalp Khanna

The Health Intelligence team combines skills in artificial intelligence, statistics and operations research to further the science behind helping the health system increase productivity and safety through optimising patient, clinician and resource flows and providing intelligent decision support. Working closely with clinicians and health system administrators, we have delivered significant impact in the space of patient flow analytics and are well recognised as leaders in this research space. The team also has a strong track record of developing and implementing precision clinical decision support at point of care for patient management in acute care and primary care settings.

Digital Solutions for Antimicrobial Resistance team

Dr Teresa Wozniak

The Digital Solutions for Antimicrobial Resistance (AMR) team is dedicated to mitigation, preparedness, and response to the threat of AMR. The team has a diverse portfolio of external and CSIRO internal collaborators and is led by experts in the field of public health, system-level and statistical modelling, and social sciences. The team has implemented innovative disease surveillance programs which support efforts in reducing AMR in regional and remote Australia and is working closely with One Health partners to respond to current matters of local and national policy relevant to AMR.

Health Data Engineering team

Team Leader: Derek Ireland

Our Health Data Engineering team is a dedicated team of software engineers who work with scientists across the AEHRC translating our science into solutions for our customers and partners.

Quality team

Senior Quality Manager: Yan Chia

The Quality team is dedicated to implementing and maintaining a comprehensive quality management system that aligns with relevant medical device standards, including ISO 13485, ISO 14971, IEC 62304, and IEC 62366, along with other applicable regulations. This system ensures effective oversight of the design and development of software as a medical device within AEHRC.

Health System Analytics: platform technologies and initiatives

Predictive modelling for operational and clinical decision support

Predicting demand is a vital component of improving efficiency and access performance of health services. Adequate hospital capacity is particularly crucial during crises such as pandemics and the pressures winter places on hospital operations.

Since 2007 we have been developing and validating models to predict demand for health services such as ED presentations, inpatient admissions and separations and operating theatres. These models can assist planners and schedulers to improve the delivery of services. For example, daily demand can typically be predicted with over 90 percent accuracy and can be used for staff resourcing, scheduling of elective surgery, identifying when demand is likely to exceed capacity, detecting the start and duration of the annual winter bed crisis, and providing early warning of disease outbreaks.

In 2023-24, we updated our demand prediction algorithms and developed and validated a new algorithm called Advanced Demand Prediction Tool (ADePT) which is significantly more accurate than the current algorithm in predicting daily inpatient admissions and is at least as accurate for both daily and hourly forecasts of ED presentations.

Demand for hospital beds is not random and can be predicted at a daily level with an accuracy of over 90 percent.

With the increasing implementation of EMRs in hospitals, there is growing potential to use the data to inform clinical decision-making in real-time. We have been developing a series of real time explainable machine learning algorithms for precision decision support at the point of care. These use data captured in EMRs and administrative systems to identify patient cohorts of interest for clinical streaming/intervention. Several past and current projects focus on clinical decision support to help reduce hospital readmissions and predict patient deterioration.

In 2023-24, we commenced work to extend our existing algorithms to predict new clinical deterioration alerting criteria (e.g. QADDS) and explore adverse outcomes such as central line associated bloodstream infections (CLABSI) and exacerbations from liver disease progression in the adult setting, and sepsis in the neonatal setting. We are also working with internal and external partners to enhance scalable deployment and clinical acceptance of these algorithms in hospital settings.

Syndromic surveillance and aberrance detection to support early detection

Syndromic surveillance aims to give early warnings of disease outbreaks and other healthcare issues. but can also assist with day-to-day hospital capacity management and operations and policy related decision making. Traditional approaches to monitoring disease outbreaks involves tracking daily or weekly counts of disease but recent work has demonstrated that monitoring the time between events may give earlier warning of disease outbreaks.

The AEHRC, in partnership with CSIRO Data61, has applied a set of algorithms and tools that can be used for syndromic surveillance and incorporate anomaly detection research from Data61.

In healthcare, seasonality and day of the week influences are a variation source that leads to non-homogeneous processes, and during disease outbreaks, there are generally stronger seasonal trends and within-day influences. These aspects make designing a monitoring plan for disease outbreaks a challenging task in practice. Our solution applicable to non-homogeneous processes is monitoring based on Weibull-distributed time between event values and incorporating differing levels of temporal memory to cover outbreaks of different sizes. The time between event approach to statistical process control is a very new concept, and to our knowledge, we are the only group working on its application to non-homogeneous processes worldwide.

Early warning of disease outbreaks or higher than normal workload is paramount for health jurisdictions.

Digital twins and simulation based operational scenario modelling and optimisation

The ability to create realistic digital representations of physical systems (or "digital twins") can support improved decision making by providing answers to what-if scenarios and generating insights from an organisation's actual data on how potential changes impact the real system. A well-developed simulation model can allow an end user to assess the impact of implementing an operational change more quickly and cheaply than implementing the change.

We have developed multiple simulation-based scenario models. These typically use discrete event simulations to asses the flow of patients through the health system.

In 2023-24, the team applied this methodology to explore what-if scenario modelling for supporting statewide decision making for the high-impact "Study on Patient Flow in Queensland's Public Hospitals" project. We also commenced work on employing ambulance, ED and inpatient data to start building a digital twin of the state-wide patient flow control hub to run what-if scenarios of different operational policies.

The digital twin considers all major hospitals and emergency and elective flows to/from them to form a realistic model of the system. Different scenarios can be tested such as changes in demand, hospital capacity, the proportion of elective surgeries undertaken and patient discharge time. This model will provide a tool to assess the impacts of policies in near real-time. This will provide decision makers with real time situational intelligence to understand current and potential demand impacts on Queensland Health facilities, and ensure an optimal system-wide response.

HOTspots digital surveillance platform - monitoring and targeting interventions against antibiotic resistant infections

The HOTspots digital surveillance platform facilitates access for healthcare providers, public health practitioners, and policy makers with up-to-date information on evolving AMR in hospitals and community clinics.

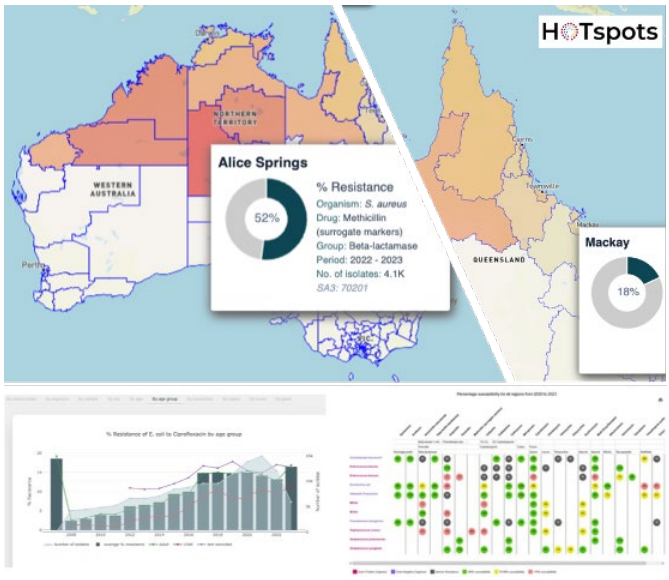
This tool forms part of a suite of resources provided by the HOTspots Surveillance and Response Program that supports antimicrobial stewardship activities, updating treatment guidelines and capacity building in regional and remote settings of northern Australia.

Following the successful partnership with the Commonwealth Department of Health and Aged Care, the data from HOTspots now regularly contributes to national AMR policies. In collaboration with local experts across northern Australia, this platform continues to be used to support stewardship activities in hospitals and community clinics in northern Australia.

Simulation models can help quantify the impact of operational changes on efficiency performance.

Currently HOTspots is available to clinicians through organisational intranet, Northern Territory Primary Health Network and integrated into general practice HealthPathways. The HOTspots Program will continue to build partnerships with local data custodians and end-users to assist in the strategic direction for mitigating the treatment of AMR in regional and remote settings of Australia.

The expansion to other regions and collation of Australia-wide patterns of AMR is currently being planned.

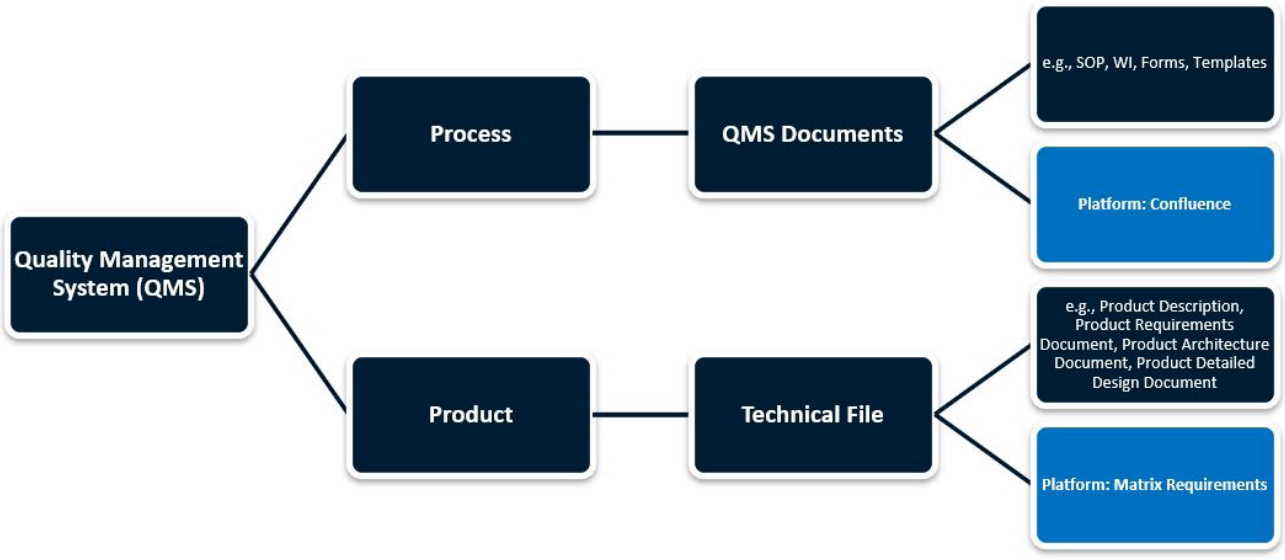


Quality management system (QMS)

We are implementing a QMS to manage the design and development of SaMD products to ensure our ability to deliver outputs that meet industry needs and expectations.

This initiative will position CSIRO as a differentiated digital health innovation partner by ensuring our products are safe and reliable and research outcomes are justified and reproducible. Transitioning commercially focussed research products under a QMS framework, CSIRO's digital health innovations will have accelerated translation pathways and hold higher commercial value for CSIRO from our funders, partners, and collaborators.

Implementing QMS will increase our focus on quality and ensure smooth transitions for early-stage R&D to commercially focussed products. This team is working with group leaders (change champions) to embark on cross program education and training, documentation generation, software rebuilds and refinement, audits and certification to change to fully embrace quality as a key performance indicator of our science.



There are two key components to the QMS—process and product

Health System Analytics: full project reports

HOTspots supporting regional antimicrobial resistance stewardship and workforce development

Collaborator: Australian Government Department of Health and Aged Care, National Aboriginal Community-Controlled Organisation, Northern Territory Primary Health Network

The HOTspots disease surveillance and response program aims to build resilience to AMR and maintain the benefits of effective antibiotics in northern Australia. During 2022-23 we worked with the Department of Health and Aged Care to pilot integration of the HOTspots program into the Antimicrobial Use and Resistance in Australia (AURA) program. This work demonstrated the feasibility of including AMR data from HOTspots to the program. HOTspots remains the only program providing susceptibility data to AURA from all public hospitals in the NT, including community healthcare clinics in the NT and far north WA. HOTspots contribution to AURA ensured inclusion of AMR surveillance data from northern Australia that has historically fallen outside of AMR surveillance reach.

HOTspots is the only implemented and evaluated AMR digital surveillance tool used by clinicians at the point of care. Access to local region-specific susceptibly data is critical for updating guidelines, for stewardship, and the health service's ability to initiate appropriate, timely responses to changing AMR epidemiology. Local and timely data provided at the point of care helps ensure clinicians choose the right drug for the right bug at the right time.

During the pilot period, 214 healthcare services comprised of 164 community health centres and 50 hospitals contributed data from 489,138 susceptibility tests to HOTspots. This data showed geographical differences within northern Australia, and between northern and southern parts of the country, demonstrating the need for ongoing surveillance and response to AMR in this region.

HOTspots impact across northern Australia during the pilot period included:

- inclusion of previously unrepresented regional data and addressing surveillance blind spots in resource-poor and geographically isolated settings
- contribution to general practice HealthPathways and clinical decisions in community healthcare sector
- provision of local evidence for updating clinical guidelines
- support for capacity building in rural healthcare by collaborating with local health service providers including Northern Territory Primary Health Network
- strengthening stewardship programs using relevant and local AMR data for decision making
- delivery of outreach education sessions to rural practitioners and National Aboriginal Community Controlled Organisation Antimicrobial Stewardship Academy
- implementation of digital solutions for AMR data sharing and public health actions

Enhancing public health surveillance with Bayesian spatial modelling

Funder: AI4M funding

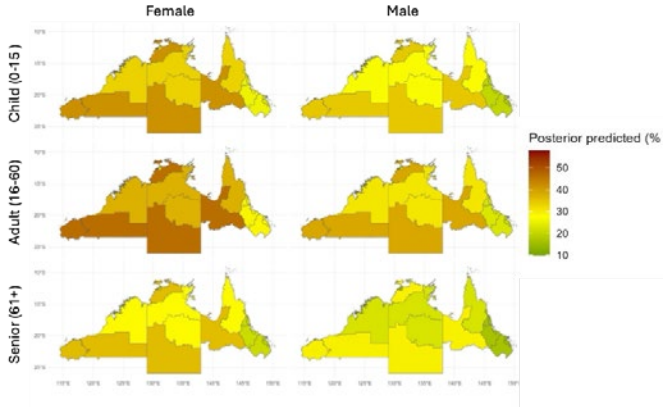
Disease surveillance is an essential element of an effective response to AMR. Associations between resistant cases and area-level drivers such as remoteness and socio-economic disadvantage have been observed, but spatial associations using routinely collected surveillance data have not been considered.

We aimed to use spatial modelling to adjust for area-level variables and to enhance surveillance for sparse data, providing more actionable epidemiological information.

We used monthly antimicrobial susceptibility data for methicillin-resistant Staphylococcus aureus (MRSA) from a surveillance system in Australia. MRSA was assessed for the effects of age, gender, socio-economic and access to healthcare services indices by fitting Bayesian spatial models.

MRSA infections were highest in adult females aged 16-60 living in very remote regions and lowest in senior males aged 60+ years living in inner regional areas. Current disease surveillance approaches for antimicrobial resistant infections often use thematic maps which have limited spatial comparability, cannot be represented on a monthly basis and hence are not timely, and are at risk of sampling bias in regions with sparse data.

The approach of spatial modelling and 'borrowing' information from neighbouring regions is especially suitable to regions with sparse or unbalanced geographical information. Integrating Bayesian spatial models into routine AMR surveillance systems, such as HOTspots, and developing disease cluster detection methods for future analysis would provide public health practitioners and policy makers with practical actions (target regions and at-risk populations) to reduce the continuous and worsening burden of AMR in northern Australia.



ECMOCARD

Collaborators: COVID-19 Critical Care Consortium incorporating ECMOCARD led by Prof John Fraser

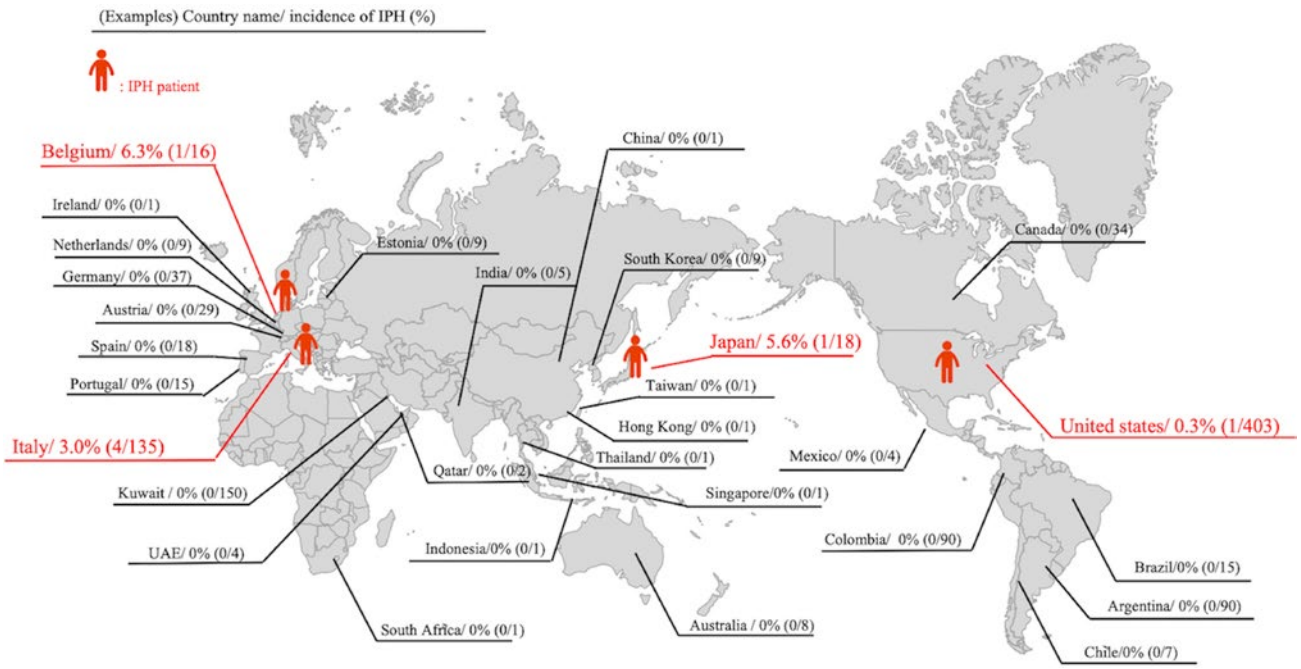
The COVID-19 Critical Care Consortium was established at the start of the pandemic before coronavirus was even named. As of January 2023, the collaboration comprises 441 centres from 63 countries across 6 continents and has collected data from over 26,000 patients admitted to intensive care units.

