Deloitte Access Economics

The social and economic contribution of the Menzies School of Health Research in 2015

Menzies School of Health Research

September 2015

Deloitte.

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Glossary

A&F	audit and feedback
ABCD	Audit and Best Practice for Chronic Disease Project
ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
AIMHI	Australian Integrated Mental Health Initiative
ANZSIC	Australia and New Zealand Standard Industrial Classification
ARF	acute rheumatic fever
BCR	benefit-cost ratio
CARPA	Central Australian Rural Practitioners Association
CBA	cost-benefit analysis
CCDE	Centre for Child Development and Education
CDU	Charles Darwin University
CQI	continuous quality improvement
CRCAH	Cooperative Research Centre for Aboriginal Health
CRE	Centre of Research Excellence
CSOM	chronic suppurative otitis media
DALY	Disability-Adjusted Life Year
DHA	dihydroartemisinin-piperaquine
DRUID	Darwin Region Urban Indigenous Diabetes
DISCOVER-TT	Discovering Indigenous Strategies to Improve Cancer Outcomes Via Engagement, Research Translation and Training
DTF	Department of Treasury and Finance
FTE	full-time equivalent
G-CSF	granulocyte-colony stimulating factor
GAS	group A streptococcus
GDM	gestational diabetes mellitus
GOS	gross operating surplus
GDP	gross domestic product
GSP	gross state product
HBA1C	glycated haemoglobin
IO	input-output

LBW	low birth weight
LFI	lateral flow immunoassay
MDA	mass drug administration
NHMRC	National Health and Medical Research Council
NP	nurse practitioner
NPV	net present value
NT	Northern Territory
PANDORA	Pregnancy and Adverse Neonatal Diabetes Outcomes in Remote Australia
PBB	protracted bacterial bronchitis
PCV7	7-valent pneumococcal conjugate vaccine
PHID-CV10	10-valent pneumococcal Haemophilus influenzae protein D conjugate vaccine
PM&C	Department of Prime Minister and Cabinet
QLD	Queensland
RHD	rheumatic heart disease
SA	South Australia
SEAQUAMAT	Southeast Asian Quinine Artesunate Malaria Trial
UKPDS	United Kingdom Prospective Diabetes Study
VSLY	value of a statistical life year
WA	Western Australia
WHO	World Health Organization
WWARN	Worldwide Antimalarial Resistance Network

Key findings

Overview of Menzies

The Menzies School of Health Research (Menzies) was established in 1985, with a vision to "**improve health outcomes and reduce health inequity for populations in Australia and the Asia-Pacific region, particularly Aboriginal and Torres Strait Islander communities**, through excellence and leadership in research, education and capacity development".

Menzies has developed to become a **multifaceted medical research institute at the forefront of Indigenous health and tropical disease**. Headquartered in Darwin, with **more than 300 staff** and an **annual turnover of approximately $43 million** in 2015, Menzies has a track record of 30 years of scientific discovery, public health achievement and a readily demonstrated impact on health policy and practice.

Economic analysis

This report models the costs and benefits of Menzies' social and economic contribution to the Northern Territory, Australia and the Asia-Pacific.

Across the Northern Territory, Australia and the Asia-Pacific, Menzies' activities generated **a total benefit of $1.1 billion, with a net benefit of $697.9 million and a benefit-cost ratio of 2.7**. The impact of Menzies' globally-recognised work in eliminating malaria in the region is clearly evident.

In the Northern Territory, Menzies' activities generated a **total benefit of $309.1 million, with a net benefit of $168.4 million and a benefit-cost ratio of 2.2**. In addition, in 2014 Menzies **supported 252 full-time equivalent jobs in the Northern Territory**. Many of these jobs are highly skilled, largely as a function of Menzies' capacity to attract funding from outside the Territory.

Across Australia, Menzies' activities generated a **total benefit of $665.9 million, with a net benefit of $273.0 million**. Major areas of health impacted by Menzies' research in Australia include chronic cough and lung disease, chronic disease, pyoderma and scabies, middle ear infection, cancer and tropical diseases including melioidosis and rheumatic heart disease.

Conclusion

Menzies' focus on improving Indigenous health and wellbeing contributes both in economic terms, and in closing the gap in health outcomes for Indigenous people across Australia. **Menzies is poised to make a core contribution to the development of Northern Australia and to strengthen educational, health and economic partnerships with Australia's neighbours across the region**.

Executive Summary

This report updates a prior report commissioned by the Menzies School of Health Research ("Menzies") in 2012, which modelled the costs and benefits of Menzies' social and economic contribution between 2002 and 2030 to the Northern Territory (NT), Australia and the Asia-Pacific. In this report, Deloitte Access Economics analyses and documents Menzies' contributions to these regions between 2002 and 2033.

As before, this assessment considers the quantitative impact of Menzies' activities on economic activity, including economic contributions, employment impacts, health benefits, and education. The findings presented in Table i below encompass previously estimated costs from the previous report for 2002-2030, and the additional valuations in this report, which have all been adjusted to 2015 dollars.

The results in Table i and in this report have been presented differently to how they were in the 2012 report. Where results were previously outlined for the NT, Australia excluding the NT and Asia-Pacific excluding Australia, results are now outlined for the NT, the whole of Australia (including the NT) and Asia-Pacific excluding Australia.

The results of this analysis suggest that between 2002 and 2033, Menzies' activities generated significant economic benefit to the NT, Australia and the Asia-Pacific region. **Across all perspectives, Menzies' activities generated a net benefit of $697.9 million, with a benefit-cost ratio of 2.7**.

Compared to the results from the 2012 report:

- The net benefits have increased substantially for all areas: increasing by 93% in the NT, 214% in Australia and 45% in the Asia-Pacific.
- The benefit-cost ratios (BCRs) have remained relatively stable for the NT and Australia, but have fallen in the Asia-Pacific, in part due to large new capital expenditure on new buildings increasing the costs in recent years. However, this BCR (36.2) still remains very strong.

In addition to the costs and benefits shown in Table i, in 2014 it is estimated that Menzies directly supported 201 FTE jobs – many of them highly skilled – in the NT, largely as a function of Menzies' capacity to attract funding from outside the Territory.

