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Economic value of the health and medical research sector in Western Australia

Association of Australian Medical Research Institutes – WA Chapter

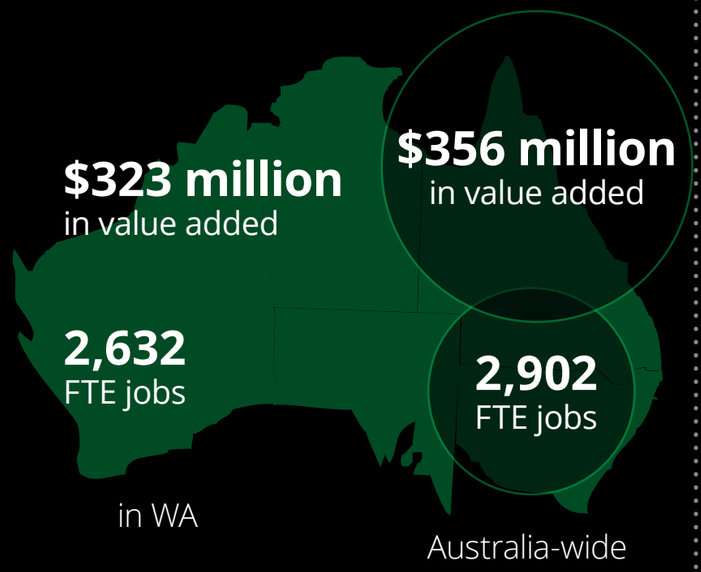
December 2023

Deloitte Access Economics

The WA medical research sector delivers substantial economic value for WA and Australia – and the world

WA medical research contributes meaningfully to the WA economy

In 2021, the WA medical research sector contributed...



WA health and medical innovations have had global impact

Some examples include...

- Spray-on skin
- Helicobacter pylori discovery
- Folate research
- Treating coronary disease
- Treating muscular dystrophy
- Perforated eardrum surgical implant
- Treating pleural disease
- Glaucoma surgical implant

A selection of case study medical research programs are estimated to generate net economic returns[1] of:

$489 million for Australia

$88 billion

for the world

Advances in medical research have increased the size and productivity of the WA and Australian labour force[2]

	To date	Next 20 years
WA	**$884 million/year** in GSP uplift	**950 FTEs/year** on average	**$2.1 billion/year** in GSP uplift	**2,100 FTEs/year** on average
Australia	**$4.5 billion/year** in GSP uplift	**9,000 FTEs/year** on average	**$10 billion/year** in GSP uplift	**18,000 FTEs/year** on average

Every $1 invested in successful WA medical research generates a return of $2.61 for Australia[1] and $7.58 globally[1]

(1) Results are estimated for a selection of case study medical research programs only and are in net present value terms, discounted at 7% (2) Results are estimated for a selection of case study medical research programs only and are in real, undiscounted, average annual terms

A researcher in the lab at Lions Eye Institute. Credit: Lions Eye Institute

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Executive summary

Health and medical research: A strategic priority sector for WA

Western Australia's thriving health and medical research sector is ideally positioned to offer solutions to two of the state's biggest long-term challenges: creating healthier communities and diversifying the economy. The strategic importance of the sector is recognised by the WA Government in its diversification agenda, which identifies health and medical life sciences as one of eight priority industries to attract investment.[1]

The WA Health and Medical Research Strategy, released in 2023, acknowledges the sector's potential for growth, setting a ten-year vision for WA's medical research to increase its international recognition, and for that research to be translated to further improve health outcomes for all.[2]

The timing for developing this potential could not be more urgent. Like economies around the world, WA is facing significant budget pressures from the growing cost of managing chronic disease and an ageing population.[3] At the same time, the increasing focus on environmental, social and governance (ESG) issues[4] is sharpening attention on the need to address social inequalities and drive better health outcomes for remote and disadvantaged communities.

WA's health and medical research sector is ideally placed to seize these opportunities. It has a proven capacity to deliver breakthrough discoveries and innovations that have improved lives on a global scale. This includes Professor Barry Marshall and Emeritus Professor Robin Warren's Nobel-prize winning discovery of the link between the bacterium *Helicobacter pylori* and stomach ulcers, and Professor Fiona Wood's 'spray-on-skin' invention that has revolutionised burns care and treatment around the world.[5]

In addition, there are many other successful WA medical research programs that have not achieved the same profile but have nonetheless generated significant benefits for society. And there are many more programs currently underway that hold great potential to deliver positive health outcomes for generations to come.

The modelling detailed in this report demonstrates the economic benefits that are generated from medical research, highlighting the value to WA from further investment in the sector. These benefits include job-creation, enhanced labour productivity through healthier communities, and a more diversified economy where research activity can help to smooth growth, and hedge against global fluctuations affecting the state's dominant industries such as mining and resources.

Valuing the economic impacts of medical research in WA

Deloitte Access Economics was engaged by the WA Chapter of the Association of Australian Medical Research Institutes (AAMRI WA) to estimate the economic value of the health and medical research sector in WA. AAMRI WA works with its research and innovation colleagues, as well as government, industry, consumers and communities with the aim of realising a vision for a health and medical research sector of international scale and impact.

This study uses three modules of analysis to describe the sector's economic value (see Figure A). Each approach offers a distinct perspective on the value generated by the sector through its activities. Further details on the study methodology are provided in the appendices of this report.

Figure A: Estimating the economic value of the WA health and medical research sector

	Economic contribution of the medical research sector	Economic return on medical research investment	Flow-on economic impacts of medical research
Modelling approach	Input-Output (IO) modelling, using Deloitte Access Economics' in-house IO model.	Cost-benefit analysis of a suite of WA research projects. Australian and global benefits are quantified and compared to the costs of investing in the research.	Computable general equilibrium (CGE) modelling, using Deloitte Access Economics' in-house CGE model.
Summary	This measures the direct and indirect contribution of the medical research sector to the WA economy. This defines the sector's operational footprint in the WA economy, including the supplier relationships and transactions that support the broader health value chain in WA. The analysis demonstrates the role the medical research sector plays in creating jobs and value in the WA economy both through its direct operations, and indirectly for other sectors of the economy.	This estimates the economic return – in terms of gains in health and wellbeing and health system savings – of a selection of research programs led by the WA medical research sector. To determine the net health benefits from medical research, the value of gains in wellbeing are monetised so they can be compared to the cost of producing those gains. The returns are estimated for Australia and globally, recognising that the size of the populations who accrue the benefits of research significantly impacts the magnitude of the return.	This quantifies the flow-on economic impacts from advances in medical research for the WA economy to date (i.e. to 2023) and in the future. This defines the sector's impact in generating economic growth in WA over time, with economic output and total employment higher as a result of the outcomes generated by medical research. The economic impacts reflect the productivity benefits from a larger and healthier workforce.
Results	A quantitative measure of both the direct and indirect economic contribution of the medical research sector to the WA economy, measured in full-time equivalent (FTE) employment and gross value added (GVA) terms.	The net economic benefits attributable to selected medical research programs. Outcomes are measured as net present values (NPV) with a benefit-cost ratio (BCR) for investment in these WA medical research programs.	A quantitative measure of the economic impact from advances in medical research for the WA economy to date and in the future, measured as an increase in FTE employment and Gross State Product (GSP).

A key objective of the analysis is to estimate the economic value of the entire medical research sector in WA, including all organisations involved in undertaking health and medical research activities. The study is wide-ranging and involved participation from 21 medical research organisations based in WA, including medical research institutes and foundations, hospital foundations and universities.

Key findings of the study are as follows:

- **The WA medical research sector plays an important role in creating jobs and value in the WA economy.** In 2021, the WA medical research sector contributed **$322.9 million** in value added and **2,632 FTE** jobs to the WA economy. This includes both a direct and indirect contribution. The sector is a significant employer of highly skilled labour in WA; its direct economic contribution is primarily derived from salaries and wages paid its people. The indirect contribution relates to the sector's spending on intermediate inputs to support its operations. This generates economic activity in other industries in WA with specialised skills, including pathology services, bioanalytical testing, and genomic and proteomic research.

- **The economic return on investment in WA medical research is significant.** A cost-benefit analysis was undertaken for a suite of eight high-impact WA medical research programs. For every dollar invested into these programs, an economic return of **$2.61** is estimated for Australia. But these benefits have extended to populations beyond Australia. Globally (including Australia), every dollar invested into these WA research programs is estimated to generate **$7.58** in benefits. This economic return is primarily driven by gains in health and wellbeing from the translation of the findings of medical research into clinical practice, and from avoided health system costs.
- **Advances in medical research lead to a larger and more productive labour force. This in turn leads to higher economic growth and employment in WA.**

The gains in health and wellbeing attributable to medical research ultimately enable a greater number of individuals to participate in the workforce, and to do so more productively. To date, the selected medical research programs have added an estimated **$884 million** and **950 FTE** jobs to the WA economy each year, on average. This means that the WA economy has been approximately 0.40% larger each year than it would have been due to the health outcomes from the research programs. Future economic impacts are estimated to be even larger as the research programs become more integrated into clinical practice over time. This has a proportionally larger positive impact on health outcomes, growing the scale and productivity of the workforce into the future.

These findings underscore the economic importance of continued financial investment and policy support for medical research in WA.

Creating jobs and value in the WA economy through operations: The economic contribution of the medical research sector

The WA medical research sector plays an important role in creating jobs and value in the WA economy, both through its direct operations and indirectly in other sectors of the economy. Deloitte Access Economics' Regional Input-Output Model (DAE-RIOM) is used to estimate the economic contribution of the WA medical research sector.

Table A shows the contribution of the WA medical research sector to both the WA and Australian economies. In 2021, it is estimated that the total contribution of the WA medical research sector to the Australian economy was approximately $355.7 million in value added terms. In addition, total employment generated by the WA sector (both direct and indirect) summed to 2,902 FTE jobs across Australia.

A significant proportion of the sector's total economic contribution is driven by its contribution to the WA economy. In 2021, the contribution of the sector to the WA economy is estimated at $322.9 million in value added terms, or 91% of the total value added to Australia. Similarly, the sector contributed 2,632 FTE jobs to WA, which accounts for 91% of total jobs contributed to Australia.

This means that an estimated 91% of the value generated from medical research activity in WA is retained within the state. This is the case even though a significant share of medical research expenditure on intermediate goods and services is directed to interstate and overseas suppliers, allowing the sector to access the required technical services and inputs to support its operations (see Appendix A).

Table A: Economic contribution of the WA medical research sector, 2021

Economic contribution	Western Australia	Australia
Value added ($ million)		
Indirect contribution	$39.0	$71.8
Direct contribution	$283.9	$283.9
Total value added	**$322.9**	**$355.7**
Employment (FTE)		
Indirect contribution	313	583
Direct contribution	2,319	2,319
Total employment	**2,632**	**2,902**

Source: Deloitte Access Economics.

The WA medical research sector's direct contribution of $322.9 million in value added terms to the WA economy (see Table A) was predominantly derived from salaries and wages paid to people employed directly by the sector. This reflects the fact that the medical research sector is labour-intensive and consists of highly skilled personnel, where research is often undertaken by qualified medical scientists. The salaries and wages within the sector therefore reflect these highly specialised skills, with total expenditure on labour across the sector estimated at $254.2 million in 2021.

In 2021, there were 2,319 FTE employees in the WA medical research sector. While this figure demonstrates that the sector is a significant employer of highly skilled labour in WA, it only partially describes the human capital aspects of the medical research endeavour. Medical research is a unique industry in which a large contribution is provided by not just employees or hired labour, but also by students, volunteers and other in-kind forms of support that are not easily quantifiable.

The combined volunteer and student labour contributed almost one third of the total labour resources that supported the medical research sector in 2021. Many of these volunteers and students receive training that eventually enables them to become highly skilled and employed workers in the future.

Delivering positive returns for society from gains in health and wellbeing: The economic return on investment in medical research

The modelling presented above considers the economic 'footprint' of the WA medical research sector at a point in time. However, the results do not demonstrate the health benefits created by various clinical applications of medical research in WA. To do this, a return on investment analysis was undertaken in the form of a cost-benefit analysis (CBA).

Over the years, there have been many successful medical research programs led by the WA medical research sector across a variety of research areas. The CBA focuses on eight high-impact case studies of WA research programs that have produced a quantifiable economic return in terms of gains in health and wellbeing and avoided health care costs. The eight case studies were chosen in collaboration with AAMRI WA, with the aim of selecting research programs that demonstrate the significant returns generated by investment in research which leads to translation of findings into changes in policy and clinical practice.

The CBA allows for the quantification of the net health benefits from medical research, by valuing the gains in health and wellbeing and comparing these to the cost of producing those gains. An overall benefit-cost ratio (BCR) is estimated for investment in WA medical research, based on the selected case studies. This reflects the expected dollar for dollar return to society from investment in successful medical research programs.

The economic benefits from advancements in medical research are quantified in the CBA from three main sources, which are described in Figure B.

Figure B: Summary of quantified economic benefits

Reduced mortality

Reduced mortality refers to the benefits derived for society through avoided loss of life. This is quantified in terms of the value of additional life years for people who experience more effective treatment as a result of advances in medical research. This usually results where a disease is cured or entirely prevented.

Reduced burden of disease

Reduced burden of disease refers to the gains in quality of life experienced by patients who receive effective treatment. This is quantified by measuring the deterioration in quality of life caused by the symptoms of disease, and applying a factor that represents the improvement in a patient's condition due to effective treatment.

Avoided costs for the health system

Avoided costs for health systems refer to the costs of treatment or management for patients with a particular condition. Advancements in medical research may reduce the overall cost of delivering treatment, or they may improve health outcomes such that less is spent on managing complications and follow-up care.

Professor Bill Morgan (Lions Eye Institute) with a patient, implanting the Virna Glaucoma Drainage Device. Credit: Lions Eye Institute

Between 1982 and 2056, the case study research programs are estimated to have generated net benefits worth $488.6 million to the Australian population (see Table B). This includes benefits generated in the past and expected in the future. This means that the investment in these programs is expected to yield a BCR of 2.61 for Australia over the period of analysis.

In simple terms, for every $1.00 invested into these research programs, an economic return of $2.61 can be expected to be generated for Australia. This economic return on this investment is largely driven by the gains in health and wellbeing realised by Australians from the translation of the findings of medical research into clinical practice, which leads to the development of new treatment methods and approaches.

Table B: Summary of cost-benefit analysis results, 1982 to 2056 ($ million, present value terms)

Cost-benefit analysis results	Australia	World
Benefits ($ millions)		
Reduced mortality	$539.7	$90,806.1
Reduced morbidity	$165.3	$10,284.7
Avoided costs for the health system	$87.3	$569.7
Total benefits	**$792.3**	**$101,660.4**
Costs ($ million)		
Research costs	$48.2	$89.8
Delivery and implementation costs	$255.5	$13,318.4
Total costs	**$303.7**	**$13,408.2**
Net present value of benefits	**$488.6**	**$88,252.2**
Benefit-cost ratio	**2.61**	**7.58**

Source: Deloitte Access Economics. Note: All values are provided in real, Australian dollars and are in present value terms, discounted at a rate of 7.0%.

The advancements in health care enabled by WA medical research have also extended far beyond Australia. Research findings have led to the adoption of new treatment methods and approaches across the world. Globally (including in Australia), these WA research programs are estimated to generate total net benefits of $88.3 billion between 1982 and 2056. This reflects a BCR of 7.58, or an economic return of $7.58 for every $1.00 invested into the research programs. These improved results owe to the wider, global patient cohort that have – and are expected to – receive the health and wellbeing benefits of improved clinical treatment owing to WA-based research.

These returns are not estimated for WA alone due to the relatively small population in WA, and because new treatment methods and approaches are usually implemented nationally, rather than in individual jurisdictions. The returns estimated only reflect the eight case studies selected (albeit high impact examples). Many other programs of research in WA have also achieved outcomes that have had important positive impacts to health care but are not measured here.

Generating growth in economic output and employment through health outcomes: The flow-on economic impacts of medical research

The CBA outcomes discussed above measure the net economic return from the eight case study research programs in WA through time. The CBA measure of welfare (or the net societal benefits) associated with the research programs measures the extent to which society is better off because of the translation of findings from medical research.

The CGE measure of economic benefit is different to a CBA, as it measures the economic impact of the research programs through time in terms of the changes they cause to various macroeconomic (economy-wide) variables, including Gross State Product (or GSP, a measure of state economic output).

The primary outcomes of medical research are related to gains in health and wellbeing that allow people to live longer and enjoy a better quality of life. In a macroeconomic context, these outcomes enable a larger number of individuals to participate in the workforce, and to do so more productively. This is a valuable economic driver, which helps to improve aggregate economic output.

The flow-on economic impacts of the eight case study WA medical research programs are estimated using Deloitte Access Economics' in-house CGE model. The CGE model measures the extent to which medical research spurs a range of secondary, 'flow-on' impacts to the economy by affecting the size and productivity of the labour force, and in turn, how that has influenced state and national economic growth to date – and into the future.

Economic impacts to date

Based on the CGE modelling, it is estimated that to date (the period 1986 to present, in line with the CBA start date), the WA medical research programs selected for this study have added an average of $884 million (undiscounted terms) to WA Gross State Product (GSP) each year, on average, through their impacts on the WA labour force.

To put this into perspective, WA GSP was worth $377 billion in 2021-22.[6] On average, this means that the WA economy has been approximately 0.40% larger each year than it would have been in the base case, as a result of the outcomes of the research programs considered in this study.

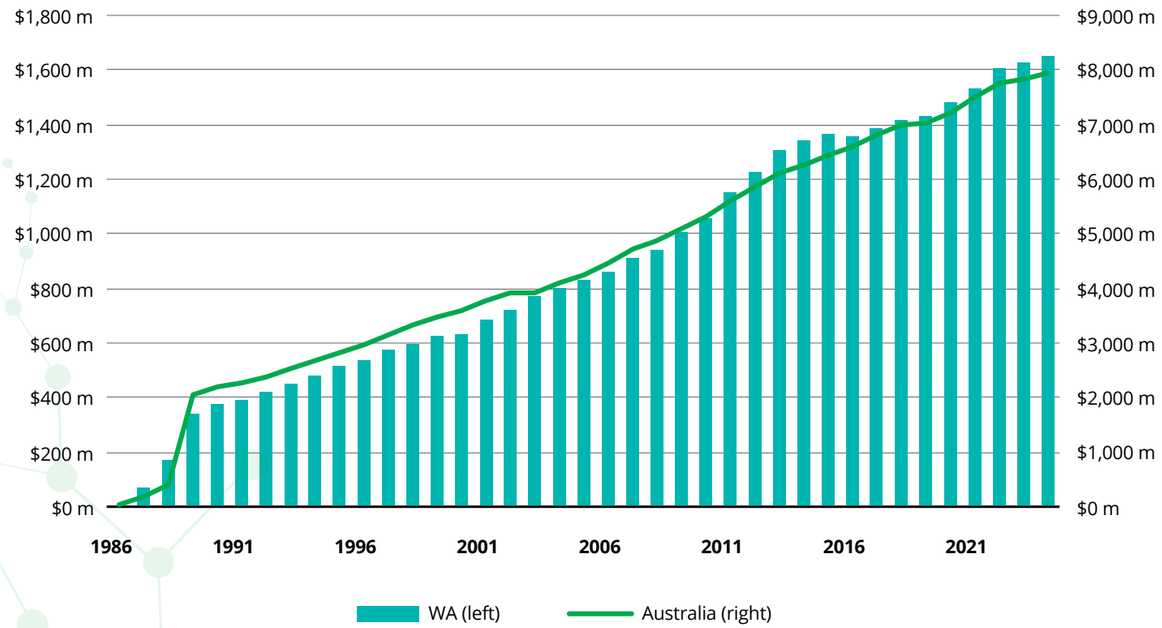
Positive impacts to the WA economy also grow over time as the outcomes of medical research affect more patients due to greater integration into clinical practice (see Chart A). In 2023, the WA economy is estimated to be $1.6 billion, or 0.44% larger, due to the impacts of the medical research case study programs.

At a national level, the health outcomes of WA medical research are estimated to have added $4.5 billion (undiscounted terms), on average each year, to national GDP over the same historical evaluation period.

The positive economic impact of medical research outcomes are typically evident through greater workforce participation, size, and improved productivity. This not only drives higher levels of direct employment but also indirect employment growth throughout the economy. For WA, it is estimated that to date, an additional 950 FTEs are filled every year, on average, due to the positive outcomes of the eight case study medical research programs. This does not constitute an additional 950 people each year, but rather that employment is higher by this amount each year relative to the base case.

Australia-wide, it is estimated that additional employment of approximately 9,000 FTEs is generated due to the WA-based medical research outcomes compared to the base case.

Chart A: Impact of medical research on economic output to date (annual, real, $AUD millions)



Source: Deloitte Access Economics.

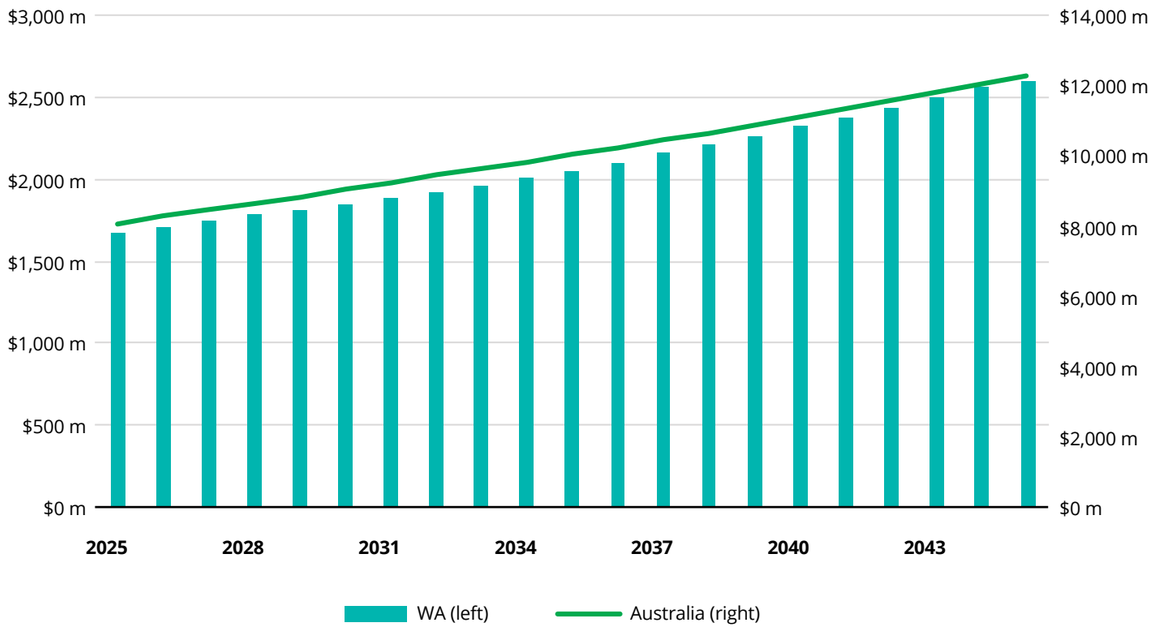
Economic impacts into the future

Future economic impacts (present day to 2045) are larger than the historical impacts described above. This is partly because several of the research case studies included in the study are presently at early stages of the commercialisation and implementation process.

Therefore, as these programs become more integrated into clinical practice over time, WA medical research outcomes are predicted to have a proportionally larger positive impact on health outcomes, growing the scale and productivity of Australia's workforce into the future. Another key factor driving this phenomenon is the increased size of the WA and Australian economies relative to the historical period, which means that changes of similar proportion lead to greater level changes in dollar metrics such as GSP and GDP.

On average, the WA economy is estimated to be 0.45%, or $2.1 billion (undiscounted terms), larger in any year of the future period than it would have been without the health outcomes delivered by the WA medical research programs included in the analysis. In 2045, at the height of the modelled impacts, the WA economy is estimated to be 0.46%, or $2.6 billion larger relative to the base case. In present value terms, this equates to the WA economy being approximately $566 million larger than the base case in 2045.

Chart B: Impact of medical research on economic output into the future (annual, real, $AUD millions)



Source: Deloitte Access Economics.

On average, in any year of the future evaluation period, the Australian economy is approximately 0.29% or $10 billion larger (undiscounted terms). By 2045, it is estimated to be $12 billion larger, in undiscounted terms, than it would have been without the health outcomes delivered by WA medical research. This reflects a present value increase in the size of the Australian economy of $2.7 billion, by 2045.

Direct and indirect employment is also expected to be generated in future due to the effect of retaining and adding people to the workforce due to better health and wellbeing from medical research breakthroughs. For WA, employment is estimated to be an *additional* 2,100 FTEs employed each year, on average, relative to a scenario where the medical research outcomes do not occur. This does not constitute an additional 2,100 FTEs each year, but rather that employment is higher by this amount each year relative to the base case.

Australia-wide, it is estimated that there will be an additional 18,000 FTEs employed, on average, each year, relative to a scenario where the research outcomes do not occur.

The economic importance of continued investment in medical research

This study analysed the economic value of the medical research sector in WA using three approaches, each of which provide a different perspective on the value generated by the sector through its activities.

The results confirm the significant value generated by medical research in terms of the operational activities of the sector, the economic and social value derived from medical research breakthroughs – which save lives and restore quality of life to individuals – and the economic uplift made possible by keeping people healthy and economically active.

The scale of the modelled impacts described in this report – both in the past and in the future – underscores the economic importance of continued financial investment and policy support for medical research endeavours around WA and Australia. Significant long-term economic value is generated by the activities of the WA medical research sector.