This study, Extra Corporeal Membrane Oxygenation (ECMO) for 2019 novel Coronavirus Acute Respiratory Disease (COVID-19 Critical Care Consortium), is a prospective/ retrospective multi-centre observational study of patients in intensive care units with COVID-19. The study's objectives employ the data being collected from across the world to describe clinical features, the severity of pulmonary dysfunction, ECMO technical characteristics, duration of ECMO, complications, and survival of patients with COVID-19.

We have been working in close collaboration with frontline ICU clinicians across several projects to address specific research questions related to ECMO use on COVID-19 patients. The insights derived from our work are being disseminated via conference presentations as well as high impact peer-reviewed journal publications.

Outcomes from this project in 2022-23 include a manuscript published in the high-impact Critical Care journal comparing the incidence, demographic profile, management and outcomes of early acute kidney infection in patients undergoing invasive mechanical ventilation for COVID-19-related acute respiratory distress syndrome with a non-COVID-19-related cohort, and another manuscript published in the high impact Perfusion journal investigating a rare bleeding complication called iliopsoas haematoma on patients undergoing ECMO support. Several other publications are in the pipeline.

In 2023-24, we submitted a manuscript titled "Worldwide Application and Valuation of ECMO Supporting during the COVID-19 Pandemic (WAVES)" to Perfusion, which was accepted for publication. Additionally, we have completed another manuscript entitled, "A Retrospective Analysis of Mechanical Ventilation Strategies in Patients on Veno-venous ECMO for COVID-19." We are seeking the most fitting journal for the manuscript.



The incidence of iliopsoas haematoma (IPS) during extracorporeal membrane oxygenation in patients with COVID-19. (image source: https://journals.sagepub.com/doi/10.1177/02676591231168285).

Study on patient flow in Queensland's public hospitals

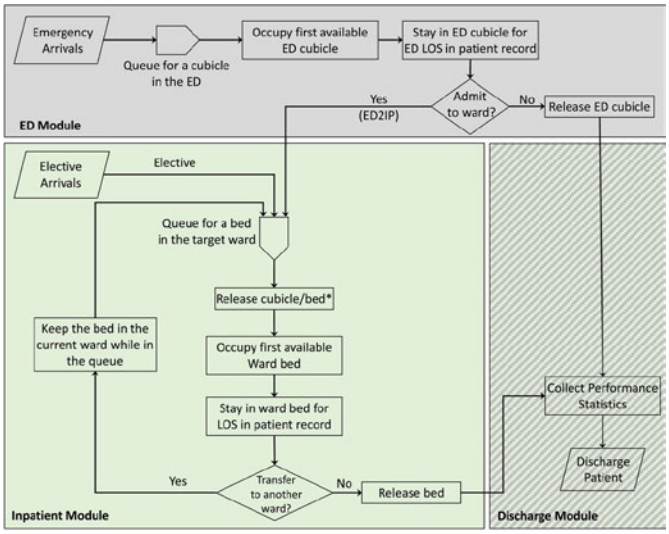
Collaborators: Queensland Ambulance Service, Queensland Department of Health – Healthcare Improvement Unit, Emergency Medicine Foundation, University of Queensland.

This study commissioned by the Emergency Medicine Foundation addresses the complex national challenge of access to hospital beds. This is a crisis that has been spotlighted by the Australasian College of Emergency Medicine as a national state of emergency. The aim of the study was to establish an evidence base for factors leading to access block and help identify solutions that are most effective in improving emergency access across Queensland.

We used a five-step process to identify access issues and inform intervention design and solutions to improve patient flow at a system level:

- literature review to provide a summary of the challenges impeding patient flow and an evidence-base for interventions
- quantitative analysis of publicly available data outside the hospital system, including spatial modelling of contextual factors associated with ED demand and access block upstream from hospitals, such as GPs per capita, and downstream from hospital, such as aged care facilities
- quantitative analysis of every ambulance journey, ED presentation, inpatient episode of care, and ward movement within the 25 largest Queensland public hospitals over six years. This was to identify system-wide barriers to patient flow and quantify the impact of local solutions in improving patient flow
- qualitative assessment of barriers to discharging patients. This was to offer a cross-sectional view of the experiences and opinions of patients and healthcare workers at the coal face of this problem
- key findings and recommendations for actionable solutions

These activities form a basis to support Queensland Health's efforts to improve patient flow at a system level.



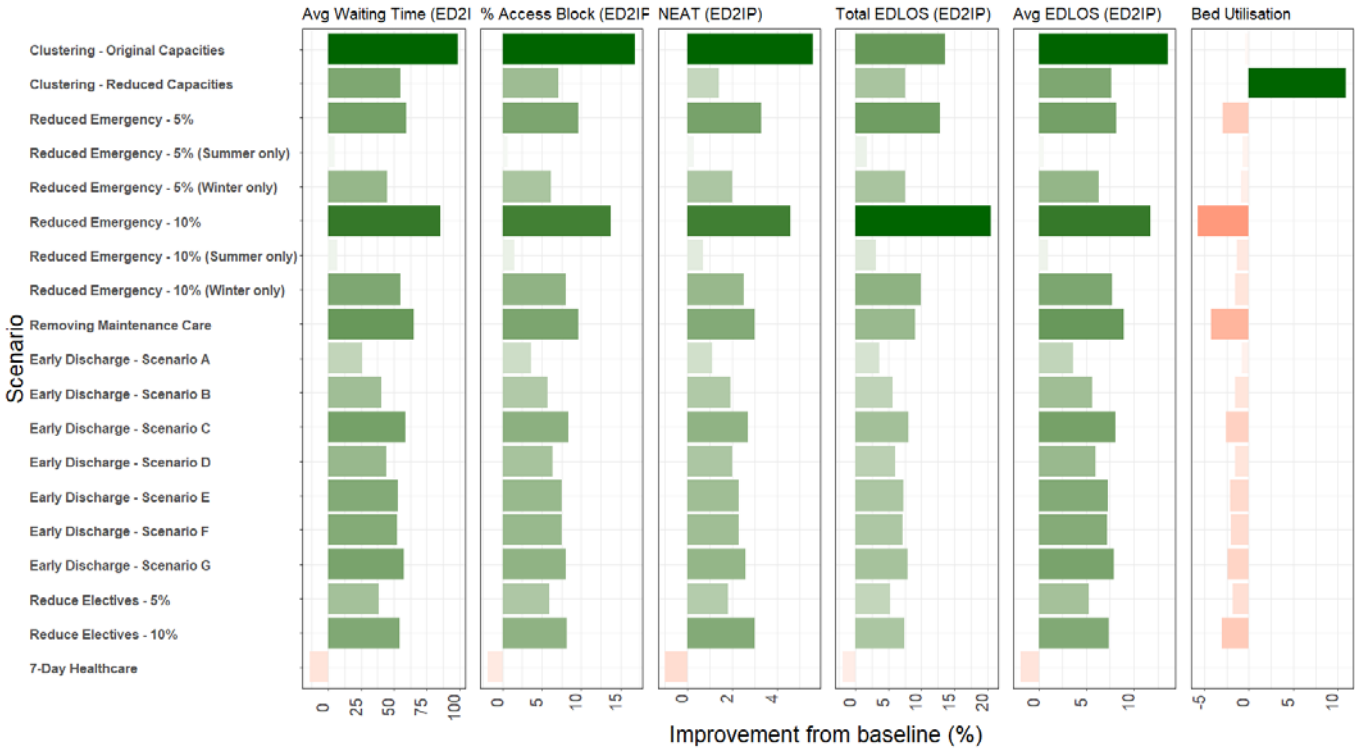


Fig: Discrete event simulation models were developed at a hospital ward level (top) to assess the impacts of local solutions on their ability to improve emergency access (bottom).

WentWest and patient centred medical homes

Collaborator: Western Sydney Primary Health Network (WentWest)

The Western Sydney Primary Health Network (WentWest) has partnered for many years with general practices in Western Sydney to set up patient centred medical homes (PCMH) to help achieve improved health of populations, enhanced patient experiences, health care cost reductions and better support for health professionals.

CSIRO worked with WentWest to analyse PCMH outcomes compared to standard GP care. This first-of-a-kind statistical study draws on linked GP and hospital data collected in the NSW Lumos program to make this comparison, as well as assess patient outcomes such as mortality, hospitalisations and emergency department visits to better understand the benefits associated with the PCMH model. Statistical modelling has been completed and a manuscript is near completion for submission to a high-impact journal for peer review.

The study found that:

- PCMH patients have a 10% lower risk of mortality compared to patients in non-PCMH GP practices
- PCMH patients were 20% less likely to have an ED visit
- PCMH patients were 11% likely to experience an unplanned hospitalisation

Rauland fall prevention study

Collaborator: Rauland Australia

Hospital falls can result in serious and permanent harm. In 2020-21 more than 47,000 falls were reported. How to prevent falls and implement the identified solutions is still unclear.

Rauland Australia have developed a falls prevention platform that consists of a speech enabled nurse call communication system, location services engine, digital dashboards (falls risk and workload allocation) and integration with chair alarms, mats, and clip on movement alarms.

We used a type-one hybrid effectiveness study design to measure the impact on clinical and implementation outcomes of the falls prevention platform before and after an implementation enhancement plan was actioned.

Major improvements were seen from two key functions with the system, however, there was not an impact on the rate of falls, despite increased uptake of the system. Other efficiencies were evident, including nurse response time. The results from this project, undertaken across two hospital sites, will form an implementation plan to facilitate the uptake of the system into practice, and possibly result in long term improvements to falls.

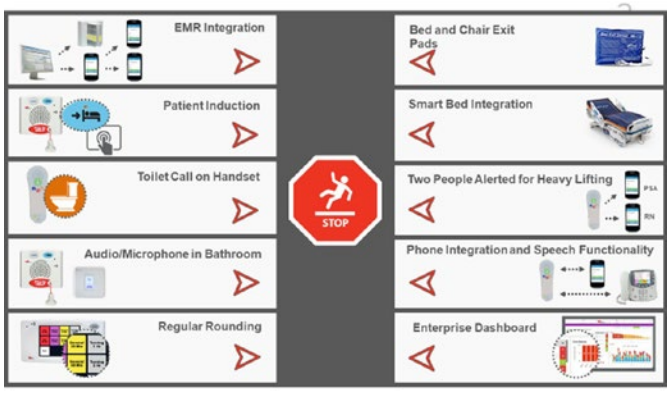
Systematic review on virtual Care implementation in primary health

Uptake of virtual care solutions in primary care settings has increased. Current evidence suggests high patient satisfaction but mixed clinician views. This review aimed to identify what factors influence the implementation of virtual care in primary settings to support delivery to the right patient in the right clinical context at the right time.

A systematic scoping review identified empirical research studies reporting factors influencing the uptake of virtual care solutions within the Australian primary care setting. Searches were undertaken in Embase, PubMed, Scopus and Web of Science. The Consolidated Framework for Implementation Research (CFIR) was used to code factors influencing the implementation of virtual care solutions.

Fourteen (14) studies were identified as eligible for inclusion. Five common influencing factors were identified. Three are from the existing CFIR framework, and two are newly developed constructs. CFIR constructs included innovation relative advantage, capability and information technology infrastructure. New constructs included accessibility and suitability. A further six new constructs are identified (trust, privacy, governance, unintended consequences, preference and choice) but they were not prominently mentioned.

There are common factors influencing virtual care uptake among Australian primary care settings. The CFIR assisted in conceptualising these but was not sufficient for capturing factors unique to virtual care. Newly developed constructs are noted to be of importance in the literature, but further research is needed to understand if they are applicable in multiple contexts.



Health System Analytics: Short project updates

System dynamics for antimicrobial resistance

Collaborators: Menzies School of Health Research, NT Health, Sax Institute, and Dynamic Operations

This project aims to develop a modelling framework to support efforts to minimise AMR in northern Australia. System dynamics, a systems thinking approach, is applied to capture the feedback loops between AMR drivers, simulate the behaviour of AMR over time, and formulate and evaluate intervention scenarios to inform decision-making.

Twenty-five interviews with professionals across One Health were conducted, and a qualitative model has been developed to unravel the complex interactions between AMR drivers in the human, animal and environmental systems. A quantitative model will be designed to simulate and predict AMR trends under alternative scenarios, including mitigation strategies for AMR.

Estimating current and future risk of AMR

Collaborators: Data61 and Environment, Human Health

This project models AMR risk, accounting for the differences in healthcare and environment across northern regions of Australia. Data from HOTspots surveillance system is used for this analysis.

A spatiotemporal ML model is proposed to predict region specific current and future risk of AMR. This highly collaborative project between AEHRC, Data61, and Environment BU commenced end of January 2023, and will be completed in June 2025. To date, we have developed a spatiotemporal model for AMR risk prediction and validated it with two AMR organism data from the HOTspots surveillance and response program. The result has been presented to AI4M panel, OneHealth, and the CSIRO Futures.

Impacts include region-specific estimates of current and future risks to guide public health professionals and clinicians in their program planning to mitigate risk of AMR.

Following the antibiotic study

Collaborators: Animal Management in Rural and Remote Indigenous Communities (AMRRIC)

Access to appropriate antibiotics is important for maintaining human and animal health and reducing the risk of antibiotic-resistant bacteria. The Following the Antibiotic study is exploring the contextual factors around antibiotic use and availability by 'following' antibiotics along the supply chain and interviewing key people who play a role in providing antibiotics (GPs, vets, pharmacists, wholesalers etc).

Data collection commenced in March 2024 and preliminary analysis has identified different journeys antibiotics have within human and animal health systems and the impact of shortages. Through this study we will deepen our understanding of the 'social life' of antibiotics and inform context-specific responses to help minimise the impact of antimicrobial resistance (AMR).

Indigenous Futures Caring for Country

Collaborators: Cross-Business Unit (BU) project with researchers from Indigenous Strategy and Engagement (Torres Webb), Ag&Food (Zaynel Sushil, Marni Williams) and Health & Biosecurity (Lorraine Bell)

The Indigenous Futures Caring for County project is an Indigenous-led project that promotes Indigenous science, innovation and engagement to ensure Indigenous knowledge shapes Australian agrifood systems in the future.

This cross-BU collaboration between Ag&Food and Health & Biosecurity links with a One Health approach and recognises the interconnections between the health of people, animals, land, seas and waters. This work will help us better understand the conditions for disease-prevention (including AMR) through learning about connections between healthy country and healthy people. The first six months of this project has been about building relationships and establishing an Indigenous Steering Committee. This Committee guides the direction of the project and informs culturally appropriate engagement. The project officially launches on 1st July 2024 with a national co-design workshop currently being planned for September 2024.

Systematic review of acute care settings

Uptake of virtual care solutions in acute care settings has increased and current evidence suggests high patient satisfaction but mixed clinician views. The systematic review will identify the factors that influence the implementation of virtual care in acute settings to support delivery to the right patient, in the right clinical context at the right time. A systematic scoping review identified empirical research studies reporting factors influencing the uptake of virtual care solutions within Australian acute care settings. Searches were undertaken in Embase, PubMed, Scopus and Web of Science. An adapted version of the Consolidated Framework for Implementation Research (CFIR) was used to code factors influencing the implementation of virtual care solutions. Twenty-one studies were identified as eligible for inclusion. Analysis is ongoing.

Sparked evaluation

Numerous FHIR accelerators have been operationalised around the world to facilitate the development and uptake of agreed core data sets used to inform systems that communicate health information. The aim of these accelerators is to develop local standards that speed up the process by which technology is adapted

and developed in a way that is interoperable. That is, health data applications that can easily and seamlessly share information regardless of vendor source.

Despite the fact that accelerators have been around for quite some time, there is very little evidence available in peer reviewed literature to explain what they are and the key attributes for developing a successful accelerator. Focused on developing a scientific evidence base that can be reported in peer reviewed journals, and accessible to all, this evaluation aims to:

- Define the components of the Sparked FHIR accelerator program
- Identify the key benefits, challenges and barriers encountered by participants
- Track the sentiment of participants at key time points and assess the degree to which the implementation enhancement plan, developed at step two, achieved its intended aims.