Table i: Summary of results (2002-2033)

	NT $NPV_{7\%}$ $2015m	Australia $NPV_{7\%}$ $2015m	Asia-Pacific (a) $NPV_{7\%}$ $2015m
Costs	**$140.67**	**$392.92**	**$12.07**
Benefits			
Direct economic contribution	$202.76	$228.79	
Indirect economic contribution	$79.61	$89.53	
Education		$2.81	
Health benefits			
Malaria		$0.84	$436.92
Melioidosis	$1.44	$8.10	
Rheumatic heart disease	$0.84	$6.71	
Oral disease	$1.05	$1.05 (b)	
Quality improvement for primary care of chronic disease	$14.60	$135.37	
Pyoderma and scabies	$5.64	$58.09	
Gestational diabetes	$0.01	$0.02	
Protracted bacterial bronchitis	$1.13	$91.48	
Cancer research		$19.17	
Otitis media	$2.03	$23.96	
Tobacco control		Not quantified	
Child development and education		Not quantified	
Nutrition		Not quantified	
Kidney disease		Not quantified	
Mental health		Not quantified	
Total benefits	**$309.10**	**$665.92**	**$436.92**
Net benefits	**$168.43**	**$273.00**	**$424.85**
Benefit cost ratio	**2.20**	**1.69**	**36.20**

Note: (a) 'Australia' refers to Australia including the NT, and 'Asia-Pacific' refers to the region excluding Australia.

Due to this change in definitions, the manner in which results have been reported in this table differs from that of the previous report. (b) The health benefits of improved treatment of oral disease derive solely from the NT.

It is important to recognise that this analysis represent a conservative estimate of the total contribution, which is likely to exceed this report's estimates as:

- it is highly likely that the application of some of the outcomes of research generated by Menzies' work have yet to be identified; and
- many of the benefits of Menzies' research cannot be accurately quantified in monetary terms.

As demonstrated by the analysis in this report, Menzies' activities contribute significant economic benefits in terms of direct and indirect economic benefits and improvements in health and wellbeing due to its research. Menzies' areas of impact extend not only domestically to the NT and to the rest of Australia, but internationally to the Asia-Pacific region as well.

In addition, Menzies' focus on health issues that affect Aboriginal and Torres Strait Islander Australians has played an important role in understanding the causes of both ill-health and resilience amongst Australia's Indigenous communities. As such, it is important to recognise that Menzies' activities have not only made considerable economic contributions to the NT, Australia and the Asia-Pacific, but have also made significant strides in addressing equitable health in this country.

Deloitte Access Economics

1 Introduction

Deloitte Access Economics was commissioned by the Menzies School of Health Research ("Menzies") to model the social and economic contribution of Menzies to the Northern Territory (NT), Australia and the Asia-Pacific. This report updates previous work undertaken by Deloitte Access Economics for Menzies in 2012 which modelled the costs and benefits of Menzies' social and economic contribution between 2002 and 2030.

The 2012 report (Deloitte Access Economics, 2012) estimated that Menzies' activities had delivered a net benefit of $393 million, with a benefit-cost ratio (BCR) of 3.1, across the NT, Australia and the Asia-Pacific.

In this report, the costs and benefits of Menzies' activities will be modelled for the years between 2002 and 2033.

This report has been structured as follows:

- **Section 1** of this report describes the background to the project, including the history, role and activities of Menzies;
- **Section 2** outlines the operational and capital expenditure incurred by Menzies;
- **Section 3** describes the economic contribution of Menzies to the NT and Australian economies;
- **Section 4** outlines the economic benefits of health research undertaken by Menzies to the NT, Australia and the Asia-Pacific;
- **Section 5** describes the qualitative benefits contributed by Menzies; and
- **Section 6** evaluates the overall impact made by Menzies, and conducts sensitivity analysis on the results.

1.1 The Menzies School of Health Research

This section outlines the history of Menzies, and the roles and activities undertaken by Menzies.

1.1.1 The history of Menzies

Menzies was established in 1985 as a body corporate of the NT Government under the *Menzies School of Health Research Act 1985* (the Act) with a vision "to improve health outcomes and reduce health inequity for populations in Australia and the Asia-Pacific region, particularly Aboriginal and Torres Strait Islander communities, through excellence and leadership in research, education and capacity development".

As outlined in the Act, the core tenets of Menzies' mission are:

- to promote improvement in the health of all people in tropical and central Australia by establishing and developing a centre of scientific excellence in health research and health education;

- to advance knowledge in the fields of health research and health education, particularly in relation to human health, and to seek and discover the origins and causes of diseases and ill health;
- to use the knowledge so gained to improve methods of prevention, diagnosis and treatment of disease and ill health in both humans and animals;
- to serve as a centre for learning and training in health research and health education; and
- to promote and encourage post graduate research into matters relating to the functions of the school within Charles Darwin University (CDU) as a research school of that university or in cooperation with other medical or educational institutions; and other such functions as the Board thinks fit.

Since its establishment, Menzies has undergone constant and strategic development to evolve into a multifaceted medical research institute at the forefront of Aboriginal and Torres Strait Islander ("Indigenous") health and tropical disease in Australia and the Asia-Pacific region. In 2004, the Act was amended to formalise Menzies' relationship with CDU, constituting Menzies as a school within the University's Institute of Advanced Studies. Since launching its postgraduate coursework programs in public health in 1994, Menzies has continuously expanded its educational capacities with the formation of its Education and Training Division in 2001 and the launch of its new professional doctorate program in 2009. Menzies has also driven various large-scale research initiatives over the years, including the establishment of the Cooperative Research Centre for Aboriginal Health (CRCAH) in 1997 and, more recently, its involvement in the opening of the Centre for Child Development and Education (CCDE) in 2011.

In 2015, Menzies celebrates 30 years of scientific discovery and public health achievement. Headquartered in Darwin, it has grown to have offices in Alice Springs, Brisbane, Melbourne, Timika (Indonesia) and Kota Kinabalu (Malaysia), and partnerships with over 60 Indigenous communities across Northern Australia and the Asia-Pacific region. Menzies has grown to employ over 300 staff and has an annual turnover of approximately $43 million (Menzies, 2015).

1.1.2 Roles and activities of Menzies

Menzies is a national and international leader in Indigenous, tropical health and medical research and is a significant contributor to health education and research training in the area. Menzies' major research programs target the main health challenges to Indigenous Australians and those living in the Asia-Pacific region with research expertise in clinical science, biomedical science, medical microbiology, epidemiology and public health assessed as "well above world standard" by the Australian Research Council (Australian Research Council, 2012). Menzies' National Health and Medical Research Council (NHMRC) success rate is twice the national average (NHRMC, 2014).

In addition to educating future researchers and facilitating research, Menzies collaborates broadly with various stakeholders, such as communities, policy makers and governments, to increase the capacity of health service providers, clinicians and researchers. Through these partnerships, Menzies has sought to establish evidence-based health practices that better diagnose, treat and/or prevent important health problems such as poor nutrition,

otitis media, chest disease, diabetes, chronic kidney disease, mental illness, substance abuse, melioidosis, malaria and tuberculosis .