1. Introduction

1.1. About medical research

Research has enabled the evolution of modern medicine by providing an evidence base for the development of new drugs, devices and therapies with the potential to improve the health and wellbeing of people worldwide and across generations. Evidence-based medicine is critical to health care providers, better enabling informed treatment decisions and improved patient care.[7]

Medical research has expanded rapidly over the last century both in terms of magnitude and complexity. This has contributed to the elimination and reduction of disease burdens on human health and extended life expectancies. For example, the total global volume of medical research – as measured by an increase in journal articles – has increased at a rate of between 3% and 6% per annum in the last 100 years.[8] This has coincided with an increase in life expectancies, with average life expectancy having increased by 27 years (46 years to 72 years) worldwide since 1950.[9] The average life expectancy of Australians has increased by 25 years (68 years to 83 years) over the same period.[10]

Although the primary benefits of medical research are related to its ability to inform improvements to medical treatments and hence patient outcomes, the medical research industry also plays an important role in the Australian economy. It supports jobs, consumes goods and services from a wide range of other sectors and generates knowledge that can be used either in enhancements to clinical practice or in commercial applications. In 2018, the medical research sector in Australia employed over 32,000 people, with a further 78,000 jobs in the downstream medical technologies and pharmaceutical sectors.[11]

1.2. Health and medical research: A strategic priority for WA

In WA, the medical research sector has produced internationally recognised research over many years, including a number of breakthrough discoveries that have meaningfully impacted humanity on a global scale. For example, the discovery of a link between the bacterium *helicobacter pylori* and stomach ulcers by Professor Barry Marshall AC and Emeritus Professor Robin Warren AC received the Nobel Prize for Physiology and Medicine in 2005. The invention of 'spray-on skin' by Professor Fiona Wood has revolutionised burns care and treatment in several countries.[12]

The health and medical life sciences sector is considered by the WA Government as one of eight key economic development priorities to diversify the WA economy.[13] *The WA Health and Medical Research Strategy*, released in 2023, recognises four unique advantages for WA health and medical research. These include:

- Internationally recognised research base and significant entrepreneurial talent in health and medical sciences, including the largest medical precinct in the southern hemisphere and strong data science infrastructure[14]
- A vibrant health and medical innovation ecosystem, with more than 40 biotechnology and pharmaceutical companies and more than 50 medical technology and digital health companies based in WA
- Unique natural environment and stable population, which has shaped local expertise and knowledge in developing health and medical life sciences products
- An attractive place to live and do business for both national and international talent.[15]

WA's health and medical research sector is also supported by the Future Health Research and Innovation (FHRI) Fund, which is backed by the State's sovereign wealth fund. The purpose of the FHRI Fund is to improve, through research and innovation, the health and prosperity of Western Australians, the sustainability of the health system and to advance the state's standing as a leader in research and innovation.[16] From 2023, the FHRI Fund has more than $50 million available each year to support health and medical research, innovation and commercialisation in WA.

WA's health and medical research sector also receives a share of funding from the Commonwealth, which provides a combined total of more than $1.5 billion nationally through the National Health and Medical Research Council (NHMRC) and the Medical Research Future Fund (MRFF). Strong support is also provided by philanthropy, industry, venture capital, the corporate sector and the community.

1.3. Estimating the economic value of the medical research sector in WA

The WA Chapter of the Association of Australian Medical Research Institutes (AAMRI WA) is the representative body for medical research institutes in WA, with membership from six institutes:

- Telethon Kids Institute
- Harry Perkins Institute of Medical Research
- Lions Eye Institute
- Ear Science Institute Australia
- Perron Institute of Neurological and Translational Science
- Institute for Respiratory Health.

These institutes work across the full spectrum of medical research, from basic laboratory research to drug development, clinical trials and public health. Research areas include child health, cancer, cardiovascular disease, eye disease and vision loss, ear disorders and hearing loss, neurological disorders, kidney disease and respiratory disease.

AAMRI WA engaged Deloitte Access Economics to estimate the economic value of the health and medical research sector in WA. This study uses three modules of analysis to describe the sector's economic value (see Figure 1.1). Each approach offers a distinct perspective on the value generated by the sector through its activities. Further details on the study methodology are provided in the appendices of this report.

A key objective of the analysis is to estimate the economic value of the entire medical research sector in WA, including all organisations involved in undertaking health and medical research activities. The study is wide-ranging and involved participation from 21 medical research organisations based in WA, including medical research institutes and foundations, hospital foundations and universities.

Figure 1.1: Estimating the economic value of the WA health and medical research sector

	Economic contribution of the medical research sector	Economic return on medical research investment	Flow-on economic impacts of medical research
Modelling approach	Input-Output (IO) modelling, using Deloitte Access Economics' in-house IO model.	Cost-benefit analysis of a suite of WA research projects. Australian and global benefits are quantified and compared to the costs of investing in the research.	Computable general equilibrium (CGE) modelling, using Deloitte Access Economics' in-house CGE model.
Summary	This measures the direct and indirect contribution of the medical research sector to the WA economy. This defines the sector's operational footprint in the WA economy, including the supplier relationships and transactions that support the broader health value chain in WA. The analysis demonstrates the role the medical research sector plays in creating jobs and value in the WA economy both through its direct operations, and indirectly for other sectors of the economy.	This estimates the economic return – in terms of gains in health and wellbeing and health system savings – of a selection of research programs led by the WA medical research sector. To determine the net health benefits from medical research, the value of gains in wellbeing are monetised so they can be compared to the cost of producing those gains. The returns are estimated for Australia and globally, recognising that the size of the populations who accrue the benefits of research significantly impacts the magnitude of the return.	This quantifies the flow-on economic impacts from advances in medical research for the WA economy to date (i.e. to 2023) and in the future. This defines the sector's impact in generating economic growth in WA over time, with economic output and total employment higher as a result of the outcomes generated by medical research. The economic impacts reflect the productivity benefits from a larger and healthier workforce.
Results	A quantitative measure of both the direct and indirect economic contribution of the medical research sector to the WA economy, measured in full-time equivalent (FTE) employment and gross value added (GVA) terms.	The net economic benefits attributable to selected medical research programs. Outcomes are measured as net present values (NPV) with a benefit-cost ratio (BCR) for investment in these WA medical research programs.	A quantitative measure of the economic impact from advances in medical research for the WA economy to date and in the future, measured as an increase in FTE employment and Gross State Product (GSP).

In referring to health and medical research, this report considers the wide variety of activities that medical research organisations may undertake. This includes the following:

- Research to understand human health, wellbeing and disease, and the biological, behavioural, social and environmental factors that contribute to these
- Research to measure the magnitude and distribution of a health problem
- Research to develop solutions, interventions, products and technologies that could contribute to improving human health and wellbeing
- Research to understand how interventions, policies and programs aimed at improving human health and wellbeing can be most effectively delivered.[17]

2. Economic contribution of the medical research sector

This chapter defines the health and medical research sector's operational footprint in the WA economy in terms of value added to the economy and employment. The analysis encompasses the entire medical research sector in WA, and is based on financial data collected from 21 medical research organisations for 2021.

2.1. Estimating the economic contribution of the medical research sector

The WA medical research sector plays an important role in creating jobs and value in the WA economy, both through its direct operations and indirectly in other sectors of the economy. *Direct* economic contribution generated by the sector involves the activities directly engaged in by the organisations that comprise the WA medical research sector, including its employment of both labour and capital to generate value added to the economy. The sector's *indirect* economic contribution involves the economic activity it generates through its demand for the outputs of other industries, which is fundamental to building the broader health value chain in WA.

Deloitte Access Economics' Regional Input-Output Model (DAE-RIOM) is used to estimate the economic contribution of the WA medical research sector. Further details about the modelling approach are provided in Appendix A.

The modelling results help to define the sector's operational footprint in the WA economy in terms of value added to the economy and full-time equivalent (FTE) employment. The analysis is underpinned by financial data collected from 21 medical research organisations for 2021, including intermediate expenditure, employment, salaries and wages, gross operating surplus and net taxes on production.

2.2. Total economic contribution

Table 2.1 presents the results of the economic contribution modelling, and shows the contribution of the WA medical research sector to both the WA and Australian economies – noting that the sector's contribution to the WA economy is a component of its contribution to the Australian economy (i.e. the results are not additive).

Table 2.1: Economic contribution of the WA medical research sector, 2021

Economic contribution	Western Australia	Australia
Value added ($ million)		
Indirect contribution	$39.0	$71.8
Direct contribution	$283.9	$283.9
Total value added	**$322.9**	**$355.7**
Employment (FTE)		
Indirect contribution	313	583
Direct contribution	2,319	2,319
Total employment	**2,632**	**2,902**

Source: Deloitte Access Economics.

In 2021, it is estimated that the total contribution of the WA medical research sector to the Australian economy was approximately $355.7 million in value added terms (see Table 2.1). In addition, total employment generated by the WA sector (both direct and indirect) summed to 2,902 FTE jobs across Australia.

A significant proportion of the sector's total economic contribution is driven by its contribution to the WA economy. In 2021, the contribution of the sector to the WA economy is estimated at $322.9 million in value added terms, or 91% of the total value added to Australia. Similarly, the sector contributed 2,632 FTE jobs to WA, which accounts for 91% of total jobs contributed to Australia.

In 2021, the WA medical research sector contributed $322.9 million in value added and 2,632 jobs to WA

Overall, this means that an estimated 91% of the value generated from medical research activity in WA is retained within the state. This is the case even though a significant share of medical research expenditure on intermediate goods and services is directed to interstate and overseas suppliers, allowing the sector to access the required technical services and inputs to support its operations (see Appendix A).

The results suggest that the WA medical research sector directly employed approximately 2.5% of the state's professional, scientific and technical services workforce. This broadly aligns with a previous estimate that the medical research sector contributed around 32,000 jobs to the Australian economy, which reflects 3.6% of the Australian professional, scientific and technical workforce at the time of the study.[18, 19]

To help understand the significance of these outcomes, it is helpful to understand the $322.9 million contribution of the medical research sector to the WA economy (as measured by its value added) relative to the size of other industries in the state. For example:

- Sports and recreation – contributed $482.5 million in direct value added in 2020-21
- Heritage, creative and performing arts – contributed $277.9 million in direct value added in 2020-21
- Human pharmaceutical and medicinal product manufacturing – contributed $285.1 million in 2020-21.[20]

2.3. Direct economic contribution

2.3.1. Output

The direct economic contribution of the WA medical research sector is the value added to the economy from the income paid to its labour (measured as wages) and income earned from its capital (measured as gross operating surplus). In 2021, the WA medical research sector's direct contribution of $322.9 million in value added terms to the WA economy (see Table 2.1) was predominantly derived from salaries and wages paid to people employed directly by the sector.

This reflects the fact that the medical research sector is labour-intensive and consists of highly skilled personnel, where research is often undertaken by qualified medical scientists. The salaries and wages within the sector therefore reflect these highly specialised skills.

Total expenditure on labour across the sector in WA is estimated at $254.2 million in 2021. By comparison, this is double the cost of the intermediate inputs required to undertake medical research activity, even when considering non-WA expenditure and spending on other medical research organisations within the sector (both of which are excluded from the economic contribution to WA; see Appendix A).

2.3.2. Employment

In 2021, there were 2,319 FTE employees in the WA medical research sector. While this figure demonstrates that the sector is a significant employer of highly skilled labour in WA, it only partially describes the human capital aspects of the medical research endeavour. Medical research is a unique industry in which a large contribution is provided by not just employees or hired labour, but also by students, volunteers and other in-kind forms of support that are not easily quantifiable.

In undertaking the economic contribution analysis, these personnel are excluded from the direct FTE contribution as they do not earn a wage or salary. However, as shown in Table 2.2, the combined volunteer (498) and student labour (622) contributed almost one third of the total labour resources that supported the medical research sector in 2021. Many of these volunteers and students receive training that eventually enables them to become highly skilled and employed workers in the future.

91% of the value generated from medical research activity in WA is retained within the state

Table 2.2: Sources of labour for the WA medical research sector, 2021 (FTE)

Source of labour	FTE
Employed labour	
Direct employment	2,319
Other labour sources	
Volunteers	498
Students	622

Source: Deloitte Access Economics analysis of data provided by medical research organisations.

2.4. Indirect economic contribution

The indirect economic contribution of the WA medical research sector relates to the economic activity it generates in other sectors of the economy from its expenditure on intermediate inputs (i.e. the goods and services purchased from suppliers). Therefore, the size of the sector's indirect contribution is determined by the values of the payments it makes to other sectors of the economy.

Table 2.3 provides a breakdown of the sources of indirect contribution to the WA and Australian economies in 2021, where the two main drivers included health care services and professional, scientific and technical services. Health care services contributed $12.6 million (32%) of indirect value added to WA; this includes spending on pathology services, health care clinics and medical consultants.

Nearly all of this spending (99%) remained within WA, reflecting the fact that the majority of medical research-dependent services are based in WA for reasons of accessibility, but also that the medical research sector itself requires close proximity to these service providers to continue operations. The demand created in the health care services sector is fundamental to building the broader health value chain in WA.

Table 2.3: Sources of indirect contribution to WA and Australia, 2021

Source of labour	Western Australia		Australia	
Industry	**Value added ($ million)**	**Share of total indirect**	**Value added ($ million)**	**Share of total indirect**
Health care services	12.6	32%	12.7	18%
Professional, scientific and technical services	8.2	21%	16.4	23%
Administrative services	2.9	7%	7.5	10%
Retail trade	1.2	3%	1.8	3%
Non-residential property services	1.8	5%	3.5	5%
Wholesale trade	1.4	4%	3.2	4%
Computer systems design and related services	1.1	3%	2.9	4%
Public administration and regulatory services	0.9	2%	1.6	2%
Professional, scientific, computer and electronic equipment manufacturing	0.7	2%	1.2	2%
Building cleaning, pest control and other support services	0.5	1%	1.3	2%
All other sectors	7.6	20%	19.8	28%
Total	**39.0**	**100%**	**71.8**	**100%**

Source: Deloitte Access Economics.

Professional, scientific and technical services contributed $8.2 million (21%) of indirect value added to WA. This includes spending on services such as bioanalytical testing, consulting services, and biological, genomic and proteomic research. However, a considerably higher proportion of these services are sourced from interstate suppliers (41%), which is seen in an equivalent $8.2 million indirect value added to the national economy (see Appendix A). This likely reflects the highly specialised and technical nature of these services, some of which can only be sourced from outside of WA.

Medical research organisations also often work in close collaboration with each other. This is particularly the case between universities and medical research institutes, facilities or foundations. Reflecting this, 17% of the sector's expenditure in WA occurred within the industry itself in 2021, representing goods and services provided by other medical research organisations (see Appendix A). This spending is excluded from sector's indirect economic contribution, although the revenue earned by suppliers within the sector is included as part of the sector's direct economic contribution (see section 2.3).

Overall, the economic contribution results demonstrate that the WA medical research sector plays an important role in creating jobs and value in the WA economy. This value is derived largely by salaries and wages paid to highly skilled personnel and spending on specialised and technical service providers. Growing the sector through further investment therefore provides a foundation to continue to attract greater numbers of highly specialised jobs and capabilities that support the sector into the future.

Economic value of the health and medical research sector in Western Australia

3. Economic return on medical research investment

This chapter details the estimated economic return – in terms of gains in health and wellbeing and health system savings – of eight high-impact research programs led by the WA health and medical research sector. The returns are estimated for Australia and globally, which recognises that the size of the populations who accrue the benefits of research significantly impacts the magnitude of the return.

3.1. Estimating the economic return on medical research investment

3.1.1. Summary

A primary objective of investment in medical research is to generate knowledge that supports the identification of new preventive methods and the development of new treatment methods and approaches, which together, ultimately result in improved health outcomes. The fact that human life expectancy has risen significantly over time underpinned by research (see section 1.1) suggests that the economic return to society from research spending and effort is significant.

However, estimating and monetising this return can be challenging given the breadth of research, and the very long lead between conception of a research idea, the undertaking of the research, and implementation of new approaches. Additionally, there is often difficulty in attributing outcomes to single streams and fields of research, given breakthroughs may often cross a range of research fields. Estimating such returns are an essential tool to demonstrate economic outcomes and thereby attract further levels of investment in the research process to continue to achieve improvements in human health.

Over the years, there have been many successful medical research programs led by the WA medical research sector across a variety of research areas. This report focuses on eight high-impact case studies of WA research programs that have produced a quantifiable economic return in terms of gains in health and wellbeing and avoided health care costs.

The eight case studies were chosen in collaboration with AAMRI WA, with the aim of selecting research programs that demonstrate the significant returns generated by investment in research which leads to translation of findings into changes in policy and clinical practice. Therefore, the results estimated are relevant for the eight chosen programs only; they are not illustrative of the expected return from investment in any medical research program.

A cost-benefit analysis (CBA) is used as the framework to quantify returns (see Appendix B). A CBA allows for the quantification of the net health benefits from medical research, by valuing the gains in health and wellbeing and comparing these to the cost of producing those gains. The returns are estimated for Australia and globally where relevant, recognising that the size of the populations who accrue the benefits of research significantly impacts the magnitude of the return.

The returns are not estimated for WA alone. The relatively small population in WA – which reflects 10.8% of the Australian population in 2023 – provides a limited view of the value of health benefits attributable to WA medical research programs,[21] especially considering that new treatment methods and approaches are usually implemented nationally, rather than in individual jurisdictions.

An overall benefit-cost ratio (BCR) is estimated for investment in WA medical research, based on the selected case studies. This reflects the expected dollar for dollar return to society from investment in successful medical research programs. It is important to acknowledge that the returns estimated in this study only reflect the eight case studies selected (albeit high impact examples). Many other programs of research in WA have also achieved outcomes that have had important positive impacts to health care but are not measured here.

3.1.2. Cost-benefit analysis parameters

A number of key parameters and concepts are relevant to the approach applied in calculating the costs and benefits for each program of research. These parameters and concepts are discussed briefly below to give context to the analysis contained in chapter 3.2. Full details of the CBA approach are provided in Appendix B.

3.1.2.1. Nature of benefits

The economic benefits from advancements in medical research are quantified in the CBA from three main sources, which are described in Figure 3.1.

Figure 3.1: Summary of quantified economic benefits

Reduced mortality

Reduced mortality refers to the benefits derived for society through avoided loss of life. This is quantified in terms of the value of additional life years for people who experience more effective treatment as a result of advances in medical research. This usually results where a disease is cured or entirely prevented.

Reduced burden of disease

Reduced burden of disease refers to the gains in quality of life experienced by patients who receive effective treatment. This is quantified by measuring the deterioration in quality of life caused by the symptoms of disease, and applying a factor that represents the improvement in a patient's condition due to effective treatment.

Avoided costs for the health system

Avoided costs for health systems refer to the costs of treatment or management for patients with a particular condition. Advancements in medical research may reduce the overall cost of delivering treatment, or they may improve health outcomes such that less is spent on managing complications and follow-up care.

3.1.2.2. Nature of costs

There are two sources of costs included in the CBA:

- **Research and development costs:** Research costs relate to the costs associated with the research activities instrumental to the innovation or discovery, and the costs of commercialisation. These costs are provided by the relevant medical research organisations.
- **Delivery and treatment costs:** The delivery cost relates to the cost of administering a particular treatment. This is different to the costs of commercialisation, and refers to the per unit cost of administering treatment to each patient, as this is a necessary cost of providing care.

Research and development costs included in the CBA do not include indirect costs of research, such as spending on overheads and stocks of equipment already owned by the medical research organisation. As such, this is accounted for using an indirect cost factor calculated from spending data across all AAMRI WA research institutes, which is applied to all research costs in this study (see Appendix B).

Economic value of the health and medical research sector in Western Australia

3.1.2.3. Period of analysis

The CBA estimates benefits and costs over 74-year period of analysis, from FY1982 to FY2056. This period reflects the commencement of research spending across the case study programs and the final year for which benefits are estimated.

For each case study included in the CBA, costs were included in the analysis from the year in which they commenced, until the research program resulted in a change in policy, guidelines or clinical practice that began to realise benefits. Benefits were then estimated for each case study program for a fixed period of 30 years, which provided a consistent measure of economic return from research spending across the case studies.

The CBA considers 41 years of historical benefits and costs, which occur during the period FY1982 to FY2023. These benefits and costs are converted to present values by adjusting them to 2023 dollars. For benefits and costs that occur in the future, values are discounted at the rate of 7.0% per annum to derive their present values. This aligns with guidance published by the Department of the Prime Minister and Cabinet on the use of CBA for policy proposals.[22]

3.1.2.4. Attribution of outcomes to research programs

Not all of the improvements in health outcomes, as evidenced in the literature, can be directly attributed to advancements in research. In most cases, medical research programs generate findings that add to the body of evidence, which then goes on to influence changes in policy, clinical guidelines and treatment methods.

In addition, there may be difficulty in attributing outcomes to single streams and fields of research where a research breakthrough builds on the findings generated from separate fields of research. To account for these complexities, an attribution factor is applied to the benefits quantified in the CBA, which recognises the contribution of the research program toward generating the improved health outcomes.

3.1.2.5. Specification of the base case

The benefits and costs quantified in the CBA are measured as the incremental change from the base case, ensuring that only the benefits and costs that can be reasonably attributed to the investment are included in the analysis. For this analysis, the base case is defined as a scenario in which the selected case study research programs are not delivered, and therefore the enhancements to policy, clinical guidelines, treatment methods and practice – which contribute toward improved health outcomes – are not realised.

Further details on the CBA parameters are provided in Appendix B.

3.2. Total economic return on medical research investment

Based on the case study research programs, between 1982 and 2056, it is estimated that these programs – net of costs – generated benefits worth $488.6 million to the Australian population. This includes benefits generated in the past and expected in the future. This means that the investment in these programs is expected to yield a benefit-cost ratio (BCR) of 2.61 for Australia over the period of analysis. In essence, for every $1.00 invested into these research programs, an economic return of $2.61 can be expected to be generated for Australia.

The economic return on this investment is largely driven by the gains in health and wellbeing realised by Australians from the translation of the findings of medical research into clinical practice, which leads to the development of new treatment methods and approaches. For the chosen case studies, investment in medical research has led to a variety of advancements in health care, including:

- Widening the use of commonly used drugs to effectively treat other conditions
- Development of entirely new drugs
- Innovations such as new devices and implants that lead to better recovery outcomes for patients
- Significant discoveries that increase the understanding of disease and enable better prevention and treatment strategies.

Between 1982 and 2056, the eight WA medical research programs are expected to generate net benefits worth $488.6 million for Australia

Researchers at Harry Perkins Institute.
Credit: Harry Perkins Institute

While the benefits noted above extend to the Australian population, it is important to note that the advancements in health care enabled by WA medical research have also extended far beyond Australia, with research findings leading to the adoption of new treatment methods and approaches across the world. Globally (including in Australia), these WA research programs are estimated to generate total net benefits of $88.3 billion between 1982 and 2056. This reflects a BCR of 7.58, or an economic return of $7.58 for every $1.00 invested into the research programs. These improved results owe to the wider, global patient cohort that have – and are expected to – receive the health and wellbeing benefits of improved clinical treatment owing to WA-based research.

Table 3.1 provides a summary of the economic returns estimated for the eight WA research programs, while Chart 3.1 illustrates the profile of benefits and costs over time. The following sections of this chapter document each of the programs in detail, including the profile of benefits and costs related to each.

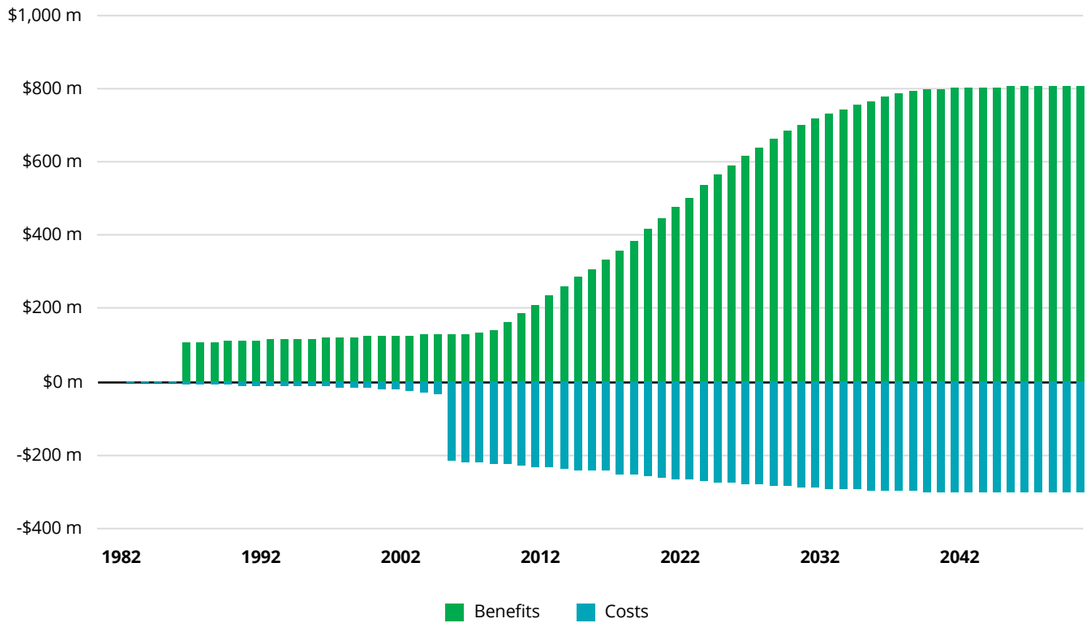
Table 3.1: Summary of cost-benefit analysis results, 1982 to 2056 ($ million, present value terms)

Cost-benefit analysis results	Australia	World
Benefits ($ millions)		
Reduced mortality	$539.7	$90,806.1
Reduced morbidity	$165.3	$10,284.7
Avoided costs for the health system	$87.3	$569.7
Total benefits	**$792.3**	**$101,660.4**
Costs ($ million)		
Research costs	$48.2	$89.8
Delivery and implementation costs	$255.5	$13,318.4
Total costs	**$303.7**	**$13,408.2**
Net present value of benefits	**$488.6**	**$88,252.2**
Benefit-cost ratio	**2.61**	**7.58**

Source: Deloitte Access Economics. Note: All values are provided in real, Australian dollars and are in present value terms, discounted at a rate of 7%.

For every $1 invested into these research programs, an economic return of $2.61 is expected for Australia

Chart 3.1: Cost-benefit analysis results, benefit and cost profile (cumulative, present value terms)



Source: Deloitte Access Economics. Note: All values are provided in real, Australian dollars and are in present value terms, discounted at a rate of 7%.

Economic value of the health and medical research sector in Western Australia

3.3. Case study 1: Telethon Kids Institute – Folate research

3.3.1. Summary of research

The Telethon Kids Institute is WA's only research institute focused on children's health and wellbeing. It was established in 1990 by Founding Director Professor Fiona Stanley. Telethon Kids brings together laboratory, clinical, and population-based research to discover ways to prevent, treat, and cure the most common and devastating diseases and issues affecting children and young people in WA and throughout the world.

The Telethon Kids Institute is one of the largest medical research institutes in Australia, comprising more than 1,000 staff, students, and honoraries. They currently have four focus research themes:

- **Indigenous Health** is embedded across all research areas, with a focus on improving the health and wellbeing of Indigenous children and families.
- **Brain and Behaviour** investigates the development, genetic, family and environment determinants of child wellbeing.
- **Chronic and Severe Disease** focus on childhood cancers, diabetes, respiratory conditions, and rare diseases.
- **Early Environment** focuses on the way in which environments early in life can affect a child's life-long health and development.

This report focuses on one of the Telethon Kids Institute's research highlights – the discovery that folate can prevent neural tube defects.

In 1989, research by Professor Fiona Stanley and Professor Carol Bower of the Telethon Kids Institute demonstrated the critical role of dietary folate in reducing the incidence of neural tube defects. This research - in conjunction with evidence from randomised controlled trials and other studies overseas – led to the world's first health promotional campaign in WA promoting periconceptional folic acid supplement use, and approval in 1995 for voluntary fortification of some foods (mainly breakfast cereals and bread) with folic acid in Australia. Mandatory fortification of wheat flour for breadmaking was approved in Australia in 2007.