CUREator AMS implementation project

Collaborators: Queensland Children's Hospital

Tests pending at discharge (TPADs) are medical investigations that are collected during a patient episode of care, but the final results of which are incomplete at the time of discharge. Evidence suggests around 40-100% of patients have medical test results returned after discharge, and of these, around 10% are actionable. This delay in results mean that sometimes patients are provided treatments that are not suitable, or, not provided with treatments which are needed (based on the results). Additionally, the processes supporting communication of these test results are currently reliant on fragmented review procedures that vary between clinician and department.

Together, these issues create a perfect storm in which patients may be lost to follow up about important investigations and inappropriate treatments may be provided. Solutions are needed that both streamline the communication of TPAD results to clinicians and enhance the efficiency of care changes and recommendations (as appropriate). This project aims to tailor (using co-design) and pilot the implementation of a pre-existing digital application within the context of microbiology test results in the emergency department setting to streamline result, review and action. If successful, this application could have much broader impact at scale by providing a framework from which to extend the scope of results to include a wider range of test results.

A digital twin of the Queensland Patient Access Coordination Hub (PACH)

Collaborator: Healthcare Improvement Unit, Clinical Excellence Queensland, Queensland Health

The Queensland Patient Access Coordination Hub (PACH) is a Queensland Health initiative designed to enhance operational performance and assist with patient flow, using real-time intelligence of ambulance and hospital operations across the major South-East Queensland hospital and health services.

We received funding from the Healthcare Improvement Unit of Queensland Health to develop a digital twin of the PACH unit. This involves developing models to simulate the flow of patients through and across hospitals and capturing processes involving queueing, to optimise organisational objectives such as patient length of stay (LOS) and patient wait times. This will allow for real-time situational intelligence to support scenario planning and informed decision-making to ensure an optimal health system response.

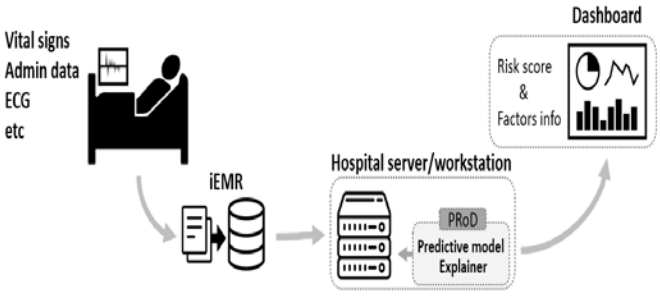
We have received ethics approval for the project and the first tranche of historical ambulance, ED and inpatient records required for the development of the digital twin and are engaging in ongoing planning activities with project stakeholders.

Predicting patient deterioration

Collaborator: Queensland Health

The EMR provides an opportunity to manage patient care efficiently and accurately. This includes the development of tools to aid in clinical decision-making at the bedside for the timely identification of adverse events or acute illnesses preceded by deterioration. Previously, we published a manuscript in the high-impact journal Scientific Reports describing the development and validation of a patient risk of deterioration (PRoD) algorithm to predict the risk of a patient triggering a clinical deterioration alerting criteria, the Australian between the flags (BTF) alert within the next 2-8 hours.

We are currently extending this algorithm to predict other deterioration criteria, including the Queensland Adult Deterioration Detection System (Q-ADDS). Following algorithm development and validation, we propose to trial the algorithm in a hospital setting. The initial study with BTF alert also has been extended to better understand the trustworthiness of the associated explanations.



Patient risk of deterioration (PRoD) - algorithm pipeline.

Syndromic Surveillance for influenza like illnesses and COVID-19 related symptoms

Collaborator: Queensland Health

The team is continuing its investigations into syndromic surveillance and the use of data collected in hospital data systems as a signal to flag outbreaks. Previous efforts have employed techniques based on control charts such as exponentially weighted moving average (EWMA) and cumulative sum charts (CUSUM), and on using the time between events (TBE). More recently, the team has been using concepts adopted from the finance sector and the TBE metric to generate new index measures (a.k.a. variability indices) that capture trends in the underlying data and the use of these to signal outbreaks. A paper describing this work appeared in the proceedings of the prestigious MEDInfo23 conference. The new methods offer advantages over classical modelling approaches for predicting disease outbreaks. Future research will focus on the continued improvement of these methods and the development of sophisticated surveillance and outbreak detection algorithms based on these methods. These algorithms will integrate machine learning (ML) techniques to harness data from diverse sources, including meteorological data, search queries, and other influenza-like illness (ILI) related data to improve prediction accuracy and overall performance, supporting our ability to detect and respond to outbreaks effectively.

Improving residential aged care placement from hospital through the implementation of a digital matching solution

Collaborators: DailyCare

Patient discharges from hospital to residential aged care are often delayed due to inefficiencies in matching them to suitable available beds. To investigate the improvements a digital solution can offer we compared hospital length of stay of patients discharged to residential aged care from the Royal Melbourne Hospital, before and after the introduction of a digital solution for matching patients' needs and preferences to available residential aged care places. The study found that the introduction of the digital solution created by a company called DailyCare was associated with a 26% reduction in hospital length of stay from the time when patients in hospital were assessed for aged care. The study also found that using a solution like DailyCare at a national scale could free up to 88,805 patients' bed days annually in Australian hospitals and save up to $105,993,947. A paper on this study has been accepted for publication and presentation at the HIC conference in August 2024.

Utility of clinically relevant biomarkers to identify people with non-alcoholic fatty liver disease at increased risk of liver disease progression

Collaborators: University of Queensland, QIMR Berghofer Medical Research Institute

Non-alcoholic fatty liver disease, fatty liver, (NAFLD) is the most common chronic liver disorder in primary care and is highly prevalent (47.3%–63.7%) in people with type 2 diabetes. Progressive liver fibrosis leading to complications of cirrhosis and hepatocellular carcinoma (HCC) develops in a subset (5%–10%) of affected individuals over 10–20 years. This is the first population-based Australian study to examine the usefulness of clinically relevant biomarkers (routine blood test results) to identify people with fatty liver at increased risk of liver disease progression, death from liver disease and liver cancer. We are working with retrospective linked longitudinal data of patients with NAFLD hospitalised in QLD over a 13-year period to develop machine learning algorithms to predict patient risk of significant liver disease, enabling early intervention to reduce disease progression and referral for specialist hepatology care before they develop liver-related complications.

Predicting CLABSI

Collaborators: Herston Infectious Diseases Institute (HeIDI)

Healthcare-associated infections (HAIs) pose a significant challenge for hospitalised patients in Australia, with approximately 165,000 cases reported annually. Central venous catheter (CVC) associated bloodstream infections (i.e. CLABSIs) carry a mortality rate of 12–25%. The current clinical approach to managing CLABSI is hindered by not being able to predict and prevent these infections from occurring. To address these challenges, this project focused on the development and validation of a ML model utilising EMR data to predict impending CLABSI. Data from critically ill adult patients were collected from four QLD Metro North Health ICUs from 2017 – 2021. Five ML methods predicted the onset of CLABSI in the 4 – 40 hours preceding CLABSI. The preliminary results demonstrate that ML methods can reliably predict the occurrence of CLABSI up to 12 hours before the onset with the AUC-ROC of 0.85. The results have immense translational significance in reducing the prevalence of CLABSI, which remains a persistent global challenge.

HeIDI - Infection Control Real-time Data Analysis and Outcome Simulation

Collaborators: Metro North Hospital and Health Service

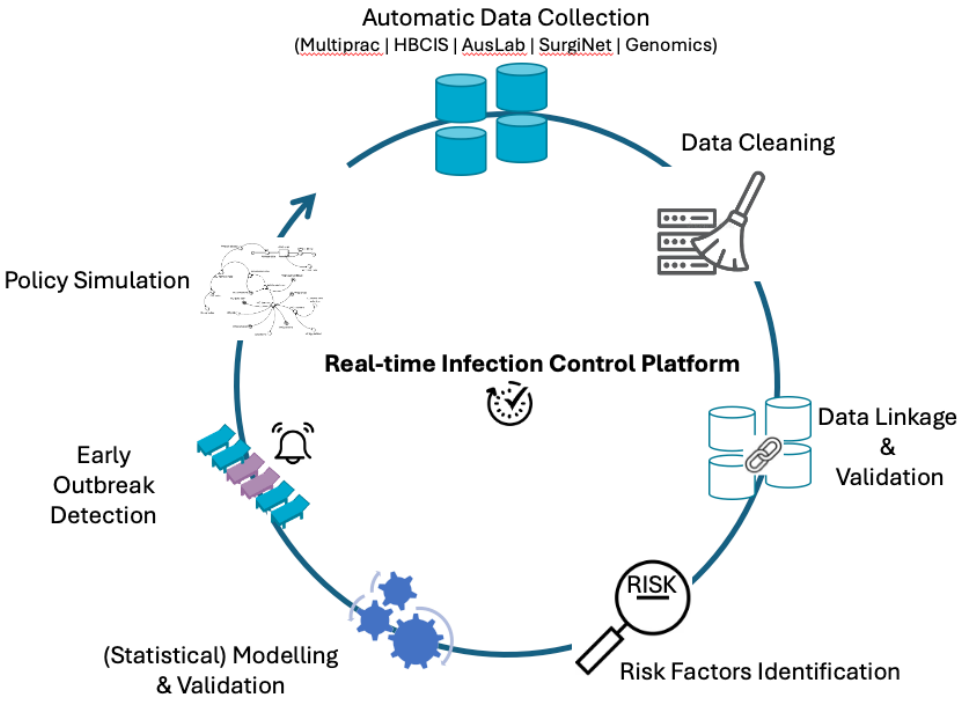
Infection control is critical to the prevention and minimisation of infectious related morbidity and mortality in both community and hospital settings. Timely and accurate data on the occurrence of outbreaks, their characteristics and predictors, is critical to successful infection control.

Current data collection procedures are limited by fragmentation of information across multiple systems, duplication of collection, and largely manual processes to collate, cleanse and identify outbreaks. This delays timely identification and response for what is a time critical initiative.

The project proposes to automate the identification of hospital infectious outbreaks and their characteristics by linking the patient administration, laboratory information, radiology information and surgical information systems with EMR and infection monitoring systems to create a near real-time outbreak identification and outcome simulation system with real potential to reduce community and hospital morbidity and mortality.

HeIDI - Evaluating i-gram tool for AMR

Antimicrobial stewardship is a proven strategy for optimising antimicrobial use and combating the increasing threat of AMR. Access to local and relevant antimicrobial susceptibility data is critical for tailoring antibiotic therapy. In 2021 we developed i-gram, a digital antibiogram available on the HOTspots surveillance platform, providing region-specific data for clinicians in northern Australia. A 2022 Delphi survey informed further refinement of the i-gram tool and this study will assess its generalisability to settings outside northern Australia. We will gain user insights from both urban and regional stewardship teams in Queensland to optimise uptake of the tool in routine stewardship practices.



Real-time infection control platform

Scalable decision support

Collaborators: InterSystems, Austin Health

Current data and ML driven decision support tools sit outside of EMR systems and do not seamlessly integrate with the EMR and its data. The current challenge for healthcare professionals, vendors and solution developers is to connect, integrate and use data, analytics and decision support solutions that work seamlessly to support clinicians in meeting patient needs. This project was motivated by the need for a standards based scalable approach to develop and deliver solutions that can integrate with the standards-based platforms. Progressive vendors have started developing using standards such as FHIR which facilitates secure data access and interoperability of such solutions across the healthcare ecosystem.

Partnering with InterSystems and Austin Health, this project is delivering a standards-based rapidly deployable and scalable model of our demand prediction algorithms to support proactive capacity management. Previous solutions such as the Patient Admission Prediction Tool (PAPT) have been implemented so far, including at Austin Health, as standalone products and limited the functionality and use of the solution. As part of this effort, we have developed and tested several statistical and machine learning forecasting approaches and compared them to the current method to validate their performance in predicting daily and hourly demand. The methods tested were the PAPT algorithm currently in use, several other statistical and machine learning approaches, and a new time series algorithm called the Advanced Demand Prediction Tool (ADePT). ADePT demonstrated superior accuracy in forecasting inpatient admissions and matched the accuracy of the current method in forecasting ED presentations. We will now work with InterSystems to implement this algorithm within their IRIS for health solution at Austin Health.

Blood-based protein biomarker panel for early detection of colorectal cancer and tumour staging

Collaborator: Molecular Diagnostic Solutions, CSIRO Health & Biosecurity

Carcinoembryonic antigen (CEA) is the current clinically accepted blood-based protein marker to identify colorectal cancer patients who are at risk of an adverse outcome after their initial cancer diagnosis. Using data across two independent studies in this cross-research-program we identified two avenues for intellectual property (IP) commercialisation pathways, as well as a research deliverable. First, we identified a panel of protein biomarkers that perform better than CEA at predicting patient incidence of metastasis or recurrence of cancer within five years. Secondly, we identified a different panel of biomarkers which are used to predict the likelihood of tumour staging upon initial diagnosis.

This valuable, interactive clinical decision support tool named ‘Dukes’ staging prediction tool, is in its early development phase and will be supported via a web-browser. Due to the nature of both IP and commercial strategies for this project, deliverables consist of confidential reports and an online app. Our final science deliverable intended for peer-review publication, involves the identification of biomarkers which are associated with colorectal cancer mortality. In this work, biomarkers associated with colorectal cancer mortality are investigated separately for early and late tumour staging patients considering demographic and incidence of metastasis or recurrence within patients.

Health System Analytics: postdoc and student highlights

Postdoctoral fellows

Dr Jessica Rahman

Jessica's research is focussed on developing explainable machine-learning approaches for clinical decision support. This includes developing algorithms for providing early warning signs of clinical deterioration linked to neonatal mortality and morbidity. Jessica is working on building predictive models using high-fidelity physiological signals using the data. In 2023-24, Jessica published a novel ML approach to bradycardia detection in preterm infants in the high-impact Computers in Biology and Medicine journal. Jessica also led the development and validation of a machine-learning algorithm to detect the risk of central line-associated bloodstream infection (CLABSI). Jessica has also been successful in obtaining 2 internal grants from CSIRO, one as lead investigator and also actively contributes to the Health & Biosecurity EMCR committee.

Dr Yen Pham

Yen's research is focussed on systems approaches, including systems thinking and dynamics modelling to address antimicrobial resistance (AMR). She uses system dynamics to unravel the interplay among drivers of AMR across One Health, and produces simulations of AMR trends under different scenarios to support strategies for minimising AMR in northern Australia. Yen is supervising PhD students to investigate the global impact of climate change and variability on AMR, and to explore the role of the environment as a source of resistance mechanism and a means to disseminate resistant bacteria and AMR genes.

PhD students

James Kemp, Centre for Big Data Research in Health, Faculty of Medicine, UNSW

Fraudulent or inappropriate claims from healthcare providers can be costly for government health programs. With increasing numbers of claims, data analysis becomes a bottleneck in the process of detecting abnormal claims. Improving analysis methods could lower the cost of detection as well as increase detection rates. This project applied machine learning techniques to whole-of-population Medicare Benefits Schedule and Pharmaceutical Benefits Scheme data sets held by the Department of Health. James was awarded his PhD in September 2023 and is now undertaking post-doctoral studies with the University of Western Australia.

Kristin McGarry, Griffith University

Bullying can have devastating consequences for school students, including impacts on their long-term mental health. Kristin is working in partnership with Hyper Theory, Griffith University and CSIRO to develop a gamified digital program to support primary school students acquire social and emotional skills that will help them cultivate positive relationships and may result in reduced instances of bullying, with long term impacts resulting in a reduced burden on the health system. Her project will use an implementation science lens to understand what digital programs currently exist, what the barriers are to implementation and undertake a pilot trial in schools to uncover how similar programs should be implemented to maximise their success.

Ruby Comte, Monash University

Ruby successfully obtained a CSIRO PhD top-up scholarship (2024-2026) and is jointly supervised by Monash University and CSIRO (with Yen Pham). Her thesis applies metagenomic and culture-based analysis to understand how climate variability influences the detection, abundance and diversity of antimicrobial resistance genes within a freshwater catchment influenced by agriculture. This will inform risk management strategies under increasingly severe weather conditions.

Joshua McRae, University of Queensland

Josh is a Nursing Director undertaking a PhD supervised by Dr. Andrew Staib (Queensland Health / University of Queensland) and Sankalp Khanna (CSIRO). His research is focussed on developing a validated hospital wide patient flow conceptual model that could be used to standardise the approach to future hospital patient flow analysis and improvement efforts. Josh successfully completed his confirmation in December 2023.

Postgraduate Placement Students

Bianca Abbott, University of Queensland

Bianca completed a placement as part of her final semester of Master of Public Health with the Digital Solutions for AMR team, supervised by Lorraine Bell. Bianca conducted a review of AMR Policies across One Health which will be published in 2024.

Yukiko Ezure (PhD Candidate), University of Queensland

Yukiko completed a placement with the Digital Solutions for AMR team as part of her PhD extension, supervised by Teresa Wozniak and Majella Murphy. Yukiko updated epidemiological and disease surveillance definitions used by the HOTspots program and developed a draft plan for the HOTspots e-modules and associated education materials.

