Australian Government
Office of the Chief Scientist

Quantum Meets Health Workshop Summary

A workshop led by Australia's Chief Scientist in partnership with the CSIRO and AusBiotech

In partnership with:

CSIRO AusBiotech QUBIC tafe Queensland Queensland Government

Acknowledgement of Country

The Office of the Chief Scientist acknowledges the traditional owners of the country throughout Australia and their continuing connection to land, sea and community. We pay our respect to them and their cultures and to their elders past and present.

Artwork: Connection to Country, 2021 by Shaenice Allan

Meeting Place icon by DISR employee Amy Huggins

Disclaimer

The purpose of this publication is to summarise the events and outcomes of the Quantum Meets Health event which occurred in Brisbane on 5 September 2024.

The Commonwealth as represented by the Department of Industry, Science and Resources has exercised due care and skill in the preparation and compilation of the information in this publication.

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Microsoft Co-Pilot was used in developing this summary.

Workshop Overview

Quantum Meets Health was an in-person workshop led by Australia's Chief Scientist and presented in partnership with the CSIRO, AusBiotech, the Queensland Government, TAFE Queensland and QUBIC. It was held at the TAFE Queensland South Bank Campus in Brisbane on 5 September 2024. Approximately 90 people attended, including representatives from the health sector, quantum businesses, universities, and government. This event was part of a broader initiative to realise the ambition embodied in Australia's National Quantum Strategy.[1]

Scene setting

Dr Cathy Foley kicked off the workshop outlining the broad applications quantum technologies offer many industry sectors including health. She identified several potential applications of quantum technologies in the health sector such as drug development, diagnostics by sensing and imaging and understanding biological processes. She also noted the very high level of global investment in quantum, commenting that pharmaceuticals were one of four industries that stand to reap the greatest short-term benefits from quantum technology.

Dr Foley went on to summarise the developments being undertaken to create a prosperous and effective quantum industry in Australia including sensors, communications, cyber security and quantum computing. She described the different types of quantum computing capabilities available now and under development, noting that all industry sectors needed to prepare to be post-quantum ready. Dr Foley concluded by encouraging all attendees to initiate collaborations across the health and quantum industries and to identify projects that could uplift the health sector.

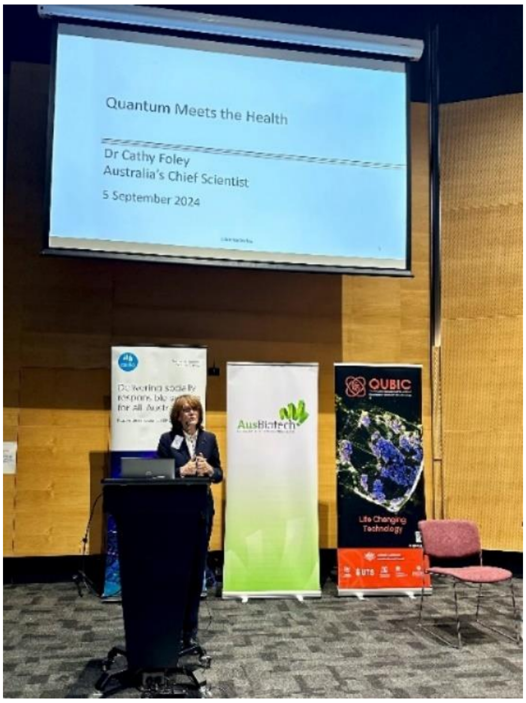

Image 1. Dr Cathy Foley presenting at Quantum Meets Health

[1] https://www.industry.gov.au/publications/national-quantum-strategy

In his scene setting speech Dr Michael Kidd AO discussed the various challenges facing healthcare, including equity, primary care, hospital care, digital health, health workforce, climate change, aging and population growth, and emergency planning. He suggested medical care needed to shift from reactive healthcare to predictive healthcare that is more personalised as a result of the genomics revolution. Dr Kidd described how the promise of quantum technology could enable genuinely personalised medicine, improvements in diagnostics and treatments, and accelerate the development of novel therapeutics. Additionally, he proposed the algorithmic processing power of quantum computers could enable digital twins; a detailed simulation of a person upon which treatment effects could be tested digitally. This could reduce the need for clinical trials. Dr Kidd finished his talk by highlighting the safety and ethical considerations that must be considered when developing new technological solutions, such as data protection around individual's genetic sequences.