Menzies' research activities and operations are broadly divided into the four interdisciplinary divisions: Child Health; Epidemiology and Health Systems; Global and Tropical Health; Wellbeing and Preventable Chronic Diseases. The Divisional structure also encompasses the Centre for Child Development and Education (see Section 1.1.2.1), Centre for Primary Health Care Systems (see Section 1.1.2.3), and Rheumatic Heart Disease Australia (see Section 1.1.2.4). In addition, Menzies hosts four NHMRC Centres for Research Excellence focussed on:

- respiratory health (see Section 1.1.2.1);
- ear health (see Section 1.1.2.1);
- Indigenous cancer (see Section 1.1.2.3); and
- primary health care Systems (see Section 1.1.2.3).

1.1.2.1 Child Health

The Child Health Division investigates strategies to improve the health of Indigenous children. The work encompasses important public health issues such as common paediatric diseases, particularly relating to respiratory disease, ear infections and skin disease. Intervention studies have investigated clinical treatments and the delivery of care ranging from clinical trials of antibiotics and vaccines through to interventions promoting health and support of families to improve child health and wellbeing. Menzies has established a travelling health program, called HealthLAB, which has a focus on youth and Indigenous communities and directly engages the public through measuring biomedical risk factors for chronic diseases to educate people about positive lifestyle choices and taking ownership of their health.

Child development and learning, child protection, families and parenting are key areas of focus through the CCDE. Established in 2011, CCDE seeks to improve health, wellbeing and education outcomes for children in the NT. Recent activities include a substantial tender for a national Foetal Alcohol Spectrum Disorder prevention initiative and adoption by the Commonwealth Government of a National Aboriginal and Torres Strait Islander Suicide Prevention Strategy that was drafted by a Menzies consultancy team.

1.1.2.2 Wellbeing and Preventable Chronic Disease

The Wellbeing and Preventable Chronic Disease Division seeks to advance the health and wellbeing of Indigenous Australians by researching the causes, prevention and treatment of chronic disease and translating the results into practical solutions. Public health research includes a focus on smoking, poor nutrition, alcohol abuse, petrol sniffing and gambling. Clinical research includes a focus on better diagnosis, treatment and prevention of diabetes, chronic kidney disease, mental illness, health effects of alcohol abuse and petrol sniffing.

Recent activities include generation of the evidence base used in the review and redesign of the national Tackling Indigenous Smoking program and empirical evidence on the role of price discounts to improve diet for residents in remote Indigenous communities – a world-first demonstration for a socially disadvantaged population in a real world setting. In

the last five years, Menzies has also undertaken evaluations of Alcohol Management Plans in various NT regions and a national evaluation of the rollout of Low Aromatic Fuel as a deterrent to petrol sniffing in Indigenous communities.

Through development of a clinical register and models of care for women with diabetes in pregnancy, Menzies is translating evidence into practice so that health outcomes for this group can be monitored and improved. Work is also underway to improve understanding of the health, social and economic impacts of the most common types of dialysis services available in the NT to provide an evidence base for a patient-centred approach to cost-effective dialysis service delivery. Resources have been established to assist clinicians and health science students to better understand the situations that lead to miscommunication between healthcare providers and Indigenous patients with kidney disease and also to assist Aboriginal patients and their families develop a better understanding of kidney health and available treatment options.

1.1.2.3 Epidemiology and Health Systems

The Epidemiology and Health Systems Division consists of two discrete programs of work: cancer and social epidemiology, and the Centre for Primary Health Care Systems, which focus on improving health outcomes across the continuum of care for Indigenous people. Each currently host an NHMRC Centre of Research Excellence (CRE):

- the CRE in Discovering Indigenous Strategies to Improve Cancer Outcomes Via Engagement, Research Translation and Training (DISCOVER-TT), which aims to build an evidence base to reduce disparities in the treatment and survival of Indigenous Australians with cancer; and
- the CRE Innovation Platform for Integrated Quality Improvement in Indigenous Primary Health Care (CRE-IQI), which focuses on generating, sharing and encouraging use of good quality, relevant evidence on how continuous quality improvement (CQI) can most effectively contribute to improving health outcomes for Aboriginal and Torres Strait Islander people.

DISCOVER-TT is a component of the National Indigenous Cancer Network, established in partnership with others under Menzies' leadership. Other activities of the Division include:

- completion of the Sentinel Sites Evaluation of the Commonwealth Government Indigenous Chronic Disease Package;
- establishment of the National Aboriginal and Torres Strait Islander Cancer Framework, which Menzies developed in partnership with Cancer Australia to provide direction around policy, programs and practice to improve cancer outcomes for Indigenous Australians;
- the National Indigenous Bowel Screening Project, which was a successful tender to trial an alternative pathway to increase participation of Indigenous Australians in the National Bowel Cancer Screening Program via primary health care services; and
- development of a National CQI Framework for Aboriginal and Torres Strait Islander PHC, which is a Menzies led consultancy in partnership with the Lowitja Institute, the National Aboriginal Community Controlled Health Organisation and Affiliates, and colleagues.

1.1.2.4 Global and Tropical Health

The Global and Tropical Health Division focuses on prevention and treatment of infections of major public health importance in disadvantaged populations of the Asia-Pacific region and in northern and central Australia. These include malaria, tuberculosis, melioidosis, staphylococcal and streptococcal disease, rheumatic heart disease, influenza and hepatitis B.

Menzies optimises the prevention and clinical management of tropical and infectious diseases through collaborations with a variety of health service providers, researchers and policy-makers in the Asia-Pacific region. As a leader within the Asia-Pacific Malaria Elimination Network, and the Worldwide Antimalarial Resistance Network (WWARN), Menzies' researchers have played a key role as primary writers of the Australian treatment guidelines for malaria and in multiple policy and practice changes over the last 5 years. Menzies' research and the subsequent impact on changes to policy and treatment guidelines have contributed substantially to the mortality from melioidosis in the Northern Territory falling to less than 10% from a previous high of over 30% (Currie et al, 2010). In addition, Menzies' researchers are the primary writers of the Australian treatment guidelines for scabies and skin sores, and devised treatment guidelines for crusted scabies are now used in the USA and Europe.

The global scope of Menzies' work includes countries such as Vanuatu, Indonesia, Thailand, Fiji, Malaysia, Afghanistan and Nepal.

2 Costs

This section presents information on the operational and capital costs of Menzies over the period 2002-2014. This data is a component of the economic contribution calculations (see Section 3).

2.1 Operational expenditure

The following yearly expenditure figures were sourced from Menzies' detailed financial statements, which were supplied to Deloitte Access Economics for this report. Table 2.1 summarises Menzies' operational expenditure from 2002 to 2014. Between 2002 and 2014, Menzies' expenditure has increased by an average annual rate of 12%. In 2014, total expenditure was almost $38 million with employee expenses, which was the largest individual cost item, accounting for 62% of total expenditure.