Ilha Byrne, Ricardo Xiang, Kusumitha Shrinivasan and Carlos Gomes (PhD Candidate) - The University of Queensland

Four UQ students completed the Global Change Scholars Program, supervised by Yen Pham and Teresa Wozniak and supported by Dana Bradford. The outcome of their project is a published research protocol for a systematic review of the global impact of climate change and variability on antibacterial resistance.

Vacation student projects

Project: Telling science stories: Science communication in digital health

Student: Darcy Millett

Supervisor: Naomi Stekelenburg

This project in science communication involved in the production of content about CSIRO's digital health research from ideation to publication. Focus skills included all facets of digital and traditional media production, brand and design. At the same time, we worked with the CSIRO media team in promoting our science and maintaining our reputation as Australia's trusted science advisor.

Project: COPD decision support tool

Student: Nimesh Garg, University of Queensland

Supervisor: Derek Ireland

COPD is a chronic condition often managed in primary care, until there is an exacerbation, and sufferers end up in the emergency department (ED). The lung foundation publishes clinical guidelines called COPD-X which are poorly utilised in ED and primary care.

This project developed a FHIR backed clinical decision support tool for use in ED so that non-respiratory trained emergency clinicians can quickly and accurately apply the COPD-X guidelines which will hopefully (yet to be trialled) reduce the frequency of ED episodes and general quality of life of COPD sufferers in the community.

Project: Synthesising CT pelvis scans from cone-beam CT with 3D diffusion models

Student: Jenna Supper, University of Queensland

Supervisor: Aaron Nicolson, Bowen Xin, Ashlee Gillman, Gregg Bellows, Hollie Min

This project developed a 3D diffusion model for synthesising CT images from cone beam CT (CBCT) scans of the pelvis. If CTs can be accurately synthesised from CBCTs, which have a lower radiation dose, radiotherapy patients will have less exposure. Jenna's model improved upon previous 2D diffusion models by reducing artefacts and achieving competitive signal-to-noise ratio levels.

Project: Genetic and epigenetic signature of Alzheimer's disease

Student: Ishika Mahajan, University of South Australia

Supervisor: Michael Vacher

The relationship between genetic variants and epigenetic factors (CpGs) remains largely unexplored and poorly understood. Understanding this relationship is of paramount importance, as genetics represents one of the primary risk factors for numerous diseases, including Alzheimer's disease (AD). In this study, we used genetic and epigenetic data from 726 individuals to identify SNPs-CpGs signatures associated to AD, potentially aiding in the early detection of the disease.

Project: Smart home for independent living

Student: Hantha Nguyễn, University of Sydney

Supervisor: Moid Sandhu, David Silvera

Traumatic brain injury (TBI) often leads to cognitive, communication, and psychological hurdles that significantly impede everyday independence. Conversational agents have the potential to offer cognitive and communication support to individuals with TBI. This project focuses on designing a smart home equipped with ambient sensors and voice assistants to provide tailored assistance to individuals with TBI in their daily tasks. By delivering timely reminders and support, this system aims to enhance efficiency in performing daily activities, ultimately enhancing users' overall quality of life.

Project: Alignment-free phylogenetics

Student: Dnyanda Kulkarni, University of New South Wales

Supervisor: Carol Lee, Anuradha Wickramarachchi

Inferring evolutionary relationships using traditional phylogenetic methods can be computationally time consuming as they involve both sequence alignment and phylogenetic tree construction. To overcome this in large datasets, this project aimed to use alignment-free k-mer-based analysis methods to produce comparable trees and track the intricate evolutionary trajectories of pathogens.

Project: Smart home architecture for precision activity tracking and optimised data pipeline

Student: Win Lynn, University of Sydney

Supervisor: Deepa Prabhu, David Silvera

This project aimed to enhance smart home architectures for aged care by addressing limitations of current systems, including developing:

- a sensor fusion method with ambient and wearable sensors for multi-residency scenarios and
- an architecture for local long-term data storage and advanced processing capabilities.

Project: Shiny Application for OML-Combine

Student: Chris Dalas Christodoulides, University of Melbourne

Supervisor: Rosita Shishegar, Rodrigo Canovas

In this project, the students modified and enhanced the R Shiny app to create an interactive data harmonisation tool. The app, called OML-Combine, facilitates the harmonisation of cognitive data from various studies on Alzheimer's disease. Through calculated prediction error as well as visualisation of predicted test scores and comparison with the original datasets, users can quality-check the outcomes and fine-tune the inputs for optimised results. OML-Combine offers researchers a platform to evaluate and refine harmonised data, thereby ensuring high accuracy in harmonised datasets and fostering collaborative research across multiple centres.

Project: Human identification using mmWave radars

Student: Jack Zhang, University of Queensland

Supervisor: Wei Lu, David Silvera

This project uses a mmWave radar to identify people. The project uses an existing model from literature but proposes a new method of data normalisation which improves the performance of the model. This new method uses homogeneous frame transformation, which standardises the geometrical properties of the raw data.

Project: Structural connectivity analysis of subcortical structures in very preterm children

Student: Ziyi Que, The University of New South Wales

Supervisor: Javier Urriola, Alex Pagnozzi, Kerstin Pannek

Preterm birth may have long-term implications on how the brain is wired and which structural networks are affected. Equipped with cutting-edge diffusion MRI data, this project explored the connectivity of subcortical and cortical structures, decoding how white matter bridge the world of thought and motion in preterm-born children. By contrasting structural insights with our recent functional MRI findings, we will gain greater insights into the long-term effects of preterm birth.

Project: How do they grow? Mapping neonatal brain development.

Student: Nina Hadzivukovic, Queensland University of Technology

Supervisor: Jess Bugeja, Alex Pagnozzi, Leo Lebrat, Rodrigo Fonseca de Santa Cruz

Neonatal imaging of preterm-born children can elucidate important structural biomarkers that may predict long-term developmental outcomes. In this project, state-of-the-art cortical surface reconstruction was performed using a deep learning model, CorticalFlow, to extract the outer surface of the brain. By measuring the shape of this surface in babies born preterm, we can track how their brain is developing, to potentially predict their long-term outcomes. This will enable us to provide earlier targeted interventions for at-risk infants.

NHMRC and MRFF grants

Scientists at the Australian e-Health Research Centre are chief and associate investigators on many grants from Australia's foremost medical research grant bodies, such as the National Health and Medical Research Council and the Medical Research Future Fund.

Updates on these projects are given in the group sections to follow, but here we give a short description of the aim of each of these projects.

Medical Research Future Fund (MRFF)

MRFF ICTC: The AUstralian-Multidomain Approach to Reduce Dementia Risk by PrOtecting Brain Health With Lifestyle Intervention (AU-ARROW) study

Years Funded: 2020-24

Chief Investigators: Professor Ralph Martins, Macquarie University

AEHRC Investigators/Chief Investigator G: Dr Jurgen Fripp

One of the greatest challenges faced by older Australians is to identify and implement strategies to optimise cognitive health and wellbeing, thereby prolonging their productivity and quality of life. The AUstralian-Multidomain Approach to Reduce Dementia Risk by PrOtecting Brain Health With Lifestyle Intervention (AU-ARROW) study is a strategically innovative and an important proposal to validate the efficacy of a multidomain treatment plan that may benefit cognitive and brain health in Australia.

MRFF Future Frontier Stage 1: New frontiers in personalised prevention of CAD

Years funded: 2021-22

Chief Investigators: Professor Gemma Figtree, University of Sydney

AEHRC Investigators: Dr Denis Bauer, Dr Natalie Twine

The proposed CAD Frontiers Program harnesses cross-disciplinary teams of clinicians, researchers, healthcare workers and industry partners to develop new approaches in the prevention and management of patients presenting with coronary artery disease.

MRFF Future Frontier Stage 1: Australian Phage Network: developing solutions for antimicrobial resistance

Years funded: 2021-22

Chief Investigators: Professor Jonathan R Iredell, University of Sydney

AEHRC Investigators: Dr Denis Bauer, Dr Natalie Twine, Dr Laurence Wilson

CSIRO will supplement the bioinformatics activity to guide clinical diagnosis and therapy and assist the forced evolution and bioengineering of phages. Building upon their existing software approaches the team will develop bespoke machine learning algorithms able to guide the design of "programmable phages". CSIRO will also contribute towards the phage characterisation and application hub, by adapting approaches from their technology developed for human health applications to associate desirable phage properties with genetic features.

MRFF Genomics Health Futures Mission: a national large scale automated reanalysis program to increase rare disease diagnosis

Years Funded: 2021-25

Chief Investigators: Professor Zornitza Stark, Murdoch Children's Research Institute

AEHRC Investigators: Dr Denis Bauer, Dr Natalie Twine

The project will develop and evaluate a national program for automated, systematic reanalysis of genomic data to deliver improved diagnostic outcomes in large cohorts of rare disease patients. They will harness continuously updated knowledge bases of disease-associated variants and genes, improvements in genomic data analysis and

interpretation, and use of cloud-based distributed systems with machine learning approaches to scale up analysis nationally. CSIRO will supplement the bioinformatics activity for the project through expertise in cloud architecture and machine learning to improve platform efficiency and scalability. The grant will fund 50% salary for a postdoc within Genome Insights team for 3 years.

MRFF Targeting Treatable Traits in COPD to Prevent Hospitalisations (TERRACOTTA)

Years Funded: 2021-24

Chief Investigators: Dr Johnson George Monash University

AEHRC Investigators: Dr Rajiv Jayasena

This project aims to evaluate the efficacy of a practice nurse-coordinated intervention - Targeting Treatable Traits in COPD to Prevent Hospitalisations (TERRACOTTA) in the Australian primary care. The specific objectives are to:

- test the efficacy of the interdisciplinary intervention at improving QoL;
- test the efficacy of the interdisciplinary intervention at preventing hospital/ED visits;
- optimise the diagnosis and management of obstructive airway diseases in primary care; and
- improve self-management using action plans and mobile health support.

MRFF Clinical Trials Activity 2019: Rare cancers, rare diseases and unmet need ataxia-telangiectasia: treating mitochondrial dysfunction with a novel form of anaplerosis

Years funded: 2020-2023

Chief Investigator: Professor David Coman, University of Queensland

AEHRC Investigators: Dr Jason Dowling

There is no effective therapy for ataxia-telangiectasia and life expectancy is approximately 25 years. This trial involves a new treatment for the correction of mitochondrial dysfunction and cell death in respiratory epithelial cells associated with the disease, and endpoints include non-invasive monitoring of lung disease status (through MRI).

MRFF School readiness child outcomes of early neuroprotection/early neurorehabilitation for infants at high risk of cerebral palsy in the first 2000 days

Years funded: 2022-2026

Chief Investigator: Professor Roslyn Boyd, University of Queensland

AEHRC Investigators: Dr Kerstin Pannek

Early intervention trials for infants at high risk of cerebral palsy so far have assessed outcomes up to 2 years age. In this study, we will follow-up children who participated in RCTs of early neurorehabilitation/neuroprotection (recruited at <6 months age) at 4-5 years old to determine school readiness and longer-term effectiveness of interventions. CSIRO will contribute image analyses of newborn brain MRI, to determine whether children with specific brain injuries are more responsive to certain interventions.

MRFF Dementia, Ageing and Aged Care Mission: Blood testing to predict and discriminate dementias

Years funded: 2021-2026

Chief Investigator: Professor Ashley Bush, University of Melbourne

AEHRC Investigators: Dr Jurgen Fripp, Dr James Doecke, Dr Vincent Dore

A predictive blood test for Alzheimer's disease (AD) is urgently needed. Our project will bring together Australia's leading dementia researchers and the largest dementia-related research cohort ever assembled in this country to accelerate the use of blood tests in clinical settings (e.g., hospitals, memory clinics) that can help to diagnose, and predict the onset of, AD. We will also examine the impact of having a diagnostic blood test for AD on health and management outcomes.

MRFF Digital Infrastructure For Improving First Nations Maternal & Children's Health

Years funded: 2022-2026

Chief Investigator: Professor Clair Sullivan, University of Queensland

AEHRC Investigators: Dr Michael Lawley

The DIFFERENCE project will deliver the largest connected First Nations data infrastructure to ensure the best possible start to life for First Nations Australians. Building on strong partnerships prioritizing First Nations data sovereignty and governance, it will develop a data linkage platform with a nationally agreed health data set for First Nations child and maternal health outcomes, and interoperability standards—all with one aim—to support closing the gap in maternal and perinatal health disparities between First Nations and non-First Nations mums and infants. This project will also generate sophisticated Machine Learning analytics to foster iterative quality improvement and will adopt international standards to support scalability.

MRFF NEWBORN GEN SEQ TRAIL: NEWBORN GENomicSEQuencing in screening: TherapyReadyAndInformation forLife

Years funded: 2022-2026

Chief Investigator: Professor Bruce Bennetts, University of Sydney

AEHRC Investigators: Dr Denis Bauer, Dr Natalie Twine

Newborn screening (NBS) enables early diagnosis and management of serious health conditions leading to better health outcomes and the number of diseases that would benefit from the inclusion in NBS continues to grow. This trial will demonstrate the use of next generation sequencing as a universal platform for genomic testing in NBS, and ultimately will ensure individuals with genetic disorders can benefit from rapid diagnosis and access to life-changing novel therapies.

National Health and Medical Research Council (NHMRC)

NHMRC Dementia Grant

Prospective imaging study of ageing: genes, brain and behaviour

Years funded: 2016-2023

Chief Investigator: Professor Michael Breakspear

AEHRC Investigators: Dr Jurgen Fripp, Dr Parnesh Raniga, Dr Ying Xia

The Prospective Imaging Study of Ageing: Genes, Brain and Behaviour examines the interplay between genetic, epigenetic and environmental factors for dementia, and also aims to identify risk factors that could be modified through intervention, such as lifestyle choices.

NHMRC GAME: Harnessing neuroplasticity to improve motor performance in infants with cerebral palsy

Years funded: 2019-2025

Chief Investigator: Iona Novak, Nadia Badawi, Cathy Morgan, Roslyn Boyd

AEHRC Investigators: Dr Dana Bradford, Dr Kerstin Pannek, Dr Alex Pagnozzi

This new pragmatic, single blind randomised controlled trial (RCT) in 300 infants with cerebral palsy or at high risk of cerebral palsy will evaluate the effects of "GAME" (Goals Activity Motor Enrichment, an early training intervention) versus traditional passive early intervention on gross and fine motor skills at two years of age. We will also evaluate the secondary outcomes of neuroplasticity on MRI, cognitive skills and quality of life.

NHMRC Centre for Research Excellence in Digital Health

Years funded: 2018-2023

Chief Investigator: Professor Enrico Coiera, Macquarie University

AEHRC Investigators: Dr David Hansen

The Centre for Research Excellence (CRE) in Digital Health is a national research centre which brings together the major Australian centres of health informatics research. The CRE delivers an integrated research program to address critical evidence gaps that limit our national capacity to exploit digital technologies in healthcare.

NHMRC Project Grant

Prediction of childhood brain outcomes in infants born preterm using neonatal MRI and concurrent clinical biomarkers

Years funded: 2019-2024

Chief Investigator: Roslyn Boyd

AEHRC Investigators: Dr Dana Bradford, Dr Alex Pagnozzi, Dr Kerstin Pannek

Preterm birth is a risk factor of adverse neurodevelopmental outcomes. In this project, preterm-born children who were previously recruited into our PPREMO and PREBO studies (2014 - 2019) and assessed using MRI and clinical assessments in the newborn period and at 2 years, will return for follow-up MRI and clinical assessments at 6 years age. This will enable us to predict longer-term outcomes at school age from newborn data.

NHMRC Early diagnosis and early intervention for infants with cerebral palsy: implementation of international evidence-based guidelines into practice

Years funded: 2022-2024

Chief Investigator: Associate Professor Alicia Spittle, University of Melbourne

AEHRC Investigators: Dr Dana Bradford, Dr Kerstin Pannek, Dr Alex Pagnozzi

Brain MRI forms an important part of the diagnostic workup of cerebral palsy. In this project, we will develop automated approaches to quantitatively evaluate clinical brain MRI of newborns and toddlers with cerebral palsy. These automated tools will support clinicians by making information in MRI more easily accessible and less time consuming.

NHMRC Dementia Research ADNET

Years funded: 2018-2023

Chief Investigator: Professor Chris Rowe

AEHRC Investigators: Dr Jurgen Fripp, Dr Vincent Dore, Dr Pierrick Bourgeat, Dr Parnesh Raniga, Dr James Doecke

The project (The Australian Dementia Network, ADNeT) will continue development of one of the world's largest longitudinal studies into Alzheimer's disease (Australian Imaging, Biomarker & Lifestyle Flagship Study of Ageing, AIBL). By recruiting a large population-based cohort of participants, the study will provide a registry for worldwide clinical trials, and an Australian network of leading clinicians to research the progression of the disease.

NHMRC Project Grant

Genetic and lifestyle susceptibility and resilience factors affecting rates of change in preclinical Alzheimer's disease

Years funded: 2019-2022

Chief Investigator A: Associate Professor Simon Laws, Edith Cowen University

AEHRC Investigators/Chief Investigator E: Dr Vincent Dore

This study combines genome wide genetic/epigenetic data with lifestyle factors to gain a thorough understanding of how they interact to impact rates of change. This will be achieved through the leverage of data from AIBL, a high quality and established longitudinal cohort and validation both nationally (Prospective Imaging Study of Ageing (PISA)) and internationally (Alzheimer's Disease Neuroimaging Initiative (ADNI), Lothian Birth Cohort (LBC) and pharmaceutical cohorts). We will undertake an integrated approach of combining genetic, epigenetic and lifestyle patterns in a large longitudinal study of ageing with respect to rates of change.