Image 2. Dr Michael Kidd presenting at Quantum Meets Health

Areas of industry impact

Logistics

Quantum computers have immense capability for solving optimisation problems, a particular type of mathematical problem, much more efficiently than classical computers. This could lead to more efficient schedules and systems, leading to better healthcare.

Drug Development

Quantum computers are very good at simulating chemical interactions and could significantly improve our understanding of how molecules interact. This could lead to better drug design and understanding of diseases like dementia that arise from protein misfolding. Quantum microscopes could also measure the effects of drugs and vaccines within cells, while quantum computing could optimise clinical trial processes.

Personalised Medicine

Quantum microscopes could be used for cellular assays in stem cell therapy and assessing antibiotic resistance, providing more precise and individualised treatment options. Quantum computers could also create a ‘digital twin’, simulating the impact of treatment on an entire body, its genetic components and predispositions and environmental factors.

Diagnostic Tools

Quantum sensors can enhance the sensitivity and specificity for measuring substances that are present in very small amounts within a sample. This could be useful for creating smaller and more mobile forms of diagnostic tools like portable magnetic brain, heart and muscle imaging. It could also lead to ‘lab-on-a-chip tools’ that measure blood iron levels, or that can detect protein biomarkers of disease long before symptoms appear.

Secure Data

Quantum communications can ensure the secure transmission of sensitive patient data, enhancing data privacy and security in healthcare.

Program schedule:

Setting the scene

- Dr Cathy Foley, Australia's Chief Scientist
- Professor Michael Kidd AO, Foundation Director of the International Centre for Future Health Systems at the University of New South Wales

Keynote 1 – Critical challenges for the health sector

- Dr Elizabeth Deveny, CEO of the Consumers Health Forum of Australia
- Dr Samarra Toby, Founder, CEO of Innovation, Science, Space Medicine and Artificial Intelligence at the Native Academy of Space, Science and Innovation

Keynote 2 – Meeting the challenge with quantum technologies

- Professor Warwick Bowen, Director of the Australian Research Council Centre of Excellence in Quantum Biotechnology (QUBIC)
- Dr Dean Moss, CEO of UniQuest

Panel 1 – Future proofing: expediting drug discovery, validation and distribution

Chair: Professor Branwen Morgan, AMR Mission Lead at the CSIRO

- Associate Professor Giuseppe Barca, Associate Professor at the University of Melbourne; Co-Founder and Head of Research at QDX Technologies
- Associate Professor Erik Streed, Deputy Director at the Centre for Quantum Dynamics, Griffith University
- Professor David Thomas, Director at the Centre for Molecular Oncology, UNSW; Chief Science and Strategy Officer at OMICO
- Dr Megan Baldwin, Chief Innovation Officer and Executive Director of Opthea

Panel 2 – Supporting better diagnosis, treatment and monitoring of disease

Chair: Professor Lezanne Ooi, Professor and Head of the Neurodevelopment and Neurodegeneration Lab at the University of Wollongong

- Dr Liam Hall, Principal Research Scientist, Science Leader and Team Leader in Quantum Biotechnology at the CSIRO
- Professor Halina Rubinsztein-Dunlop, Professor in the School of Mathematics and Physics at the University of Queensland
- Professor Mark Kendall, CEO and Founder of WearOptimo
- Dr Simon Puttick, Chief Scientific Officer at AdvanCell

Panel 3 – Quantum optimisation of health delivery problems, from supply chains to clinical trials

Chair: Professor Jeffrey Braithwaite, Professor, Health Systems Research, Macquarie University; Founding Director of the Australian Institute of Health Innovation, and Director of the Centre for Healthcare Resilience and Implementation Science

- Professor Tom Stace, Co-founder and CEO of Analog Quantum Circuits
- Dr Dylan Saunders, Director of Quantum Systems Engineering at PsiQuantum
- Dr Scott McNeil, MBA, Interim Managing Director of the Translational Science Hub at Sanofi
- Dr David Lloyd, Managing Director at Southern Star Research

Panel 4 – Health data in a quantum/AI world, opportunities and threats

Chair: Dr Allison Fish, Senior Lecturer, Senior Research Fellow and Director of Research of the Centre for Policy Futures at the University of Queensland.