3.3.1.1. Description of disease

Neural tube defects are congenital anomalies that result from early disruption in the development of the brain and spinal cord, usually occurring in the first month of pregnancy.[23] There are two classes of neural tube defects: 'open' when the brain or spinal cord is exposed through a defect in the skull or vertebrae, and 'closed' when the spinal defect is covered by skin. In addition, there are also several types of neural tube defects. This analysis focuses on three of the most prevalent forms of open neural tube defects:

- **Spina bifida** – where the vertebrae that cover the spinal cord fail to develop or close properly[24]
- **Anencephaly** – a condition where major portions of the brain, skull, and scalp are absent[25]
- **Encephalocele** – a sac-like protrusion or project of brain tissue and/or its covering membranes through an opening in the skull.[26]

In Australia, spina bifida and anencephaly are the most common, occurring in roughly equal proportions; encephalocele is much less common.[27]

There is no cure for neural tube defects as the nerve damage and loss of function that are present at birth are usually permanent. A variety of treatments – including surgery and walking aids – can prevent further damage and avoid complications.[28] However, there is no treatment for anencephaly. Most fetuses with anencephaly pass away before birth, and those that are born alive die shortly after birth.[29]

3.3.1.2. Impact of research on health care

In 1989, research by Professor Fiona Stanley and Professor Carol Bower revealed the key role of dietary folate in reducing the incidence of neural tube defects.[30] The research involved the collection and analysis of data from mothers whose infants had neural tube defects and two groups of control mothers: one group whose infants had other birth defects, and the other whose infants had no birth defects. The research included studying the mother's diet, history of illness, drug and alcohol intake, cooking methods, vitamin supplementation, and folate levels.[31]

The research demonstrated that dietary intake of folate in early pregnancy protected against the occurrence of neural tube defects in infants.[32] This contributed to worldwide research showing that neural tube defects could be reduced by up to 70% with sufficient folate intake during the very early stages of pregnancy.

What is Folate?[33]

Folate is an essential dietary vitamin. 'Folate' is the term given to the version that is found naturally in foods (vitamin B9) and 'folic acid' is the synthetic supplement that can be added to food products or taken as a tablet.

Folate is needed to produce healthy red blood cells and is critical during periods of rapid growth, such as during pregnancy and fetal development. Folate assists in the formation of DNA and RNA and is involved in protein metabolism. Doctors recommend that adults have 400 micrograms (mcg) of folate daily, with a higher level of 600 mcg recommended for women during pregnancy.

Following this research, the Telethon Kids Institute led educational campaigns encouraging women to increase their folate intake (through supplements or folate-rich foods) and raising awareness of the effectiveness of fortifying bread with folate.[34] This included a Telethon Kids Institute-led WA Health Department public health campaign to encourage women considering starting a family to take folic acid supplements and to eat folate-rich foods. These efforts reduced the occurrence of neural tube defects by around 30%. However, they were not effective in the Indigenous population, of whom a higher

proportion were vulnerable.[35] The result was an increasing disparity in the incidence of neural tube defects between Indigenous and non-Indigenous children. Therefore, there was need for fortification of wheat products with folate.[36]

For two decades, Professor Bower and Professor Stanley lobbied Food Standards Australia and New Zealand to introduce mandatory fortification of wheat flour.[37] In 1995, voluntary fortification was introduced, and in 2007, the Australian Government announced the compulsory enrichment of bread-making flour with folate (fortification), with it being implemented from 2009.[38]

In 2018, the Public Health Association of Australia rated mandatory folate fortification as one of the top 10 public health achievements of the past 20 years.[39]

The Telethon Kids Institute continues to support increased understanding of the link between neural tube defects and folate, with a current project investigating the effectiveness of folate-fortified products by monitoring the levels of folate in the blood and the rates of neural tube defects through the WA Register of Developmental Anomalies.[40]

3.3.2. Benefit parameters and assumptions

Three benefits are quantified relating to the impact of fortification on the incidence of neural tube defects (see Figure 3.2). The following subsections discuss each of the benefits in more detail, along with the data inputs and assumptions used in estimating their value.

Figure 3.2: Summary of measured economic benefits from reduced incidence of neural tube defects

Reduced mortality	The value of additional life years from the reduced incidence of neural tube defects
Reduced burden of disease	The value of improvement in quality of life from the avoidance of neural tube defects
Avoided costs for the health system	The value of additional life years from the reduced incidence of neural tube defects

Source: Deloitte Access Economics.

3.3.2.1. General assumptions

As described in section 3.3.1, this analysis focuses on the reduced incidence of three forms of open neural tube defects – spina bifida, anencephaly, and encephalocele. The impact of reducing each form of neural tube defect is quantified separately within the benefits.

A key assumption underpinning the results of the CBA is the number of children who avoid neural tube defects due to reduced incidence rates. This is estimated by calculating the number of children born in Australia each year multiplied by the difference in incidence rates of neural tube defects pre and post-fortification (see Appendix B).[41,42] Only the reduced incidence rates for children born in Australia are considered, given that following Professor Bower and Professor Stanley's research, their continued efforts to raise awareness of the benefits of folate were focused within Australia, eventually culminating in the introduction of compulsory fortification of bread in Australia in 2009.

Other assumptions, including the attribution of benefits to the Telethon Kids Institute, the value of a statistical life year, average lifespan and disability weights are detailed in Appendix B.

3.3.2.2. Reduced mortality

Spina bifida and encephalocele

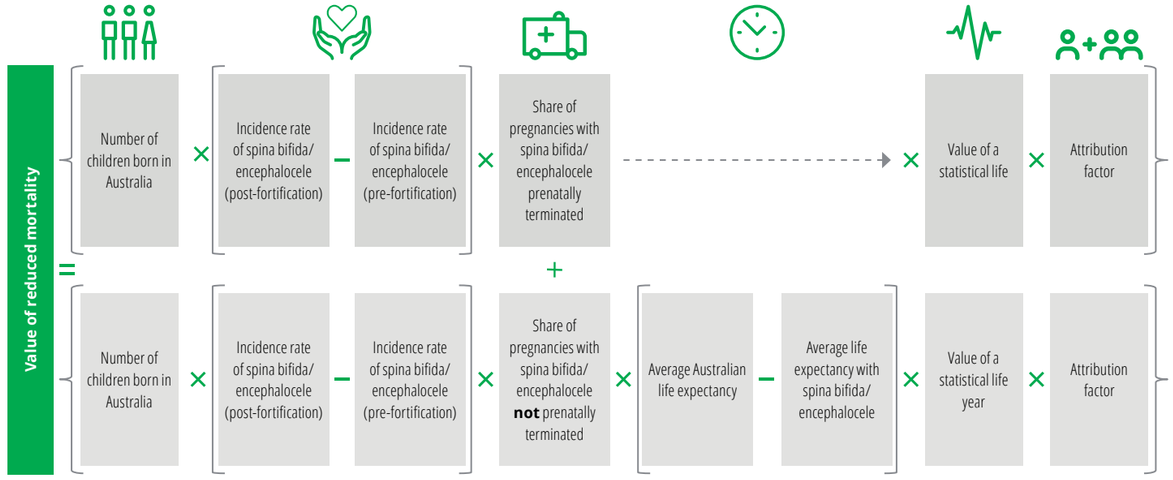
Reduced mortality benefits refer to the benefits derived by society through avoided loss of life. Neural tube defects are associated with a low life expectancy. As there is limited research regarding the life expectancy of children born with encephalocele, it is assumed to be 40 years, which is the same life expectancy associated with spina bifida.[43] Compared to the average life expectancy in Australia of 83 years, a child that avoids developing a neural tube defect effectively gains an additional 43 years of life.

However, it is recognised that a proportion of prenatally diagnosed neural tube defects are likely to result in termination of pregnancy. Between 1980 and 2006, 40.1% of pregnancies affected by spina bifida and 43.3% of pregnancies affected by encephalocele were prenatally terminated.[44] To account for this, reduced mortality benefits are estimated both for fetuses that would have resulted in termination, and for children that would have been born with either spina bifida or encephalocele (and thus lived a 40-year lifespan on average).

For children that would have been born with spina bifida or encephalocele, the difference between the average Australian life expectancy and life expectancy of those with spina bifida/encephalocele is used to estimate the average additional life years gained from the folate intervention. This is multiplied by the value of a statistical life year (see Figure 3.3). For pregnancies that would likely have been terminated, the value of a statistical life is used, which is commonly used to reflect the value of an avoided fatality. These two components are added together to provide the total value of reduced mortality benefits.[45]

Finally, the total benefit is adjusted to account for the Telethon Kids Institute's contribution to the outcome (see Appendix B).

Figure 3.3: Calculating the reduced mortality from reduced incidence of neural tube defects – spina bifida and encephalocele

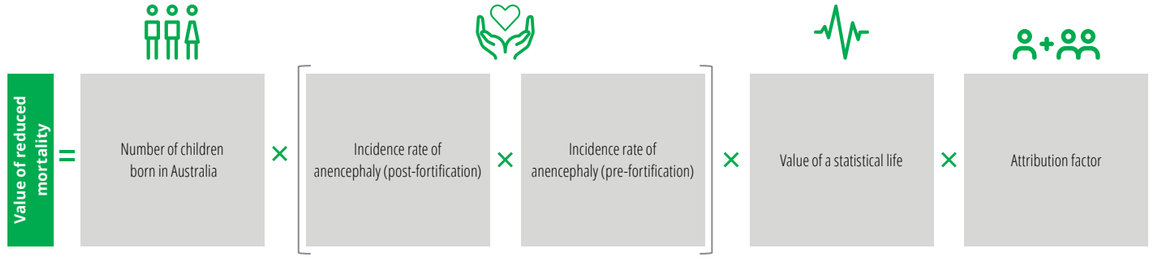


Source: Deloitte Access Economics.

Anencephaly

Most fetuses with anencephaly pass away before birth or shortly after birth (see section 3.3.1.1).[46] However, in many cases, prenatally diagnosed cases result in termination of the pregnancy; between 1980 and 2006, 78.5% of pregnancies affected by anencephaly were prenatally terminated.[47] Therefore, the benefits of reduced incidence of this disease are measured differently to spina bifida and encephalocele. In this case, the number of children who avoid anencephaly is multiplied by the value of a statistical life (see Figure 3.4). Similarly, the total benefit is adjusted to account for the Telethon Kids Institute's contribution to the outcome (see Appendix B).

Figure 3.4: Calculating the reduced mortality from reduced incidence of neural tube defects – anencephaly



Source: Deloitte Access Economics.

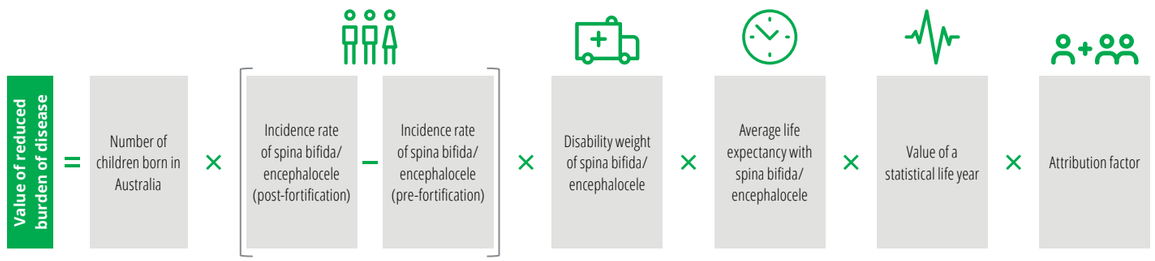
3.3.2.3. Reduced burden of disease

Some people who live with neural tube defects – including spina bifida and encephalocele – experience disabilities including paralysis, nerve injury, difficulty walking and intellectual disability. Reduced burden of disease benefits refer to the gains in quality of life experienced by people who avoid developing neural tube defects due to the fortification of wheat products.

The reduced burden of disease is not calculated for children who avoid anencephaly, as most fetuses with anencephaly pass away before birth or shortly after birth, and so all the benefits associated with avoided anencephaly are reflected as reduced mortality alone.[48]

The number of children who avoid spina bifida and encephalocele is multiplied by the years lived with the disease, which is assumed to be 40 years.[49] This is adjusted for the deterioration in quality of life caused by neural tube defects (disability weights), and then multiplied by the value of a statistical life year (see Figure 3.5). Finally, the total benefit is adjusted to account for the Telethon Kids Institute's contribution to the outcome (see Appendix B).

Figure 3.5: Calculating the reduced burden of disease from reduced incidence of neural tube defects – spina bifida and encephalocele

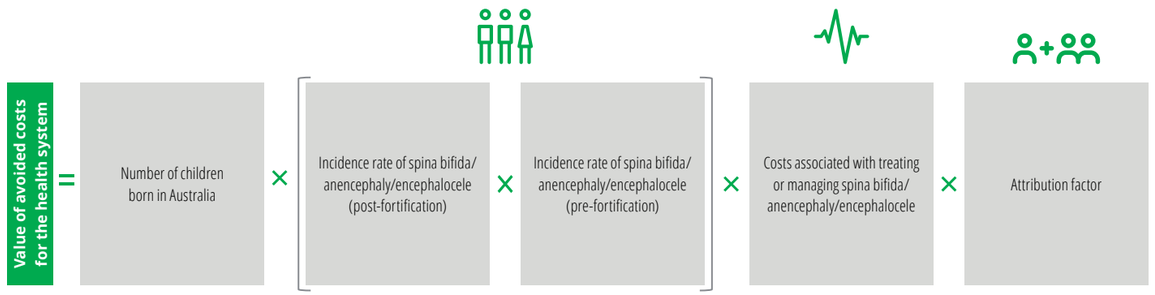


Source: Deloitte Access Economics.

3.3.2.4. Avoided costs for the health system

Avoided costs for the health system refers to the costs of treatment or management for children born with neural tube defects that are avoided as a result of the folate intervention. To calculate avoided health care costs, the number of children who avoid each form of neural tube defect (spina bifida, encephalocele and anencephaly) is multiplied by the lifetime health system costs associated with treating or managing neural tube defects (see Figure 3.6).[50,51] Finally, the total benefit is adjusted to account for Telethon Kids Institute's contribution to the outcome (see Appendix B).

Figure 3.6: Calculating the avoided costs for the health system from reduced incidence of neural tube defects – spina bifida, encephalocele and anencephaly



Source: Deloitte Access Economics.

3.3.3. Cost parameters and assumptions

The costs included in the CBA are sourced from the Telethon Kids Institute and research by Deloitte Access Economics. Costs include outlays related to conducting research into the role of dietary folate in reducing the incidence of neural tube defects, and the cost of fortification to industry and to government (see Figure 3.7). Research costs were provided by the Telethon Kids Institute and reflect the total grant funding received, salaries of the researchers, and internal funding. The research costs reflected only direct costs, and did not include the indirect costs of research. An indirect cost factor was applied to account for the indirect costs of research (see Appendix B).

Fortification costs were sourced from a previous study undertaken by Access Economics, and include costs to industry (labelling, packaging, capital equipment, folic acid, and operational costs) and costs to government (administering and enforcing the regulation).[52] Fortification costs constitute the majority of total costs considered in the analysis.

Figure 3.2: Summary of measured economic benefits from reduced incidence of neural tube defects

Research costs	The costs of conducting research into low dose colchicine and coronary disease
Treatment costs	The cost of colchicine to patients with proven coronary disease

Source: Deloitte Access Economics.

3.4. Case study 2: Harry Perkins Institute of Medical Research – Colchicine

3.4.1. Summary of research

The Harry Perkins Institute of Medical Research was established in 1998 (then known as the Western Australia Institute for Medical Research) as a collaboration between the University of Western Australia, Royal Perth Hospital and Sir Charles Gardiner Hospital. The Harry Perkins Institute focuses on major diseases that impact the WA community, including cancer, heart disease, diabetes and rare genetic diseases.

This report focuses on one of the Harry Perkins Institute's research highlights – the role of low dose colchicine in cardiovascular events. Research by the Harry Perkins Institute of Medical Research demonstrated that low dose colchicine prevents cardiovascular events in patients with proven coronary disease. Colchicine is a common medicine that is primarily used to treat gout. In the US, oral colchicine has been used for many years as an unapproved drug, with no US Food and Drug Administration (FDA) approved prescribing information, dosage recommendations, or drug interaction warnings.

On 30 July 2009, the FDA approved colchicine as a monotherapy for the treatment of three different indications, including familial Mediterranean fever, acute gout flares, and the prophylaxis of gout flares.[53] Similarly, in Australia, colchicine is approved for the treatment of gout.[54] However, the Harry Perkins Institute was instrumental in extending the use of colchicine to treat cardiovascular events.

3.4.1.1. Description of disease

Coronary artery disease is a type of cardiovascular disease that is caused by plaque build-up in the walls of the arteries that supply blood to the heart.[55] Coronary disease is associated with several adverse events, and can lead to:

- Cardiovascular death, which is death due to a cardiovascular cause that occurs within one hour of the onset of symptoms[56]
- Heart attack, when the flow of blood to the heart is severely reduced or blocked. Each day, an average of 21 Australians die from a heart attack, and one patient is admitted to an Australian hospital with a heart attack every nine minutes[57]
- Ischemic stroke when blood supply to part of the brain is interrupted or reduced, preventing brain tissue from getting oxygen and nutrients.[58]
- The need for coronary revascularisation with either coronary bypass or coronary stenting.

3.4.1.2. Impact of research on health care

Between 2008 and 2012, Professor Peter Thompson of the Harry Perkins Institute and Dr Mark Nidorf of GenesisCare conducted the low dose colchicine (LoDoCo) trial that examined the effect of a daily dose of colchicine (0.5 mg) added to usual therapy in over 500 patients in WA.

The results from that trial showed that the 0.5 mg dose of colchicine had the potential to significantly reduce the risk of major cardiovascular events in patients with chronic heart disease. The results were published in the Journal of the American College of Cardiology, with the researchers noting that further testing was required in a larger trial.[59] As such, the LoDoCo2 was designed; this was an international collaboration between researchers in WA and the Netherlands, with Professor Peter Thompson and Dr Mark Nidorf collaborating with the Dutch Network for Cardiovascular Research.

The results of the LoDoCo2 trial were published in the New England Journal of Medicine in 2020 and showed that there was a 31% reduction of major adverse cardiovascular events in patients on optimal medical therapy with cholesterol-lowering drugs. Results of the LoDoCo2 trial also indicated that a low dose of 0.5 mg of colchicine per day was well tolerated and appeared safe without any increase in the incidence of infection, cancer or interaction with other commonly used medications including statin therapy (used in the management and treatment of hypercholesteremia).[60]

Since LoDoCo2 was reported, over 13,000 patients in other clinical trials conducted in Australia and Canada have confirmed the benefits and safety of adding low dose colchicine to traditional medical therapy in patients with coronary disease.[61]

As a result of this work, low-dose colchicine received FDA approval to be used in low doses to prevent cardiovascular events in patients with proven coronary disease in July 2023, and is included in guideline therapy for secondary prevention in patients with heart disease in the US, Canada, and South America and Europe. The approval process in Australia is ongoing.[62]

3.4.2. Benefit parameters and assumptions

Two benefits are quantified for the use of low dose colchicine treatment in patients with proven coronary disease (see Figure 3.7). The following subsections discuss each of the benefits in more detail, along with the data inputs and assumptions used in estimating their value.

Economic value of the health and medical research sector in Western Australia

Figure 3.8: Summary of measured economic benefits from using low dose colchicine treatment for patients with proven coronary disease

Reduced burden of disease	The value of improvement in quality of life for patients who avoid a major adverse cardiovascular event
Avoided costs for the health system	The avoided costs for the health system from reduced major adverse cardiovascular events

3.4.2.1. General assumptions

A key assumption underpinning the results of the CBA is the number of proven coronary disease patients using colchicine. This is estimated by taking the population of the USA, Europe, Canada, South America and Europe (countries in which colchicine is approved or registered) and applying the incidence rate of coronary disease. Due to data limitations, the incidence rate for the US was used for all jurisdictions.[63]

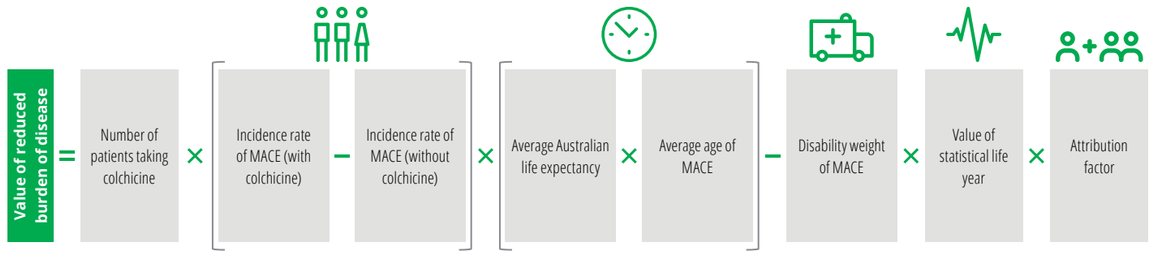
Given that colchicine is a relatively new secondary treatment for coronary artery disease, the calculation assumes that it has not been fully adopted into standardised practice. This is based on research estimating the time required for new clinical treatments and drugs to be 'fully adopted' in Australia.[64] Other assumptions, including the attribution of benefits to the Harry Perkins Institute, the value of a statistical life year, average lifespan, and disability weights are detailed in Appendix B.

3.4.2.2. Reduced burden of disease

Reduced burden of disease benefits refer to the gains in quality of life experienced by coronary disease patients due to low dose colchicine treatment. Low dose colchicine treatment has been proven to reduce the incidence rate of major adverse cardiovascular events (MACE) – including myocardial infarction, ischemic stroke and ischemia driven coronary revascularisation – by 1.1 percentage points.[65] These patients experience a greater quality of life, or a lower degree of morbidity.

The number of patients using colchicine for coronary disease is multiplied by the reduction in the incidence rate of MACE and coronary revascularisation for patients taking the drug (see Figure 3.9). This is multiplied by the years lived by a patient following a MACE and adjusted for the deterioration in quality of life caused by the symptoms of major adverse cardiovascular events (disability weights). This is then multiplied by the value of a statistical life year. Finally, the total benefit is adjusted to account for the Harry Perkins Institute's contribution to the outcome (see Appendix B).

Figure 3.9: Calculating the reduced burden of disease from low dose colchicine treatment for patients with proven coronary disease



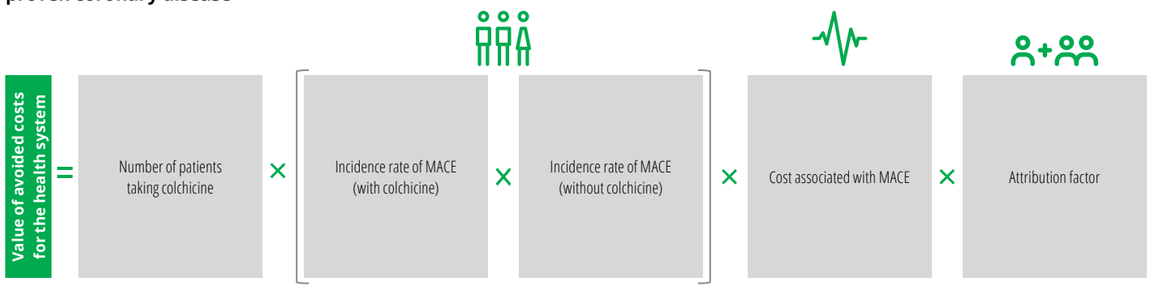
Source: Deloitte Access Economics.

3.4.2.3. Avoided costs for the health system

Avoided costs for the health system refers to the avoided costs of treatment or management for patients who experience MACE. Although such patients can require several different forms of treatment, the CBA focuses on bypass surgeries and stents due to the availability of data and research on these topics.

To calculate the avoided health care costs, the number of patients using colchicine for coronary disease is multiplied by the reduction in the incidence rate of MACE and coronary revascularisation, and this is then multiplied by the costs associated with MACE (see Figure 3.10).[66] Finally, the total benefit is adjusted to account for the Harry Perkins Institute's contribution to the outcome.

Figure 3.10: Calculating the avoided costs for the health system from low dose colchicine treatment for patients with proven coronary disease



Source: Deloitte Access Economics.

3.4.3. Cost parameters and assumptions

The costs included in the CBA are sourced from the Harry Perkins Institute and research by Deloitte Access Economics, and include the costs of conducting research into low dose colchicine and coronary disease, and the per patient treatment cost (see Figure 3.11).

Research costs were provided by the Harry Perkins Institute and reflect the total grant funding received, the GenesisCare contribution, and trail coordination and drug distribution. The research costs reflected only direct costs, and did not include the indirect costs of research. An indirect cost factor was applied to account for the indirect costs of research (see Appendix B). Finally, the cost of colchicine for each patient using the drug was publicly sourced using a private prescription price.[67]

Figure 3.11: Summary of estimated costs for using low dose colchicine for patients with proven coronary disease

Research costs	The costs of conducting research into low dose colchicine and coronary disease
Treatment costs	The cost of colchicine to patients with proven coronary disease

Source: Deloitte Access Economics.

Cardiologists Dr Mark Nidorf (Perth GenesisCare) and Professor Peter Thompson (Perth GenesisCare and Harry Perkins Institute of Medical Research) led research on the the role of low dose colchicine in preventing progression of coronary disease. Credit: Harry Perkins Institute.

Researchers at Harry Perkins Institute.
Credit: Harry Perkins Institute

3.5. Case study 3: Perron Institute – Duchenne muscular dystrophy

3.5.1. Summary of research

The Perron Institute for Neurological and Translation Science (formerly the Western Australian Neuroscience Research Institute) was the first medical research institute in WA. The Perron Institute focuses on a broad spectrum of neurological conditions, including, stroke, Parkinson's, muscular dystrophy, motor neuron disease and multiple sclerosis.

In 1961, the Perron Institute's Founding Director Emeritus Professor Byron A Kakulas found that a paralytic disease in Quokka's was due to the breakdown of muscle resulting from vitamin E deficiency – this discovery highlighted that muscles were able to regenerate. This was a momentous breakthrough since it demonstrated the potential for all muscle diseases including muscular dystrophy to be curable. This had the effect of stimulating worldwide research in the field, and these discoveries led to a treatment for sufferers of Duchenne muscular dystrophy (DMD).

The Perron Institute has developed three drugs to treat Duchenne muscular dystrophy (DMD) – a genetic disorder characterised by muscle degeneration. The FDA has granted accelerated approval to all three drugs.