NHMRC Boosting Dementia Research Grants Holistic approach in primary care for preventing memory impairment and dementia (HAPPI MIND)

Years funded: 2019-2024

Chief Investigator: Dr Johnson George, Monash University, Melbourne

AEHRC Investigators: Dr Rajiv Jayasena, Dr Marlien Varnfield

To evaluate the efficacy and cost-effectiveness of the Holistic Approach in primary care for Preventing Memory Impairment and Dementia (HAPPI MIND) program in reducing the risk of dementia among middle-aged people attending Australian general practices.

NHMRC/JPND Project Grant

Early detection of Alzheimer's disease subtypes (E-DADS)

Years funded: 2020-2023

AEHRC Investigators/Chief Investigator A for NHMRC: Dr Pierrick Bourgeat

Collaboration Lead for JPND:Professor Daniel C Alexander, UCL

E-DADS aims to untangle the heterogeneity of Alzheimer's disease (AD) by defining data-driven subtypes of the clinical manifestation of AD based on brain imaging, cognitive markers and fluid biomarkers that are robustly identifiable from predictive risk factors (genetics, co-morbidities, physiological and lifestyle factors) years before disease onset. To achieve this we are developing novel multi-view learning strategies that relate end-stage disease manifestations observable in clinical cohorts to features of early-stage or at-risk individuals in preclinical cohorts and the general pre-affected population from population or aging studies.

NHMRC PROTECTMe

Assessing antenatal maternal melatonin supplementation in fetal growth restriction to improve neurodevelopmental outcomes

Years funded: 2020-2024

Chief Investigator: Dr Kirsten Palmer, Monash University

AEHRC Investigators: Dr Kerstin Pannek, Dr Alex Pagnozzi

Foetal growth restriction is a risk factor for adverse neurodevelopmental outcome. This randomised clinical trial investigates whether maternal melatonin supplementation during pregnancy can improve outcomes. We will determine whether there are any observable differences in brain structure and microstructure between newborns in the treatment group compared to placebo group and investigate whether these brain changes lead to differences in outcomes at 2 years age.

NHMRC Project Grant Developing and innovative mobile health avatar to enhance smoking cessation

Years funded: 2020-2025

Chief Investigator: Dr. Henry Marshall

AEHRC Investigators: Dr David Ireland

Our multidisciplinary team of computer scientists, psychologists, public health and clinical medicine specialists will develop a state-of-the-art AI based mHealth app (AI Avatar, akin to Apple's Siri) to deliver tailored counselling and expert smoking cessation advice to smokers.

NHMRC Australian Genomics Health Alliance

Years funded: 2016-2023

Chief Investigator: Professor Katherine North, Murdoch Children's Research Institute

AEHRC Investigators: Dr David Hansen, Dr Denis Bauer

The Australian Genomics Health Alliance (Australian Genomics) was launched in 2016 to address the challenges and to build the evidence to inform the integration of genomic medicine into mainstream healthcare.

NHMRC-EU Collaborative Research Grants: Clinical validation of artificial intelligence for providing a personalized motor clinical profile assessment and rehabilitation of upper limb in children with unilateral cerebral palsy

Years funded: 2022-2027

Chief Investigator: Professor Roslyn Boyd, University of Queensland

AEHRC Investigators: Dr Alex Pagnozzi, Dr Jurgen Fripp

The broad aim of the AINCP program will be to identify, collect and combine multiple clinical and digital biomarkers (clinical multiaxial assessments, brain structure and function, upper limb (UpL) daily movement) to stratify distinct functional subgroups in children with unilateral cerebral palsy (UCP), and create the first diagnostic decision support tool (dDST). This will inform the decision-making process for providing an accurate prognosis and individualised rehabilitation.

NHMRC Synergy Grant: Cerebral Palsy SYNERGY Network to protect, repair and improve outcomes

Years funded: 2022-2027

Chief Investigator: Professor Roslyn Boyd, University of Queensland

AEHRC Investigators: Dr Jurgen Fripp

Cerebral Palsy (CP) is a life-long disability with immense burden (0.14% GDP, $1.47b p.a.). Recently, the incidence of CP has reduced by 30% to 1 in 700 children as a result of international multidisciplinary research on prevention, neuroprotection and improved maternal and neonatal care. Our diverse CP Synergy Network will accelerate this reduction in the rate and severity of CP by developing novel early biomarkers (neuroimaging, EEG, genomics, liquid biopsy) to improve fetal and neonatal diagnosis, prognosis, prediction to inform precision medicine clinical trials of neuroprotectants (melatonin, cell therapies) and intensive neurorehabilitation to improve motor, cognitive, psychological and health outcomes for children with CP and their families. Our main aim is to prevent CP and/or ameliorate the early brain injury by developing and testing new interventions then translate effective interventions rapidly into clinical practice. We have engaged consumers at every step in the research process to ensure relevance to persons with CP. Involvement of the Australian CP Register will enable testing of longer-term network outcomes at 5 years of age. Our translation objective is to ensure effective treatments are implemented earlier into clinical practice by determining costs, consequences and effectiveness to inform the NDIS.

NHMRC Ideas Grant: Imaging, fluid and genetic markers of Alzheimer's disease

Years funded: 2021-2026

Chief Investigator A: Associate Professor Simon Laws, Edith Cowen University

AEHRC Investigator: Dr Pierrick Bourgeat

Markers of pathology and inflammation are useful tools for the diagnosis and staging of neurodegenerative conditions such as Alzheimer's disease. This approach will deepen our basic understanding of this disease, improving early detection and prediction of cognitive impairment. This work will make possible more accurate diagnosis, and improved monitoring of therapeutic interventions.

NHMRC Marshall and Warren Ideas Grant Award

Exploiting anti-capsid humoral immunity induced in infants receiving gene therapy for spinal muscular atrophy

Years funded: 2021-2023

Chief Investigator: Professor Ian Alexander, University of Sydney

AEHRC Investigator: A/Prof Denis Bauer

Exploiting anti-capsid humoral immunity induced in infants receiving gene therapy for spinal muscular atrophy to engineer the next generation of gene transfer vectors.

After 25 years of incremental progress the possibility of treating genetic disease by gene therapy has become a therapeutic reality. This has been achieved by harnessing the gene transfer power of viruses made harmless by genetic engineering. A major limitation is that up to 50 percent of patients are currently excluded by pre-existing immunity to these powerful tools. Using 'evolution in a dish', we will engineer a new generation of these tools capable of bypassing pre-existing immunity by stealth.

NHMRC Centre for Research Excellence: DRIVE CP

Years funded: 2023-2027

Chief Investigator: Professor Iona Novak, University of Sydney

AEHRC Investigators: Dr Dana Bradford, Dr Alex Pagnozzi, Dr Wei Lu

The DRIVE Directing Research Very Early in Cerebral Palsy Health Network CRE will achieve a continuing reduction in the rate and severity of Cerebral Palsy (CP) towards full participation in society, through knowledge creation, translation, capacity building, and collaboration. In our previous CRE, we collaboratively achieved a 30% reduction in CP incidence, resulting in Australia having the lowest rate of CP worldwide. Now, children at high risk of CP will be detected in the first 3 months of life (using our early diagnosis guideline, paired with new universal screening) and fast tracked to receive early evidence-based rehabilitation in multi-centre clinical trials, underpinned by enhanced value-based care. Our previous clinical trial findings will be implemented into practice and policy through our clinical practice guidelines, mobile health aide and partnership with the NDIS. Improvement in outcomes and enhanced healthcare will be measured on our population Australian Cerebral Palsy Register.

NHMRC TRANSMIT

Years funded: 2023-2027

Chief Investigator: Professor Iona Novak, University of Sydney

AEHRC Investigators: Dr Dana Bradford

Cerebral palsy (CP) is the most common physical disability of childhood, the 5th most common cause of childhood death, and Australia's 5th most expensive healthcare condition. CP is lifelong with no known cure. 43% do not receive known effective interventions, and 20% receive harmful or ineffective care; resulting in lost opportunity that decreases the likelihood of long-term independent living and employment– the chief object of the National Disability Insurance Scheme (NDIS). Children with CP and their families need us to urgently close the gap, between what is known from research, and what is done in clinical practice. Our partnership will close the research-practice gap using evidence-based multifaceted knowledge translation (KT) strategies. We will develop a mobile health (mHealth) aide that streamlines and filters evidenced-based intervention options for children with CP, inclusive of 5 KT strategies that directly overcome implementation barriers identified by our 3 stakeholder groups – consumers, clinicians, and policymakers

Australian Research Council

Personalised learning for per-pixel prediction tasks in image analysis

Years funded: 2020-2022

Chief Investigator: Luping Zhou, University of Sydney

AEHRC Investigators: Dr Jurgen Fripp, Dr Pierrick Bourgeat

This project proposes a new paradigm of "personalised learning" for image analysis. It is argued that rather than learning a unified prediction model, each sample (including both the training and the test samples) is allowed to have a specific model that caters for its own characteristics. Catering for both the commonality and the particularity of samples, the proposed new paradigm and learning techniques are expected to help significantly advance the state-of-the-art methods for per-pixel prediction and provide better solutions tailored to individual samples.

Training centre for next-gen technologies in biomedical analysis

Years funded: 2022-2026

Chief Investigator: Prof Killugudi Swaminatha Iyer, Western Australia University

AEHRC Investigators: Dr Denis Bauer

The ARC Training Centre for Next-Gen Technologies in Biomedical Analysis, led by UWA, will deliver a workforce trained in the development of transformative technologies that will rapidly expand the Australian pharmaceutical, diagnostic and defence sector.

AEHRC Publications 2023–2024

Journal Publications

1. A. Nicolson, J. Dowling, B. Koopman, "Improving Chest X-Ray Report Generation by Leveraging Warm-Starting", *Artificial Intelligence In Medicine*, pp. 102633, Oct 2023.

2. A. Bollack, P. Markiewicz, A. Wink, L. Prosser, J. Lilja, P. Bourgeat, J. Schott, W. Coath, L. Collij, H. Pemberton, G. Farrar, F. Barkhof, D. Cash, "Evaluation of novel data-driven metrics of amyloid β deposition for longitudinal PET studies", *Neuroimage*, pp. 120313, Oct 2023.

3. C. Orsingher, J. McColl-Kennedy, T. Green, M. Zaki, M. Varnfield, J. Li, K. Butten, J. Titman, D. Hansen, "Mobile applications (apps) as service provider actors", *International Journal of Consumer Studies*, pp. e13016, Feb 2024.

4. H. Bendotti, S. Lawler, C. Gartner, D. Ireland, H. Marshall, "Smoking cessation counselling in practice: A qualitative analysis of Quitline conversations in Queensland, Australia", *Health Education and Behaviour*, vol. 0, pp. 1-11, Oct 2023.

5. N. Twine, D. Bauer, R. Dunne, P. Szul, L. Sng, S. Burnham, A. Bayat, G. Cuellar-Partida, "VariantSpark, a cloud-based random forest GWAS platform, identifies novel loci and epistasis in Alzheimer's disease", *Scientific Reports*, pp. 17662, Oct 2023.

6. R. Reguant Comellas, M. O'Brien, A. Bayat, B. Hosking, Y. Jain, N. Twine, D. Bauer, "PEPS: Polygenic Epistatic Phenotype Simulation", *Student Health Technology Information*, vol. 0, pp. 810-814, Jan 2024.

7. S. Ahnaf, S. Saha, S. Frost, G. Rahaman, "Understanding and interpreting CNN's decision in Optical Coherence Tomography-based AMD detection", *European Journal of Ophthalmology*, vol. 0, pp. 1-13, Sep 2023.

8. Y. Jain, A. Mohamed Izzath, L. Wilson, D. Bauer, "Data Visualization of CRISPR-Cas9 Guide RNA Design Tools", *Student Health Technology Information*, vol. 0, pp. 770 - 774, Jan 2024.

9. Y. Quek, Y. Fung, S. Vogrin, P. Bourgeat, S. Vogrin, J. Fripp, S. Collins, S. Bowden, "Standardizing MRI Orientation Improves Reliability of Entorhinal Cortex and Transentorhinal Cortex Volume Measurement", *Psychiatry Research: Neuroimaging*, pp. 111735, Dec 2023.

10. Y. Xia, P. Maruff, V. Dore, P. Bourgeat, F. Simon M. Laws, S. Rainey-Smith, R. Martins, V. Villemagne, C. Rowe, C. Masters, E. Coulson, J. Mejan-Fripp, "Longitudinal trajectories of basal forebrain volume in normal ageing and Alzheimer's disease", *Neurobiology of Aging*, pp. 120-130, Sep 2023.

11. A. Abbosh, A. Zamani, B. Konstanty, Aida, L. Guo, A. Al-Saffar, A. Trakic, G. Zhu, S. Crozier, D. Cook, "Clinical Electromagnetic Brain Scanner", *Scientific Reports*, pp. 5760, Mar 2024.

12. A. Kaphle, A. Oliva, R. Reguant Comellas, L. Sng, Y. Jain, D. Bauer, N. Twine, Y. Malakar, A. Wickramarachchi, M. Keller, T. Ranbaduge, E. K F Chan, J. Breen, S. Buckberry, B. Guennewig, M. Haas, M. J Cowley, N. Thorne, "Future-proofing genomic data and consent management: a comprehensive review of technology innovations", *Giga Science*, pp. 1-16, Apr 2024.

13. A. Wickramarachchi, B. Hosking, Y. Jain, J. Grimes, M. O'Brien, T. Wright, M. Burgess, V. Lin, F. Reisinger, M. Lawley, L. Wilson, N. Twine, D. Bauer, "Scalable genomic data exchange and analytics with sBeacon", *Nature Biotechnology*, pp. 1, Sep 2023.

14. A. Feizpour, V. Dore, J. Doecke, Z. Saad, G. Triana-Baltzer, R. Slemmon, P. Maruff, N. Krishnadas, P. Bourgeat, K. Huang, C. Fowler, S. Rainey-Smith, A. Bush, L. Ward, J. Robertson, R. Martins, C. Masters, V. Villemagne, J. Mejan-Fripp, H. Kolb, C. Rowe, "Two-year prognostic utility of plasma p217+tau across the Alzheimer's continuum", *Journal of Alzheimer's Disease*, pp. NA, Jul 2023.

15. B. Shum, L. Sng, I. Henner, P. Barahona, M. Hinchcliffe, E. Basar, D. Leigh, J. McGill, C. Pretorius, U. Wilgen, A. Zournazi, L. Downie, N. Taylor, L. Cheney, S. Wu, N. Twine, D. Bauer, G. Watts, A. Navilebasappa, R. Kumar, J. Ungerer, Bennett, Glenn, "Feasibility of targeted next generation DNA sequencing for expanding population newborn screening", *Clinical Chemistry*, pp. 890-900, Jul 2023.

16. C. Farah, K. Shearston, E. Turner, M. Vacher, S. Fox, "Global gene expression profile of proliferative verrucous leukoplakia and its underlying biological disease mechanisms", *Oral Oncology*, pp. 151, Feb 2024.

17. D. Ireland, Nicole, V. Andrews, L. Burvill, E. Hay, D. Westerman, T. Rose, M. Schlumpf, J. Strong, A. Claus, "Creating a digitally enhanced interactive and individualized experience to record of pain history and deliver pain education across different age groups: chatbot development, pilot testing and acceptability of the Dolores mobile app", *JMIR Formative Research*, pp. 1-39, Aug 2023.

18. E. Coiera, K. Verspoor, D. Hansen, "We need to chat about AI", *The Medical Journal of Australia*, pp. 98-100, Aug 2023.

19. E. Martin, A. Cook, S. Frost, A. Turner, F. Chen, I. McAllister, J. Nolde, M. Schlaich, "Ocular Biomarkers: Useful Incidental Findings by Deep Learning Algorithms in Retinal Photographs", *Eye*, pp. 1-8, May 2024.

20. F. Pervez, M. Shoukat, M. Usama, M. Sandhu, S. Latif, J. Qadir, "Affective Computing and the Road to an Emotionally Intelligent Metaverse", IEEE Open *Journal of the Computer Society*, pp. 20, Apr 2024.

21. H. Bendotti, S. Lawler, G. Chan, C. Gartner, D. Ireland, H. Marshall, "Conversational artificial intelligence interventions to support smoking cessation: a systematic review and meta-analysis", *Digital Health*, pp. 1-13, Nov 2023.

22. H. Bendotti, D. Ireland, S. Lawler, D. Oates, C. Gartner, H. Marshall, "Introducing Quin: The design and development of a prototype chatbot to support smoking cessation", *Nicotine & Tobacco Research*, pp. 1-9, Nov 2023.

23. J. Bugeja, Y. Xia, S. Chandra, N. Murphy, S. Crozier, D. Hunter, J. Mejan-Fripp, C. Engstrom, "Analysis of cam location characteristics in FAI syndrome patients from 3D MR images demonstrates sex-specific differences", *Journal of Orthopaedic Research*, pp. 1-10, Jul 2023.