- Dr Riddhi Gupta, Senior Research Fellow at the Queensland Digital Health Centre
- Associate Professor Sally Shrapnel, Deputy Director at the ARC Centre of Excellence for Engineered Quantum Systems
- Dr Elizabeth Deveny, CEO of the Consumers Health Forum of Australia
- Dr David Hansen, CEO of the Australian e-Health Research Centre

Breakout sessions

- Five breakout sessions focused on exploring specific issues for the health sector that could be solved by quantum technologies.

Overview of government funding opportunities

- Ms Lizz Affleck, Assistant Manager, Quantum Branch, Department of Industry, Science and Resources

Next steps and closing statement

- Dr Cathy Foley, Australia's Chief Scientist

Keynotes

Challenges and opportunities

Dr Elizabeth Deveney, CEO of Consumers Health Forum of Australia, used her keynote to outline issues facing consumers such as affordability of, and access to healthcare. Quantum technology has the potential to help with prevention and reduce access issues. While there are many potential opportunities, it is important to ensure quantum technology benefits all Australians and is used safely. Developers of the technology would need to engage with end users to ensure the technology is equitable and beneficial for all. Australians want technology that makes a real difference, not just something that is "cool”.

Dr Samarra Toby focused on the integration of First Nations science and Western medicine in her keynote presentation. There are potential impacts of quantum technology on First Nations health and the importance of precision medicine; considering the genetics, environment and lifestyle of a person in their treatment. It is also important to combine ancient wisdom with modern technology to improve health outcomes for Indigenous communities. Development of quantum technology must consider its safe usage and data sovereignty. To conclude, Dr Toby discussed the significance of getting Indigenous and First Nations youth into careers in STEM and quantum science to create a robust and inclusive technology ecosystem.

Meeting the challenges with quantum

Professor Warwick Bowen, Director of QUBIC, explored the opportunities available to the health sector from quantum computing, quantum sensing, and quantum imaging technologies. Many existing medical devices and treatments already leverage quantum principles to enhance their functionality and sensitivity. For example, Magnetic Resonance Imaging (MRI) machines use the principles of nuclear magnetic resonance, which is a quantum phenomenon. Future applications of quantum technology could revolutionise healthcare, potentially discovering new drugs, improving understanding of dementia, and providing personalised medicine. Amidst this potential however, it will also be important to consider how the anticipated ability of quantum computers to break current cybersecurity encryption could affect secure communications for patient data.

Dr Dean Moss, CEO of UniQuest, addressed the challenges of taking quantum technology to market, including access to patient capital and the need for long-term investment. It is important to advocate for quality science and funding at scale. There is also a need for infrastructure improvements and government support to ensure the successful commercialisation of quantum technology. Facilitating cross-fertilisation of ideas will further enhance the potential impact of quantum technology on healthcare.

Image 3. Dr Elizabeth Deveney speaking at Quantum Meets Health

Image 4. Dr Samarra Toby speaking at Quantum Meets Health

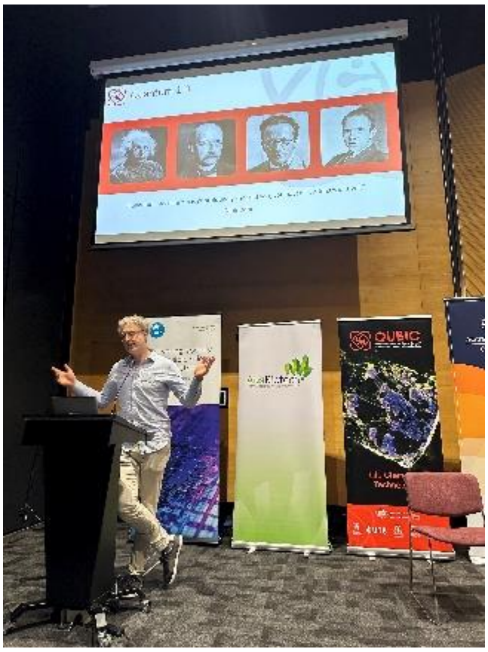

Image 5. Professor Warwick Bowen speaking at Quantum Meets Health

Image 6. Dr Dean Moss speaking at Quantum Meets Health

Panel composition and discussions

Panel 1 – Future proofing: expediting drug discovery, validation and distribution

Chair: Professor Branwen Morgan, Minimising AMR (anti-microbial resistance) Mission Lead at the CSIRO.