3.5.1.1. Description of disease

Duchenne muscular dystrophy (DMD) is a rare (1 in 3,500-5,000 male live-born infants) genetic disorder characterised by progressive muscle degeneration and weakness due to alterations of the protein 'dystrophin'.[68,69] The muscle degeneration in DMD affects all muscles of the body; and children affected by DMD generally lose the ability to walk by 12 years of age, after which they require the use of a wheelchair. DMD primarily affects boys, and usually begins from the age of four, with an average life expectancy of between 28 and 30 years.[70]

Although there is no known cure, physical therapy, braces, and corrective surgery can help with some of the symptoms of DMD. Night-assisted ventilation was a major advancement in the treatment of DMD, for patients with weaknesses in muscles that affect breathing.

3.5.1.2. Impact of research on health care

Over nearly three decades, the Perron Institute has undertaken research that has led to the development of three drugs (see Figure 3.12) to treat DMD. The drugs are designed to treat a specific type of dystrophin gene mutation that is amenable to a specific exon skipping. An exon is a section of a gene that provides instructions for the production of proteins. Exon skipping 'skips' over faulty or misaligned sections (exons) of genetic code, allowing the creation of partially functional dystrophin, the muscle protein missing in cases of DMD.

DMD-causing mutations cause premature termination of reading, or protein translation of the dystrophin gene message, so that a functional gene product cannot be made. The three drugs are designed to redirect defective dystrophin expression to bypass or skip the disease-causing region of the gene message so that a functional gene product can be synthesised.
Each of the drugs are required to be administered once per week via an intravenous infusion that takes 35 minutesto one hour.[71]

All three drugs increase the expression of functional isoforms of dystrophin following treatment. Dystrophin is a protein that is essential in maintaining muscle fibre strength and stability. In the absence of dystrophin, muscle is susceptible to damage during normal activity, leading to loss of muscle and ultimately the ability to walk and breathe. Although the drugs are not a cure for DMD, they have the potential to lessen severe muscle weakness and atrophy caused by DMD.[72, 73, 74]

Figure 3.12: Overview of the Perron Institute's DMD drugs

	Drug 1:	Drug 2:	Drug 3:
Drug name	**EXONDYS 51 (eteplirsen)**	**VYONDYS 53 (golodirsen)**	**AMONDYS 45 (casimersen)**
Patients	Appropriate for patients amenable to exon 51 skipping (10-13 per cent of DMD patients).	Appropriate for patients amenable to exon 53 skipping (8-10 per cent of DMD patients).	Appropriate for patients amenable to exon 45 skipping (8-10 per cent of DMD patients).
FDA approval	The FDA granted EXONDYS 51 accelerated approval in 2016.	The FDA granted VYONDYS 53 accelerated approval in 2019.	The FDA granted AMONDYS 45 accelerated approval in 2021.

Source: Deloitte Access Economics.[75,76,77]

The drugs are available in the US (licensed by Sarepta Therapeutics) and have been granted accelerated approval by the FDA.[78] The FDA uses this pathway to allow the marketing of therapies that have a high likelihood of benefiting patients, based on early clinical biomarker data. As a condition of accelerated approval, the developers of a therapy are required to conduct additional clinical testing to confirm that the treatment offers confirmed benefits to patients.[79]

3.5.2. Benefits of treatment for DMD

Most treatments for DMD patients are aimed at alleviating the symptoms of the disorder and keeping a patient as healthy and active as possible, for as long as possible. Over the years, many medical therapies have been tried, with extremely few providing any improvement in a patient's ability to move and breathe.

When Exondys 51 was granted accelerated approval by the FDA in 2016, it became the first disease-modifying drug approved to treat patients with DMD.[80] This advancement, along with the subsequent approvals of Vyondys 53 and Amondys 45, have provided patients with particular types of DMD with access to approved treatments that may assist in the management and progression of their condition.

The drugs have the potential to lessen severe muscle weakness and atrophy caused by DMD, leading to improvements in walking and breathing.[81,82,83] Recent studies have shown that Exondys 51 can increase ambulation by 29.5%, while Vyondys 53 can increase ambulation by 17.0%.[84,85] Any improvement in ambulation for patients with DMD offers the potential of an improvement in quality of life.

The gains in quality of life for DMD patients who receive treatment with one of the approved drugs are not quantified in the CBA. This is because there is limited data available about patients who receive treatment with the drugs due to its approval and deployment in the US alone. Although the incidence rate of DMD is known, the proportion of patients who receive the drug in the US is unknown and difficult to estimate, especially given the high cost of treatment, which is estimated at between AUD$250,000 to AUD$500,000 per year for each patient.[86]

(L to R) Professor Steve Wilton AO (Perron Institute), Professor Sue Fletcher (Perron Institute) and former WA Governor Kerry Sanderson with Billy Elsworth, a participant in the EXONDYS 51 (etiplersen) clinical trial in the United States. Credit: Perron Institute.

3.6. Case study 4: Ear Science Institute – ClearDrum

3.6.1. Summary of research

Ear Science Institute Australia was established in 2001 as a research institute dedicated to improving the lives of people with ear and hearing disorders.

In 2019, the Ear Science Institute's research and clinical services was recognised by the World Health Organization. The Institute now acts as a world Collaborating Centre for Ear and Hearing Care.

The Ear Science Institute focuses on two areas:

- **Brain and Hearing** focuses on understanding the link between hearing and cognition to develop new treatments for hearing loss
- **Hearing Therapeutics** focuses on hearing restoration research and finding a cure for hearing loss.

In addition to its research, the Ear Science Institute currently delivers the following services:

- Provides hearing treatments through Lions Hearing Clinic and Ear Science Implant Clinic
- Coordinates the Lions Hearing Aid Bank (in conjunction with the Lions Hearing Foundation), donating hearing aids to local, national and international organisations
- Develop resources & training for Audiology students, GPs and Surgeons
- Arranges Lions Healthy Hearing Pop Ups for local community groups & events – providing free hearing checks and hearing health information
- The Lions Healthy Hearing Outback team take hearing services to the Pilbara in conjunction with Puntukurnu Aboriginal Medical Service (PAMS).

Research by the Ear Science Institute has led to the development of 'ClearDrum' to support the treatment of perforated eardrums. Perforation often occurs as a result of Chronic Middle Ear Disease (CMED), whereby an ongoing infection or persistent fluid in the middle ear creates pressure than can cause the eardrum to rupture. ClearDrum is an implantable silk membrane that can be used to repair perforated eardrums.

3.6.1.1. Description of disease

CMED is an ongoing infection or persistent fluid in the middle ear that can cause the eardrum to rupture (also known as tympanic membrane perforations). The infection can be difficult to contain, resulting in damage to the eardrum and mastoid bone with hearing loss and pain occurring within the ear.[87] The World Health Organization estimates that between 65 and 330 million people suffer from CMED, 50% of whom also suffer from hearing impairment.[88]

The current surgical procedure used for repairing perforated eardrums, tympanoplasty, usually involves making a graft from the patient's own tissue and using specialised microsurgery techniques to close the perforation.[89] Since the introduction of tympanoplasty in 1952, numerous graft materials and methods of placement have been described to reconstruct the tympanic membrane.[90] Two types of materials are commonly used:

- Fascia tympanoplasty – the repair of the tympanic membrane through the grafting of temporalis fascia
- Cartilage tympanoplasty – the repair of tympanic membrane through the grafting of cartilage.

While fascia tympanoplasty is more common, cartilage tympanoplasty has lower revision rates and higher morphological success.[91]

3.6.1.2. Impact of research on health care

The Ear Science Institute, in collaboration with Deakin University researchers, developed ClearDrum as an implantable silk membrane that can be used to repair perforated eardrums. [92]ClearDrum is implanted in the ear in a straightforward surgical procedure. Once implanted, the patient's cells grow over it, gradually repairing the eardrum as ClearDrum naturally degrades.

ClearDrum is similar in appearance and size to a contact lens; the transparent material enables ongoing monitoring of healing of the middle ear.[93] The use of ClearDrum to perform the repair of a perforated eardrum holds several benefits compared to the current traditional approach. For example, in vitro studies suggest that ClearDrum may provide superior acoustic properties to cartilage while having similar failure resistance.[94]

Additionally, unlike fascia and cartilage, ClearDrum is transparent, allowing for improved monitoring post-surgery. The use of ClearDrum for the repair of a perforated eardrum also does not involve a graft, which decreases surgical time and removes potential complications and other risks associated with grafts.

ClearDrum is still in development, with a clinical trial expected to occur in 2023, and the device expected to be commercialised and available from FY2026. In 2017, the Ear Science Institute received nearly $4 million from The Welcome Trust Translation Fund to finance human clinical trials, [95]and in 2020, the program was awarded a $993,500 grant to advance commercialisation.[96]

3.6.2. Benefit parameters and assumptions

Two benefits are quantified relating to the use of ClearDrum for the repair of perforated eardrums (see Figure 3.12). The following subsections discuss each of the benefits in more detail, along with the data inputs and assumptions used in estimating their value.

Figure 3.13: Summary of measured economic benefits from using ClearDrum for the repair of perforated eardrums

Reduced burden of disease	The value of improvement in quality of life for patients who receive ClearDrum for the treatment of perforated eardrums
Avoid costs for the health care system	The avoided costs for the health system from avoided revision surgeries

Source: Deloitte Access Economics.

3.6.2.1. General assumptions

The number of patients who receive ClearDrum is a key assumption underpinning the results of the CBA, given the treatment is in the development phase. Expected patient numbers are based on an estimate of the annual number of tympanoplasties performed in the US, which is the first major market targeted by ClearDrum.

An assumption is then applied about the size of the US market of tympanoplasties that ClearDrum will achieve, with the addition of a 'ramp-up period' to recognise that ClearDrum's market size is likely to grow over time as it gains traction in the US market. The assumed market share is capped at 10% of the US market of tympanoplasty surgeries. In reality, ClearDrum may achieve a higher market share, so a 10% cap is likely to reflect a conservative approach.

Although ClearDrum has not yet completed clinical trials, in vitro studies suggest that it may provide superior acoustic properties to cartilage with similar failure resistance (see section 3.6.1.2). As such, it is assumed that ClearDrum can generate a hearing outcome for patients that is equivalent to cartilage (likely a conservative assumption), and the rate of patients who require revision surgery is the same.

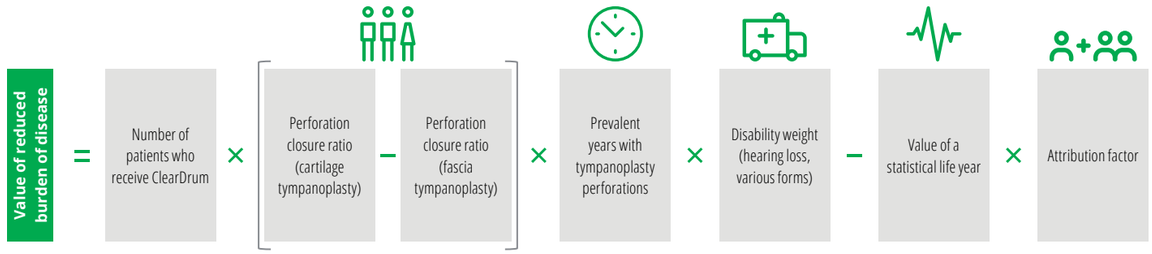
Fascia tympanoplasties, on the other hand, are associated with a less optimal hearing outcome and higher rates of revision surgeries. Fascia is the material used for the majority (69%) of tympanoplasty surgeries performed globally; therefore, 69% of the market achieved by ClearDrum is assumed to receive the benefits of an improved hearing outcome and avoided revision surgery.[97,98] Other assumptions, including the attribution of benefits to the Ear Science Institute, the value of a statistical life year, average lifespan, and disability weights are detailed in Appendix B.

3.6.2.2. Reduced burden of disease

Benefits related to a reduced burden of disease refer to the gains in quality of life experienced by patients who receive ClearDrum as part of their treatment to repair a perforated eardrum. As noted above, it is assumed that ClearDrum can generate a hearing outcome for patients that is equivalent to cartilage, which is likely conservative based on the findings of in vitro studies to date. The benefits of ClearDrum are therefore estimated in terms of an improved perforation closure ratio compared to that of fascia tympanoplasty.

The number of patients who receive ClearDrum is multiplied by the expected improvement in the perforation closure ratio compared to fascia tympanoplasty (see Figure 3.14). A conservative estimate was chosen that reflects non-complex Type 1 tympanoplasties performed on adults. This is then multiplied by the number of prevalent years for the disease,[99] and adjusted for the deterioration in quality of life caused by the symptoms of a perforated eardrum (disability weights). Finally, this is multiplied by the value of a statistical life year and the total benefit is adjusted to account for the Ear Science Institute's contribution to the outcome.

Figure 3.14: Calculating the reduced burden of disease from using ClearDrum for the repair of perforated eardrums



Source: Deloitte Access Economics.

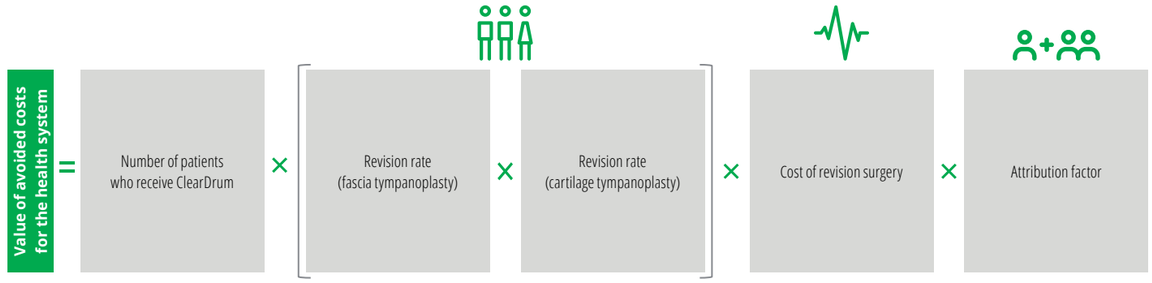
Economic value of the health and medical research sector in Western Australia

3.6.2.3. Avoided costs for the health system

Avoided costs for the health system refers to costs of treatment or management for patients who require revision surgery, which are avoided as a result of treatment with ClearDrum. As noted above, ClearDrum is assumed to have a lower revision rate compared to fascia tympanoplasty.

To calculate the avoided health care costs, the number of patients who receive ClearDrum is multiplied by the reduction in the revision rate compared to fascia tympanoplasty (see Figure 3.15). This is then multiplied by the average cost of revision surgery. Finally, the total benefit is adjusted to account for the Ear Science Institute's contribution to the outcome.

Figure 3.15: Calculating the avoided costs for the health system from using ClearDrum for the repair of perforated eardrums



Source: Deloitte Access Economics.

3.6.3. Cost parameters and assumptions

The costs included in the CBA are sourced from the Ear Science Institute and include the costs of conducting the research to develop ClearDrum, and the per patient cost of the implant and insertion (see Figure 3.16).

Research and development costs were provided by the Ear Science Institute and reflect the total grant funding received and funding contributed by the Ear Science Institute. The research costs reflected only direct costs, and did not include the indirect costs of research. An indirect cost factor was applied to account for the indirect costs of research (see Appendix B).

Figure 3.16: Summary of estimated costs for using ClearDrum for the repair of perforated eardrums

Research costs	The costs of conducting research and developing ClearDrum
Treatment costs	The cost of implantation of ClearDrum in patients

Source: Deloitte Access Economics.

Researchers working on ClearDrum trials.
Credit: Ear Science Institute

3.7. Case study 5: Lions Eye Institute – XEN Gel Stent and Virna GDD

3.7.1. Summary of research

The Lions Eye Institute is one of Australia's largest eye clinic and vision research centres. It has a focus on ophthalmological care and the prevention of blindness. The Lions Eye Institute investigates all major causes of blindness including cataracts, diabetes-related eye disease, glaucoma, retinal degenerations, corneal, and immune-based diseases.

The Lions Eye Institute was developed in 1983 with the support of the Lions Clubs of Western Australia. In 1970, the Western Australian Lions Clubs created the Lions Save Sight Foundation (WA) Inc. with the aim of leading the development of ophthalmic care.

The Lions Eye Institute employs scientists, clinicians, and support staff to conduct scientific research into blindness with known ophthalmic practices in Australia. The Institute also includes a Laser Vision Centre, Western Australia's refractive surgery centre, the Lions Eye Bank, Lions Outback Vision, Lions Optics and the Lions Save-Sight Foundation. Additionally, the Lions Eye Institute actively participates in numerous clinical trials for the development of new treatments for eye diseases, in collaboration with scientists, ophthalmologists, and pharmaceutical companies.

This report focuses on two of the Lions Eye Institute's research highlights – the development of Virna GDD and XEN Gel Stent. These two surgical innovations are developed to reduce intraocular pressure (IOP) in the eye, the biggest risk factor for glaucoma.

3.7.1.1. Description of disease

Glaucoma is a group of eye conditions characterised by damage to the optic nerve. This damage is often associated with increased pressure within the eye, known as intraocular pressure (IOP).[100] IOP is the fluid pressure of the eye. A certain level of IOP is needed for the eye to keep its shape and function normally, but if pressure gets too high, it can press on the optic nerve and increase the risk of damaging the nerve fibres. The optic nerve is responsible for carrying information from the eye to the brain, so damage can cause misty and patchy vision. If left untreated, this can lead to blindness.[101]

The most common types of glaucoma are open-angle glaucoma, and acute or chronic angle-closure glaucoma. These are characterised as follows:

- **Open-angle glaucoma** – This is the most common type of glaucoma, accounting for 90% of glaucoma cases in Australia. It is caused by a blockage of drainage canals in the eye, whereby fluid accumulation results in a gradual increase in eye pressure, which can cause damage to the optic nerve. Loss of vision occurs gradually.
- **Angle-closure glaucoma** - This occurs when the entrance to the drainage canal is either too narrow or is closed completely, and fluid is unable to be drained properly. The pressure can rise very quickly and should be treated immediately.[102]

Globally, approximately 80 million people suffer from glaucoma, with 50% of this cohort unaware that they are affected. Glaucoma is the second-leading cause of blindness worldwide (after cataracts) and is the leading cause of irreversible blindness.[103]

With glaucoma, the loss of sight is usually gradual and a considerable amount of peripheral (side) vision may be lost before there is an awareness of any problem. There is currently no cure for glaucoma, but there are treatments which can halt the loss of vision. If treated early, it is possible to slow or stop the progression of glaucoma.[104]

Many forms of glaucoma are first treated with medication, which is usually administered as eyedrops. If patients are not well managed on eye drops, surgery is the next step – traditionally a trabeculectomy or filtration surgery. Laser treatment may also be considered.[105]

Box 3: What is trabeculectomy?[106,107,108]

What is trabeculectomy?

Trabeculectomy is considered the 'gold standard' of glaucoma surgery. It aims to lower IOP by creating a pathway for aqueous fluid to drain out of the eye. When trabeculectomy is performed, a small opening is made at the top part of the wall of the eyeball (the sclera) to allow fluid to drain out in a controlled way, and into the skin around the eye (the conjunctiva).

The fluid drains into a space under the conjunctiva to form a 'drainage bleb', and once the fluid is out of the eye the pressure is reduced. The drainage bleb sits under the upper eyelid and is not visible unless a person looks down and the eyelid is lifted up at the same time.

Although an effective treatment, trabeculectomy has significant short-term risks (approximately 50% rate of perioperative complications), as well as long-term risks of failure (up to 50% at five years post-surgery).

3.7.1.2. Impact of research on health care

Glaucoma research conducted by the Lions Eye Institute has resulted in two surgical inventions – the Xen Gel Stent and the Virna Glaucoma Drainage Device (GDD). Both reduce intraocular pressure in the eye – the biggest risk factor for glaucoma.

XEN Gel Stent

The XEN Gel Stent is a surgical implant designed to lower high eye pressure in open-angle glaucoma patients where previous surgical treatment has failed and/or medications were insufficient. XEN Gel Stent is a small tube (about the length of an eyelash) that, when inserted into the eye, becomes soft and flexible.[109]

XEN Gel Stent works on the same principle as a trabeculectomy, creating a small tunnel to allow the excess fluid to drain away and lower the pressure inside the eye. The XEN Gel Stent is designed to stay in the eye permanently to create a new outflow pathway. The insertion of the XEN Gel Stent is a day surgery and takes approximately 20 minutes on average, compared to an hour with trabeculectomy.[110]

Studies comparing trabeculectomy with the XEN Gel Stent have found that:

- Trabeculectomy achieved a statistically lower mean IOP
- Trabeculectomy achieved a numerically lower failure rate
- Trabeculectomy achieved a numerically lower need for supplemental medications
- The XEN Gel Stent resulted in fewer postoperative interventions, better visual recovery, and fewer adverse events.[111]

The Xen Gel Stent was approved by the FDA in 2016 for use in primary open-angle glaucoma and pseudoexfoliative glaucoma, or for pigmentary glaucoma with open angles that are unresponsive to maximum tolerated medical therapy. It is also approved for refractory open-angle glaucoma that has failed previous surgical treatment. In Europe, the Xen Gel Stent is indicated to reduce IOP in patients with open-angle glaucoma who have failed previous medical treatments, and it has also been approved in Australia, Canada, the USA and New Zealand.[112]

VIRNA GDD

The Lions Eye Institute also developed the Virna GDD, in collaboration with a team from Universitas Indonesia. In Indonesia, trabeculectomy frequently fails and traditional GDDs are expensive. As part of her Ph.D., Dr Virna Oktariana with Professor Bill Morgan developed the Virna GDD as an affordable and easy-to-manufacture GDD that could be readily taught to and used by other surgeons.[113]

As part of the design, a focus was placed on ensuring Virna GDD was made of obtainable materials that could be manufactured locally in Indonesia, reducing the reliance of international supply chains. This supported the cost-effectiveness of the device, with Virna GDD costing approximately USD$150 in comparison to alternative devices costing approximately USD$700.[114] Considering the cost of GDD surgery in Indonesia is about USD$1,000 (excluding the cost of the device itself), the Virna GDD significantly lowers the overall cost of treatment.

Virna GDD is a silicone tube attached to a plastic plate, which acts as a soak well to drain fluid. It is implanted in the eye and drains fluid to relieve intraocular pressure. Virna GDD was approved and implemented in Indonesia in June 2019, and since then is estimated to have been implanted in more than 2,000 patients eyes. Given the success of the Virna GDD to date, there are plans to expand the device into other countries from 2024 onwards.

3.7.2. Benefit parameters and assumptions

The gains in quality of life for patients in Indonesia who receive the Virna GDD are not quantified in the CBA, given limited data on the number of patients who receive the device. However, the benefits for patients from the use of the XEN Gel Stent to treat open-angle glaucoma are quantified in the CBA (see Figure 3.17). The following subsections discuss the benefits in more detail, along with the data inputs and assumptions used in estimating their value.

3.7.2.1. General assumptions

The number of glaucoma patients who receive the XEN Gel Stent is a key assumption that underpins the results of the CBA. Global patient numbers for the period 2014 to 2022 were provided by the Lions Eye Institute and forecasts were prepared by Deloitte Access Economics based on population growth.

To estimate the number of patients receiving the XEN Gel Stent in Australia, the incidence rate of open-angle glaucoma was applied to the population of Australia. However, not all glaucoma patients require surgery, and so the estimated patient numbers were adjusted downwards by a factor to reflect those cases that would require glaucoma surgery.[115]

Figure 3.17: Summary of measured economic benefits from using XEN Gel Stent for patients with open-angle glaucoma

Reduced burden of disease	The value of improvement in quality of life for patients who receive XEN Gel Stent for the treatment of glaucoma

Source: Deloitte Access Economics.

Economic value of the health and medical research sector in Western Australia

Furthermore, not all patients who receive the XEN Gel Stent achieve a long-term reduction in IOP. Studies have shown that while the XEN Gel Stent results in fewer postoperative interventions, better visual recovery, and fewer adverse events compared to trabeculectomy, it is associated with an average 2-year failure rate of 40%.[116] Therefore, the number of patients who receive a long-term reduction in IOP and increased quality of life is adjusted to account for those patients for which the XEN Gel Stent may not provide long-term results.

Other assumptions, including the attribution of benefits to the Lions Eye Institute, the value of a statistical life year, average lifespan, and disability weights are detailed in Appendix B.

3.7.2.2. Reduced burden of disease

Reduced burden of disease refers to the gains in quality of life experienced by glaucoma patients who receive the XEN Gel Stent. The XEN Gel Stent is designed to decrease IOP for open-angle glaucoma patients, and therefore will reduce the complications and symptoms associated with glaucoma, which include vision loss.

The number of patients who receive the XEN Gel Stent is multiplied by the prevalent years for the disease, which is the difference between life expectancy and the average age of glaucoma surgery (see Figure 3.18). This is multiplied by the value of a statistical life year, adjusted for the deterioration in quality of life caused by glaucoma (using a disability weight). This is further multiplied by an assumed reduction in the burden of disease, assumed to be equal to the average reduction in IOP achieved by the device.[117] Finally, the total benefit is adjusted to account for the Lions Eye Institute's contribution to the outcome.

Figure 3.18: Calculating the reduced burden of disease from XEN Gel Stent for patients with open-angle glaucoma

Source: Deloitte Access Economics.

Figure 3.19: Summary of estimated costs for using XEN Gel Stent for patients with open-angle glaucoma

Research costs	The costs of conducting research and developing XEN Gel Stent
Treatment costs	The cost of implantation of XEN Gel Stent in patients

Source: Deloitte Access Economics.

3.7.3 Cost parameters and assumptions

The costs included in the CBA are sourced from the Lions Eye Institute and research by Deloitte Access Economics, and include the costs of the research and development associated with the XEN Gel Stent, and the cost of implantation of XEN Gel Stent (see Figure 3.19).

Research and development costs were provided by the Lions Eye Institute and reflect the total grant funding received. The research costs reflected only direct costs, and did not include the indirect costs of research. An indirect cost factor was applied to account for the indirect costs of research (see Appendix B). The costs of the XEN Gel Stent (including insertion) for each patient was publicly sourced.[118]

A researcher at Harry Perkins Institute. Credit: Harry Perkins Institute.

3.8. Case study 6: Institute for Respiratory Health – Pleural disease

3.8.1. Summary of research

The Institute for Respiratory Health is a WA medical research institute dedicated specifically to investigating respiratory disease. Having been in operation for more than 20 years, it is one of the two most active research institutions in the whole of Australia focusing on respiratory health.

The Institute for Respiratory Health conducts and fosters basic and clinical research programs designed to improve our understanding of respiratory diseases in order to improve their diagnosis and management. The Institute for Respiratory Health is also involved with the translation of these improved treatments to clinical practice, and advocating for an increased awareness of and investment in respiratory education and research.

Over the course of its history, the Institute for Respiratory Health has contributed to breakthroughs in several areas:

- **Stem cell therapy:** the Institute's researchers have demonstrated that a type of cell associated with the placenta, may help in reducing, or even repairing, injury and scarring in human lungs, with profound implications for people with chronic lung diseases.
- **Cancer:** the Institute's clinicians helped develop a new, non-invasive treatment for pleural effusions – a fluid build-up in the chest caused by many cancers.
- **Growing new lung tissue:** the Institute's scientists have helped investigate new ways to grow lung tissue and examine molecular and cellular cues that drive regenerative lung growth.
- **Asthma and allergy:** the Institute's researchers have identified 10 different genetic variants that increase the risk of developing allergies, such as asthma.