Table 2.1: Menzies' operational expenditure (2002-2014)

Expenses	2002-2010 ($'000)	2011 ($'000)	2012 ($'000)	2013 ($'000)	2014 ($'000)	Total ($'000)
Employee expenses	119,289	23,953	25,854	24,466	23,383	216,945
Depreciation	3,170	402	368	298	640	4,877
Other expenses	73,427	12,587	13,517	14,126	13,233	128,833
Total	**195,886**	**36,541**	**40,509**	**39,666**	**37,975**	**350,576**

Source: Detailed financial data provided to Deloitte Access Economics.
Note: All figures have been brought forward to 2015 using historical consumer price index data (ABS, 2015).
Totals may not add due to rounding.

The majority of expenditure associated with Menzies between 2002 and 2014 has been operational, with the remaining expenditure attributed to capital.

2.2 Capital expenditure

Table 2.2 provides a summary of the capital expenditure from 2002 to 2014. The work in progress category relates to Menzies' expenditure on its new building project, which commenced in 2011. The spike in expenditure in 2012, 2013 in particular and 2014 is attributed to costs incurred by that item of capital expense.

Table 2.2: Menzies' capital expenditure (2002-2014)

Capital Expenses	2002-2010 ($'000)	2011 ($'000)	2012 ($'000)	2013 ($'000)	2014 ($'000)	Total ($'000)
Leasehold property	320					320
Plant and equipment	3,044	403	85	227	3,101	6,861
Motor vehicles	301	72	19	75	39	506
Work in progress		2,324	5,168	27,779	11,457	46,728
Total	**3,665**	**2,799**	**5,272**	**28,080**	**14,598**	**54,415**

Source: Detailed financial data provided to Deloitte Access Economics.
Note: All figures have been brought forward to 2015 using historical consumer price index data (ABS, 2015).
Totals may not add due to rounding.

3 Methodology

Menzies contributes to economic activity in Australia, in terms of its own direct contribution to employment and other expenditure, and the demand created in supplier (upstream) industries. Using standard input-output (IO) multipliers, it is possible to estimate the flow-on impacts in gross output, value added, wages and total employment that are generated by Menzies. The following section provides an assessment of Menzies' contribution to economic activity, including employment impacts, in the NT and Australia between 2002 and 2014.

3.1 Economic multipliers

The economic activity generated by Menzies is the sum of direct and indirect components.

- The **direct** component measures economic activity directly associated with Menzies' activities – that is, the payments to the factors of production such as labour, which is a key input in the service provision process, with the total salaries of professors and other educators representing a direct measure of the activity generated by Menzies.
- The **indirect** component measures the economic activity generated by Menzies through its demand for the outputs of other industries.

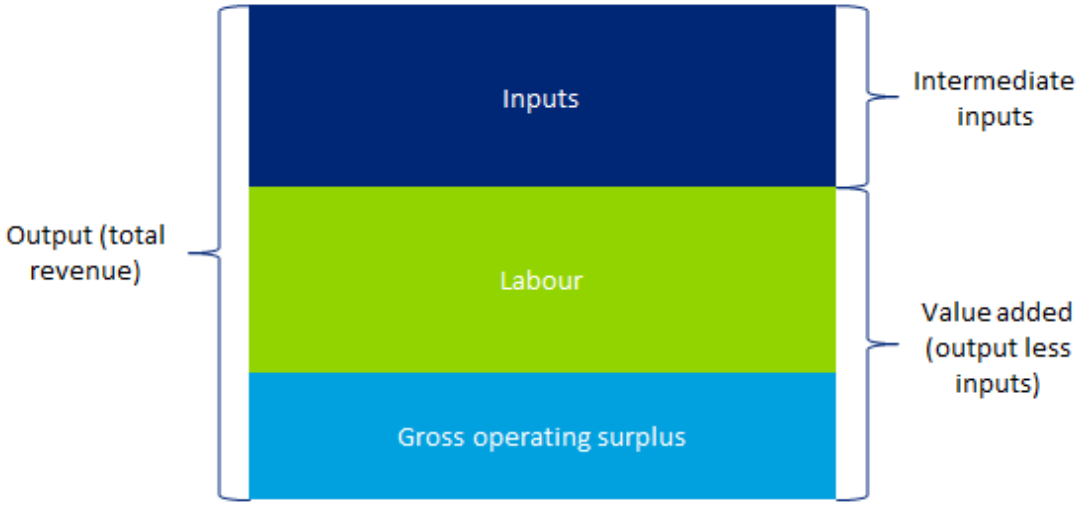
There are four widely used direct measures of economic activity. Each tells a different story about the economic contribution of a firm.

- **Value added** measures the value of output (goods and services) generated by the firm's factors of production (which are labour and capital). The sum of value added across all entities in the economy equals GDP.
    - **Labour income** is a subcomponent of value added. It measures the value of output generated by the firm's direct labour inputs. The capital analogue to this measure is called **gross operating surplus** (GOS). Labour income includes payroll tax paid by companies.
    - **GOS** measures the value of output generated by the firm's direct capital inputs. In addition to profit this includes depreciation, interest payments and taxation, as these are all paid from returns to capital. GOS is often measured as earnings before interest, taxation, depreciation and amortisation. GOS includes corporate tax paid by companies.
- **Gross output** measures the total sales value of all the goods and services that are supplied by the firm. This is a broader measure than value added because in addition to the value added by the firm, it also includes the value of intermediate inputs that are utilised during the production process.
- **Employment** is a fundamentally different measure of activity from those above. It measures the number of workers who are employed by the firm, rather than the value of the workers' output. It is typically measured using headcount and/or the number of full-time equivalent (FTE) employees.

Figure 3.1 provides a useful summary of the components that make up gross output. Value added can be calculated directly by summing the payments to the primary factors of production – labour (payments take the form of salaries) and capital (payments take the

form of GOS). The value of intermediate inputs can also be calculated directly by summing expenses related to non-primary factor inputs (for example, materials from local suppliers and externally sourced services).

Figure 3.1: Measuring direct economic activity



The economic contribution of Menzies is described by the following multipliers.

- The **gross output multiplier** measures the total economy-wide gross output required by all industries in the economy to satisfy a one dollar increase in Menzies' gross output.
- The **gross value added multiplier** measures the ratio of the total economy-wide gross value added required by all industries in the economy to satisfy a one dollar increase in Menzies' gross value added output.
- The **labour income multiplier** measures the ratio of the total economy-wide labour income required by all industries in the economy to satisfy a one dollar increase in Menzies' labour income.
- The **employment multiplier** measures the ratio of the total economy-wide employment required by all industries in the economy to satisfy a one unit increase in Menzies' total employment. The metric in this report is FTE jobs.

An explanation of the mathematical principles that are used to calculate Menzies' economic contribution is provided at Appendix B.