- Associate Professor Giuseppe Barca, Associate Professor at the University of Melbourne; Co-Founder and Head of Research at QDX Technologies.
- Dr Erik Streed, Deputy Director of the Centre for Quantum Dynamics at Griffith University.
- Professor David Thomas, Director of the Centre for Molecular Oncology at University of New South Wales; Chief Science and Strategy Officer at OMICO.
- Dr Megan Baldwin, Chief Innovation Officer and Executive Director of Opthea.

The integration of quantum chemistry and computing could improve drug development and delivery. Quantum computers could be used to explore chemical interactions at a molecular level, helping to further understanding of how drugs interact with the body at a molecular level. This could make it easier to develop new drugs and getting new drug products into commercial use faster. Not only could this accelerate the drug discovery processes, it could also enable drug development that considers genetic and lifestyle factors, providing medical treatment precisely tailored to the individual. Individualised or precision medicine is just one example of the commercial opportunities and societal impact quantum technology could have in the health sector. To achieve this, it is important researchers engage in cross-disciplinary collaboration and that there are infrastructure improvements that capitalise on the potential benefits offered by quantum technologies.

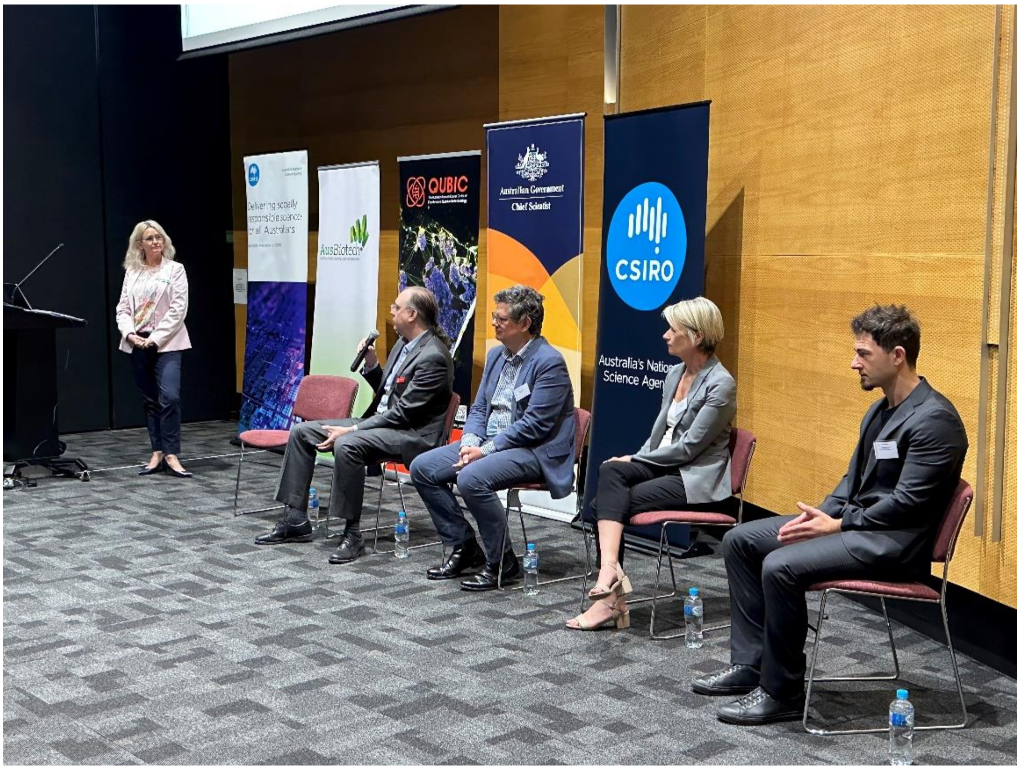

Image 7. Panel 1

Panel 2 – Supporting better diagnosis, treatment and monitoring of disease

Chair: Professor Lezanne Ooi, Professor and Head of the Neurodevelopment and Neurodegeneration Lab at the University of Wollongong.