This study explores research conducted by the Institute for Respiratory Health into the treatment of pleural disease – a disease that affects 60,000 people each year in Australia.[119]

3.8.1.1. Description of disease

The pleura are two thin membranes which cover the chest cavity and the lungs that enable the lungs to expand and contract correctly during breathing. There is little space between them but many diseases, especially cancer and respiratory infection, can cause fluid to accumulate within this space (the pleural cavity), causing major breathing difficulties.

'Pleural effusion' refers to a build-up of fluid in the pleural cavity. When there is an inflammation of the pleural cavity due to an infection, it is referred to as a pleural infection.

Pleural infections affect 1 million people each year globally,[120] with more than 30% either dying or requiring surgery.[121] Pleural infection most commonly affects older adults, and presents with symptoms such as fever, cough, chest pain, breathlessness, and the build-up of infected fluid in the pleural cavity.[122] It is often a complication caused by another illness, such as pneumonia, and has a mortality rate of up to 20%.[123]

Malignant pleural effusions (MPE) are often complications experienced by cancer patients and occur when malignant cells accumulate in the pleural cavity. It is estimated that almost 15% of all patients with cancer develop MPE,[124] which is associated with a mortality rate of 74% in the first year.[125]

Treatments for pleural disease were first described by Hippocrates in Ancient Greece,[126] and draining infected fluid from the pleural cavity has since been the cornerstone of all clinical treatment.[127] However, in some cases, the viscosity of the pleural fluid and other complications can make drainage difficult, leaving surgery as the primary recourse.[128] Given that there are significant risks and costs associated with the required surgery,[129] there has been a need for less invasive approaches.

Despite the prevalence of pleural disease, pleural medicine has attracted limited attention in medical research, leading to a lack of high-quality research that can inform standardised care and practice around the world.[130] However, recent studies, including large-scale randomised trials, have led to significant strides in the understanding of pleural disease, and an expansion in treatment options.

3.8.1.2. Impact of research on health care

The Institute for Respiratory Health runs several research units aimed at furthering the understanding of respiratory illnesses. One of these groups is the Pleural Medicine Group led by Professor Gary Lee, which focuses on translational research in common pleural diseases, especially cancer and infection.

Research from this unit has directly impacted clinical practice around the world and helped reduce patient mortality and morbidity from pleural disease.

Multi-centre trials run by Professor Lee have helped to identify and optimise the use of indwelling pleural catheters (IPCs) for MPE patients. IPCs help improve quality of life for cancer patients with MPE,[131] relieving common symptoms such as difficulty breathing and significantly reducing the number of days spent in hospital.[132]

Research from Professor Lee's team at the Institute for Respiratory Health has also pioneered the use of intrapleural tPA/DNAse therapy, for pleural infections where infected pleural fluid is difficult to drain using conventional methods. This treatment cures between 90 to 96% of all patients, sparing 20% from surgery, and on average, saves a patient up to 6.7 days in hospital.[133] This constitutes a significant improvement for patients for whom standard therapy – usually antibiotics and tube drainage – has failed, as it reduces the risk of complications such as sepsis and the need for surgery.[134]

The avoided mortality and morbidity costs from utilising tPA/DNAse to treat certain cases of pleural infection are estimated quantitatively in this analysis.

3.8.2. Benefit parameters and assumptions

Two benefits are quantified relating to the use of tPA/DNAse for the treatment of pleural infection (see Figure 3.20). The following subsections discuss each of the benefits in more detail, along with the data inputs and assumptions used in estimating their value.

Figure 3.20: Summary of measured economic benefits from using tPA/DNAse to treat pleural infection

Reduced mortality	The value of lives saved, or deaths avoided, from the use of tPA/DNAse to treat a subset of patients suffering from pleural infection
Avoided costs for the health care system	The avoided costs for the health system from a reduced length of stay and fewer procedures in hospital for patients suffering from pleural infection

Source: Deloitte Access Economics.

3.8.2.1. General assumptions

The number of patients treated using tPA/DNAse for pleural infection is a key assumption underpinning the results of the CBA. This is estimated using the incidence rate of pleural infection,[135] and adjusted for the proportion of patients that would likely receive tPA/DNAse treatment.[136] This accounts for the fact that tPA/DNAse would primarily be used in cases that do not respond to conventional treatment. In addition, the number of patients treated globally is adjusted to account for limited access to healthcare services in developing countries.

Like colchicine treatment for cardiovascular events (see Case Study 2 in section 3.4), tPA/DNAse is a relatively new treatment, meaning the CBA assumes that it has not been fully adopted into standardised practice. This is based on research estimating the time required for new clinical treatments and drugs to be 'fully adopted' in Australia.[137] Other assumptions, including the attribution of benefits to the Institute for Respiratory Health, the value of a statistical life year and average lifespan are detailed in Appendix B.

3.8.2.2. Reduced mortality

Reduced mortality refer to the benefits derived for society through avoided loss of life. Pleural infection is generally associated with a mortality rate of up to 20%.[138] Treatment with tPA/DNAse, using conservative assumptions, results in a cure rate of 90%.[139] This means that the estimated reduction in mortality equates to 10% of all patients.

However, pleural infection is associated with several comorbidities; it is often a complication arising from diseases such as pneumonia, cancer, or heart disease. On average, as many as 30% of people with pleural infection could have heart disease or a history of cancer, but this increases to almost 60% for high-risk patients.[140] This means that despite successful treatment of pleural infection with tPA/DNAse, the number of additional life-years experienced by patients may not reflect average life expectancy.

To account for this, mortality benefits are estimated for two groups of patients – those with additional complications and those without. Those with additional complications are assumed to have a lower life expectancy of 5 years, and the total benefit derived from their gain in additional life years is adjusted for the disability weight of the most common recorded comorbidity.

These values are obtained from a study which assesses the short-term mortality risk for patients with pleural infection, controlling for various comorbidities and other risk factors. Findings suggest that on average, approximately 43% of patients die early from complications following successful treatment for pleural infection, and heart disease is reported as the most common comorbidity.[141]

Figure 3.21: Calculating the reduced mortality from tPA/DNAse treatment for pleural infection

Source: Deloitte Access Economics.

Multiplying the number of patients eligible to receive tPA/DNAse as a treatment by the 10% estimated reduction in mortality provides the number of patients saved. This is adjusted for the number of patients likely to experience complications, and then multiplied by the number of years added, on average to the patient's life (see Figure 3.21). This is then multiplied by the value of a statistical life-year, and adjusted to account for the disability weight of the most common comorbidity experienced by pleural patients.

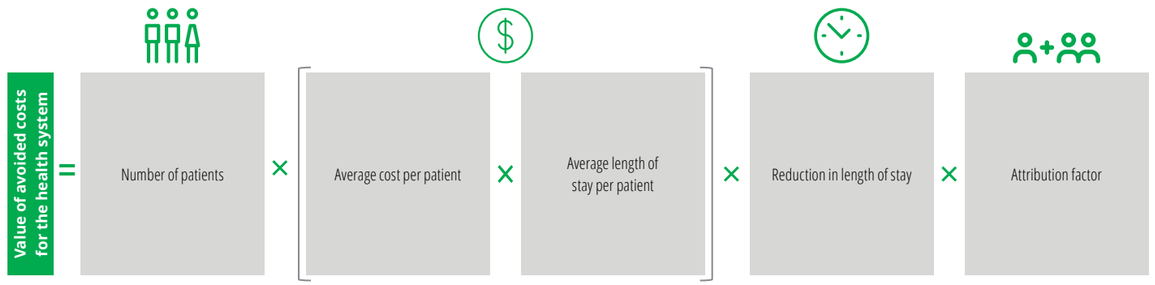
For patients without complications, the number of patients without a comorbidity is multiplied by the number of years added to the patient's life, on average, and then the value of a statistical life year. The sum of the benefits from these two groups provides the total reduced mortality benefits for patients that receive tPA/DNAse treatment. Finally, the total benefit is adjusted to account for the Institute for Respiratory Health's contribution to the outcome.

3.8.2.3. Avoided costs for the health system

Avoided costs for the health system refers to reductions in the cost of treatment as a result of research conducted by the Institute for Respiratory Health. In this case, cost savings for the health system are provided due to a reduction in the average length of stay for patients treated with tPA/DNAse. Treating pleural infections with tPA/DNAse reduces the need for invasive surgery, and therefore the length of hospital stay, on average, by 6.7 days.[142]

The value of avoided costs is calculated by multiplying the reduction in hospital days by the average cost per day of an admitted patient to the health system (see Figure 3.22). The total benefit is then adjusted to account for the Institute for Respiratory Health's contribution to the outcome.

Figure 3.22: Calculating avoided costs for the health system due to tPA/DNAse treatment



Source: Deloitte Access Economics.

3.8.3. Cost parameters and assumptions

The costs included in the CBA are sourced from the Institute for Respiratory Health and research by Deloitte Access Economics and include the costs of conducting the research to identify and assess the efficacy of tPA/DNAse, and the per patient treatment cost (see Figure 3.23).

Research costs were provided by the Institute for Respiratory Health and reflect the total grant funding received for relevant research projects run by the Institute's Pleural Medicine Group led by Professor Gary Lee. The research costs reflected only direct costs, and did not include the indirect costs of research. An indirect cost factor was applied to account for the indirect costs of research (see Appendix B).

Notably, tPA/DNAse treatment utilises two items that are already available to healthcare professionals, and as such, the research does not necessitate the development of a new drug. The cost associated with treatment was sourced publicly.[143] Treatment costs constitute the majority of total costs considered in the analysis. This is because, apart from research, there was limited investment required to develop the treatment, as both tPA and DNAse were readily accessible to clinical professionals.

Figure 3.23: Summary of estimated costs for using tPA/DNAse as treatment for pleural infection

Research costs	The costs of conducting research to assess the suitability of tPA/DNAse to treat patients with pleural infection
Treatment costs	The cost of delivering the tPA/DNAse to patients with pleural infection

Source: Deloitte Access Economics.

Lions Outback Vision in WA's Kimberley region. Credit: Lions Eye Institute.

3.9. Case study 7: The Marshall Centre for Infectious Diseases – Helicobacter Pylori

3.9.1. Summary of research

Barry Marshall is a Western Australian physician and researcher who is best known for his work on the bacterium Helicobacter pylori (*H. pylori*) and its role in causing peptic ulcers and gastritis. In the 1980s, the prevailing medical belief was that stress and excess stomach acid were the primary causes of these conditions. However, Marshall, along with his colleague Robin Warren, provided evidence that changed this view.

To prove his theory, Marshall conducted a self-experiment in 1984 by drinking a culture of *H. pylori*, ultimately developing gastritis and then successfully treating it with antibiotics.

Marshall's work has had a profound impact on medical research and practice, as it not only revolutionized our understanding of gastrointestinal diseases but also led to the development of more effective treatments, contributing to a decline in the prevalence of peptic ulcers and related complications worldwide. His research also earned him the Nobel Prize in Physiology or Medicine in 2005. The Marshall Centre was founded in 2007 at the University of Western Australia to celebrate the awarding of the Nobel Prize in Physiology or Medicine to Professor Barry Marshall and Emeritus Professor Robin Warren.

This analysis considers the economic return on investment into Marshall and Warren's research into the bacterium *H. pylori*.

3.9.1.1. Description of disease

H. pylori is a type of bacteria that can inhabit the stomach lining. It is commonly associated with chronic gastritis, but can also progress to more severe illnesses, such as peptic ulcer disease (PUD) and stomach cancer.[144] Left untreated, *H. pylori* infections can persist for life.[145]

PUD is a condition characterised by open sores or ulcers that form on the inner lining of the stomach (gastric ulcers), or the upper part of the small intestine (duodenal ulcers). Prior to the discovery of helicobacter pylori, it was widely believed that peptic ulcers were primarily caused by stress and diet. However, it has since been established that over 90% of duodenal ulcers and 80% of gastric ulcers are caused by *H. pylori*.[146]

H. pylori is also a major risk factor for stomach cancer, specifically gastric adenocarcinoma.[147] The bacterium can induce chronic inflammation in the stomach lining, which is believed to lead to cellular damage and potentially cancerous changes over time.[148] Findings from recent studies suggest that people infected with *H. pylori* are six times as likely to develop stomach cancer as those not infected with the bacterium.[149]

While *H. pylori* is estimated to infect approximately half the world's population,[150] not everyone infected with the bacterium is likely to present with symptoms.[151] For example, only 5% to 10% of infected patients develop PUD,[152] and it is estimated that only 1% to 3% develop stomach cancer.[153] However, both diseases carry significant morbidity and mortality risks, with the 5-year survival rates for stomach cancer estimated at 68% on average, and decreasing to just 39% for Stage 3 patients.[154]

The discovery of *H. pylori* has constituted a paradigm shift in the treatment of gastric illness, and the provision of quality treatment to infected patients has led to a fast decline in infections, especially in Western countries.[155]

3.9.1.2. Impact of research on health care

Professor Barry Marshall and Emeritus Professor Robin Warren discovered *H. pylori* in the early 1980s and were awarded the Nobel Prize in Medicine in 2005 for their research.[156] Their research challenged conventional medical wisdom and proposed that *H. pylori* infection was the primary cause of peptic ulcers. This constituted a significant paradigm shift in gastroenterology, as it provided a clear link between a bacterial infection and a chronic digestive disorder.

Initially, their findings were met with scepticism and criticism, leading to a significant time lag between their discovery and its translation to clinical practice.[157] However, as consequent research further solidified the link between *H. pylori* and PUD and other gastric illnesses, *H. pylori* quickly grew into one of the most researched pathogens at the turn of the millennium.[158] Today, the term *H. pylori*' is associated with over 50,000 medical research publications.[159]

Marshall and Warren's research has contributed directly to the improved treatment of patients with illnesses such as PUD and gastritis. For example, patients with PUD now receive treatment to eradicate *H. pylori* – usually through a course of antibiotics – instead of treatment designed to alleviate PUD symptoms. This has led to significant health care improvements, whereby PUD has since changed in status as a chronic disease to a one-off condition.[160] Additionally, further research into the link between *H. pylori* and stomach cancers has helped develop strategies for the early detection and prevention of stomach cancer.

Since the 1990s, the prevalence of *H. pylori* in Australia has declined from nearly 40% to just 15% in 2002.[161] However, prevalence rates for *H. pylori* globally remain as high as 50%, and gastric cancer remains the fifth most common cancer globally[162] and the fourth leading cause of cancer deaths worldwide.[163] As such, there is likely still potential to replicate Australian successes in treating *H. pylori* on a global scale.

3.9.2. Benefit parameters and assumptions

Two benefits are quantified relating to the impact of the discovery of *H. pylori* and its role in causing peptic ulcers and gastritis (see Figure 3.24). The following subsections discuss each benefits in more detail, along with the data inputs and assumptions used in estimating their value.

Figure 3.24: Summary of measured economic benefits from the discovery of *H. pylori*

Reduced burden of disease	The value of improvement in quality of life for patients with peptic ulcer disease (PUD) after receiving treatment to eradicate *H. pylori*
Reduced mortality	The value of lives saved, or deaths avoided, from the eradication of *H. pylori* in the population and associated reduced incidence of stomach cancer

Source: Deloitte Access Economics.

3.9.2.1. General assumptions

The number of patients that received treatment for the eradication of *H. pylori* is a key assumption underpinning the results of the CBA. This is estimated using the prevalence of *H. pylori* in Australia and worldwide, and adjusted for the proportion of people that present with severe symptoms, such as those associated with PUD. This assumption is made as the standard treatment for PUD for patients with *H. pylori* prevalence is to eradicate *H. pylori* using antibiotics.[164]

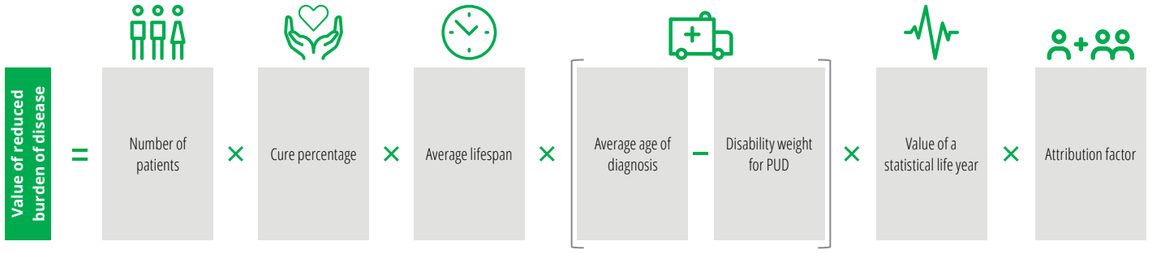
Only new patients for every year are considered to avoid double-counting people affected by the disease. In addition, the number of patients treated globally is adjusted to account for limited access to healthcare services in developing countries. Other assumptions, including the attribution of benefits to Professor Marshall's research, the value of a statistical life year and average lifespan are detailed in Appendix B.

3.9.2.2. Reduced burden of disease

Benefits from reduced burden of disease refer to the gains in quality of life experienced by PUD patients due to more effective treatment. In the case of PUD, the discovery of the link between stomach ulcers and *H. pylori* revolutionised treatment and enabled the eradication of the bacteria, and hence made it possible to cure PUD. The eradication of *H. pylori* using antibiotics is effective in curing PUD in approximately 70% of all cases,[165] and has contributed to significant improvement in clinical outcomes for PUD patients.

For the calculation of benefits, it is assumed that all patients with PUD are able to access treatment for the disease in Australia, and that it is diagnosed, on average, at 50 years of age.[166] The number of prevalent years lived with PUD – which can be chronic and is listed as a disability condition by the Australian Bureau of Statistics – is significant, as it can last for life if left untreated.[167]

Figure 3.25: Calculating the reduced burden of disease from improved treatment for PUD patients



Source: Deloitte Access Economics.

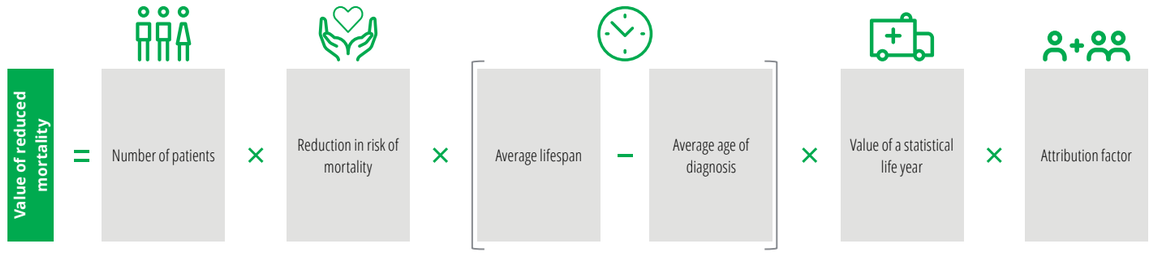
The total number of patients affected is multiplied by the prevalent years of the disease (see Figure 3.25). This is then multiplied by the value of a statistical life year adjusted for the deterioration in quality of life caused by the symptoms of PUD (using a disability weight). Finally, the total benefit is adjusted to account for the contribution of Professor Marshall's research to the outcome.

3.9.2.3. Reduced mortality

Treatment for PUD involves the eradication of *H. pylori* in patients, which is also linked to reduced incidence of stomach cancer later in life. Patients who receive effective treatment for *H. pylori* experience a 62% reduction in the risk of mortality from stomach cancer.[168] A reduction in mortality leads to patients enjoying additional years of life, relative to what they would have experienced otherwise. This forms the basis of quantification for this benefit. Importantly, this benefit is only applied to patients that have received treatment for PUD, which is calculated in line with the assumptions detailed in section 3.9.2.1.

To estimate the number of patients that would likely experience reduced mortality, the number of patients that receive treatment for PUD in any given year is adjusted for the proportion that would likely develop stomach cancer at some point in the future. This represents approximately 1-3% of patients that receive treatment for PUD.[169]

Figure 3.26: Calculating the value of reduced mortality from the prevention of stomach cancer incidence



Source: Deloitte Access Economics.

The calculated number of patients is multiplied by the percentage reduction in mortality risk and the value of a statistical life year to obtain the expected value of one additional life-year gained (see Figure 3.26). This value is then multiplied by the number of additional life-years gained by affected patients to estimate the total benefit. Finally, the total benefit is adjusted to account for the contribution of Professor Marshall's research to the outcome.

3.9.3. Cost parameters and assumptions

The costs included in the CBA are sourced from The Marshall Centre for Infectious Diseases (TMCID) and research by Deloitte Access Economics, and include the costs of conducting the research to identify and prove the link between *H. pylori* and PUD, and the per patient treatment cost to eradicate *H. pylori* (see Figure 3.27).

Figure 3.27: Summary of estimated costs to enable *H. pylori* eradication

Research costs	The costs of conducting research used to link *H. pylori* infections to peptic ulcer disease
Treatment costs	The costs of delivering the treatment for *H. pylori* (antibiotics to eradicate the bacteria) to patients with peptic ulcer disease

Source: Deloitte Access Economics.

Research costs were provided by TMCID and reflect the total grant funding received for relevant research projects run by Professor Marshall and Emeritus Professor Warren to identify and prove the link between *H. pylori* and PUD. The research costs reflected only direct costs, and did not include the indirect costs of research. An indirect cost factor was applied to account for the indirect costs of research (see Appendix B).

Notably, the treatment for the eradication of *H. pylori* utilises widely available medication. As such, there were no costs associated with the development of a new drug. The standard treatment for *H. pylori* eradication is assumed to be proton pump inhibitor **(PPI)** based triple therapy, which includes two types of antibiotics. [170]

The per patient costs of this treatment are publicly sourced, using the private prescription price of the standard treatment.[171] Treatment costs constitute the majority of total costs considered in this analysis. This is because apart from research, there was limited investment required to develop the treatment.

Lions Outback Vision in WA's Kimberley region. Credit: Lions Eye Institute

3.10. Case study 8: Fiona Wood Foundation – Spray-on skin

3.10.1. Summary of research

The Fiona Wood Foundation is a research organisation in WA, founded by Professor Fiona Wood, a renowned plastic and reconstructive surgeon. The foundation is dedicated to advancing the treatment and understanding of burn injuries, particularly in the areas of burns, trauma, and wound healing.

The Fiona Wood Foundation conducts research into burn injuries and related areas, seeking to develop innovative treatments, technologies, and approaches to improve outcomes for burn patients. It is also involved in improving education and awareness for burns first aid and emergency management.

One of the notable achievements associated with the Fiona Wood Foundation is the development of the "spray-on skin" technique, known as ReCell, which is used in the treatment of burn injuries. This innovation allows for faster and more effective healing of burn wounds. The economic return on investment and research used to develop ReCell is explored in this case study.

3.10.1.1. Description of disease

Spray-on skin, also known as autologous cell suspension or cell-spray grafting, is a medical technique used for the treatment of burn injuries. It involves the isolation and expansion of a patient's own healthy skin cells (keratinocytes and melanocytes), which are then suspended in a solution. These cultured cells are sprayed directly onto burn wounds, creating a thin, protective layer that promotes wound healing and regeneration. The primary goal of this technique is to accelerate the healing process, minimize pain and scarring, and reduce the risk of infection associated with burn injuries.

Spray-on skin has become an essential component of modern burn care, offering a versatile and adaptable method for addressing a wide range of burn injuries, from minor to extensive. This technique allows for customised and efficient wound coverage,[172] is less invasive compared to traditional grafting methods, and minimises the need for donor site grafts, which can cause additional complications.[173]

3.10.1.2. Impact of research on health care

Professor Fiona Wood is credited with the invention of 'spray-on skin', having pioneered this method of skin grafting for burns patients in the early 1990s. However, due to a lack of clinical trials demonstrating its comparative advantages over conventional methods, it was initially received with some scepticism.[174]

This changed following the Bali bombings in October 2002, when the largest portion of survivors arrived at Royal Perth Hospital to be treated by Professor Wood and her team. The team worked around the clock to save 28 patients suffering from between 2% and 92% body burns, deadly infections, and delayed shock. This crisis response shone a spotlight on the model of care for burns, which included the use of 'spray-on-skin'.

Professor Wood had further developed the technology, enabling clinical practitioners to harvest skin cells from burn victims that could be directly applied to burn wounds without cultivation in a laboratory. The cells can be applied to burn wounds as spray-on skin cells. This technology has been commercialised by Avita Medical as ReCell, and in 2018 received FDA approval in the United States for clinical use.[175] To date, ReCell has been used to treat over 15,000 people around the world with thermal burn injuries.[176]

A primary benefit of ReCell is that it uses non-cultured cells, meaning that it avoids the long laboratory time (typically several weeks) required to culture skin grafts grown from a patient's own skin cells.[177] Instead, it provides a kit that allows burn surgeons to complete the process in under 30 minutes without any laboratory staff or support.[178] Additionally, because it requires a significantly smaller donor site for the skin graft (which can be 40 times smaller than for conventional treatment [179]), it is also associated with reduced length of stay in hospitals,[180] and lower levels of post-operative pain.

The ReCell system pioneered by research from Professor Wood has led to cheaper, less invasive, and more efficient treatment for burn victims, without compromising on the quality of care delivered by more conventional skin grafting methods.[181]

This analysis quantifies the economic benefits of reduced burns treatment costs associated with ReCell. While there are other benefits that are realised through the use of ReCell for burns patients, these are challenging to quantify in a CBA framework. These include, as mentioned above, lower levels of post-operative pain and improved appearance at the donor site,[182] which are difficult to measure in economic terms. Nevertheless, these benefits contribute greatly to improving patient outcomes and overall patient experience.

3.10.2. Benefit parameters and assumptions

The primary benefits quantified are the avoided costs for the health system from the use of ReCell for the treatment of severe burns compared to traditional treatment methods (see Figure 3.28). This results from a reduction in the average length of hospital stay and the number of surgical procedures required to achieve 'closure', or completion of care.[183]

Figure 3.28: Summary of estimated benefits from ReCell

Avoided costs for the health system	The avoided costs for the health system from a reduced length of stay and fewer procedures in hospital for burns patients

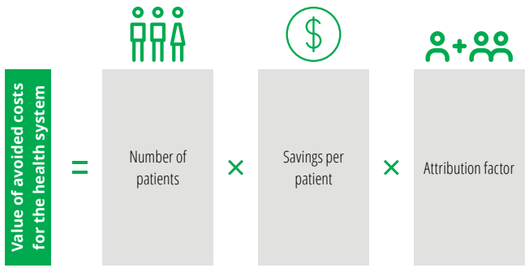
Source: Deloitte Access Economics.