This report provides estimates of measures of gross output and value added, along with labour income and employment. The following general assumptions are present (ABS[1], 2013a):

- no supply-side constraints, which means that any increase in production by Menzies would not decrease production in other sectors of the economy;
- fixed prices with no crowding out effects, which means that costs would not increase elsewhere because of an increase in production;

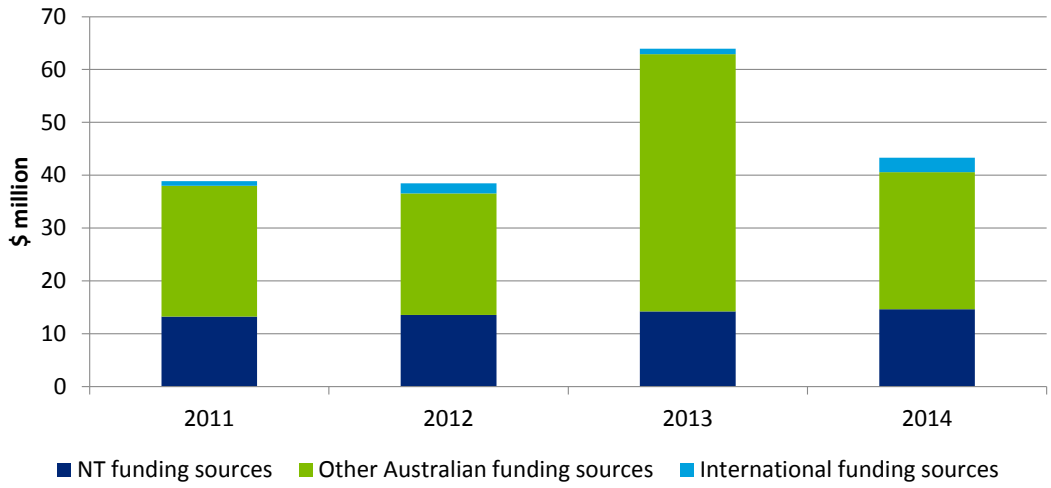
[1] Australian Bureau of Statistics.

- no allowance for marginal responses to the change in expenditure, and so preferences for goods or services by others would not adjust from an increase in production; and
- an absence of budget constraints, which means no constraint in the flow of funds.

3.1.1 Distribution of costs

The relative proportions of Menzies' costs to the NT, Australia and the Asia-Pacific region have been calculated on the basis of the origin of Menzies' funding. Menzies' costs to the NT economy have been attributed to the proportion of Menzies' funding that comes from the NT. Menzies' costs to the Australian economy have been attributed to the proportion of Menzies' funding that comes from Australian sources while Menzies' costs to the Asia-Pacific region have been attributed to the proportion that comes from international sources. Chart 3.1 illustrates the growth in funding and the relative contribution from different funding sources.

Chart 3.1: Menzies' funding sources (2011-2014)



Source: Detailed financial data provided to Deloitte Access Economics.
Note: All figures have been brought forward to 2015 using historical consumer price index data (ABS, 2015).

The large increase in funding from other Australian sources in 2013 is attributed to funding received from the Australian Government to construct new buildings and facilities. Funding from all sources has remained relatively consistent in the other three years.

3.1.2 Distribution of benefits

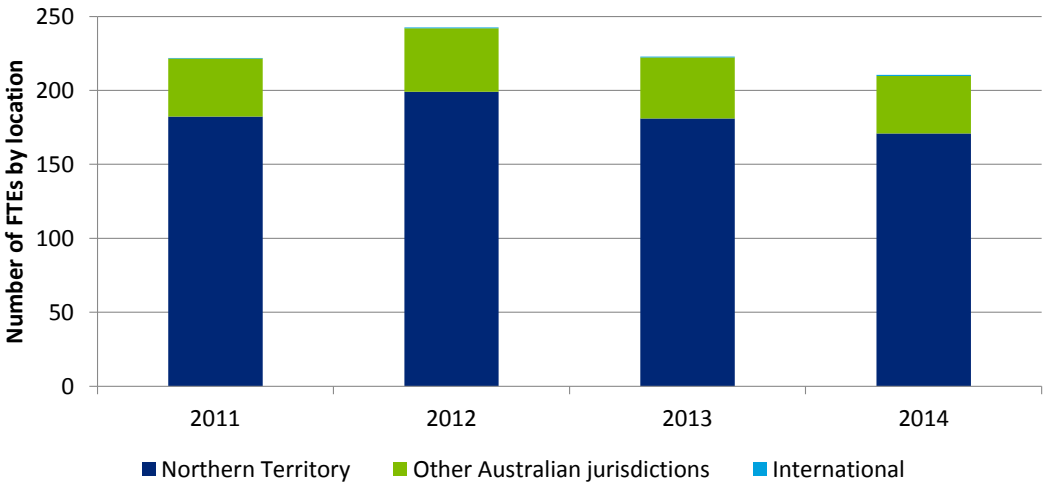
The relative proportions of Menzies' contributions to the NT and Australian economy have been calculated on the basis of the origin of Menzies' FTEs. This differs to the approach previously undertaken for the 2012 report, which calculated contributions on the basis of the origin of funding, and has been changed to better reflect the nature of Menzies' contributions.

Menzies' contributions to the NT economy have been attributed based on the proportion of Menzies' staff who are located in the NT while Menzies' contributions to the Australian economy encompass contributions to the NT economy and to the rest of Australia.

Although a small proportion of Menzies' staff are located overseas, their contributions are to economies overseas and have not been included for the purposes of this analysis.

Chart 3.2 illustrates the FTE breakdown of Menzies employees by location.

Chart 3.2: Menzies' FTEs by location (2011-2014)



Source: Data provided by Menzies.

3.2 Direct economic contribution

The direct contribution of Menzies is the value added by Menzies to the NT and Australian economies through GOS and labour income.

The direct contribution of Menzies to the NT from 2002 to 2014 is summarised in Table 3.1. Based on financial data obtained from Menzies it was determined that in 2014, total gross output attributable to Menzies' staff located in the NT was $31.8 million. Of this income, $18.4 million was returned to labour in the form of labour income (wages and salaries) and $1.2 million was the return to capital in the form of GOS. The direct economic contribution of Menzies to the NT was $20.1 million in 2014. The total direct contribution of Menzies to the NT between 2002 and 2014 is estimated to be $202.8 million.

Table 3.1: Direct economic contribution of Menzies to the NT (2002-2014)

Year	Gross output ($'000)	GOS ($'000)	Depreciation ($'000)	Labour income ($'000)	Value added ($'000)
2002-2010	149,195	24,620	1,956	75,403	101,978
2011	31,727	2,037	335	19,050	21,422
2012	32,162	-1,012	310	20,709	20,006
2013	51,825	19,424	249	19,537	39,209
2014	31,773	1,196	528	18,419	20,143
Total	**296,682**	**46,264**	**3,377**	**153,117**	**202,759**

Source: Detailed financial data provided to Deloitte Access Economics.
Note: All figures have been brought forward to 2015 using historical consumer price index data (ABS, 2015).
Totals may not add due to rounding.