24. J. Yoon, D. McGregor, E. Nordberg, K. Youngentob, L. Schwarzkopf, A. Krockenberger, "Comparison of home range size, habitat use and the influence of resource variations between two species of greater gliders (Petauroides minor and Petauroides volans)", *PLoS ONE*, pp. 1-26, Oct 2023.

25. K. Butten, J. Laurie, M. Varnfield, S. Wilkinson, "Gestational diabetes mellitus care re-imagined: women's experiences of a major model of care change at a large metropolitan hospital", *Practical Diabetes*, pp. 22-30, May 2024.

26. L. Liu, O. Perez Concha, A. Nguyen, Bennett, Vicki, V. Blake, G. Blanca, L. Jorm, "Web-Based Application Based on Human-in-the-Loop Deep Learning for Deidentifying Free-Text Data in Electronic Medical Records: Development and Usability Study", *Interactive Journal of Medical Research*, pp. 1-17, Aug 2023.

27. L. Allan, L. Beilei, J. Cameron, M. Olaiya, D. Silvera, A. Adcock, C. English, S. Gall, D. Cadilhac, "mHealth interventions for the prevention of stroke: implications for policy and practice.", *Stroke (American Heart Association)*, pp. 2935-2945, Oct 2023.

28. L. Pivac, B. Brown, K. Sewell, J. Doecke, V. Villemagne, V. Dore, M. Weinborn, H. Sohrabi, S. Gardener, R. Bucks, S. Laws, K. Taddei, P. Maruff, C. Masters, C. Rowe, R. Martins, S. Rainey-Smith, "Suboptimal self-reported sleep efficiency and duration predict faster accumulation of brain Aβ-Amyloid in cognitively unimpaired older adults", *Alzheimer's & Dementia*, pp. 1-11, Mar 2024.

29. M. Mellow, D. Dumuid, T. Olds, T. Stanford, J. Dorrian, A. Wade, J. Mejan-Fripp, Y. Xia, M. Goldsworthy, F. Karayanidis, M. Breakspear, A. Smith, "Cross-sectional associations between 24-hour time-use composition, grey matter volume and cognitive function in healthy older adults", *International Journal of Behavioral Nutrition and Physical Activity*, pp. 1-17, Jan 2024.

30. M. Samadbeik, A. Staib, J. Boyle, S. Khanna, E. Bosley, D. Bodnar, J. Lind, J. Austin, S. Tanner, Y. Meshkat, C. Sullivan, "Patient flow in emergency departments: a comprehensive umbrella review of solutions and challenges across the health system", *BMC Health Services Research*, pp. 274, Mar 2024.

31. M. Simunovic, J. Boyle, B. Erbas, P. Baker, J. Davies, "Airborne grass pollen and thunderstorms influence emergency department asthma presentations in a subtropical climate", *Environmental Research*, pp. 116754, Nov 2023.

32. M. Eustace, L. Hall, B. Patel, T. Wozniak, "Responding to the AMR threat: Data and information needs of stakeholders working in remote Australia", *Antimicrobial Stewardship and Healthcare Epidemiology*, pp. e, May 2024.

33. M. Vacher, R. Canovas, S. Laws, J. Doecke, "A Comprehensive Multi-omics Analysis Reveals Unique Signatures to predict Alzheimer's Disease", *Frontiers in Bioinformatics*, pp. 4:1390607, Jun 2024.

34. M. Sandhu, D. Silvera, P. Borges, Q. Zhang, B. Kusy, "Internet of Robotic Things for Independent Living: Critical Analysis and Future Directions", *Internet of Things*, pp. 101120, Feb 2024.

35. M. Sohail, A. Khan, M. Sandhu, I. Shoukat, M. Jafri, H. Shin, "Radar Sensor Based Machine Learning Approach for Precise Vehicle Position Estimation", *Scientific Reports*, pp. 13837, Aug 2023.

36. A. Nicole, D. Ireland, P. Vijayakumar, L. Burvill, E. Hay, D. Westerman, T. Rose, M. Schlumpf, A. Claus, J. Strong, "Acceptability of a pain history and pain education chatbot across different age groups: designing and pilot testing the Dolores mobile app", *Journal of Medical Internet Research: mHealth and uHealth*, pp. 1-17, Oct 2023.

37. O. Laporta-Hoyos, S. Fiori, K. Pannek, A. Pagnozzi, R. Ware, R. Boyd, "Longitudinal assessment of brain lesions in children with cerebral palsy and association with motor functioning", European *Journal of Paediatric Neurology*, pp. 27-34, Mar 2024.

38. O. Lopez, V. Villemagne, Y. Chan, A. Cohen, W. Klunk, C. Mathis, T. Pascoal, M. Ikonomovic, C. Rowe, V. Dore, B. Snitz, B. Lopresti, I. Kamboh, H. Aizenstein, L. Kuller, "Accelerated A-beta deposition is associated with incident dementia and mortality in non-demented individuals age 80+", *Neurology*, pp. e207920, Jan 2024.

39. P. Bourgeat, V. Dore, C. Rowe, T. Benzinger, D. Tosun, M. Goyal, P. LaMontagne, Jin, Liang, M. Weiner, C. Masters, J. Mejan-Fripp, V. Villemagne, "A Universal neocortical mask for Centiloid quantification", Alzheimer's & Dementia: Diagnosis, *Assessment & Disease Monitoring*, pp. e12457, Jul 2023.

40. R. Cummins, R. Preston, S. Topp, J. Taylor, S. Larkins, E. Callander, L. Bell, B. Arley, G. Garvey, "A qualitative exploration of the non-financial costs of cancer care for Aboriginal and Torres Strait Islander Australians", *Australian and New Zealand Journal of Public Health*, pp. 8p, Oct 2023.

41. R. Poldrack, “The Past, Present, and Future of the Brain Imaging Data Structure (BIDS)”, *Imaging Neuroscience*, pp. 1-19, Mar 2024.

42. S. Saha, J. Vignarajan, S. Frost, “A fast and fully automated system for glaucoma detection using color fundus photographs”, *Scientific Reports*, pp. 1-11, Oct 2023.

43. S. Mortlock, M. Asada, P. Soh, W. Hsu, C. Lee, Bennett, Peter F., R. Taylor, M. Khatkar, P. Williamson, “Genomic analysis of lymphoma risk in bullmastiff dogs”, *Veterinary Sciences*, pp. 703, Dec 2023.

44. S. Hasan, A. Zamani, A. Brankovic, K. Bialkowski, A. Abbosh, “Stroke Classification with Microwave Signals using Explainable Wavelet Convolutional Neural Network”, *IEEE Journal on Biomedical and Health Informatics*, pp. 1 - 10, Oct 2023.

45. V. Riahi, H. Hassanzadeh, S. Khanna, J. Boyle, F. Syed, B. Biki, E. Borkwood, L. Sweeney, “Improving preoperative prediction of surgery duration”, *BMC Health Services Research*, pp. 15, Dec 2023.

46. V. Villemagne, A. Leuzy, S. Sanabria Bohorquez, S. Bullich, H. Shimada, C. Rowe, P. Bourgeat, B. Lopresti, K. Huang, N. Krishnadas, J. Mejan-Fripp, Y. Takado, A. Gogola, D. Minhas, R. Weimer, M. Higuchi, A. Stephens, O. Hansson, V. Dore, “CenTauR: Towards a Universal Scale and Masks for Standardizing Tau Imaging Studies”, *Alzheimer’s & Dementia: Diagnosis, Assessment & Disease Monitoring*, pp. e12454, Jul 2023.

47. W. Cuningham, S. Perera, S. Coulter, Z. Wang, S. Tong, T. Wozniak, “Repurposing antibiotic resistance surveillance data to support treatment of recurrent infections in a remote setting”, *Scientific Reports*, pp. XX, Jan 2024.

48. Y. Quek, P. Bourgeat, Y. Fung, S. Vogrin, S. Collins, S. Bowden, “Validating ASHS-T1 Automated Entorhinal and Transentorhinal Cortical Segmentation in Alzheimer’s Disease”, Psychiatry Research: *Neuroimaging*, pp. 111707, Oct 2023.

49. Y. Quek, Y. Fung, P. Bourgeat, S. Vogrin, S. Collins, S. Bowden, “Combining neuropsychological assessment and structural neuroimaging to detect early Alzheimer’s disease in a memory clinic cohort”, *Brain and Behavior*, pp. e3505, Apr 2024.

50. Y. Xia, V. Dore, J. Mejan-Fripp, P. Bourgeat, S. Laws, C. Fowler, S. Rainey-Smith, R. Martins, C. Rowe, C. Masters, E. Coulson, P. Maruff, “Association of Basal Forebrain Atrophy with Cognitive Decline in Early Alzheimer Disease”, *Neurology*, pp. e209626 (1-12), Jun 2024.

51. Z. Wang, V. Lewis, C. Stehmann, S. Varghese, M. Senesi, A. McGlade, L. Ellett, J. Doecke, D. Eratne, D. Velakoulis, C. Masters, S. Collins, Q. Li, “Alzheimer disease biomarkers utilisation at first referral enhance differential diagnostic precision with simultaneous exclusion of Creutzfeldt-Jakob disease”, *Alzheimer’s & Dementia: DADM,* pp. 1-10, Dec 2023.

52. A. Hashem, L. Sara A, S. Bakhtiari, P. Nordlie, S. Helen Magee, J. Efthymiou, P. Heim, M. Cornejo, N. Zaki, S. Anwar, F. Maqbool, D. Rahman, A. Neilson, Vemuri, J. Sheng Chih, Y. Xiao-Ru, et al, “TRAPPC6B biallelic variants cause a neurodevelopmental disorder with TRAPP II and trafficking disruptions”, *Brain*, pp. 311–324, Jan 2024.

53. A. Roesler, K. Butten, C. Calyx, E. Holmes-Truscott, P. Taylor, “Use and Preferences of Health Apps among Women and Healthcare Professionals Regarding GDM Postpartum Care Related to Diet, Physical Activity, and Weight Management: A Cross-Sectional Survey”, *Nutrients*, pp. 3304, Jul 2023.

54. D. Vukovic, A. Wang, M. Antico, M. Steffens, I. Ruvinov, R. van Sloun, D. Canty, A. Royse, C. Royse, K. Haji, J. Dowling, G. Chetty, D. Fontanarosa, “Automatic Deep Learning-Based Pleural Effusion Segmentation in Lung Ultrasound Images”, *BMC Medical Informatics and Decision Making*, pp. 1-14, Nov 2023.

55. D. Vukovic, I. Ruvinov, M. Antico, M. Steffens, D. Fontanarosa, “Automatic GAN-based MRI volume synthesis from US volumes: a proof of concept investigation”, *Scientific Reports*, pp. 1-14, Dec 2023.

56. J. Yuan, S. Pedrini, R. Thota, J. Doecke, P. Chatterjee, H. Sohrabi, C. Teunissen, I. Verberk, E. Stoops, H. Vanderstichele, B. Meloni, Mitchell, Christopher, S. Rainey-Smith, K. Goozee, A. Tai, N. Ashton, H. Zetterberg, K. Blennow, J. Gao, D. Liu, F. Mastaglia, C. Inderjeeth, M. Zheng, R. Martins, “Elevated Plasma Sclerostin is Associated with High Brain Amyloid-β Load in Cognitively Normal Older Adults”, *Nature ageing*, pp. 1-8, Sep 2023.

57. J. Mejan-Fripp, “A robust harmonization approach for cognitive data from multiple aging and dementia cohorts”, *Alzheimers Dement (Amst)*, pp. e12453, Jul 2023.

58. L. Liu, O. Perez Concha, A. Nguyen, Bennett, Vicki, L. Jorm, “Automated ICD Coding using Extreme Multi-label Long Text Transformer-based Models”, *Artificial Intelligence In Medicine*, pp. 1-10, Oct 2023.

59. M. Kanki, A. Nath, R. Xiang, S. Yiallourou, P. Fuller, T. Cole, R. Canovas, M. Young, “Poor sleep and shift work associate with increased blood pressure and inflammation in UK Biobank participants”, *Nature Communications*, pp. 7096, Nov 2023.

60. D. Silvera-Tawil, “Robotics in Healthcare: A Survey.”, *SN Computer Science*, vol. 5, pp. 189, Jan 2024.

61. C. McKenzie, R. Bucks, M. Weinborn, P. Bourgeat, O. Salvado, B. Gavett, “Tau and amyloid biomarkers modify the degree to which cognitive reserve and brain reserve predict cognitive decline”, *Journal of the International Neuropsychological Society*, vol. 29, pp. 572-281, Jul 2023.

62. R. Dunne, R. Reguant, P. Ramarao-Milne, P. Szul, L. Sng, M. Lundberg, N. Twine, D. Bauer, “Thresholding Gini variable importance with a single-trained random forest: An empirical Bayes approach.”, *Computational and Structural Biotechnology Journal*, vol. 21, pp. 4354-4360, Sep 2023.

63. A. Roesler, K. Butten, P. Taylor, M. Morrison, M. Varnfield, E. Holmes-Truscott, “The experiences of individuals who have had gestational diabetes: A qualitative exploration”, *Diabetic Medicine*, pp. 1-13, Jun 2024.

64. S. Naismith, J. Michaelian, C. Santos, I. Mehrani, J. Robertson, K. Wallis, X. Lin, S. Ward, R. Martins, C. Masters, M. Breakspear, S. Ahern, J. Fripp, P. Schofield, P. Sachdev, C. Rowe, “Tackling Dementia Together via The Australian Dementia Network (ADNeT): A Summary of Initiatives, Progress and Plans”, *Journal of Alzheimer’s Disease*, pp. 913–925, Nov 2023. ()

65. M. Mehdizadeh, D. Alonso Caneiro, S. Saha, J. Kugelman, C. MacNish, F. Chen, “Texture loss to denoise OCT images using Generative Adversarial Networks”, *Journal of Biomedical Optics*, pp. 2262-2280, Mar 2024.

66. B. Woo, C. Engstrom, W. Baresic, J. Fripp, S. Crozier, S. Chandra, “Automated anomaly-aware 3D segmentation of bones and cartilages in knee MR images from the Osteoarthritis Initiative”, *Medical Image Analysis*, pp. Epub, Apr 2024.

67. K. Sewell, S. Rainey-Smith, J. Peiffer, H. Sohrabi, J. Doecke, N. Frost, S. Markovic, K. Erickson, B. Brown, “The influence of baseline sleep on exercise-induced cognitive change in cognitively unimpaired older adults: A randomised clinical trial”, *Int J Geriatr Psychiatry*, pp. 1-10, Oct 2023.

68. O. Lopez, V. Villemagne, Y. Chang, A. Cohen, W. Klunk, C. Mathis, T. Pascoal, M. Ikonomovic, C. Rowe, V. Dore, B. Snitz, B. Lopresti, I. Kamboh, H. Aizenstein, L. Kuller, “Association Between β-Amyloid Accumulation and Incident Dementia in Individuals 80 Years or Older Without Dementia”, *Neurology*, pp. e207920, Jan 2024.

69. V. Villemagne, V. Dore, L. Chong, M. Kassiou, R. Mulligan, A. Feizpour, J. Taylor, M. Roesner, T. Miller, C. Rowe, “Brain 11β-Hydroxysteroid Dehydrogenase Type 1 Occupancy by Xanamem™ Assessed by PET in Alzheimer’s Disease and Cognitively Normal Individuals”, *Journal of Alzheimer’s Disease*, pp. 1463-1475, Jan 2024.

70. A. Sewify, M. Antico, M. Steffens, J. Roots, A. Gupta, K. Cutbush, P. Pivonka, D. Fontanarosa, “3D ultrasound mosaic visualisation of the whole shoulder: A Feasibility Study”, *Applied Sciences*, pp. 2152, Mar 2024.

71. 71. A. Fazlollahi, S. Lee, F. Coleman, E. McCann, M. Cloos, P. Bourgeat, P. Nestor, “Increased Resolution of Structural MRI at 3T Improves Estimation of Regional Cortical Degeneration in Individual Dementia Patients Using Surface Thickness Maps”, *Journal of Alzheimer’s Disease*, pp. 1253-1262, Sep 2023.

72. J. Liu, D. Capurro, A. Nguyen, K. Verspoor, “Attention-based multimodal fusion with contrast for robust clinical prediction in the face of missing modalities”, *Journal of Biomedical Informatics*, pp. 104466, Sep 2023.

73. Y. Quek, P. Bourgeat, Y. Fung, S. Vogrin, S. Collins, S. Bowden, “Validating ASHS-T1 Automated Entorhinal and Transentorhinal Cortical Segmentation in Alzheimer’s Disease”, *Psychiatry Research: Neuroimaging*, pp. 111707, Oct 2023.

74. S. Wootton, M. Dale, Y. Tian, M. King, J. Alison, A. Chan, M. Varnfield, I. Yang, Z. McKeough, “User experience testing of the mobile pulmonary rehabilitation (m-PR™) app in people with chronic obstructive pulmonary disease”, *Digital Health*, pp. 1, Mar 2024.