ReCell requires a significantly smaller donor site for the skin graft (see section 3.10.1.2). This drives a significant portion of overall cost savings and becomes increasingly important as the size of the burn wound increases.[184] The following subsection discusses the benefits in more detail, along with the data inputs and assumptions used in estimating their value.

3.10.2.1. Avoided costs for the health system

Avoided costs for the health system arise because the ReCell system presents a more cost and time efficient alternative to traditional burn treatment methods. Reducing patient length of stay at a hospital alleviates hospital capacity to enable treatment of other patients, and allows for time and resources to be spent in other areas, improving the overall quality of care provided for patients.

Figure 3.29: Calculating the avoided costs for the health system from the use of ReCell to treat burn injuries



Source: Deloitte Access Economics.

Using ReCell as an alternative to conventional treatment for burns care is estimated to reduce total annual operating costs by 14% to 17% at burns treatment centres, or by approximately $19,000 to $32,000 per patient for patients with burns up to 30% of total body surface area (TBSA).[185] For patients with burns in excess of 40% of TBSA, total savings per patient could be up to $172,000.[186] These estimated cost savings are calculated based on available literature and are adjusted for variations in cost across various levels of severity and type of burn injury.

The total number of patients that have used ReCell is obtained from public reports made available by Avita Medical, and forecasted based on historical trends. This value is multiplied by the estimated cost savings per patient from using ReCell to calculate the total avoided costs for the health system (see Figure 3.29). Finally, the total benefit is adjusted to account for the contribution of Professor Wood's research to the outcome.

Economic value of the health and medical research sector in Western Australia

3.10.3. Cost parameters and assumptions

The costs included in the CBA are sourced from the Fiona Wood Foundation and research by Deloitte Access Economics, and include the costs of conducting the research to develop the ReCell system and prove its efficacy for clinical use, and commercialisation (see Figure 3.30).

Because the incremental change in delivery costs for ReCell relative to conventional treatment for burn wounds constitutes an overall saving for the health system, only research costs are considered. However, the research costs do not include the indirect costs of research. An indirect cost factor was applied to account for the indirect costs of research (see Appendix B).

Figure 3.30: Summary of estimated costs for ReCell

Research costs	The costs of conducting research used to develop the ReCell system and substantiate its efficacy for clinical use

Source: Deloitte Access Economics.

4. Flow-on economic impacts of medical research

This chapter defines the health and medical research sector's impact in generating economic growth in WA over time, with economic output and total employment higher due to the outcomes generated by research. The analysis focuses on the same eight high-impact research programs considered in Chapter 3. The economic impacts reflect the productivity benefits from a larger and healthier workforce.

4.1. Estimating the flow-on economic impacts of medical research

4.1.1. Summary

As discussed in section 1.3, three separate approaches to valuing economic benefits are used in this study to describe the value generated by the medical research sector in WA. The final approach detailed in this section involves economic impact analysis, which uses computable general equilibrium (CGE) modelling.

Chapter 2 outlines the economic contribution (or footprint) of the medical research sector to WA, based on a point in time, and has a focus on measuring the importance of the sector through the WA supply chain through input-output (IO) analysis.

Chapter 3 outlines the net economic return from the eight case study medical research programs in WA through time, using a CBA framework. The CBA measure of welfare (or the net societal benefits) associated with the research programs measures the extent to which society is better off because of the translation of findings from medical research.

The CGE measure is different to both CBA and IO-based analysis, as it measures the economic impact of the research programs through time in terms of the changes they cause to various macroeconomic (economy-wide) variables, including Gross State Product (or GSP), a measure of state economic output).

The economy-wide lens provided by CGE analysis is valuable alongside the CBA (chapter 3) and economic contribution analysis (chapter 2), given that the primary outcomes of medical research are related to gains in health and wellbeing that allow people to live longer and enjoy a better quality of life. In a macroeconomic context, such outcomes enable a larger number of individuals to participate in the workforce, and to do so more productively. This is a valuable economic driver, which helps to improve aggregate economic output.

The CGE model measures the extent to which medical research spurs a range of secondary, 'flow-on' impacts to the economy by affecting the size and productivity of the labour force.

4.1.2. CGE modelling

The flow-on economic impacts of a larger and healthier population resulting from advances in WA medical research are estimated using Deloitte Access Economics' in-house CGE model (DAE-RGEM). Further details about the modelling approach are provided in Appendix C.

As noted above, the CGE analysis focuses on how medical research outcomes have impacted WA and Australia's labour force, and in turn, how that has influenced state and national economic growth to date – and into the future. The economic impacts are expressed in terms of increases to GSP and gross domestic product (GDP) for WA and Australia, and are a result of two main effects:

- Reduced mortality, which has enabled people to remain active in the workforce for longer than would otherwise be the case.
- Reduced burden of disease, which has enabled greater workplace productivity and economic participation.

The economic impact of WA medical research is estimated for WA and for Australia, focused on the same eight high-impact case studies considered as part of the CBA in chapter 3. The results of the CGE analysis are presented on a similar basis to the CBA, relative to a counter-factual scenario (or base case) where these high-impact research programs were not conducted.

The modelling was undertaken for a historical period and a future period reflecting the benefits profile obtained from the CBA module of this study for the identified case studies. This ranges from the first year of benefits recorded in the CBA module in 1986 to 20 years into the future to 2045. This period is referred to as the evaluation period. The results are reported below according to two components – impacts to date and expected impacts into the future.

4.2. Summary of modelling approach

4.2.1. Policy scenario and base case

CGE models estimate economic impacts by comparing a 'policy scenario' against a 'base case'. The base case is identical to the CBA, in that is assumes no such breakthroughs would have been achieved in the absence of the WA medical research effort.

The policy scenario is developed by applying changes (known as 'shocks') to the baseline scenario, which reflect the nature of an intervention or disruption. In this case, the policy intervention refers to the impact of the identified eight, high-impact research programs on the respective Australian and WA labour force.

4.2.2. Defining the economic 'shock'

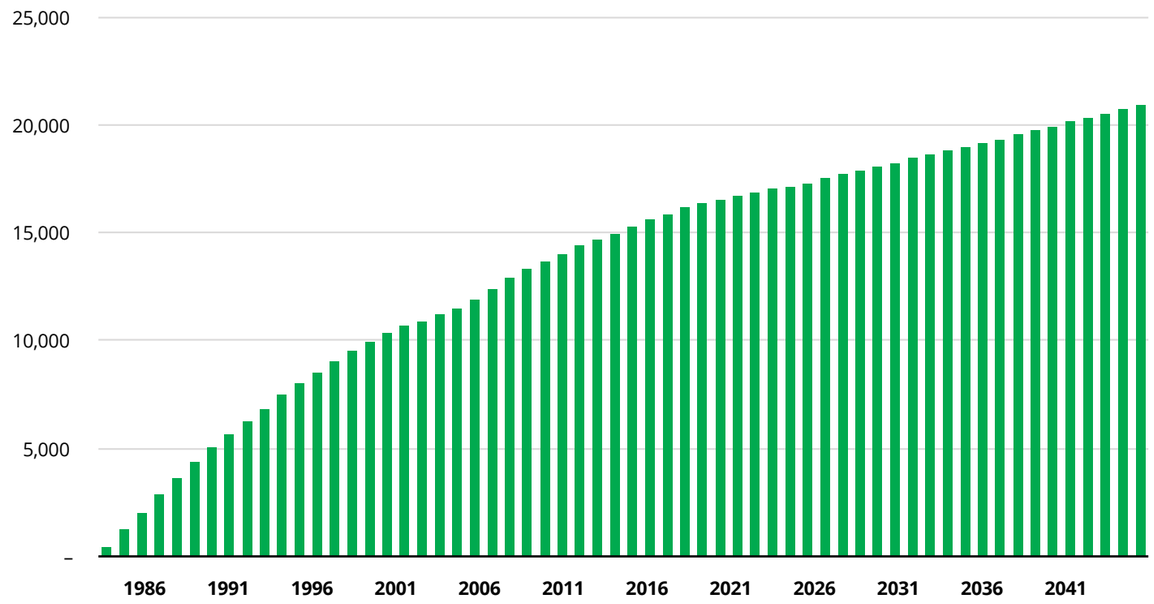
The modelling shock in this study relates to the increased size of the labour force relative to the base case, which is enabled via the program outcomes in keeping people healthy and economically active. Over the period of analysis, WA medical research is estimated to add, on average, 13,500 FTEs to the Australian labour force each year, with an average of 1,500 FTEs added each year in WA. The increase in labour supply is directly correlated with the number of patients benefitting from the health outcomes of WA medical research, and as such, grows over time.

For example, by 2023, the number of FTEs added to Australian labour supply is approximately 17,000, and by 2045, it is estimated that more than 20,000 FTEs are available than would otherwise be the case, in the absence of treatment enabled via the research outcomes (see Chart 4.1). This includes the uplift in labour supply from reduced rates of mortality and from increased economic participation by patients benefitting from a reduced burden of disease.

Importantly, only a subset of patients that receive treatment are included in the labour supply shock. This reflects the average ages of patients treated by the identified programs, which are skewed towards older populations. Older populations are typically associated with lower rates of labour force participation and are more likely to exit the labour force over the evaluation period than younger cohorts. These dynamics are accounted for in the calculation of the labour supply shock, which is, as a result, significantly lower than the number of patients treated in any given year (see Appendix C for more details).

Additionally, higher labour productivity is also assumed for a subset of patients that are already in the labour force and experiencing reduced burden of disease. This is approximated using academic literature available on the disability pay gap.[187] More details as to the shock calculation approach is provided in Appendix C. The 'shock' values calculated above are used to model the policy case in DAE-RGEM. The results presented in the following sections reflect the response of the WA and Australian economies to these estimated and forecast increases in labour supply and labour productivity.

Chart 4.1: FTEs added to Australian labour supply due the impacts of WA medical research (FTEs)



Source: Deloitte Access Economics. Note: FTEs for each year are cumulative, and include FTEs added in previous years, adjusted for changes in participation rate by age. For more detail on this calculation, see Appendix C.

4.3. Economic impacts to date

4.3.1. Economic output

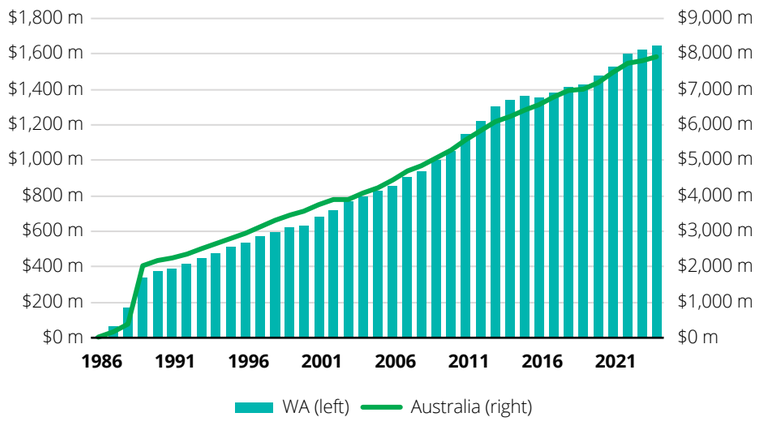
The CGE modelling results suggest that to date (the period 1986 to present), the WA medical research programs profiled in this study have added, on average, $884 million to WA GSP each year. On average, this means that the WA economy has been approximately 0.40% larger each year than it would have been in the base case as a result of the health outcomes from the research programs considered in this study.

As the outcomes of medical research affect more patients over time due to greater integration into clinical practice, impacts to the WA economy also rise over the modelling horizon. This is shown in Chart 4.2. In 2023, the WA economy is estimated to be $1.6 billion, or 0.44% larger due to the impacts of the medical research case study programs. As a point of comparison, the WA economy has grown at an average annual rate of 2.6% over the 10 years to 2022.[188]

For all of Australia, the health outcomes of WA medical research are estimated to have added $4.5 billion, on average each year, to national GDP over the evaluation period.

From 1986 to present, the eight WA medical research programs have added $884 million to the WA economy and $4.5 billion to the Australian economy, each year, on average

Chart 4.2: Annual impact of medical research on economic output (real, $AUD millions)



Source: Deloitte Access Economics.

This means, on average, in any year of the evaluation period, the Australian economy has been approximately 0.25% larger each year than it would have been in the base case. By 2023, the Australian economy is estimated to be $7.8 billion larger than it would have been without the health outcomes delivered by WA medical research.

The GSP/GDP impacts over time for WA and Australia are shown in Chart 4.2. These values reflect the increase in the size of the WA and Australian economies relative to the base case in each year from 1986 through to present-day.

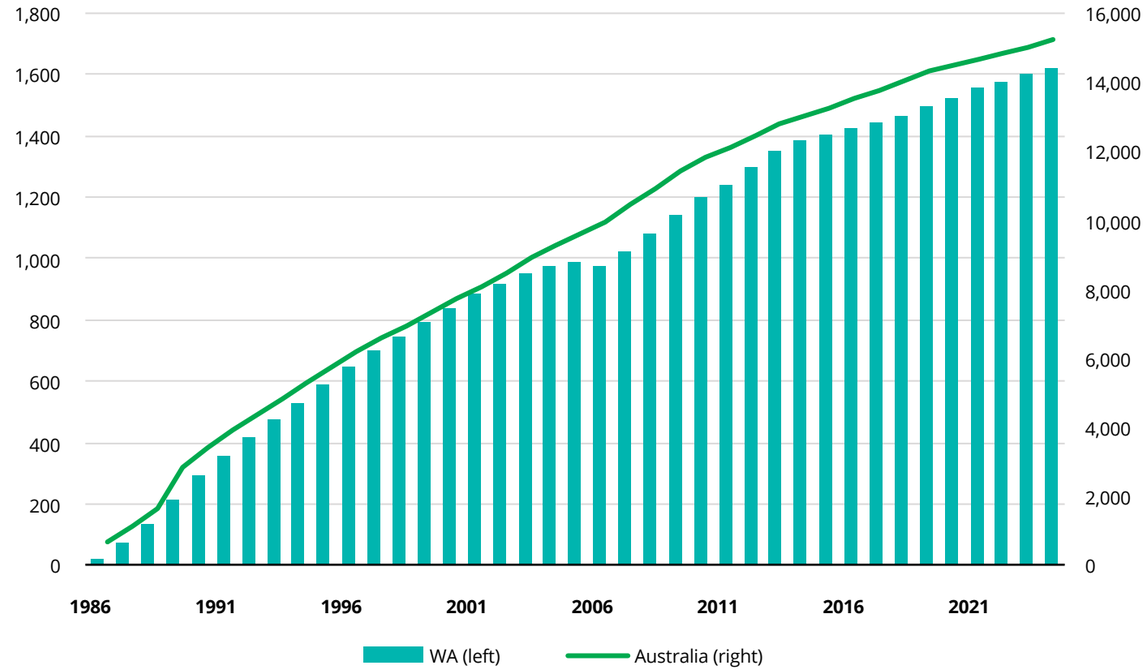
4.3.2. Employment

As noted above, the positive economic impact of medical research outcomes are typically evident through greater workforce participation, size, and increased productivity benefits. This not only drives higher levels of *direct* employment but also indirect employment growth throughout the economy.

For WA, it is estimated that between 1986 and 2024, employment is higher by 950 FTEs every year, on average, relative to the base case due to the positive outcomes of the eight case study medical research programs. It is important to note that this does not constitute an *additional* 950 people each year, but rather that employment is higher by this amount each year relative to the counterfactual base case.

Australia-wide, it is estimated that additional employment of approximately 9,000 FTEs is sustained each year over the same time period due to the WA-based medical research outcomes, compared to the base case. The employment impact of WA medical research to date is summarised in Chart 4.3.

Chart 4.3: Annual impact of medical research on employment (FTEs)



Source: Deloitte Access Economics.

4.4. Economic impacts into the future

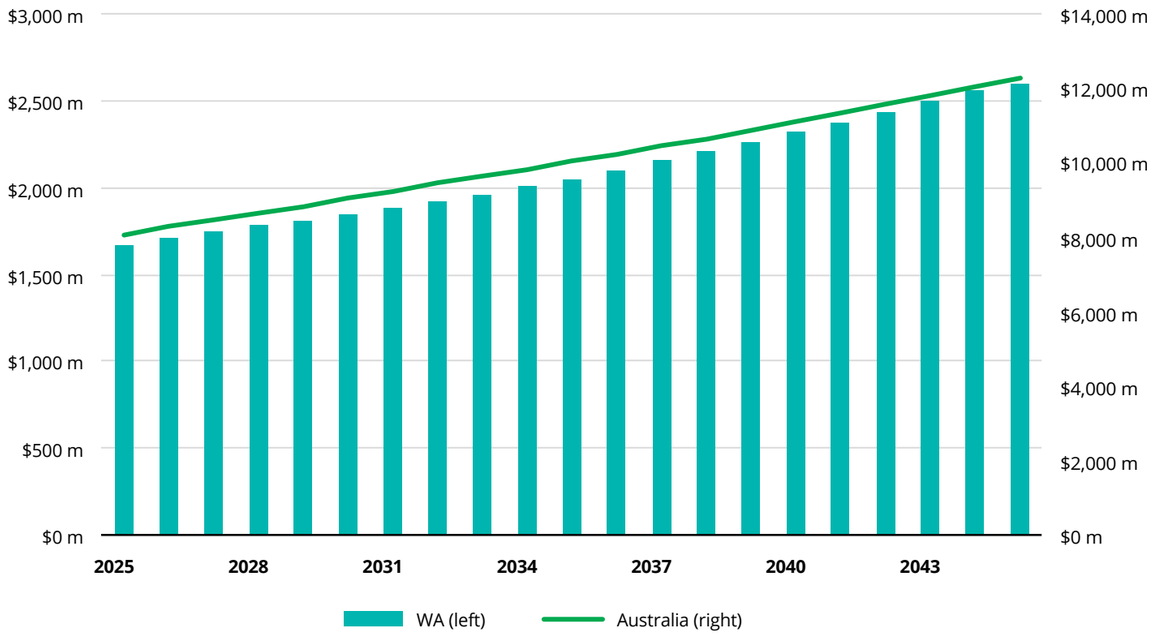
4.4.1. Economic output

Future economic impacts (present day to 2045) are materially larger than the historical impacts described above. This is partly because several of the research case studies identified in chapter 3 and modelled in DAE-RGEM are presently at early stages of the commercialisation and implementation process.

Therefore, as these programs become more integrated into clinical practice over time, WA medical research outcomes are predicted to have a proportionally larger positive impact on health outcomes, growing the scale and productivity of Australia's workforce into the future. Another key factor driving this phenomenon is the increased size of the WA and the Australian economies relative to the historical period, which means that changes of similar proportion lead to greater level changes in dollar metrics such as GSP and GDP.

Economic impacts to WA and Australia into the future are summarised in Chart 4.4.

Chart 4.4: Impact of medical research on economic output into the future (real, $AUD millions)



Source: Deloitte Access Economics.

The future economic impact of the selected medical research programs is estimated to add $2.1 billion on average, in real undiscounted terms each year to the WA economy from present-day to 2045. This reflects a proportional increase in the size of the WA economy of approximately 0.45% relative to the base case in each year, on average. In 2045, at the height of the modelled impacts, the WA economy is estimated to be 0.46%, or $2.6 billion larger, in real undiscounted terms, than without the health outcomes delivered by the selected WA medical research programs. In present value terms, this equates to the WA economy being approximately $566 million larger than the base case in 2045.

For all of Australia, the health outcomes of WA medical research are estimated to add $10 billion to GDP, on average each year, relative to the base case over the future evaluation period. This means the Australian economy is, on average, 0.29% larger than the base case in each year of the future evaluation period. By 2045, the Australian economy is approximately $12 billion larger, in undiscounted terms, than without the health outcomes provided by WA medical research. This reflects a present value increase in the size of the Australian economy of $2.7 billion, by 2045.

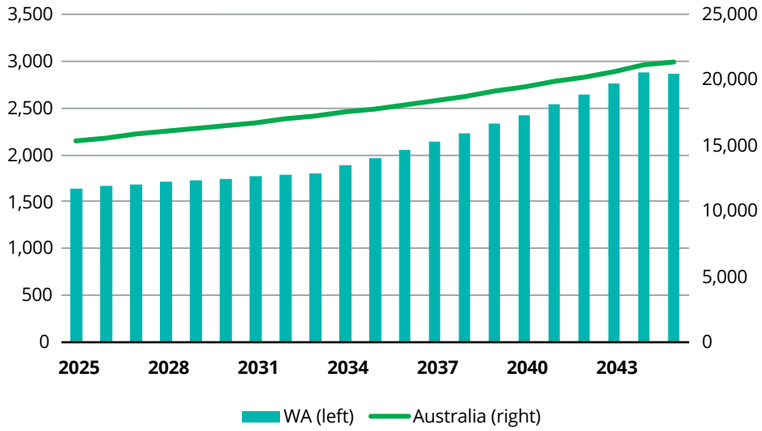
4.4.2. Employment

Direct and indirect employment is also expected to be generated in future due to the effect of retaining and adding people to the workforce, which results from better health and wellbeing outcomes from the selected medical research breakthroughs.

For WA, employment is estimated to 2,100 FTEs higher each year, on average, relative to the base case. As noted above, it is important to clarify that this does not constitute an *additional* 2,100 FTEs each year, but rather that employment is higher by this amount each year relative to the base case.

Australia-wide, it is estimated that employment is 18,000 FTEs higher, on average, each year, relative to the base case. Employment impacts to WA and Australia into the future are summarised in Chart 4.5.

Chart 4.5: Impact of medical research on employment into the future (FTEs)



Source: Deloitte Access Economics.

Through to 2045, the eight WA medical research programs are estimated to add $2.1 billion to the WA economy, and $10 billion to the Australian economy, each year, on average

Appendix A
Economic contribution analysis

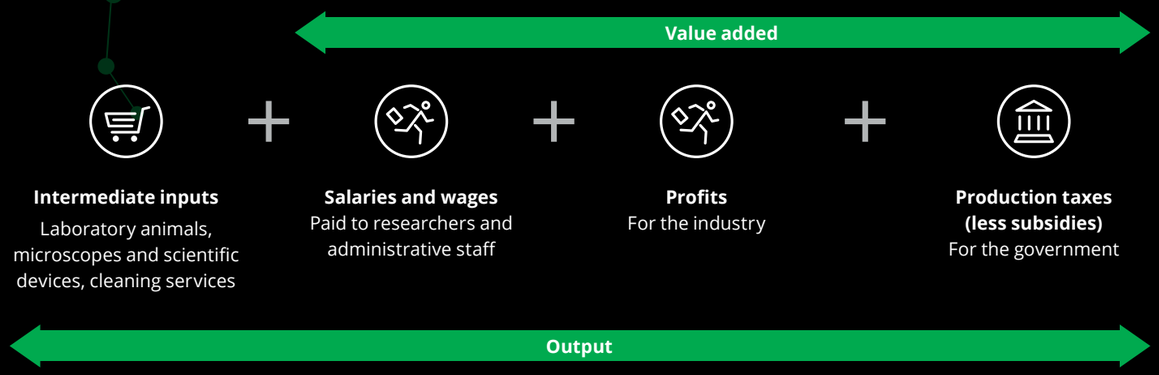
Deloitte Access Economics' Regional Input-Output Model (DAE-RIOM) is used to estimate the economic contribution of the WA medical research sector. This approach defines the sector's operational footprint in the WA economy in terms of value added to the economy and full-time equivalent (FTE) employment. The following sections provide a summary of the economic contribution methodology, including definitions and concepts, inputs and assumptions.

A.1. About economic contribution analysis

The economic contribution of the medical research sector in WA is estimated using Deloitte Access Economics' Regional Input-Output Model (DAE-RIOM). The model is based on Australian Bureau of Statistics (ABS) Input-Output (IO) tables, which account for the intermediate flows between sectors. The model uses these intermediate flows to estimate the change in economic activity in one sector as a result of a change in economic activity in another sector. The IO tables used in the analysis were for the 2020 financial year, which are based on industry surveys and published by the ABS.

Two measures – value added and employment – are used to describe different aspects of the economic contribution of the medical research sector to align with the national accounting framework (see Figure 4.1). Value added measures the value of goods and services supported by the industry's factors of production (i.e. labour and capital) as measured by the income to those factors of production, including salaries and wages, profits to the industry (which represent the gross operating surplus or GOS), and net taxes on production. The sum of value added across all industries in the economy is equal to gross domestic product (GDP) at the national level, and gross state product (GSP) at the state level. Given the relationship to GDP, value added can be considered a measure of the increased contribution to economic welfare.

Figure A.1: Understanding value-added and total output in input-output analysis".



Employment is an alternative measure of economic activity. It measures the number of workers that are employed by the WA medical research sector – both directly and indirectly as a result of the sector's operations – rather than the value of workers' output.

There are two key components of economic contribution: the direct contribution and the indirect contribution, which are defined as:

- **Direct economic contribution** – measured by the value added to the economy arising from the activities of the WA medical research sector. The direct value added is estimated from the medical research sector's returns to capital (i.e. gross operating surplus and labour income), and the direct employment is based on the number of FTE employees within the sector (see Appendix A: Economic contribution methodology).
- **Indirect economic contribution** – reflects the goods and services produced in upstream sectors as a result of demand generated by the activities of the WA medical research sector. Indirect value added captures the economic activity associated with inputs, such as pharmaceutical products, bioanalytical services, pathology services and other research inputs. Indirect employment reflects the additional employment generated in other sectors as a result of expenditure on inputs by the WA medical research sector.

The total economic contribution is measured by adding the direct and indirect economic contribution. However, economic contribution studies cannot be used to infer how much larger or smaller the WA economy is as a result of a given activity, as resources would be reallocated in the economy if this activity did not exist.

A.2. Modelling inputs

The inputs to the economic contribution modelling are based on financial data collected from 21 medical research organisations for the 2021 calendar year, including financial statements published by the Australian Charities and Not-For-Profits Commission (ACNC). As reflected in Figure 4.1 above, the key components of the economic contribution modelling include intermediate expenditure, employment, salaries and wages, gross operating surplus and net taxes on production. These inputs are discussed in further detail below.

A.2.1. Intermediate expenditure

A.2.1.1. Data collected and assumptions

Data was extracted from general ledgers supplied by research organisations to ascertain supplier information on the following key items:

- **Expenditure by industry** – expenditure by industry was used to define the inter-relationships between the medical research sector and other sectors of the economy at both a state and national level.
- **Expenditure by location** – supplier location was used to estimate the indirect contribution to the WA economy and the indirect contribution to the Australian economy. Expenditure to overseas-based suppliers was excluded from the analysis.
- **Expenditure by status** – expenditure that occurs within the industry itself (i.e. payments from one medical research organisation to another) was also excluded from the analysis. This avoids double counting, as the expenditure from one medical research organisation in the sector contributes to the output of another, and this is captured in an organisation's value added.