- Dr Liam Hall, Principal Research Scientist, Science Leader and Team Leader in Quantum Biotechnology at the CSIRO.
- Professor Halina Rubinsztein-Dunlop, Professor in the School of Mathematics and Physics at the University of Queensland.
- Professor Mark Kendall, CEO and Founder of WearOptimo.
- Dr Simon Puttick, Chief Scientific Officer at AdvanCell.

Quantum technology has much potential for early diagnosis and treatment of diseases, particularly quantum sensing and imaging. For example, quantum sensors could detect biomarkers present in very low amounts in samples. This could provide early diagnosis of diseases or track small changes in a body over time. The ability to perform such measurements with smaller pieces of equipment opens opportunities for broader access, such as wearable devices, or portable devices that can be taken to remote communities. However, translating research from the lab into commercial products is challenging. Companies need better access to patient capital for funding, as well as the right skills and knowledge to be competitive. Researchers need to make their technology relevant and useful for clinicians to develop practical fundings. It is also important to encourage understanding across the fields of quantum technology and healthcare, training both emerging scientists and healthcare professionals to work with quantum technology.

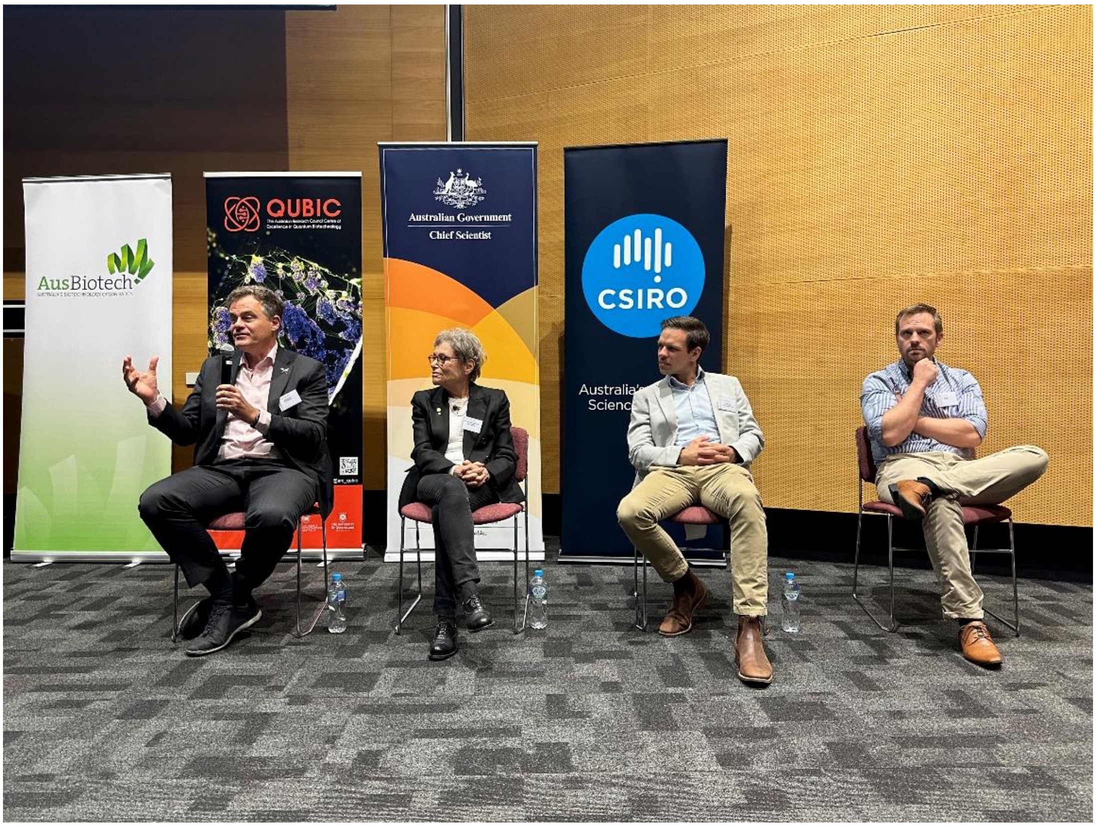

Image 8. Panel 2

Panel 3 – Quantum optimisation of health delivery problems from supply chains to clinical trials

Chair: Professor Jeffrey Braithwaite, Professor in Health Systems Research at Macquarie University; Founding Director of the Australian Institute of Health Innovation, and Director of the Centre for Healthcare Resilience and Implementation Science.