75. A. Fazlollahi, S. Lee, F. Coleman, E. McCann, M. Cloos, P. Bourgeat, P. Nestor, “Increased Resolution of Structural MRI at 3T Improves Estimation of Regional Cortical Degeneration in Individual Dementia Patients Using Surface Thickness Maps”, *Journal of Alzheimer’s Disease*, pp. 1253-1262, Sep 2023.

76. E. Huijbena et al , “Generating Synthetic Computed Tomography for Radiotherapy: SynthRAD2023 Challenge Report”, *Medical Image Analysis*, pp. 103276, Jul 2024.

77. B. Texier, C. Hémon, P. Lekieffre, E. Collot, S. Tahri, H. Chourak, J. Dowling, P. Greer, I. Bessieres, O. Acosta, A. Boue-Rafle, J. Le Guevelou, R. de Crevoisier, C. Lafond, J. Castelli, A. Barateau, J. Nunes, “Computed tomography synthesis from magnetic resonance imaging using cycle Generative Adversarial Networks with multicenter learning”, *Physics and Imaging in Radiation Oncology*, pp. 7, Nov 2023.

78. H. Chourak, A. Barateau, P. Greer, C. Lafond, J. Nunes, R. de Crevoisier, J. Dowling, O. Acosta, “Determination of acceptable Hounsfield units uncertainties via a sensitivity analysis for an accurate dose calculation in the context of prostate MRI-only radiotherapy”, *Physical and Engineering Sciences in Medicine*, pp. 1703-1711, Oct 2023.

79. L. O’Connor, A. Quinn, S. Denley, L. Leigh, J. Martin, J. Dowling, K. Skehan, H. Warren-Forward, P. Greer, “Cone beam computed tomography image guidance within a magnetic resonance imaging-only planning workflow”, *Physics and Imaging in Radiation Oncology*, pp. 6, Jul 2023.

80. P. Chlap, H. Min, J. Dowling, M. Field, K. Cloak, T. Leong, M. Lee, J. Chu, J. Tan, P. Tran, T. Kron, M. Sidhom, K. Wiltshire, S. Keats, A. Kneebone, A. Haworth, M. Ebert, S. Vinod, L. Holloway, “Uncertainty Estimation using a 3D Probabilistic UNet for Segmentation with Small Radiotherapy Clinical Trial Datasets”, *Computerized Medical Imaging and Graphics*, pp. 17, Jun 2024.

81. S. Leung, S. Chandra, K. Lim, T. Young, L. Holloway, J. Dowling, “Automatic segmentation of tumour and organs at risk in 3D MRI for cervical cancer radiation therapy with anatomical variations”, *Physical and Engineering Sciences in Medicine*, pp. 10, Apr 2024.

82. V. Le Bao, A. Haworth, J. Dowling, A. Walker, S. Arumugam, M. Jameson, P. Chlap, K. Wiltshire, S. Keats, K. Cloak, M. Sidhom, A. Kneebone, L. Holloway, “Evaluating the relationship between contouring variability and modelled treatment outcome for prostate bed radiotherapy”, *Physics in Medicine and Biology*, pp. 15, Apr 2024.

83. A. Sewify, M. Antico, M. Steffens, J. Roots, A. Gupta, K. Cutbush, P. Pivonka, D. Fontanarosa, "3D ultrasound mosaic visualisation of the whole shoulder: A Feasibility Study", *Applied Sciences*, pp. 2152, Mar 2024.

84. S. Naismith et al, "Tackling Dementia Together via The Australian Dementia Network (ADNeT): A Summary of Initiatives, Progress and Plans", *Journal of Alzheimer's Disease*, pp. 913–925, Nov 2023.

85. J. F. Fraim et al, "Accuracy of TrUE-Net in comparison to established white matter hyperintensity segmentation methods: An independent validation study", *NeuroImage*, pp. 120494, Jan 2024.

86. J. Wen at al, "Genomic loci influence patterns of structural covariance in the human brain", *Proceedings of the National Academy of Sciences (PNAS)*, pp. 1-12, Dec 2023.

87. Z. Yang, "Gene-SGAN: discovering disease subtypes with imaging and genetic signatures via multi-view weakly-supervised deep clustering", *Nature Communications*, pp. 1-8, Jan 2024.

Conference Publications

1. A. Brankovic, W. Huang, D. Cook, S. Khanna, K. Bialkowski, "Elucidating Discrepancy in Explanations of Predictive Models Developed using EMR", *Medinfo23*, Sydney, Australia, 08 to end of 12 Jul 2023.

2. A. Pagnozzi, J. Mejan-Fripp, "Improved prediction of outcomes in preterm infants", *MEDInfo23*, Sydney, NSW, 08 to end of 12 Jul 2023.

3. D. Bradford, D. Silvera, J. Freyne, "Simple solution for a complex problem: facilitating clinician-patient communication in the absence of an interpreter", *MEDInfo23*, Sydney NSW Australia, 08 to end of 12 Jul 2023.

4. D. Bradford, K. Von Richter, G. Thayaparan, S. Gibson, P. D-Urso, "Sensing swelling: Towards remote monitoring of craniectomy patients", *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

5. D. Ireland, A. Lam, S. Naismith, D. Bradford, "A new role for chatbots: Automation of a sleep-dependent memory task", *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

6. G. Hobson, R. Mahoney, A. Goodman, "Best Practice in Digital Health Research with Aboriginal and Torres Strait Islander people", *MEDInfo23*, Sydney, 08 to end of 11 Jul 2023.

7. I. Diouf, J. Grimes, M. O'Brien, H. Hassanzadeh, D. Truran, H. Ngo, P. Raniga, M. Lawley, D. Bauer, D. Hansen, S. Khanna, R. Reguant Comellas, "An approach for generating realistic Australian synthetic healthcare data", *Medinfo23*, Sydney, 08 to end of 12 Jul 2023.

8. J. Rahman, A. Brankovic, R. Halliday, S. Khanna, M. Tracy, "Towards accurate search for neonatal heartbeat: Weighted algorithm for reliable ECG analysis of premature infants", *The 19th World Congress on Medical and Health Informatics*, Sydney, Australia, 08 to end of 12 Jul 2023.

9. J. Yoon, J. Boyle, "A new statistical method to detect disease outbreaks from hospital Emergency Department data", *MEDInfo23*, Sydney, Australia, 07 to end of 12 Jul 2023.

10. J. Boyle, S. Khanna, James Lind, "Emergency Department Demand and the first year of the COVID-19 pandemic", *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

11. J. Boyle, J. Vignarajan, S. Saha, "Automated diabetic retinopathy diagnosis for improved clinical decision support", *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

12. J. Boyle, H. Hassanzadeh, S. Khanna, B. Biki, F. Syed, E. Borkwood, L. Sweeney, "Modelling planned vs actual start time to control the efficiency of surgery", *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

13. M. Kholghi, D. Silvera, G. Wong, J. Walker, J. Wilson, D. Bradford, "LIV well when life is limited: Technology to support independence at home", *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

14. M. Varnfield, K. Butten, A. Hayat, R. Rogers, M. Budd, "PD-Buddy: a feasibility study of mobile health to support the management of peritoneal dialysis", *MEDInfo23*, Sydney Australia, 08 to end of 12 Jul 2023.

15. S. Jones, M. Gerdtz, D. Ukovich, M. Merolli, "Case based learning in a simulated Electronic Medical Record: digital health education for nursing students", *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

16. Y. Wu, J. Hughes, A. Lyrstedt, S. Hazelwood, N. Brown, L. Jones, C. Douglas, A. Nguyen, K. Chu, "Developing Robust Clinical Text Deep Learning Models - a "Painless" Approach", *MEDInfo23*, Sydney, Australia, 08 to end of 12 Jul 2023.

17. A. Delaforce, J. Li, M. Grujovski, J. Parkinson, N. Good, R. Jayasena, "Enablers and barriers to the implementation of a falls prevention platform", *MEDINFO23*, Sydney, 08 to end of 12 Jul 2023.

18. A. Pagnozzi, K. Pannek, L. van Eijk, J. George, S. Bora, D. Bradford, R. Boyd, M. Fahey, M. Ditchfield, A. Malhotra, P. Colditz, J. Mejan-Fripp, "Neonatal brain MRI of very preterm infants before and at term equivalent age predicts 2-year motor and cognitive outcomes", *Australasian Academy of Cerebral Palsy and Developmental Medicine (AusACPDM)*, Cairns, 31 Jul 2024 to end of 03 Aug 2024.

19. A. Shausan, T. Wozniak, "Predicting Risk of Antimicrobial Resistance (AMR) in Northern Australia: A Bayesian Spatio-Temporal Machine Learning Analysis Using AMR Surveillance Data", *ASA Antimicrobials 2024*, Sydney, Australia, 14 to end of 17 Feb 2024.

20. A. Shausan, A. Dyda, F. May, S. Anuradha, "Digital data sources and machine learning to enhance infectious disease surveillance, Australia", *Communicable Diseases & Immunisation Conference 2024*, Brisbane, 11 to end of 13 Jun 2024.

21. A. Klein, L. Wilson, M. Kuiper, D. Bauer, L. Lisowski, A. Venkateswaran, A. Lin, S. Scott, M. Cabanes-Creus, “In Silico Design of New Capsids for AAV Therapeutical Applications”, *International Conference of Genetics 2023*, Melbourne, 16 to end of 21 Jul 2023.

22. A. Kaphle, A. Oliva, R. Reguant Comellas, Y. Jain, D. Bauer, L. Sng, A. Wickramarachchi, “Empowering Patient Sovereignty in Genomics Research”, *International Conference of Genetics 2023*, Melbourne, 16 to end of 21 Jul 2023.

23. A. Wickramarachchi, B. Hosking, Y. Jain, A. Kaphle, J. Grimes, M. O’Brien, T. Wright, M. Burgess, V. Lin, F. Reisinger, O. Hofmann, M. Lawley, N. Twine, D. Bauer, “sBeacon - ontology aware querying of genomic data at scale”, *International Conference of Genetics 2023*, Melbourne, 16 to end of 21 Jul 2023.

24. B. Xin, T. Young, C. Wainwright, T. Blake, T. Gaass, T. Benkert, A. Stemmer, D. Coman, J. Dowling, “Deformation-aware GAN for Medical Image Synthesis with Substantially Misaligned Pairs”, *Medical Imaging with Deep Learning (MIDL2024)*, France, 03 to end of 05 Jul 2024.

25. B. Segon, M. Banks, M. Varnfield, J. Bauer, D. Prabhu, W. Lu, J. Brown, E. Vujcich, A. Plaza, A. McKittrick, Trevor, Dale, D. Silvera, “Feasibility of using wearable devices to non-invasively measure energy expenditure in patients with burn injury”, *Herston Health Precinct Symposium*, Education Centre RBWH, Brisbane, Queensland, 04 to end of 07 Sep 2023.

26. C. Lee, S. Mangalaganesh, Y. Jain, N. Kargarfard, M. Kuiper, T. Drew, V. Vasan, A. Oliva, D. Bauer, L. Wilson, “Data-driven analysis of pathogen genomes”, *International Congress of Genetics*, Melbourne Convention & Exhibition Centre, 16 to end of 21 Jul 2023.

27. C. Lauw, J. Rahman, A. Brankovic, M. Tracy, S. Khanna, “Development of an Interactive Dashboard to Analyse Physiological Signals in the Neonatal Intensive Care Unit”, *IEEE Engineering in Medicine and Biology EMBC 2023*, Sydney, Australia, 24 to end of 28 Jul 2023.

28. D. Wong, R. Stolwyk, D. Lawson, N. Feast, M. Olaiya, N. Kamberis, N. Khan, L. Allan, J. Kim, R. das Nair, D. Cadilhac, “How can the benefits of post-stroke memory rehabilitation be maintained over time? Findings from the Memory-SuSTAIN pilot randomised controlled trial”, *Stroke SSA*, Melbourne, VIC, Australia, 22 to end of 22 Aug 2023.

29. D. Prabhu, Dennis, Mitchell, M. Kholghi, W. Lu, M. Sandhu, K. Packer, J. Bomke, L. Higgins, Q. Zhang, D. Silvera, “Detecting Depression-related Movement Changes in Older Adults using Smart Home Motion Sensors - A Feasibility Study”, *45th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Sydney, Australia, 24 to end of 28 Jul 2023.

30. D. McMurtrie, “Benefits and challenges of international medicines terminology standardisation”, *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

31. F. Rusak, B. Koopman, N. Brown, K. Chu, J. Liu, A. Nguyen, “Catching Misdiagnosed Limb Fractures in the Emergency Department Using Cross-institution Transfer Learning”, *The 21th Annual Workshop of the Australasian Language Technology Association*, Melbourne, Australia, 29 Nov 2023 to end of 01 Dec 2023.

32. H. Hassanzadeh, J. Boyle, S. Khanna, “A step towards building health digital twins: patient phenotype representation for health outcome prediction”, *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

33. H. Ngo, B. Koopman, “From Free-text Drug Labels to Structured Medication Terminology with BERT and GPT”, *American Medical Informatics Association 2023*, New Orleans, LA, 11 to end of 15 Nov 2023.

34. I. Mahajan, M. Vacher, S. Laws, J. Doecke, “Understanding the relevance of genetic variants on DNA methylation changes in Alzheimer’s Disease pathogenesis”, *Australian Dementia Research Forum*, Gold Coast, 03 to end of 05 Jun 2024.

35. J. Doecke, R. Canovas, C. Fowler, Q. Li, M. Carboni, I. Suridjan, G. Kollmorgen, C. Logan, S. Collins, P. Maruff, R. Martins, J. Mejan-Fripp, H. Zetterberg, K. Blennow, C. Masters, “CSF markers YKL40, sTREM2, and alpha-synuclein enhance the Alzheimer’s disease A/T/N criteria to detect early changes in cognition”, *Alzheimer’s Association International Conference*, Amsterdam, 16 to end of 20 Jul 2023.

36. J. Camerion, D. Silvera, J. Li, L. Allan, N. Lannin, D. Cadilhac, “Co-design of a multicomponent digital Care Assistant and support Program for people after Stroke or transient ischaemic attack (CAPS)”, *Stroke Society of Australia*, Melbourne, 22 to end of 25 Aug 2023.

37. J. Grimes, S. Khanna, “FHIR-powered analytics for clinical decision support”, *Herston Health Precinct Symposium 2023*, Brisbane, Australia, 04 to end of 04 Sep 2023.()

38. J. Grimes, N. Good, M. Lawley, “A new tool for representing SNOMED CT concepts for use in model training”, *SNOMED CT Expo 2023*, Atlanta, United States, 26 to end of 27 Oct 2023.

39. L. Sng, M. O’Brien, B. Hosking, P. Szul, R. Dunne, R. Reguant Comellas, N. Twine, D. Bauer, “Modelling variant interactions reveals non-linear genetic disease associations”, *A Multidisciplinary Approach to Epistasis Detection*, Leiden, The Netherlands, 17 to end of 21 Jul 2023.

40. L. Sng, M. O’Brien, P. Szul, A. Panagopoulos, J. Verjans, D. Bauer, N. Twine, “VariantSpark Shows Improved Detection Power and Finds Epistatic Interactions”, *ISMB/ECCB 2023*, Lyon, France, 23 to end of 27 Jul 2023.

41. L. Allan, D. Silvera, J. Cameron, J. Li, M. Varnfield, J. Bomke, C. Redd, N. Lannin, M. Olaiya, D. Cadilhac, "A feasibility study of a multicomponent digital care assistant and support program for people after stroke or transient ischaemic attack (CAPS).", *Stroke Society of Australia*, Melbourne, 22 to end of 25 Aug 2023.

42. M. Antico, "Integration of AI in Ultrasound Imaging: Current Landscape and Future Directions for Clinical Practice (Plenary talk)", *ASUM 2023 (Australasian Society for Ultrasound in Medicine)*, Sydney, 13 to end of 15 Oct 2023.

43. M. Varnfield, T. Dippenaar, C. Redd, "Informing Personalised Gamification Interventions Through a Novel Gamified Quiz", *MEDInfo23*, Sydney, 08 to end of 12 Jul 2023.

44. M. Vacher, R. Canovas, J. Doecke, "Uncovering biological signatures of Alzheimer's Disease through integrative omics", *Australian Statistical Conference*, Wollongong, 10 to end of 15 Dec 2023.

45. M. Deumer, M. Sandhu, S. Khalifa, B. Kusy, K. Geissdoerfer, M. Zimmerling, R. Jurdak, "A battery-free wearable system for on-device human activity recognition using kinetic energy harvesting", *The International Conference on Embedded Wireless Systems and Networks (EWSN) 2023*, Rende, Italy, 25 to end of 27 Sep 2023.

46. M. O'Brien, L. Sng, N. Twine, D. Bauer, "Prioritisation of Rare Genetic Disease Variants Using Machine Learning", *The XXIII International Congress of Genetics*, Melbourne, 16 to end of 21 Jul 2023.

47. 47. M. Sandhu, D. Prabhu, W. Lu, M. Kholghi, D. Silvera, K. Packer, L. Higgins, M. Varnfield, "The Significance and Limitations of Sensor-based Agitation Detection in People Living with Dementia", *IEEE EMBC 2023*, Sydney, Australia, 24 to end of 28 Jul 2023.