Although data was collected for all medical research organisations identified as part of the sector, there was some variation in the level of detail. Where data gaps existed – for example, intermediate expenditure information to identify items as either intra-industry spend or supplier location – assumptions were applied based on the detailed data of nine organisations. The detailed data covered 62% of total intermediate expenditure recorded across the sector. Assumptions were applied based on the type of organisation, including universities, medical research institutes, foundations and facilities (see Table 4.1).

Table A.1: Medical research organisations included in the analysis

Name	Type of medication research organisation
Telethon Kids Institute	Medical research institute (AAMRI WA member)
Harry Perkins Institute of Medical Research	Medical research institute (AAMRI WA member)
Perron Institute for Neurological and Translation Science	Medical research institute (AAMRI WA member)
Ear Science Institute Australia	Medical research institute (AAMRI WA member)
Lions Eye Institute	Medical research institute (AAMRI WA member)
Institute for Respiratory Health	Medical research institute (AAMRI WA member)
University of Western Australia[(a)]	University
Curtin University[(a)]	University
Edith Cowan University[(a)]	University
Murdoch University[(a)]	University
Royal Perth Hospital Medical Research Foundation	Medical research foundation
Fiona Wood Foundation	Medical research foundation
Women and Infants Research Foundation	Medical research foundation
Linear Clinical Research	Medical research facility
Charlie's Foundation for Research	Medical research foundation
Spinnaker Health Research Foundation	Medical research foundation
Perth Children's Hospital Foundation	Medical research foundation
Australian Alzheimer's Research Foundation	Medical research foundation
Busselton Population Medical Research Institute	Medical Research Institute
KEOGH Institute for medical Research	Medical Research Institute
Perth Blood Institute	Medical Research Institute

Notes: (a) Only research attributed to defined fields of research or relevant faculties was considered for universities.

Source: Deloitte Access Economics.

A.2.1.2. Key observations

Table 4.2 outlines the top 10 supplier industries in Western Australia and Australia considered for the analysis. Overall, it is evident that the medical research sector uses specialised technical services and inputs that are required to be sourced from outside of Western Australia.

For example, only 37% of wholesale products and 59% of electronic equipment manufactured products are sourced from Western Australian suppliers.[189] As such, $71.4 million (72%) of total WA medical research sector expenditure occurred in Western Australia, with the remaining $26.6 million (27%) and 0.6 million (1%) directed to interstate and overseas suppliers respectively.[190]

Within WA, it is notable that a significant proportion of expenditure (37%) occurs in health care services, which include pathology, health care clinics and medical consultants. Professional, scientific and technical services are also key beneficiaries, where 24% of expenditure occurred; this includes services such as bioanalytical testing, consulting services, and biological, genomic and proteomic research.

Table A.2: Supplier industry expenditure by location, 2021 ($ millions)

	Western Australia		Australia	
Supplier industry	**Expenditure ($ million)**	**Share of total (%)**	**Expenditure ($ million)**	**Share of total (%)**
Health care services	19.2	37%	19.3	24%
Professional, scientific and technical services	12.7	24%	21.4	27%
Administrative services	2.8	5%	7.0	9%
Retail trade	2.0	4%	2.9	4%
Non-residential property services	1.9	4%	1.8	2%
Wholesale trade	1.9	4%	3.9	5%
Computer systems design services	1.5	3%	3.5	4%
Public administration services	1.3	2%	2.0	3%
Electronic equipment manufacturing	1.1	2%	1.9	2%
Building, cleaning and pest control	0.7	1%	1.7	2%
All other industries	7.2	14%	13.5	17%
Total	**52.3**	**100%**	**79.0**	**100%**

Source: Deloitte Access Economics analysis of data provided by medical research organisations.

While health care service providers are predominantly based in WA, professional, scientific and technical services are mostly based interstate. Almost half of WA medical research sector expenditure on professional, scientific and technical services is directed to interstate suppliers, compared to less than 1% of health care services.

Medical research organisations often work in close collaboration with each other, particularly between universities and medical research institutes, facilities or foundations. Reflecting this, a proportion of WA expenditure occurs within the industry itself. Of the WA medical research sector expenditure, $19.0 million (17%) was spent on goods and services provided by other organisations within the sector.

Non-WA expenditure and expenditure directed to other organisations within the medical research sector was subtracted from the total. As a result, 52% of the total expenditure data provided ($52.3 million) was used to estimate the sector's indirect economic contribution to Western Australia.

A total of $79.0 million was used to estimate the sector's indirect economic contribution to Australia. This includes the $52.3 million of expenditure to Western Australia and an additional $26.6 million of expenditure to interstate suppliers (nothing these figures do not add due to rounding). Although spend that occurs within the WA medical research sector is excluded to avoid double counting when estimating the indirect contribution to WA, expenditure directed to interstate medical research organisations is included in estimating the indirect contribution to Australia.

A.2.2. Gross operating surplus

Although there are some profitable activities that occur thorough adjacent clinical services, medical research institutes and related organisations are mostly considered not-for-profit charities. The gross operating surplus component of value added is the proportion of income generated from capital. The ABS recognises that the closest proxy for this in a for-profit organisation is earnings before tax, interest, depreciation and amortisation (EBITDA). However, for not-for-profit organisations, residual income contributes to the operations of the business rather than being distributed to shareholders or partnerships.

According to the Australian System of National Accounts:

> Non-profit institutions serving households (NPISH) GOS is calculated as gross output less the costs incurred in producing that output (but before deducting consumption of fixed capital), leaving consumption of fixed capital (COFC) as the residual.[191]

Given non-profit organisations are exempt from corporate taxes and other output taxes included in EBITDA, the sum of interest expenses, depreciation and amortisation are considered proxies for the consumption of fixed capital, which is conceptually reflected as GOS for the NPISH sector.[192] This aligns with NPISH GOS reported in the ABS Economic Activity Survey. The sum of depreciation, amortisation and interest in 2021 for the WA medical research sector is estimated at $16.1 million.

A.2.3. Net taxes on production

Taxes included in value added estimates include taxes on a sector's factors of production, capital and labour. This includes land tax, motor vehicle charges and payroll tax. Taxes on products, or output, such as Goods and Services Tax (GST) are not included in value added calculations. As medical research institutions are considered a Public Benevolent Institute (PBI), they are exempt from such taxes.

Appendix B
Cost-benefit analysis

A cost-benefit analysis (CBA) is used to estimate the economic return from investment in medical research in terms of gains in health and wellbeing and health system savings. The following sections provide a summary of the CBA methodology, including key assumptions and parameters.

B.1. About cost-benefit analysis

For a given policy or investment, a CBA compares the total estimated costs to the community and economy with the total estimated benefits. As such, a CBA determines whether the benefits outweigh the costs, and if so, to what extent.

In undertaking a CBA, the benefits and costs expected to accrue over time are modelled using a discounted cash flow (DCF) framework, to determine whether the benefits exceed the costs in present value terms. The net return (discounted benefits over discounted costs) is expressed in the form of a ratio, referred to as the benefit-cost ratio (BCR).

A BCR greater than one indicates that net benefits related to the policy or investment are greater than net costs, suggesting value in undertaking the investment (or for every $1.00 of investment, a return greater than $1.00 is achieved). The reverse is true if the BCR is below one. However, invariably it is not possible to quantify and monetise all benefits that an investment may deliver. In many cases, significant, non-quantifiable benefits are relevant and should be reported to provide a complete analysis of the value of the investment.

B.2. Approach to undertaking this cost-benefit analysis

B.2.1. Summary of approach

This CBA compares the costs and benefits associated with a selection of case study research programs led by the WA medical research sector. The benefits and costs are modelled as the difference between a 'base case' and an 'investment case' scenario. Five key steps have been taken to prepare this CBA:

01. Scenario definition
02. Period of analysis definition
03. Benefit specification and estimation
04. Cost specification and estimation
05. Discounted cash flow modelling.

B.2.2. Scenario definition

B.2.2.1. Base case

Defining a counterfactual scenario, or base case, is a critical component of a CBA. The benefits and costs are measured as the incremental change from the base case. This ensures that only the benefits and costs that can be reasonably attributed to the investment are included in the analysis.

For this analysis, the base case is defined as a scenario in which the selected case study research programs are not delivered, and therefore the enhancements to policy, clinical guidelines, treatment methods and practice – which contribute toward improved health outcomes – are not realised. However, it is recognised that there are often several programs of research work which together lead to improvements in clinical practice, and so even without the findings of the selected case study research programs, clinical practice will likely improve over time, and so will health outcomes. To account for this, an adjustment is made using an 'attribution factor', to recognise only the share of benefits that can be attributed to the research programs' role in informing changes to clinical practice and generating improvements in health outcomes (see section B.3.1).

B.2.2.2. Investment case

The investment case of a CBA reflects a scenario where the economic benefits and costs associated with an investment are realised. This analysis defines the investment case as the status quo; that is, a scenario in which case study research programs are delivered and lead to enhancements to clinical guidelines, treatment methods and practice. These changes contribute toward improved health outcomes, which are measured in economic terms in the CBA.

B.2.3. Period of analysis definition

The period of analysis for the CBA is defined as a timeframe of 74 years, from FY1982 to FY2056. This period reflects the commencement of research spending across the case study programs and the final year for which benefits are estimated. For each case study included in the CBA, costs were included in the analysis from the year in which they commenced, until the research program resulted in a change in policy, guidelines or clinical practice that began to realise benefits. Benefits were then estimated for each case study program for a fixed period of 30 years, which provided a consistent measure of economic return from research spending across the case studies.

B.2.4. Benefit specification and estimation

The specification of benefits in a CBA involves identifying the impacts of the investment that result in positive or desirable effects. To be included within the CBA framework, the benefits must be measurable; that is, it must be possible to attribute each benefit with a meaningful measure of economic value.

For the purposes of this analysis, the economic benefits associated with the selected case study research programs have been quantified from three main sources. These include:

01. Reduced mortality
02. Reduced burden of disease
03. Avoided costs for the health system.

Chapter 3 provides a description of each of the benefits across the case study research programs, along with the key data inputs and assumptions that have been used in estimating their value.

B.2.5. Cost specification and estimation

The specification of costs in a CBA takes into account all the impacts of the investment that produce negative or undesirable effects, including what has to be given up or forgone in order to implement the investment. Importantly, all costs that are incurred in achieving the benefits must be captured within a CBA.

The CBA considers two sources of costs across the case study research programs:

01. Research and development costs (direct and indirect)
02. Delivery and treatment costs.

These costs are described in Chapter 3 for each of the case study research programs, along with the approach that has been used in estimating their value.

B.2.6. Discounted cash flow modelling

Discounted cash flow modelling is undertaken to estimate the present values of future costs and benefits. The discounting of future costs and benefits to derive present values reflects the time value of money and uncertainty of future cash flows, and the fact that people generally attribute a higher value to consumption today than consumption in the future. The BCR is calculated by dividing the total present value of benefits by the total present value of costs.

Future benefits and costs are discounted at the rate of 7.0% per annum to derive their present values. This aligns with guidance published by the Department of the Prime Minister and Cabinet on the use of CBA for policy proposals.[193] As the CBA also considers 41 years of historical benefits and costs, which occur during the period FY1982 to FY2023, these benefits and costs are converted to present values by adjusting them to 2023 dollars.

B.3. Key assumptions and parameters

A range of key assumptions and parameters underpin the CBA for the case study research programs. These assumptions and parameters are detailed in the following sections.

B.3.1. Attribution of benefits to research

Medical research undertaken in WA contributes to improved health outcomes across Australia and the rest of the world by adding to the body of evidence that influences changes in policy, clinical guidelines, treatment methods and practice. To estimate the contribution of WA medical research to improved health outcomes, two approaches are used to recognise the varying role that medical research organisations play in undertaking research and the translation of findings. These are as follows:

01. The attribution of WA medical research where the research contributes to changes in policy and clinical practice through additions to the evidence base
02. The attribution of WA medical research where the research organisation plays a direct role in development of a new medical device that enhances clinical practice.

These two approaches are described in the sections that follow.

B.3.1.1. Attribution where research contributes to the evidence base

Most medical research builds upon an existing body of previous work, and will often spur additional research that extends and substantiates its findings before they can be translated to clinical practice. This includes the process of peer-review, as well as research that builds an evidence-base for new treatments to support their adoption into mainstream clinical practice across jurisdictions and different populations. As such, the health outcomes of any medical research program cannot be fully attributed to the program alone, but must consider the contribution of the system it was developed in.

For academic research articles, one measure of its contribution is the number of citations it has received from other articles. This indicates the contribution it has made to the overall body of literature and is often used to judge the importance of an article to its field. By measuring the number of citations received by a researcher on articles they have published on a topic, it is possible to gauge the researcher's eminence in the field.

For this study, the proportion of overall health outcomes for Australia that can be attributed to research conducted by WA medical research organisations has been determined using the number of citations received by the research, relative to the number of existing citations within the broader body of literature on a topic. For example, if the research publications by a medical research organisation on a topic have a combined citation count of 1,000 citations, and the broader body of literature encompasses 10,000 citations, the attribution of health outcomes from this research to the organisation is estimated to be 10%.

This process was conducted using citation data available from Google Scholar. A script written in the programming language R was used to filter the number of citations within a topic of literature to only consider relevant articles. This was then used to calculate the number of citations within a specified body of literature. The number of citations received by WA researchers was sourced from their Google Scholar profile, and the total attribution of health outcomes to the research institution was calculated as a ratio of citations received by the institution to the broader number of citations existing in the body of literature. Filters such as relevant date ranges were also applied, to ensure the citations considered were as relevant as possible.

While the process above calculates the academic contribution of research conducted by an organisation, it does not account for the time and effort required to translate these findings into practice. Research from Hatfield et al (2000) suggests that health research is responsible for between 33% and 67% of all improvements in health outcomes. As such, this analysis assumes that 50% of all improvements in health outcomes can be attributed to health and medical research, with the remainder attributed to efforts related to the commercialisation of research findings or the translation of findings into changes in policy and clinical practice. This approach is consistent with other reputed studies that assess the economic return of investment in health and medical research in Australia.[194] The attribution of health outcomes to WA medical research is therefore adjusted for this factor.

The methodology above is only applied for WA medical research where the research contributes to changes in policy and clinical practice through additions to the evidence base. Where the research directly contributes to the development of a device or product, the approach differs, and is explained in the section that follows.

B.3.1.2. Attribution where the research organisation implements a new device, treatment method or practice

For research programs in which the medical research organisation plays a direct role in the development of a new medical device, the CBA assumes that attribution is shared evenly between two essential activities involved in the implementation of new devices and treatment methods: the research itself, along with the necessary commercialisation activity.

For example, in a situation where a WA medical research organisation undertakes research and develops a new device or treatment method, which is then later commercialised by a biotechnology company, the WA medical research organisation's role in the advancement is assumed to be 50%. In this case, the approach described in section above is also applied, whereby health research is assumed to be responsible for 50% of improvements in health outcomes. Therefore, in the example, the attribution of WA medical research is assumed to be 25%.

B.3.2. Value of statistical life

The value of a statistical life year is used to estimate the economic value of a person's remaining years of life. The analysis uses a value of $235,000 for the value of a statistical life year, which is based on an estimate of the value society places on a year of life published by the Department of the Prime Minister and Cabinet.[195]

The value of a statistical life is used to estimate the economic value of a person's life. This differs from the value of a statistical life year because it estimates the value society places on reducing the risk of dying rather than on a year of life. The analysis uses a value of $5.4 million for the value of a statistical life, which is derived from the same study published by the Department of the Prime Minister and Cabinet.[196]

The estimation of the value of a statistical life year and a life are based on the life of a young adult with at least 40 years of life ahead of them.[197] While no such value exists for the life year or life of a child, children have a greater number of remaining years of life than a young adult (based on an average life expectancy), and the value society places on a child's life is likely to be greater than the value placed on an adult's life. Therefore, both values are considered conservative estimates for either the value of a child's remaining years of life or their life.

B.3.3. Disability weights

A reduction in the burden of disease is estimated by measuring the expected reduction in a person's disability weight. A disability weight is a factor that reflects the severity of non-fatal health loss from a particular health state, on a scale from zero (perfect health) to one (equivalent to death).[198] The benefit from a reduction in the burden of disease reflects the improvement in a person's quality of life owing to the findings of WA medical research.

Disability weights for relevant conditions were primarily sourced from the Australian Institute of Health and Welfare's *Australian Burden of Disease Study*.[199] Where appropriate, several disability weights reflecting varying degrees of severity of a condition were used to construct an average disability weight for that condition.

B.3.4. Indirect cost factor

Research and development costs included in the CBA were provided by individual medical research organisations. In most cases, these costs reflected total grant funding for research activities instrumental to the innovation or discovery, in-kind contributions, and commercialisation costs.

However, these costs do not include the indirect costs of research, such as spending on overheads and stocks of equipment already owned by the medical research organisation. As such, an indirect cost factor is calculated from spending data across all AAMRI WA research institutes. This indirect cost factor is applied to all research costs in this study to estimate the indirect costs of undertaking research. The indirect cost factor used is $1.07 of indirect costs for every $1.00 of research spending.

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B.3.5. Assumptions for individual case studies

B.3.5.1. Telethon Kids Institute – Folate research

Parameter	Value	Source
Population		
Number of children born in Australia	Varies each year	Australian Bureau of Statistics, Births Australia (October 2022)
Prenatal termination rate		
Spina bifida	40.1%	C Bower, H D'Antoine, FJ Stanley 'Neural tube defects in Australia: trends in encephaloceles and other neural tube defects before and after promotion of folic acid supplementation and voluntary food fortification', *Birth Defects Research Part A- Clinical and Molecular Teratology* 2009; 85:269-273.
Anencephaly	78.5%	
Encephalocele	43.3%	
Incidence rates		
Spina Bifida (pre-folate)	0.063%	AIHW, *Neural tube defects in Australia Prevalence before mandatory folic acid fortification* (December 2011)
Anencephaly (pre-folate)	0.055%	
Encephalocele (pre-folate)	0.014%	
Reduction in incidence rate due to folate	15.0%	C Bower, S Maxwell, S Hickling et al. 'Folate status in Aboriginal people before and after mandatory fortification of flour for bread-making in Australia', *The Australian and New Zealand Journal of Obstetrics and Gynaecology* (201), 56(3), 233.
Life expectancy		
Average Australian life expectancy	83.04	World Health Organisation, *Life Expectancy at Birth (years),* 2023
Life expectancy with spina bifida and en-cephalocele	40.00	P Oakeshoot, G Hunt, A Poulton, F Reid, 'Expectation of life and unexpected death in open spina bifida: a 40-year complete, non-selective, longitudinal cohort study', *Developmental Medicine & Child Neurology* (201) 52 (8)
Life expectancy with anencephaly	–	J Pomerance, A Morrison, R L Williams, BS Schifrin, 'Anen-cephalic infants: life expectancy and organ donation', *Journal of Perinatology* (1989) 9(1) 33.
Disability weights		
Low level spina bifida	0.15	M Stouthard, ML Essink-Bot, GJ Bonsel, 'Disability weights for diseases: a modified protocol and results for a Western European region', *European Journal of Public Health* 2000 10(1).
Medium level spina bifida	0.40	
High level spina bifida	0.65	
Proportion of spina bifida cases		
Mild spina bifida	10%	C Mathers, T Vos, and C Stevenson, 'The burden of disease and injury in Australia', *Australian Institute of Health and Welfare* (1999).
Moderate spina bifida	60%	
Severe spina bifida	30%	
Costs for the health system		
Spina bifida	USD$577,000	SD Grosse, RJ Berry, JM Tilford et al. 'Retrospective assessment of cost savings from prevention: folic acid fortification and spina bifida in the U.S', *American Journal of Preventive Medicine* (2016) 50(5)
Anencephaly	USD$3,760	
Encephalocele	USD$45,047	
Attribution of benefits to Telethon Kids Institute	3.7%	See Appendix B, section B.3.1

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B.3.5.2. Harry Perkins Institute of Medical Research – Colchicine

Parameter	Value	Source
Population		
Population of USA	Varies each year	Word Bank, *Population estimates and projections* (2023)
Population of Canada	Varies each year	
Population of South America	Varies each year	
Population of Europe	Varies each year	
Proportion of population above 20 (global)	67.0%	United Nations, Pew Research Centre, *World Population Prospects 2022*
Incidence rates		
Incidence rate of heart dis-ease	5.0%	Centres for Disease Control and Prevention, Heart Disease (2023)
Proportion of cardiovascular patients on statins	29.0%	F Brown, 'Statin-prescribing trends for pri-mary and secondary prevention of cardio-vascular disease', Canadian Family Physi-cian (2017) 63(1) 495.
Incidence of MACE		
Patients taking colchicine	2.50%	S Nidorf, A Fiolet, A Mosterd et al. 'Colchicine in Patients with Chronic Coronary Disease', *New England Journal of Medicine* (2023) 383(19) 1838.
Patients not taking colchicine	3.60%	
Disability weights		
Severe heart failure due to cardiomyopathy	0.179	Australian Institute of Health and Welfare, *Australian Burden of Disease Study: Meth-ods and supplementary material 2018*, (No-vember 2021).
Average age of MACE		
Average age of myocardial infarction	68.75	Medical News Today, 'What is the risk of heart attack based on age?', (2023)
Average age of ischemic stroke	74.15	Healthline, 'Is Your Risk of Having a Stroke Different Based on Your Age Range?' (2023)
Average age of ischemia driven coronary revascularisa-tion	69.70	T Sato, S Goto, S Kishi et al. 'Predictors and outcomes of ischemia-driven target lesion revascularization in deferred lesion based on fractional flow reserve: a multi-center retro-spective cohort study', *Cardiovascular Diag-nosis and Therapy* (2022) 12 (3)
Average life expectancy (USA)	77.28	World Bank, Life expectancy at birth (years)
Cost of colchicine (per tablet)	$0.33	*Colgout 0.5mg Tablets 30 – Colchi-cine*, Chemist Warehouse (2023), <https://www.chemistwarehouse.com.au/buy/61783/colgout-0-5mg-tablets-30-colchicine>
Cost of MACE	USD$44,495	A Berger, A Simpson, T Bhagnani et al. 'Inci-dence and Cost of Major Adverse Cardio-vascular Events and Major Adverse Limb Events in Patients With Chronic Coronary Artery Disease or Peripheral Artery Disease', *American Journal of Cardiology* (2019) 123 (12) 1893.
Attribution of benefits to Harry Perkins Institute	7.3%	See Appendix B, section B.3.1

B.3.5.3. Ear Science Institute – ClearDrum

Parameter	Value	Source
Population		
ClearDrum market share	10.0%	Ear Science Institute – increases progressively and capped at 10%.
Number of tympanoplasties in the US	150,000 (2020) – increased based on population in 2023	R Saadi, A Meyers, 'Middle Ear, Tympanic Membrane, Perforations', *MedScape* (2022), <https://emedicine.medscape.com/article/858684-overview?form=fpf#a5>
Proportion of fascia tympanoplasty patients	69%	S Ferlito, G Fadda, JLechien, G Cammaroto, et al. ' Type 1 Tympanoplasty Outcomes between Cartilage and Temporal Fascia Grafts: A Long-Term Retrospective Study', *Journal of Clinical Medicine* (2022), 11(23), 7000.
Perforation closure ratio – cartilage	0.89	E Sözen, Y O Uçal, HD Tansuker, et al 'Is the tragal cartilage necessary for type 1 tympanoplasties?' *Journal of Craniofacial Surgery*, (2012) 23(4), 280. These ratios reflect non-complex Type 1 tympanoplasties performed on adults. Closure ratios can be as low as 65% for fascia in paediatric or more complex cases.[200,201,202]
Perforation closure ratio – fascia	0.81	
Disability weights		
Hearing loss: mild, with ring-ing	0.021	Australian Institute of Health and Welfare, *Australian Burden of Disease Study: Methods and supplementary material 2018,* (November 2021).
Hearing loss: moderate, with ringing	0.074	
Hearing loss: severe, with ringing	0.261	
Prevalent years with tympanoplasty perforations	18.15	AS Kim, J Betz, N Reed at al. 'Prevalence of Tympanic Membrane Perforations Among Adolescents, Adults, and Older Adults in the United States', *Otolaryngology–Head and Neck Surgery* (2022) 167 (2) 356.
Revision rate		
Fascia tympanoplasty	19.0%	SH Mohamad, K Imran, SS Hussain, 'Is cartilage tympanoplasty more effective than fascia tympanoplasty? A systematic review', *Otology & Neurotology* (2012) 33(5) 699.
Cartilage tympanoplasty	10.0%	
Cost of ClearDrum	*Undisclosed – provided by Ear Science Institute on a confidential basis*	Ear Science Institute
Cost of tympanoplasty surgery	USD$3,491	GC Casazza, AJ Thomas,, RK Gurgel et al. 'Variation in tympanoplasty cost in a multihospital network', Otology & Neurotology (2018) 39(10) e1047-e1053
Attribution of benefits to Ear Science Institute	25.0%	See Appendix B, section B.3.1

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B.3.5.4. Lions Eye Institute – XEN Gel Stent

Parameter	Value	Source
Population of Australia	Varies each year	Word Bank, *Population estimates and projections* (2023)
Global XEN Gel Stent Patients	Varies each year – based on an estimated 200,000 patients from 2014-2022	Lions Eye Institute
Incidence rate of open-angle glaucoma	2.0%	K Allison, D Patel, O Alabi, 'Epidemiology of Glaucoma: The Past, Present, and Predictions for the Future', *Cureus* (2020) 12(11)
Share of patients that get glaucoma surgery	5.0%	G Schwartz, A Patel, R Naik et al. 'Characteristics and Treatment Patterns of Newly Diagnosed Open-Angle Glaucoma Patients in the United States: An Administrative Database Analysis', *Ophthalmology Glaucoma* (2021) 4(2) 117.
Disability weights		
Blindness	0.187	Australian Institute of Health and Welfare, *Australian Burden of Disease Study: Methods and supplementary material 2018,* (November 2021).
Severe vision impairment	0.184	
Moderate vision impairment	0.031	
Average life expectancy		
Average life expectancy in Australia	83.04	World Health Organisation, *Life Expectancy at Birth (years),* 2023
Average global life expectancy	80.10	
Average age of glaucoma surgery	70	JF Kirwan, AJ Lockwood et al. 'Trabeculectomy in the 21st Century: A Multicenter Analysis', American Academy of Ophthalmology (2013) 120(12)
Reduction in disability burden due to XEN Gel Stent (based on IOP reduction)	35.0%	X-Z Chen, Z-Q Liang, K-Y Yang et al. 'The Outcomes of XEN Gel Stent Implantation: A Systematic Review and Meta-Analysis', Frontiers in Medicine (Lausanne) (2022) 4(9)
XEN Gel Stent Success Rates	60.0%	X-Z Chen, Z-Q Liang, K-Y Yang et al. 'The Outcomes of XEN Gel Stent Implantation: A Systematic Review and Meta-Analysis', *Frontiers in Medicine (Lausanne)* (2022) 4(9)
Cost of XEN Gel Stent	USD$3,500	Frantz Eyecare, 'Cost of Suncoast Surgery Centre' (2023)
Attribution of benefits to Lions Eye Institute	25.0%	See Appendix B, section B.3.1