- Professor Tom Stace, Co-founder and CEO of Analog Quantum Circuits.
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- Dr Scott McNeil, MBA, Interim Managing Director of Translational Science Hub at Sanofi.
- Dr David Lloyd, Managing Director at Southern Star Research.
- Professor Branwen Morgan, Minimising AMR Mission Lead at the CSIRO.

Quantum computers are expected to bring several advantages to healthcare, especially for applications in supply chain management and clinical trials. The significant computing capability of quantum computers gives them an advantage over classical computers in analysing large data sets with high numbers of variables. This could enhance the processing and analysing of the vast amounts of data generated during clinical trials. Quantum computers are also anticipated to be particularly good at solving optimisation types of mathematical problems, which could speed up implementation of clinical trials and improve healthcare delivery. Quantum computers may also be able to help with meeting regulatory requirements by providing more efficient programming and data management solutions. Ultimately, to realise these potential applications more collaboration is needed between researchers, healthcare professionals, and policymakers, to ensure the successful implementation of quantum technology in healthcare.

Image 9. Panel 3

Panel 4 – Health data in a quantum/AI world, opportunities and threats

Chair: Dr Allison Fish, Senior Lecturer in Law at the University of Queensland; Senior Research Fellow and Director of Research in the Centre for Policy Futures at the University of Queensland.

- Dr Riddhi Gupta, Senior Research Fellow at the Queensland Digital Health Centre.
- Associate Professor Sally Shrapnel, Deputy Director at the ARC Centre of Excellence for Engineered Quantum Systems.
- Dr Elizabeth Deveny, CEO of the Consumers Health Forum of Australia.
- Dr David Hansen, CEO of the Australian e-Health Research Centre.

Artificial intelligence (AI) and quantum technology present both opportunities and threats in health, particularly concerning access, privacy, and security. Combined with AI, quantum computing could make machine learning faster and more energy efficient. This has the potential to improve disease detection and treatment, lowering the cost of treatment and making healthcare more accessible and affordable. For instance, coming up with better ways of detecting diseases like melanoma. However, regulatory frameworks are needed to ensure the safe and equitable use of this technology. Furthermore, educating the public and healthcare professionals about these technologies is crucial for people to engage effectively. Quantum enhanced machine learning is an emerging field, and there is already currently a lack of digital health professionals to handle genomics and AI as it stands. To this end, it is important healthcare professionals are educated about quantum technologies, and that learning materials are made accessible in multiple languages.

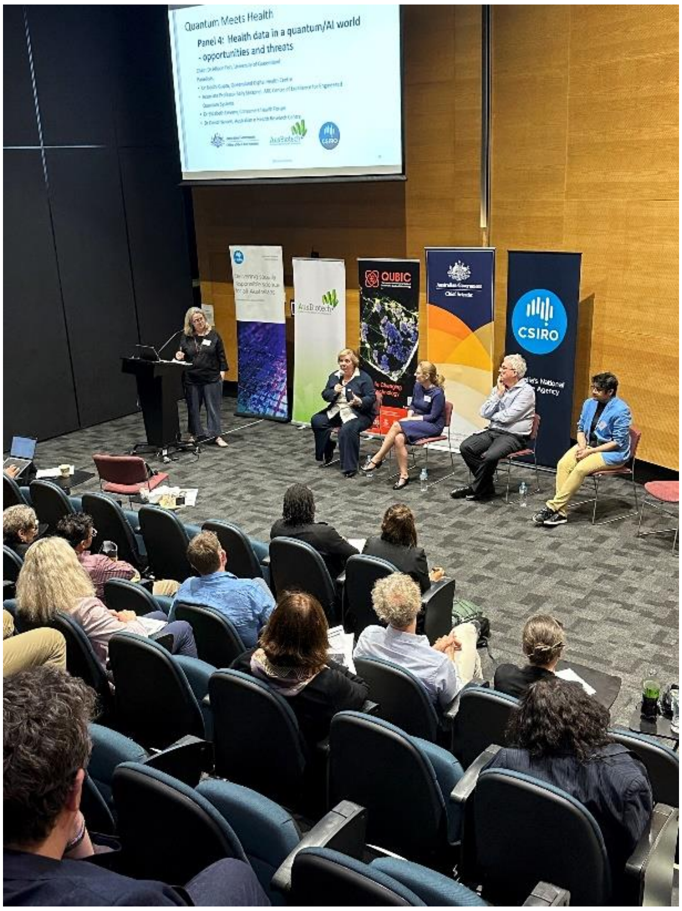

Image 10. Panel 4

Breakout sessions

During smaller group discussions, attendees explored new ideas, including:

Breakout 1: Closing the gap – harnessing quantum. This breakout explored how quantum technology could be used to address the significant gap in health outcomes for First Nations Australians. Some approaches discussed include improving health information systems, automating identification of abnormal results, and streamlining efficiencies for health systems.