The direct contribution of Menzies to the Australian economy from 2002 to 2014 is summarised in Table 3.2. Based on financial data received from Menzies, it was determined that in 2014 total gross output attributable to Menzies' staff in Australia was $39.0 million. Of this amount, $22.6 million was returned to labour in the form of wages and salaries and $1.5 million was the return to capital in the form of GOS. The direct economic contribution of Menzies to the Australian economy was $24.7 million in 2014. The total direct contribution of Menzies to the Australian economy between 2002 and 2014 is estimated to be $228.8 million.

Table 3.2: Direct economic contribution of Menzies to Australia* (2002-2014)

Year	Gross output ($'000)	GOS ($'000)	Depreciation ($'000)	Labour income ($'000)	Value added ($'000)
2002-2010	154,589	25,344	2,033	78,175	105,533
2011	38,556	2,476	407	23,151	26,034
2012	39,085	-1,230	376	25,167	24,313
2013	63,646	23,854	305	23,993	48,152
2014	39,020	1,469	648	22,620	24,737
Total	**334,896**	**51,913**	**3,770**	**173,106**	**228,789**

Source: Detailed financial data provided to Deloitte Access Economics.
Note: All figures have been brought forward to 2015 using historical consumer price index data (ABS, 2015).
Totals may not add due to rounding. * Figures for Australia include contributions to the NT economy.

3.3 Indirect economic contribution

The indirect economic contribution measures the "multiplier" impacts generated as a result of the direct expenditure associated with Menzies' activities. For example, the expenditure on professional and technical services by Menzies staff will generate expenditure by the providers of these services to purchase further inputs, such as specialised equipment and advertising. These purchases will in turn create demand for inputs to the production processes of the suppliers of these services, thus resulting in a flow-on effect throughout the economy caused by Menzies' initial expenditure in these areas.

The indirect contribution of Menzies is the value added that is created by economic activity stemming from Menzies' demand for goods and services.

Table 3.3 shows Menzies' multipliers that were calculated for 2014. They are used to calculate Menzies' impact on gross output, value added, labour income and employment in related industries.

Table 3.3: Menzies' multipliers (2014)

	Multiplier	Ratio of total to direct
Gross output	1.57	1.57
Value added	0.91	1.44
Labour income	0.75	1.29
Employment (FTE)	8.05	1.47

Source: Deloitte Access Economics calculations.

3.3.1 Contribution to the NT economy

The indirect economic contribution of Menzies to the NT via the demand created for services and products to support Menzies' operations is summarised in Table 3.4. In 2014, the total indirect economic contribution of Menzies to the NT is estimated to be $8.9 million. The total indirect contribution of Menzies to the NT between 2002 and 2014 is estimated to be $79.6 million.

Table 3.4: Indirect economic contribution of Menzies to the NT (2002-2014)

Year	Gross output ($'000)	GOS ($'000)	Labour income ($'000)	Value added ($'000)
2002-2010	84,907	14,644	27,494	42,138
2011	17,190	3,429	5,112	8,541
2012	20,960	4,115	6,196	10,310
2013	19,968	3,903	5,864	9,767
2014	18,049	3,509	5,341	8,850
Total	**161,074**	**29,599**	**50,007**	**79,606**

Source: Detailed financial data provided to Deloitte Access Economics.
Note: All figures have been brought forward to 2015 using historical consumer price index data (ABS, 2015).
Totals may not add due to rounding.

3.3.2 Contribution to the Australian economy

Table 3.5 summarises the indirect economic contribution attributable to Menzies in Australia via demand created by Menzies' operations. In 2014, the total indirect economic contribution of Menzies' activities is estimated to be $10.9 million. The total indirect contribution of Menzies to Australia between 2002 and 2014 is estimated to be $89.5 million.

Table 3.5: Indirect economic contribution of Menzies to Australia* (2002-2014)

Year	Gross output ($'000)	GOS ($'000)	Labour income ($'000)	Value added ($'000)
2002-2010	88,166	15,206	28,555	43,761
2011	20,891	4,167	6,212	10,379
2012	25,472	5,000	7,529	12,530
2013	24,522	4,793	7,202	11,995
2014	22,166	4,309	6,560	10,869
Total	**181,217**	**33,475**	**56,058**	**89,533**

Source: Detailed financial data provided to Deloitte Access Economics.
Note: All figures have been brought forward to 2015 using historical consumer price index data (ABS, 2015). Totals may not add due to rounding. * Figures for Australia include contributions to the NT economy.

3.4 Total contribution

The total contribution of Menzies to the NT and Australian economies is equal to the direct value added by Menzies and the indirect value added that is attributable to the demand for intermediate goods resulting from Menzies' operations.

Between 2002 and 2014, Menzies contributed $282.4 million to the NT economy and $318.3 million to the Australian economy.

3.5 Impact on employment

Direct expenditure by Menzies would be expected to increase demand for labour in the NT, relative to existing demand that would otherwise be in place. The majority of Menzies' personnel are employed within the NT, as shown in Chart 3.2 (see Section 3.1.2). By 2014, Menzies directly employed 171 FTE jobs in the NT. In addition to the direct jobs created, direct expenditure by Menzies from FTE in the NT had a flow-on effect to employment in those industries supported by that direct expenditure. Table 3.6 provides a summary of the contributions to employment of expenditure by Menzies between 2011 and 2014.

Table 3.6: Menzies' effect on employment in the NT (2011-2014)

	2011	2012	2013	2014
Attributable direct employment in NT	182	199	181	171
Attributable indirect employment in NT	77	90	86	80
Total attributable employment	**259**	**289**	**267**	**252**

Source: Deloitte Access Economics calculations.

The total additional impact to employment by Menzies in the NT has grown from 53 FTE jobs in 2002 to 252 FTE jobs in 2014.

4 Health benefits or policy and program improvements

Estimating the economic value to society of health research is a complex but essential step in establishing and justifying appropriate levels of investment in research. Complexities include:

- identifying and valuing the relevant research inputs (when many pieces of research may contribute to a clinical advance);
- accurately ascribing the impact of the research; and
- appropriately valuing the attributed economic impact.

As such, it has not been possible to quantify the economic benefits for all of the activities undertaken by Menzies between 2002 and 2014. Where activities have not been quantified, it should not be assumed that these impacts are not important nor valued, but rather that there is insufficient evidence to robustly identify an economic value for these impacts.

Therefore, the impacts presented in this section should be interpreted as lower bound estimates of the total impacts of Menzies for the time period being assessed. Impacts that have not been quantified will be discussed further in Section 5.