48. M. Sandhu, D. Silvera, W. Lu, B. Kusy, P. Borges, "Exploring Activity Recognition in Multi-device Environments using Hierarchical Federated Learning", *IEEE PerCom*, France, 11 to end of 15 Mar 2024.

49. 49. R. Shishegar, M. Lee, T. Cox, T. Chai, V. Dore, P. Bourgeat, J. Mejan-Fripp, S. Burnham, T. Porter, G. Savage, J. Hassenstab, J. Morris, A. Aschenbrenner, M. Weiner, C. Masters, C. Rowe, V. Villemagne, Y. Lim, J. Doecke, H. Sohrabi, P. Maruff, "A comparison of machine learning based-composite cognitive test scores to track cognitive decline in early stages of Alzheimer's disease dementia: ADOPIC study", *Alzheimer's Association International Conference*, Amsterdam, Netherlands, 16 to end of 20 Jul 2023.

50. R. Shishegar, T. Cox, H. Sohrabi, S. Markovic, J. Mejan-Fripp, V. Dore, P. Bourgeat, J. Hassenstab, Y. Lim, P. Maruff, C. Masters, J. Doecke, "Characterising progressive decline across multiple cognitive domains in preclinical Alzheimer's disease", *Clinical Trials on Alzheimer's Disease conference (CTAD)*, Boston, 24 to end of 27 Oct 2023.

51. Y. Asadi, M. Brereton, A. Hufana Ambe, A. Soro, M. Kholghi, "Calming Down in Lockdown: Rethinking Technologies for a Slower Pace of Life", *The ACM Designing Interactive Systems (DIS) 2023*, Pittsburgh, Pennsylvania, USA, 10 to end of 14 Jul 2023.

52. Z. Que, J. Urriola Yaksic, D. Bradford, S. Bora, R. Boyd, J. Mejan-Fripp, J. George, A. Pagnozzi, "Premature Birth and Its Effects on Brain Structural Networks in School-Age Children", *Australasian Academy of Cerebral Palsy and Developmental Medicine (AusACPDM)*, Cairns, 31 Jul 2024 to end of 03 Aug 2024.

53. C. Lee, S. Mangalaganesh, Y. Jain, N. Kargarfard, M. Kuiper, T. Drew, V. Vasan, D. Bauer, L. Wilson, "Data-Driven Analysis of Pathogen Genomes", *Westmead Research & Innovation Conference 2023*, Westmead, 21 to end of 22 Sep 2023.

54. D. Vukovic, A. Wang, M. Antico, M. Steffens, I. Ruvinov, R. van Sloun, D. Canty, A. Royse, C. Royse, K. Haji, G. Chetty, D. Fontanarosa, "Automated Lung Ultrasound Image Segmentation Using a Deep Learning Approach", *ILUS 2023 (International Lung Ultrasound Symposium)*, Trento, 10 to end of 12 Jul 2023.

55. D. Vukovic, M. Antico, D. Canty, A. Royse, D. Fontanarosa, "Machine Learning technologies for automatic lung ultrasound interpretation and detection of complex lung pathologies (Invited Presentation)", *ILUS 2023 (International Lung Ultrasound Symposium)*, Trento, 10 Jul 2023 to end of 12 Dec 2023.

56. D. Vukovic, I. Ruvinov, M. Antico, M. Steffens, C. Kazantzidou, D. Fontanarosa, "Automatic Thoracic US-MRI Volume Registration Using a Generative Adversarial Network", *ILUS 2023 (International Lung Ultrasound Symposium)*, Trento, 10 Jul 2023 to end of 12 Dec 2023.

57. H. Min, Santamaria Hormaechea, R. Gorane, J. Dowling, "Evaluating the Impact of Sequence Combinations on Breast Tumor Segmentation in Multiparametric MRI", *https://arxiv.org/, https://arxiv.org/*, 12 to end of 12 Jun 2024.

58. J. Liu, A. Nguyen, "Enhancing Bacterial Infection Prediction in Critically Ill Patients by Integrating Clinical Text", *The 21th Annual Workshop of the Australasian Language Technology Association*, Melbourne, Victoria, Australia, 29 Nov 2023 to end of 01 Dec 2023.

59. L. Brattain, M. Antico, D. Fontanarosa, B. Telfer, W. Gifari, "Advances in Procedure Guidance with AI, Ultrasound, and Robotics (Invited Presentation)", *45th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Sydney, 24 to end of 27 Jul 2023.

60. L. Sng, A. Kaphle, M. O'Brien, B. Hosking, R. Reguant, J. Verjans, N. Twine, D. Bauer, "Accounting for Epistasis Increases Power to Identify Genetic Variants Associated with Coronary Artery Disease", *1st Australian UK Biobank Research Symposium*, Brisbane, Australia, 07 to end of 08 Feb 2024.

61. M. Antico, K. Moafa, J. Dowling, D. Canty, D. Fontanarosa, "Automated lung ultrasound diagnosis of interstitial lung disease using a state-of-the-art transformer for video classification", *ILUS 2023 (International Lung Ultrasound Symposium)*, Trento, 10 to end of 12 Jul 2023.

62. M. Antico, K. Moafa, C. Edwards, J. Dowling, D. Canty, M. Steffens, D. Fontanarosa, "Innovative AI techniques to aid clinical diagnosis of complex lung pathologies in ultrasound images (Invited Presentation)", *Acoustics 2023 Sydney*, Sydney, 04 to end of 08 Dec 2023.

63. M. Cordell, "Everything Everywhere all in ECL (Comparing ECL across time and space)", *SNOMED CT Expo*, Atlanta, USA, 26 to end of 27 Oct 2023.

64. M. Braunstein, B. Barry, J. Steel, D. Ukovich, J. Grimes, D. Conlan, S. Jones, D. Hansen, "CBL on FHIR: A FHIR-based Platform for Health Professional Education", *MEDINFO2023*, Sydney, 08 to end of 12 Jul 2023.

65. A. Nicolson, J. Dowling, B. Koopman, "e-health CSIRO at RadSum23: Adapting a chest X-ray report generator to multimodal radiology report summarisation", *BioNLP Workshop at ACL '23*, Toronto, Canada, 09 to end of 14 Jul 2023.

66. A. Nicolson, J. Dowling, B. Koopman, "A Concise Model for Medical Image Captioning", *CLEF 2023*, Thessaloniki, Greece, 18 to end of 21 Sep 2023.

67. H. Ngo, D. Truran, W. Hardman, M. Banks, R. Davidson, N. Widita Ayuningtyas, A. Johnson, T. Pollard, "SNOMED CT Entity Linking Challenge", *SNOMED EXPO 2023*, Atlanta, Georgia, USA, 21 to end of 25 Oct 2023.

68. L. Bell, M. Murphy, T. Wozniak, "One Health collaboration to combat antimicrobial resistance (AMR)", *Australian Public Health Conference*, Hobart, Australia, 26 to end of 28 Sep 2023.

69. P. Ramarao-Milne, D. Bauer, "Bioinformatics Students Exchange Program (BSEP)", *German–Australian Science and Innovation Day 2023*, UQ Customs House, Brisbane, 10 Oct 2023.

70. P. Ramarao-Milne, "CSIRO Infectious Diseases Workshop", *CSIRO Infectious Diseases Workshop*, MGVI, Putrajaya, 20 to end of 22 Feb 2024.

71. T. Wozniak, "Uncovering antimicrobial resistance surveillance blind spots in northern Australia", *Public Health Association of Australia*, Hobart, Tasmani, 25 to end of 28 Sep 2023.

72. T. Wozniak, B. Morgan, A. Bowskill, K. Lapham, "Curbing AMR: beyond the medicines (panel)", *Ausbiotech '23 – Advancing Biotech: It's in our DNA*, Brisbane, 01 to end of 03 Nov 2023.

73. T. Wozniak, A. Shausan, M. Cespedes, "Using routine surveillance data to inform spatial risk mapping for an effective public health response", *ESCMID Global (formerly known as ECCMID)*, Barcelona, Spain, 27 to end of 30 Apr 2024.

74. T. Wozniak, M. Murphy, T. Ewin, "Using disease surveillance skills to collect, understand and use resistance data", *NACCHO Antimicrobial Stewardship Academy*, Online, 05 to end of 05 Jun 2024.

75. M. Murphy, T. Wozniak, "HOTspots surveillance and response program.", *SAAFE CRC Solutuons Summit*, Adelaide, 18 to end of 19 Sep 2023.

76. H. Ngo, "Building Semantic Search for Clinical Terminology", *MEDInfo23*, International Convention Centre (ICC) in Sydney, Australia, 07 to end of 12 Jul 2023.

77. H. Ngo, "Deep Learning based Automation of AMT Modelling", *MEDInfo23*, International Convention Centre (ICC) in Sydney, Australia, 07 to end of 12 Jul 2023.

78. H. Ngo, B. Koopman, M. Lawley, "OntoGPT: a Natural Language Interface for SNOMED CT via a FHIR Terminology Server", *SNOMED CT Expo 2023*, Atlanta USA + Virtual, 26 to end of 27 Oct 2023.

79. M. Harris, E. Martin, M. Kemp, A. Metke-Jimenez, J. Grimes, R. Rius, E. Madelli, S. Casuaria, M. Brion, C. Sue, D. Coman, K. Joy, B. Maina, S. Sallevelt, R. Ghaoui, P. Lamont, C. Bursle, A. Samarasinghe, MitoMDT Diagnostic Network for Genomics and Omics, J. Christodoulou, D. Thorburn, "Genomic diagnostic yield in cohorts of patients with mitochondrial disease: optimising inclusion criteria based on HPO terminology", *XXIII International Congress of Genetics and Genomics*, Melbourne, 16 to end of 21 Jul 2023.

80. M. Antico, A. Gillman, G. Belous, L. Lebrat, L. Petersson, B. Schmutz, J. Mejan-Fripp, J. Dowling, D. Fontanarosa, "Real-time 3-D reconstruction from multiple simultaneous ultrasound scans for enhanced imaging (Invited Presentation)", A*coustics 2023 Sydney*, Sydney, 04 to end of 08 Dec 2023.

81. 81. W. Lu, R. Kumar, M. Sandhu, Q. Zhang, "An Unobtrusive Fall Detection System Using Ceiling-mounted Ultra-wideband Radar", *The 45th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Sydney, Australia, 24 to end of 27 Jul 2023.

82. Y. Wu, D. Conlan, A. Nguyen, S. Perez, "Leveraging Unlabeled Clinical Data to Boost Performance of Risk Stratification Models for Suspected Acute Coronary Syndrome", *AMIA 2023 Annual Symposium Submission Site*, New Orleans, 11 to end of 15 Nov 2023.

83. J. Liu, D. Capurro, A. Nguyen, K. Verspoor, "Uncovering Variations in Clinical Notes for NLP Modeling", *MEDInfo23*, Sydney, Australia, 08 to end of 12 Jul 2023.

84. J. Grimes, "Querying FHIR and clinical terminology from Python, using Pathling", *NHS-R Community Conference*, Virtual, 10 to end of 10 Oct 2023.

Book Chapters

1. V. Villemagne, B. Lopresti, V. Dore, D. Minhas, A. Gogola, N. Nadkarni, S. Mason, P. Bourgeat, O. Lopez, M. Ikonomovic, A. Cohen, “Traits and Trammels of Tau Tracer Imaging”, in Molecular Imaging of Neurodegenerative Disorders (Springer International Publishing: Cham), August 2023.

2. P. Mayne, D. Bradford, N. Groves, J. McGrath, T. Burne, “Adult Vitamin D Deficiency and Adverse Brain Outcomes”. Feldman and Pike’s vitamin D: volume one: biochemistry, physiology and diagnostics. Edited by Martin Hewison, Roger Bouillon, Edward Giovannucci, David Goltzman, Mark Meyer, and JoEllen Welsh. London, United Kingdom: Elsevier.975-996 Oct 2023.

Client and Internal Reports

1. D. Ireland, “Twelve Months of Spatial Tracking of Tobacco & Vaping Retail using the Google Maps API”, CSIRO Internal Report Number: EP2023-2933, Aug 2023.

2. I. Diouf, J. Boyle, S. Khanna, J. Yoon, V. Riahi, H. Hassanzadeh, “Individual level and contextual factors associated with ED demand in Queensland - A component analysis of the Study on Patient Flow in Queensland’s public hospitals”, CSIRO Internal Report Number: EP2024-0674, Feb 2024.

3. J. Boyle, S. Khanna, H. Hassanzadeh, J. Yoon, I. Diouf, V. Riahi, C. Sullivan, M. Samadbeik, J. Lind, A. Staib, E. Bosley, “Study on Patient Flow in Queensland’s public hospitals - Final Report Prepared for the Emergency Medicine Foundation and Queensland Health’s Healthcare Improvement Unit”, CSIRO Internal Report Number: EP2024-2485, Jun 2024.

4. K. Gibson, K. Ebrill, K. Loi, K. Freeman, N. Stekelenburg, “Data standards for interoperability - Supporting effective primary health care starting with health checks for Aboriginal and Torres Strait Islander people”, CSIRO Internal Report Number: EP2023-2703, Jul 2023.

5. R. Reguant Comellas, M. Burgess, Y. Jain, D. Bauer, “Synthetic data for quality control in genomic pathology”, CSIRO Internal Report Number: EP2023-4348, Sep 2023.

6. T. Wozniak, “HOTspots Surveillance Report - revised. January 2022-December 2022. (Version 1.4)”, CSIRO Internal Report Number: EP2023-5829, Nov 2023.

7. L. Higgins, M. Varnfield, D. Ireland, D. Silvera, A. Delaforce, N. Good, R. Jayasena, P. Taylor, S. Farnworth, N. Stekelenburg, J. Fox, K. Forestier, D. Hansen, “The Virtual Care APaIR Project: Driving the digital transformation of health”, CSIRO Internal Report Number: EP2024-2970, Jun 2024.

8.

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Kun Huang, Site Visitor December 2019 - current

Dr Linda Bird, Visiting Scientist March 2021 - Current

Lynden Roberts, Visiting Scientist 2023 to current

Dr Suzanne Scott, Visiting Scientist January 2023 - Current

Mayur Divate, Visiting Scientist 2023 to current

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Finance Manager - Allan Caldwell from May 2024 to current

Finance Support - Bronwen Brotton

HSE Support - Megan Tilley

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ACCOUNTANTS. AUDITORS. ADVISORS.

INDEPENDENT AUDITOR'S REPORT

TO THE DIRECTORS OF THE AUSTRALIAN E-HEALTH RESEARCH CENTRE

Report on the Audit of the Financial Report

Opinion

We have audited the accompanying special purpose financial report of The Australian E-Health Research Centre ("the unincorporated joint venture"), which comprises the statement of financial position as at 30 June 2024, and the statement of comprehensive income, statement of changes in joint venture funds and statement of cash flows for the year then ended, notes comprising a summary of significant accounting policies, other explanatory information and the directors' declaration.

In our opinion, the accompanying financial report presents fairly, in all material respects, the financial position of the unincorporated joint venture as at 30 June 2024 and its financial performance and its cash flows for the year then ended in accordance with the accounting policies described in Note 1 to the financial statements.

Basis for Opinion

We conducted our audit in accordance with Australian Auditing Standards. Our responsibilities under those standards are further described in the *Auditor's Responsibilities for the Audit of the Financial Report* section of our report. We are independent of the unincorporated joint venture in accordance with the ethical requirements of the Accounting Professional and Ethical Standards Board's APES 110: *Code of Ethics for Professional Accountants* (the Code) that are relevant to our audit of the financial report in Australia. We have also fulfilled our other ethical responsibilities in accordance with the Code.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Emphasis of Matter – Basis of Accounting

We draw attention to Note 1 to the financial statements which describes the basis of accounting. The financial report has been prepared to assist The Australian E-Health Research Centre to meet the requirements of the Joint Venture Agreement with Commonwealth Scientific and Industrial Research Organisation and the State Government of Queensland. As a result the financial report may not be suitable for another purpose. Our opinion is not modified in respect of this matter.

Responsibilities of the Directors' for the Financial Report

The directors of the unincorporated joint venture are responsible for the preparation and fair presentation of the financial report in accordance with the joint venture agreement and the accounting policies described in Note 1 to the financial report. The directors are also responsible for such internal control as they determine is necessary to enable the preparation and fair presentation of the financial report that is free from material misstatement, whether due to fraud or error.

In preparing the financial report, the directors are responsible for assessing the unincorporated joint venture's ability to continue as a going concern, disclosing, as applicable, matters relating to going concern and using the going concern basis of accounting unless the directors either intends to liquidate the unincorporated joint venture or to cease operations, or has no realistic alternative but to do so.

Auditor's Responsibilities for the Audit of the Financial Report

Our objectives are to obtain reasonable assurance about whether the financial report as a whole is free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with the Australian Auditing Standards will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of this financial report.

As part of an audit in accordance with Australian Auditing Standards, we exercise professional judgement and maintain professional scepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial report, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

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- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the unincorporated joint venture's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the unincorporated joint venture.
- Conclude on the appropriateness of the unincorporated joint venture's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the association's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial report or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the association to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the financial report, including the disclosures, and whether the financial report represents the underlying transactions and events in a manner that achieves fair presentation.

We communicate with the directors regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

CAAA

CAAA TR

Peter Bray

Peter Bray
Director

Chatswood

Dated: 23 September 2024

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