B.3.5.5. Institute for Respiratory Health – Pleural Disease

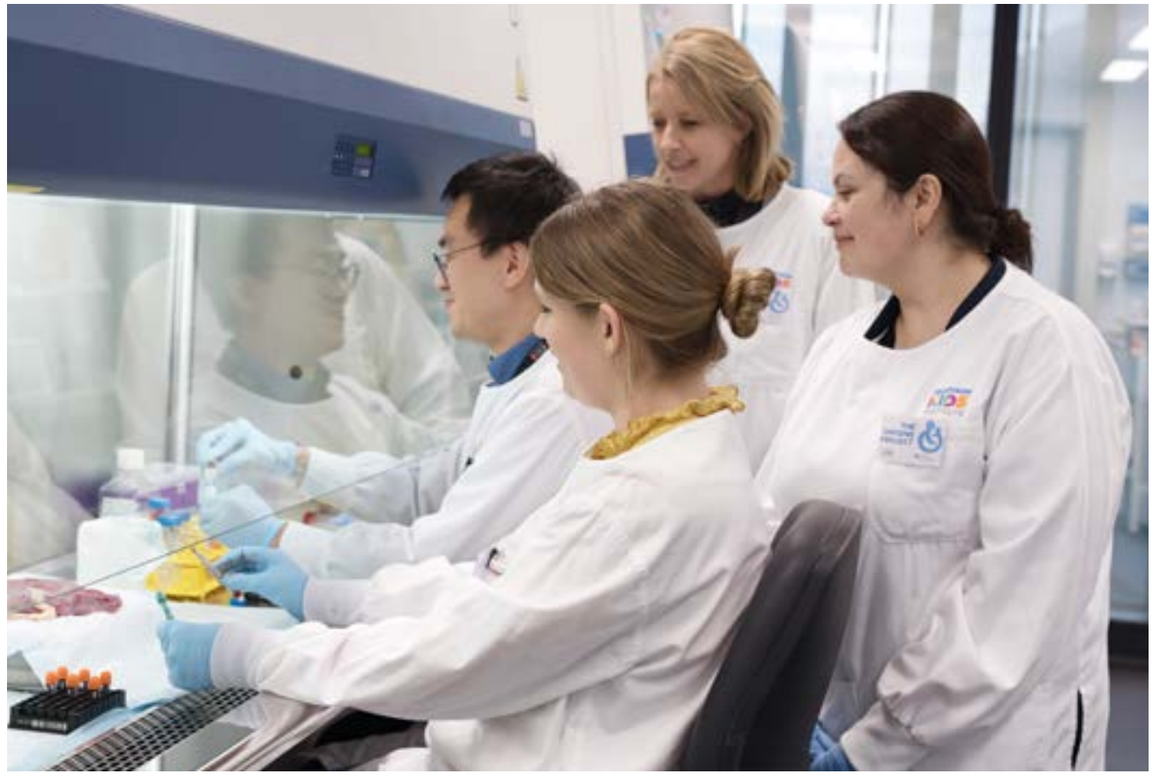
Parameter	Value	Source
Population		
Population of Australia	Varies each year	Word Bank, *Population estimates and projections* (2023)
Population of World	Varies each year	
Incidence of pleural infection	0.0067%	Hassan M. et.al, 'Recent Insights into the Management of Pleural Infection', (2021), *International Journal of General Medicine*
Proportion of patients that would receive tPA/DNAse treatment	30%	Luengo F. et al, 'Cost-effectiveness of intrapleural use of tissue plasminogen activator and DNAse in pleural infection: Evidence from the MIST2 randomised controlled trial'
Years to adoption of treatment	8	Dunn et al, 'Nation-scale adoption of new medicines by doctors: an application of the Bass diffusion model', (2012), *BMC Health Services Research*, 12,248
Average age of diagnosis	63	Hassan M. et.al, 'Recent Insights into the Management of Pleural Infection', (2021), *International Journal of General Medicine*
Share of people without access to healthcare, globally	25%	Calculated based on findings from Chattu et al,. 'Access to medicines through global health diplomacy', (2023), *Health Promotion Perspectives*, 13(1): 40-46
Proportion of patients experiencing additional complications	43%	White et. al, 'Predicting Long-Term Outcomes in Pleural Infections. RAPID Score for Risk Stratification', (2015) Annals of the American Thoracic Society Vol 12;9
Life expectancy		
Australia	83.04	World Health Organisation, *Life Expectancy at Birth (years)*, 2023
World	77.28	World Health Organisation, *Life Expectancy at Birth (years),* 2023
Mortality assumptions		
Mortality rate of pleural infection	20%	Davies CW, Kearney SE, Gleeson FV, Davies RJ. 'Predictors of outcome and long-term survival in patients with pleural infection', (1999), *American Journal of Respiratory Critical Care Medicine* Nov;160(5 Pt 1):1682-7.
Treatment effectiveness	90%	Rahman et. al, 'Intrapleural Use of Tissue Plasminogen Activator and DNase in Pleural Infection', (2011) *New England Journal of Medicine* 365:518-526
Reduction in cost of healthcare assumptions		
Average length of stay at hospital (days)	2.7	Medical News Today, 'What is the risk of heart attack based on age?', (2023)
Average cost of admitted patient	AUD$5,315	Independent health and Aged Care Pricing Authority, National Hospital Cost Data Col-lection (2021)
Reduction in hospital days due to tPA/DNAse	6.7	Rahman et. al, 'Intrapleural Use of Tissue Plasminogen Activator and DNase in Pleural Infection', (2011) *New England Journal of Medicine* 365:518-526
Cost of treatment		
Per patient cost of treatment	EU € 7,248	Luengo F. et al, 'Cost-effectiveness of intra-pleural use of tissue plasminogen activator and DNAse in pleural infection: Evidence from the MIST2 randomised controlled trial'
Attribution of benefits to the Institute for Respiratory Health	5.6%	See Appendix B, section B.3.1

B.3.5.6. The Marshall Centre for Infectious Diseases – Helicobacter pylori

Parameter	Value	Source
Population		
Population of Australia	Varies each year	Word Bank, *Population estimates and projections* (2023)
Population of World	Varies each year	
Prevalence of H. pylori	15%	Hassan M. et.al, 'Recent Insights into the Management of Pleural Infection', (2021), *International Journal of General Medicine*
Proportion of H. pylori patients with PUD	5-10%	Prabhu V, Shivani A. 'An overview of history, pathogenesis and treatment of perforated peptic ulcer disease with evaluation of prognostic scoring in adults'. (2014) *Ann Med Health Sci Res* Jan;4(1):22-9.
Average age of PUD diagnosis	50	Harvard Medical School, 'Peptic ulcer', (2014), <https://www.health.harvard.edu/digestive-health/peptic-ulcer-overview>
Proportion of H. pylori patients with stomach cancer	1-3%	Wroblewski LE, Peek RM Jr, Wilson KT, 'Helicobacter pylori and gastric cancer: factors that modulate disease risk', (2010) *Clin Microbiol Rev,* 23(4):713-39
Average age of stomach cancer diagnosis	74	Thrift, A., Hashem, B, 'Burden of Gastric Cancer', (2020), *Clinical Gastroenterology and Hepatology*, 18(3); 534-542
Treatment effectiveness	70%	Yaxley, J, Chakravarty, B, 'Helicobacter py-lori eradication- an update on the latest therapies', (2014), *Australian Family* Physi-cian, 5:43
Share of people without access to healthcare, globally	25%	Calculated based on findings from Chattu et al,. 'Access to medicines through global health diplomacy', (2023), *Health Promotion Perspectives*, 13(1): 40-46
Life expectancy		
Australia	83.04	World Health Organisation, *Life Expectancy at Birth (years)*, 2023
World	77.28	World Health Organisation, *Life Expectancy at Birth (years),* 2023
Mortality assumptions		
Reduction in mortality rate for stomach cancer	62%	Qing-Li, et. al, 'Effects of Helicobacter pylori treatment and vitamin and garlic supple-mentation on gastric cancer incidence and mortality: follow-up of a randomized inter-vention trial.' (2019) *BMJ* ;366:l5016
Reduced burden of disease assumptions		
Disability weight for PUD	0.28	Ock M, Lee JY, Oh IH, Park H, Yoon SJ, Jo MW, 'Disability Weights Measurement for 228 Causes of Disease in the Korean Burden of Disease Study' (2016) *J Korean Med Sci*. S129-S138.
Cost of treatment		
Cost of HP7- standard PPI treatment	AUD$42.00	Sourced from the Online Pharmacy: <https://theonlinepharmacy.com.au/nexium-hp7.html>
Attribution of benefits to Professor Marshall's research	8.6%	See Appendix B, section B.3.1

B.3.5.7. The Fiona Wood Foundation – Spray-on skin

Parameter	Value	Source
Population		
Cases in Australia	Varies each year	Avita Medical Annual Reports, 2012-2023
Cases in the world	Varies each year	
Cost of treatment		
Total costs of treatment in the base case with standard treatment	USD $149,000 – $454,000	Kowal, S, et. al, 'Cost-Effectiveness of the Use of Autologous Cell Harvesting Device Compared to Standard of Care for Treat-ment of Severe Burns in the United States', (2019), *Advanced Therapy,* 35;1715-1729
Total costs of treatment using ReCell	USD $129,000 – $282,000	Kowal, S, et. al, 'Cost-Effectiveness of the Use of Autologous Cell Harvesting Device Compared to Standard of Care for Treat-ment of Severe Burns in the United States', (2019), *Advanced Therapy,* 35;1715-1729
Proportion of patients with Category 1 – 3 burns	Varies by type of burn	Kowal, S, et. al, 'Cost-Effectiveness of the Use of Autologous Cell Harvesting Device Compared to Standard of Care for Treat-ment of Severe Burns in the United States', (2019), *Advanced Therapy,* 35;1715-1729
Attribution of benefits to Professor Wood's research	25.0%	See Appendix B, section B.3.1



Researchers at the Telethon Kids Institute. Credit: Telethon Kids Institute

Appendix C CGE modelling

C.1. About CGE modelling

CGE modelling is the best-practice methodology for estimating the economic impact of changes in any one part of the economy. It is the preferred method for most major Commonwealth and State agencies in estimating the economic impact of a particular development in the economy.

CGE modelling is preferred because it can explicitly account for a range of impacts that are otherwise omitted in alternative static modelling frameworks. Importantly, CGE frameworks incorporate:

- The impact of resource constraints throughout the economy, as the use of labour or capital by one sector is often at the expense of uses elsewhere
- The possibility of changes in the mix of inputs used in production due to changes in relative prices or technology
- The responsiveness of prices and other variables to policy changes that affect such things such as tariffs on imported goods, budgetary support to industry, industry productivity, and workforce participation.

These assumptions allow for the modelling of 'second-round' impacts – where agents respond to changes in price signals. This feature enables CGE models to account for impacts of a policy change or program across the *entire* economy. Second-round impacts enable the development of 'real-world' insights such as crowding out effects (where some industries and regions lose out from an injection of economic activity elsewhere) and/or positive spill overs to other regions and industries resulting from the policy, program, or disruption modelled.

This functionality is especially important for modelling material changes to the labour force across WA and Australia due to improved health outcomes from medical research. These impacts will occur at a whole-of-economy level, and have far-reaching impacts for all industries. Other economic modelling techniques (such as the input-output modelling described in Appendix A) are useful for historical or point-in-time analysis but are not sufficiently dynamic to address the above issues and are therefore not considered fit for purpose for these types of long term, scenario-based modelling tasks.

C.2. Scenario definition

CGE models estimate economic impacts by comparing a 'policy scenario' against a 'base case scenario'. These scenarios are defined to help the analysis determine the economic impact that can be attributed solely to the policy intervention. In this case, the policy intervention relates to the improved health outcomes generated by WA medical research.

C.2.1. Defining the base case

The base case modelled in this analysis reflects a scenario in which the WA and Australian economies grow in line with historical macroeconomic data, and follow a business-as-usual trajectory into the future. These assumptions are sourced from Deloitte Access Economics' Quarterly Business Outlook publication for June 2023, which includes historical and forecast data relating to economic output and labour supply at the state and national level.

Given the base case is modelled on historical data, it implicitly includes the positive economic impacts of medical research over time. This has been accounted for in modelling the policy intervention, which is explained in the following section.

C.2.2. Defining the policy case

The policy scenario is developed by applying changes (known as 'shocks') to the baseline scenario, which reflect the nature of an intervention or disruption. In this case, the policy scenario is developed using the health outcomes from the eight high-impact research programs selected for this study. This is detailed in chapter 3 of this report.

The improved health outcomes from the case studies primarily relate to a reduction in mortality rates and in the burden of disease. A reduced mortality rate has a positive effect on labour supply, as it increases the overall population and hence the number of people in the workforce. Reduced burden of disease leads to greater economic participation and is shown to have positive impacts on labour productivity, even when controlling for hours worked.[203]

Noting that the modelled base case implicitly includes the benefits from the medical research programs considered in the policy case, the policy scenario has been modelled in DAE-RGEM as reflecting the economic impact that would result from the removal of these benefits. The results reflect the net additions to GDP, GSP, and employment resulting from the health outcomes of the medical research programs assessed.

The shocks for the policy case scenario are modelled based on the outputs of the CBA module of this study. For each of the modelled case studies, it is determined how many patients are affected by a reduction in mortality and/or a reduction in burden of disease in each year.

C.2.2.1. Modelling an increase in labour supply and hours worked

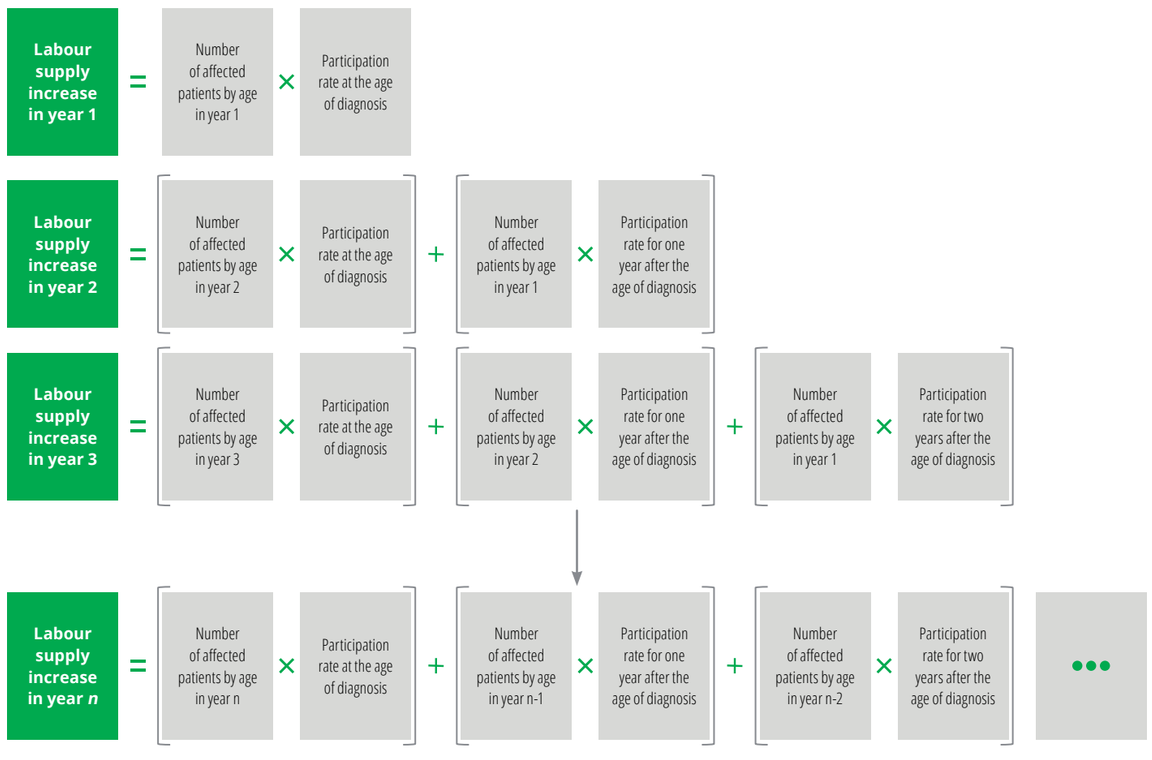
Labour supply is modelled for this analysis using the size of the reduced mortality effect and the reduced burden of disease effect calculated in the CBA component of this study.

The shock calculation uses the following assumptions to estimate the impact to the labour force over time:

- the average age of diagnosis for each of the diseases addressed by the eight high-impact case studies
- the number of patients affected by the research each year
- the average labour force participation rate at the age of diagnosis.

A summary of the overall shock calculation approach is provided in Figure 4.2. This approach assumes that people receiving treatment in one year join the labour force for that year, adjusted for the average rate of labour force participation for the average age of diagnosis. These people then continue to work in the following years, but at a different rate of participation that reflects their age. This is extended to the average life expectancy for Australians, assumed to be 83 years of age.[204] However, the calculation does not consider the age distribution of patients diagnosed for each disease. This is because of a lack of verifiable data and considerable variance between the research programs assessed.

Figure 4.2 Overall approach to calculating the size of the labour supply shock



The approach illustrated in Figure 4.2 is specifically for the increase in labour supply attributable to avoided mortality in the WA and Australian populations. The increase in labour supply from a reduction in mortality rates is assumed to be the number of patients that have avoided mortality as a result of the outcomes of WA medical research, multiplied by the rate of economic participation.

For people experiencing a reduced burden of disease, a different approach is used. For this population, ABS Census data was used to calibrate the assumption that people with morbidities, such as stomach ulcers and glaucoma, typically have a lower rate of economic participation compared to healthy people. Therefore, the participation rate utilised in the calculation only reflects the *improvement* in participation due to the improved health outcomes of medical research.

C.2.2.2. Modelling an increase in labour productivity due to reduced burden of disease

Labour productivity shocks are calculated based on the size of the reduced burden of disease estimated in the CBA module of this study.

A reduction in the burden of disease is expected to increase employment through greater economic participation (see section C.2.2.2). For those that are already employed or in the labour force, eliminating the burden of disease is assumed to lead to an increase in labour productivity. This can be approximated through an increase in wages, controlling for other key labour market factors such as education levels, gender, and industry. Additionally, given the difference in participation rates, the analysis controls for the number of hours worked.

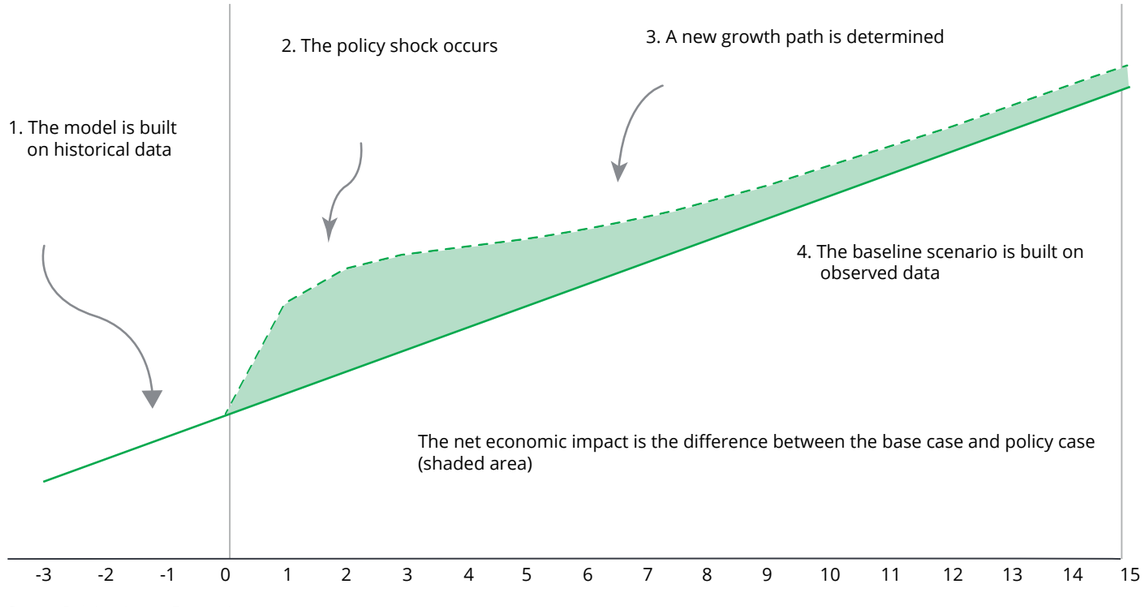
The average increase in wages is estimated from academic literature on disability pay gaps, and is assumed to vary between the type of disease.[205] This is applied in DAE-RGEM as a percentage change in wages for the affected population, which is obtained from the CBA module of this study.

C.2.3. Modelling in DAE-RGEM

The shocks developed for the base and policy cases are applied to DAE-RGEM for the evaluated period, ranging from 1995 to 2045. The results are presented for the policy case as relative to the base case, as an incremental change in the size of the economy, or in total employment (Figure 4.3).

Importantly, outputs from CGE modelling do not reflect year-on-year change. This means that if the WA economy experiences increased GSP to the order of $100 million for a given year, WA GSP is $100 million higher than it would have been in the baseline estimate for that year. This is different to a $100 million increase in GSP relative to the previous year. Similarly, for a sector that sees full-time employment increase by 100 jobs, this means that the sector is expected to sustain 100 more jobs than the baseline projection for the same given year – not an increase in jobs from one modelled year to the next. As such, average annual FTE increases presented cannot be summed across the evaluation period.

Figure 4.3 Stylised representation of economic impact modelling using a CGE framework



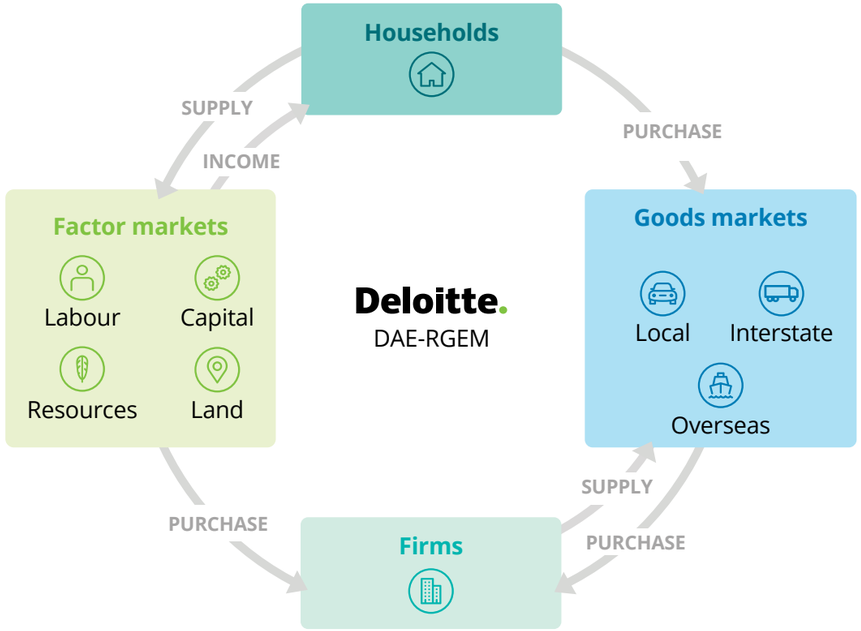
Source: Deloitte Access Economics

C.3. Deloitte Access Economics' in-house model (DAE-RGEM)- Detail

The scenario modelling in this study utilises DAE-RGEM. DAE-RGEM is a large scale, dynamic, multi-region, multi-commodity computable general equilibrium (CGE) model of the world economy with bottom-up modelling of Australian regions. DAE-RGEM encompasses all economic activity in an economy – including production, consumption, employment, taxes and trade – and the inter-linkages between them. For this analysis, the model has been customised to explicitly identify core sectors of the Australian and global economy and has split each jurisdiction into greater city and rest of jurisdiction regions.

Figure 4.4 is a stylised diagram showing the circular flow of income and spending that occurs in DAE-RGEM. To meet demand for products, firms purchase inputs from other producers and hire factors of production (labour and capital). Producers pay wages and rent (factor income) which accrue to households. Households spend their income on goods and services, pay taxes and put some away for savings. The government uses tax revenue to purchase goods and services, while savings are used by investors to buy capital goods to facilitate future consumption. As DAE-RGEM is an open economy model, it also includes trade flows with other regions, interstate and foreign countries.

Figure 4.4 The components of DAE-RGEM and their relationships



Source: Deloitte Access Economics.

DAE-RGEM is based on a substantial body of accepted microeconomic theory. Key assumptions underpinning the model are:

- The model contains a 'regional consumer' that receives all income from factor payments (labour, capital, land and natural resources), taxes and net foreign income from borrowing (lending).
- Income is allocated across household consumption, government consumption and savings so as to maximise a Cobb-Douglas (C-D) utility function.
- Household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In the Australian regions, households can also source goods from interstate. In all cases, the choice of commodities by source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption for composite goods, and goods from different sources (domestic, imported and interstate), is determined by maximising utility via a C-D utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital.
- Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a constant elasticity of substitution production function.
- Producers are cost minimisers, and in doing so, choose between domestic, imported and interstate intermediate inputs via a CRESH production function.
- The model contains a more detailed treatment of the electricity sector that is based on the 'technology bundle' approach for general equilibrium modelling developed by ABARE (1996).
- The supply of labour is positively influenced by movements in the real wage rate governed by an elasticity of supply.
- Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: global investment and rates of return in a given region compared with global rates of return. Once the aggregate investment has been determined for Australia, aggregate investment in each Australian sub-region is determined by an Australian investor based on: Australian investment and rates of return in a given sub-region compared with the national rate of return.
- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.
- Prices are determined via market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other Australian regions (interstate exports).
- For internationally traded goods (imports and exports), the Armington assumption is applied whereby the same goods produced in different countries are treated as imperfect substitutes. But, in relative terms, imported goods from different regions are treated as closer substitutes than domestically produced goods and imported composites. Goods traded interstate within the Australian regions are assumed to be closer substitutes again.

The model accounts for greenhouse gas emissions from fossil fuel combustion. Taxes can be applied to emissions, which are converted to good-specific sales taxes that impact on demand. Emission quotas can be set by region and these can be traded, at a value equal to the carbon tax avoided, where a region's emissions fall below or exceed their quota.

Limitation of our work

General use restriction

This report is prepared solely for the use of AAMRI WA. This report is not intended to and should not be used or relied upon by anyone else and we accept no duty of care to any other person or entity. The report has been prepared for the purpose of estimating the economic value of the medical research sector in WA. You should not refer to or use our name or the advice for any other purpose.

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