4.1 Overview of methodology

This section provides an overview of the methodology that was used to calculate net present values, ascribe the impact of research, and to value the impact that has been attributed to Menzies.

4.1.1 Net present value

There are several evaluation measures that can be used in the analysis of the value of Menzies benefit impacts. The two most commonly used discounted measures of benefits derived from research are the net present value (NPV) and the return on investment. Future benefits are discounted because the value of a dollar today is worth more than a dollar tomorrow. This study uses the NPV measure. The NPV of research is also known as the discounted value of the net benefit stream. It is obtained by discounting the stream of net benefits produced by the research back to its value in the chosen base period, in this case 2015. The general NPV formula can be represented by:

$$NPV = \sum_{t-0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

where:

B_t is the benefits from research in period t

C_t is the expenditure on research in period t

r is the economic discount rate (7%[2])

n is the number of years the benefits from research are accrued.

Within this study, benefits and costs that occurred in years prior to 2015 were increased to 2015 prices. This includes cost and benefits streams that were reported in the 2012 report. Please note that some benefits streams (rheumatic heart disease, oral health, improved quality of primary healthcare for chronic disease, and pyoderma) that were included in the 2012 report have been revised down, to take account of downward revisions to Indigenous population estimates from the ABS.

4.1.2 Ascribing the impact of research

The following approach has been used to estimate the proportion of health research benefits generated in areas where a contribution by Menzies has been identified.

First, the proportion of health improvements that can be reasonably attributed to health research has been considered. Academic research has proposed that 33% of total health gains related to a reduction in mortality and morbidity from cardiovascular disease is the result of medical research, while a share of the remaining 67% can be linked to research since gains attributed to changes in public policy and individual behaviour depend on research-derived information (Hatfield et al, 2000). Health research, therefore, is assumed to be responsible for 50% of improvements in healthy lifespan. The remaining 50% is attributed to the other factors associated with the implementation of health research. This approach is consistent with prior studies such as Access Economics (2008a), Access Economics (2008b) and Deloitte Access Economics (2012).

Second, Australia's contribution to health research was considered using bibliometric analysis. Bibliometric analysis involves the use of publication and citation data in the assessment of research performance (Pollitt et al, 2011). This analysis has been used to estimate the efficacy of health research in Australia. Bibliometric analysis undertaken by the NHMRC (2013) found that the Australian global proportion of clinical science publications was 3.09% over the period 2005-2009[3] (this is a slight fall from 3.14%, which

[2] This discount rate is recommended by the Department of Prime Minister and Cabinet (PM&C, 2014).

[3] This is calculated as 21,998 / 711,536 = 3.09% (see page 38 of NHMRC, 2013).

was the proportion over 2002-2006). The clinical science cohort of publications was chosen as this cohort covers the Menzies work under investigation.[4]

> Therefore, only 1.55% (50% of 3.09%) of the value resulting from improved health benefits supported by Menzies research will be attributed to Menzies.

4.1.3 Valuing the attributed economic impact

Studies typically consider one or more of the following streams of benefit as a result of health research:

1. direct cost savings arising from research leading to either new less costly treatments or to developments such as vaccines that reduce the number of patients needing treatment;
2. the value to the economy of a healthy workforce;
3. the value to the economy in terms of product development, consequent employment and sales; and/or
4. the intrinsic value to society of health gains generated by research by placing a monetary value on a life.

The following assessment of the value of health research uses the fourth approach. To determine the net benefits from Menzies' activities, the value of gains in wellbeing need to be monetised so they can be compared to the cost of producing those gains. The value of gains in wellbeing can be calculated by multiplying the Value of a Statistical Life Year (VSLY) by the total number of Disability-Adjusted Life Years (DALYs). These concepts are explained in the following sections.

4.1.3.1 Value of a Statistical Life Year

The concept of VSLY is widely used for the evaluation of public policies in the areas of health, environment and safety. The VSLY represents a trade-off between wealth (budgetary resources for a government decision) and a reduction in the probability of death.

For the purposes of this study the VSLY and Value of a Statistical Life (VSL) recommended by the Department of Prime Minister and Cabinet (PM&C) are adopted, which are $182,000 and $4.2 million, respectively, in 2014 dollars (PM&C, 2014).

As the PM&C describes, the VSLY estimates the value society places on reducing the risk of premature death, expressed in terms of saving a statistical life year. This is measured by estimating how much society is willing to pay to reduce the risk of death. The PM&C's recommended VSLY is based on a number of recent empirical studies relevant to Australia

[4] The Web of Science journal sets analysed within NHMRC (2013) include: andrology; anaesthesiology; cardiac and cardiovascular systems; clinical neurology; dermatology and venereal diseases; emergency medicine and critical care; endocrinology and metabolism; gastroenterology and hepatology; geriatrics and gerontology; haematology; infectious diseases; medicine, general and internal; obstetrics and gynaecology; oncology; ophthalmology; orthopaedics; otorhinolaryngology; pathology; paediatrics; peripheral vascular disease; psychiatry; psychology; radiology, nuclear medicine and medical imaging; rehabilitation; rheumatology; respiratory system; transplantation; surgery; urology and nephrology; and tropical medicine.

that derive estimates for the value of statistical life. The PM&C states that this empirical evidence has been assessed to ensure that it is comprehensive and rigorous. These studies use different methods of measuring society's willingness to pay to reduce the risk of death:

- one direct method is to ask individuals through a survey what they would pay to save or prolong life;
- one method which incorporates a budget constraint is to observe how much consumers pay for products that reduce the risk of death or injury; and
- another indirect method (the most commonly used) is to observe how much workers are willing to pay (through reduced wages) for an improvement in workplace safety.

These are just three of the many methods that have been used to estimate VSLY. There has been a lot of debate about the appropriate method of estimating VSLY. The PM&C's recommended VSLY represents an average across empirical studies, informed by economic theory, international research and international practice and is based on a healthy person living for another 40 years.

Significant debate also surrounds the application of VSLY. It is argued by some that it is not possible to place a value on human life and that to do so is callous and demeaning. However, despite the difficulties in measurement, most economists and public policy makers recognise that, given the scarcity of resources for public projects and the consequent need for efficient allocation, if such valuations are not made explicitly then they will be made implicitly through decisions about which projects proceed and the funding accorded to completing projects. The concept of the VSLY enhances transparency around trade-offs and decisions that are being made every day by government.

It is also important to note that the VSLY does not measure the more nebulous concept of the worth of a life. Rather it measures the value of a statistical life in monetary terms only. Yet VSLY is also not the same as measuring what a person would give up for their own life, which in monetary terms would likely be all of their wealth. In contrast, reflecting that it has been developed to inform policy-making decisions, the VSLY only measures the value of small risk reductions in premature death or reduced quality of life. Both individuals and governments often make budget-constrained decisions on small risk reductions with respect to their health and safety every day. The VSLY simply formalises and adds rigour to this process.