Breakout 2: Access and affordability. This breakout discussed equitable access to health services, products, and medications. It explored how quantum technology could help by making sensing equipment smaller, using quantum machine learning for automated telehealth, and analysing multivariate data dependencies.

Breakout 3: Accelerating drug design. This breakout considered ways quantum technology could reduce the high cost and time required for drug development. Using quantum computers for chemistry simulation was proposed to speed up the development process, reduce harm to animals, and unlock opportunities for new drug discoveries.

Breakout 4: Responsible Innovation. This breakout addressed ethical and privacy concerns around the more powerful sensing capability and data analysis of quantum technologies. However, quantum communications were also noted as a solution that could help ease ethical and privacy concerns by providing secure data protected by quantum algorithms.

Breakout 5: Diagnostics and Biomarkers. This breakout focused on the early detection of biomarkers across many diseases. Quantum technology could help identify biomarkers from a single drop of blood.

Some common challenges raised across all breakout groups included:

- Legislation and guidance: Clarifying guidance for the use of patient data and cybersecurity rules.
- Quantum literacy: Improving quantum literacy among healthcare professionals and the public.
- Optimised solutions: Determining when quantum computing would be worthwhile and how to prepare reliable, affordable de-identified data that can be input into quantum computers.

The interest and discussions on these topics are the foundation of the case studies in the appendix. These case studies show the opportunities to understand and capture market value by leveraging existing national strengths, infrastructure, and expertise.

Next steps and closing

Dr Foley closed off the workshop with a high-level summary of the day. Dr Foley reiterated Michael Kidd's comments that the role of health care is "do no harm". She reminded the participants quantum sensing and imaging are technologies accessible now. The opportunities afforded by quantum computing are developing rapidly and drug development will be one of the first applications. She indicated equitable access to quantum computing will be essential. It is expected that quantum computing will have major impacts on health care from hospital logistics to management and security of data. She emphasised the importance of taking patient-centric approaches where affordability and equitable access, regardless of location and socioeconomic status, were critical. She indicated these issues were aligned closely with the recently released National Science and Research Priorities. She finished by saying there is the balance of risk and benefit needed to use quantum technologies to address the challenges identified for health care in Australia, and the quantum community were keen to connect with the health community to affect change and build opportunities.

Image 11. From left to right: Robyn Linder, General Manager at AusBiotech; Cathy Foley, Australia's Chief Scientist; Rosanne Hyland, Deputy CEO of AusBiotech; Megan Baldwin, Director at AusBiotech and Chief Innovation Officer at Opthea

Appendix: Case studies

Case study 1: Accelerating drug design

Big picture problem

The high cost and time required for drug development is a huge barrier to developing novel therapeutic treatments. Successful development of a drug to market can require a decade of work and significant financial investment.

Breaking the problem down

The drug development process involves multiple stages including discovery and development: pre-clinical research to test drug safety, clinical trials to test drug safety and efficacy in humans, regulatory review and post market monitoring.

At each stage, multiple drug candidates may be tested with a potentially high degree of uncertainty of progressing through to the next stage. Ways to speed up this process, such as more accurate identification of initial drug candidates or more efficient trials, could significantly reduce timeframes and costs for delivery. Having more targeted approaches could increase the likelihood of successful drug development.

How could quantum technology help?

Quantum sensors and quantum computer simulations are the two main ways quantum technology could enhance the drug development process.

Quantum sensing can provide better molecular imaging technologies and bioassays, allowing for more accurate monitoring and understanding of drug interactions in cells.

Quantum computers are anticipated to be much better simulators of molecular interactions than classical computers, as these are essentially quantum interactions. Quantum simulations are expected to be better at handling the complexity and individuality of humans and drug interactions.

Although quantum computing currently has significant limitations for real-world applications, recent test cases have shown it has potential to accelerate drug discovery and development through better prediction and calculation capabilities. It is anticipated quantum computers may be able to manage more complex optimisation problems found in biomedical data sets than classical computing, which could make clinical trials more efficient.

Next steps

- Continue to improve molecular imaging technologies and develop better bioassays.
- Make quantum computing accessible to healthcare professionals involved in drug discovery to encourage development of quantum algorithms for drug discovery.

Case study 2: Diagnostics and Biomarkers

Big picture problem

Biomarkers can be used to diagnose diseases such as cancer at early stages using non-invasive techniques before other symptoms/indications arise. However, biomarkers are often present in extremely low concentrations and difficult to definitively detect with current technologies – especially as biological structures/fluids contain multitudes of potentially interfering or confounding substances.

Breaking the problem down

Challenges include:

- Identifying low levels of biomarkers in the biological samples (such as blood, urine, cerebrospinal fluid) dynamically
- Identifying and understanding how genes interact in an individual
- Analysing the vast amount of data and processing molecular fingerprints.

How could quantum technology help?

Quantum sensors can detect physical field changes with more sensitivity and specificity, providing more accurate and earlier detection of disease biomarkers. For example, improved sensitivities could enable biomarker testing from single drops of blood.

An example application of this could be early detection of cerebrospinal fluid or blood biomarkers that would identify people at risk of, or in the early stages of, developing dementia or Alzheimer's disease. Mental health is another area where quantum technology could help by dynamically detecting serotonin levels, providing insights that could support more targeted treatment for people experiencing physical and psychological health problems due to fluctuating serotonin levels.

Quantum computing could also provide the analytical power needed for analysing complex genetic traits and processing vast amounts of data. Developing algorithms that are approved, rapid, and safe could help predict outcomes, such as the chances of a live birth in in-vitro fertilisation (IVF).

Next steps

Further research and development in quantum sensing and molecular imaging technologies are necessary to fully realise the potential of quantum technology in diagnostics and biomarkers. This includes:

- Aligning detection methods with known biomarkers when there is a need for increased sensitivity and specificity of detection.

Case study 3: Equitable access to healthcare

Big picture problem

The Australian population does not have equitable access to health services, products, medications, and diagnostics. If this problem isn't solved, future benefits of quantum technology in healthcare will not be equitably shared.

Breaking the problem down

Equitable access to health services is affected by socioeconomic and demographic factors such as gender, age, cultural and linguistic diversity, as well as by geographic location and the inconsistency of health systems across jurisdictions and states.

Some population groups such as First Nations Australians have further challenges to equitable access to healthcare such as health literacy and cultural safety.

As technology advances there is an increasing digital divide, and digital literacy is now another factor that affects healthcare access. Technology is often moving faster than regulation can keep up and this also brings in ethical and privacy concerns around data usage and security.

How could quantum technology help?

Quantum technology could improve health information systems, automate and assist in the identification of abnormal results, and streamline workflows for health systems to free up clinic time. The use of de-identified data to train learning algorithms could also be beneficial.

Making sensing equipment smaller, enabling better modelling for decision-making (such as determining the location of pharmacies), and providing quantum machine learning for automated telehealth and triage systems in the future are other potential benefits. Quantum computing is also anticipated to be particularly good at analysing multivariate data dependencies: how different factors are connected and influence each other. This could be used to help analyse how genetic, environmental and lifestyle factors contribute to a disease.

Quantum communications may be able to help ease ethical and privacy concerns by providing secure data protected by quantum algorithms.

Next steps

Several steps around obtaining, handling and storing data are proposed:

- Obtaining inclusive data for algorithm development that represents the diversity of the population, for instance it is important to ensure First Nations data profiles are used.
- Protecting and securing data through developing post-quantum cryptography.
- Preparing and collecting reliable and affordable de-identified data, such as MRI data to train machine learning models, is essential.
- Clarifying guidance for the use of patient data and cybersecurity rules is also necessary.
- Addressing data sovereignty issues is crucial, especially when data leaves Australian shores.
- Improving quantum literacy among healthcare professionals and the public.
- Finally, investment in quantum technology should be accompanied by subsidised public access to ensure equity.