The parameters pertaining to VSL, VSLY and attribution of benefits are summarised in Table 4.1.

Table 4.1: Parameters for valuing health benefits

Parameter	Value	Source
VSL	$4.2 million	PM&C (2014)
VSLY	$182,000	PM&C (2014)
Discount rate	7%	PM&C (2014)
Attribution of benefits	1.55%	NHMRC (2013)

Source: Deloitte Access Economics.
Note: VSL and VSLY values are in 2014 dollars.

4.1.3.2 Disability adjusted life years

To calculate the pain, suffering and premature mortality of a particular conditions, health economists use disability adjusted life years (DALYs). These include years of life lost due to premature mortality (YLLs) from a particular condition, as well as years of healthy life lost due to disability (YLDs) living with the condition.

To calculate the DALYs for a particular medical condition, it is necessary to know the disease weight of the condition, as well as the duration of the condition[5]. Estimates for both of these parameters are obtained from publications such as Mathers et al (1999), Stouthard et al (1997), Begg et al (2007), and Murray and Lopez (1996). These publications allow for standard parameters to be used in health policy assessments around the world.

The disease weight is expressed as a decimal between 0 and 1, where 0 represents perfect health and 1 represents death. For example, the disease weight for a broken wrist is 0.18. The duration is expressed as the number of years lived with the condition. For example, a broken wrist may have a duration of 8 weeks, which would equal 0.15 years.

The DALY approach has been successful in avoiding the subjectivity of individual valuation and is capable of overcoming the problem of comparability between individuals and between nations, although nations have subsequently adopted variations in weighting systems. For example, in some countries DALYs are age-weighted for older people although in Australia the minority approach is adopted – valuing a DALY equally for people of all ages.

The particular disease weights and durations which have been used to calculate the economic benefits of Menzies' research are presented in the applicable sections below.

[5] This report uses both prevalence and incidence approaches to calculate economic benefits, given limitations in data availability. A prevalence approach uses a duration of one year (except when the duration is less than one year), as the economic burden is calculated for the prevalent cohort in each year. An incidence approach uses a duration that can be any positive value (with an upper limit being the average life expectancy), as the economic burden is calculated based on the incident cohort in each year.

4.1.4 Population forecasts

As the economic modelling is using an NPV approach, a critical component of the economic modelling presented in Section 4 are the population estimates out to 2033. These were obtained from detailed data provided by the Northern Territory Department of Treasury and Finance (NT DTF, 2014), which provides the estimated population by single year of age for:

- location (NT and rest of Australia);
- gender (male and female); and
- Indigenous status (Indigenous and non-Indigenous)

The population forecasts from this data are used throughout the analysis.

4.2 Malaria

The Menzies malaria research program spans a broad range of research activities aimed at both prevention and treatment, from epidemiology, diagnosis, pathophysiology, immunology, molecular parasitology, clinical trials, and evaluation of the impact and cost-effectiveness of public health interventions.

Menzies conducts work on all five species of the plasmodium parasite that cause human malaria (WHO[6], 2015a):

- plasmodium falciparum, one of the two most common types of malaria and the most deadly;
- plasmodium vivax, the other most common types of malaria;
- plasmodium malariae;
- plasmodium ovale; and
- plasmodium knowlesi, a type of monkey malaria that occurs in certain forested areas of Southeast Asia and has only caused some human cases of malaria in recent years.

Menzies' research activities have a particular focus on the three types of plasmodium parasite that cause most disease and death in the Asia-Pacific region: plasmodium falciparum, plasmodium vivax and plasmodium knowlesi.

The WHO estimates that in 2013 there were 128 million cases of malaria and an estimated 584,000 deaths as a result of malaria, with 78% of deaths occurring in children under five years of age, and 90% of deaths occurring in the Africa Region (WHO, 2015a).

[6] World Health Organization.

Malaria causes significant economic losses, with the WHO estimating that the disease can decrease GDP by as much as 1.3% in countries with high disease rates and long term aggregated annual losses resulting in substantial differences in GDP between countries with and without malaria over the long term, particularly in Africa. It is estimated that, in some heavy-burden countries, the health costs of malaria account for up to 40% of public health expenditures, 30% to 50% of inpatient hospital admissions, and up to 60% of outpatient health clinic visits (WHO, 2011).

These significant impacts of malaria also disproportionately affect poorer people who have limited access to health care because, while many countries – especially in temperate and sub-tropical zones – have successfully eliminated malaria, most malaria cases and deaths occur in sub-Saharan Africa, as well as the developing countries of Asia, Latin America, and to a lesser extent the Middle East and parts of Europe (WHO, 2011).

Major research efforts involving Menzies that have resulted in changes in malaria treatment regimes in Australia and throughout Southeast Asia include demonstrating the benefits of:

- treating severe malaria with artesunate rather than quinine;
- treating multi-drug resistant plasmodium falciparum and plasmodium vivax malaria with dihydroartemisinin-piperaquine (DHA-piperaquine) rather than artesunate-amodiaquine;
- using DHA-piperaquine as first line treatment of malaria in pregnancy.

The economic benefits of these research efforts are explored in the following sections.

4.2.1 Severe malaria treatment

Research conducted by Menzies in collaboration with others as part of the Southeast Asian Quinine Artesunate Malaria Trial (SEAQUAMAT) demonstrated that artesunate reduces the mortality of severe malaria by 34.7% compared with conventional intravenous quinine (Dondorp et al, 2005). While this study was not the only study to demonstrate the benefits of artesunate for the treatment of severe malaria, it was the largest and most extensive.

This research made a substantial contribution to the body of evidence supporting artesunate as treatment for severe malaria, which led to changes in the WHO's Global Malaria Treatment Guidelines.

The economic benefits of a reduction in severe malaria across the Asia-Pacific and Australia were calculated[7]. The parameters and methodology for this calculation are set out in the following paragraphs.

The incidence of reported malaria cases in Asia-Pacific has been declining on average by approximately 3.5% per year over 2004-2013 indicating that, in areas sufficiently developed

[7] Due to limitations in the available data, it was not possible to separate the NT benefits from Australian benefits. As such, the NT benefits have been included in Australia benefits.

to have appropriate health care, community wide control methods are having an impact (WHO, 2014a). It has been assumed that the incidence of malaria cases will continue to decline. This is a conservative assumption, as it is clear that there is still significant unmet demand for treatment of malaria in the Asia-Pacific. Conversely, however, individuals receiving malaria treatment and hence the reported cases and deaths resulting from malaria may fall as countries in the Asia-Pacific become more affluent and health care becomes more widely available (WHO, 2014a). The uncertainty surrounding the trajectory of improvements in the availability of health care should be noted.

Recently, Menzies has made significant contributions to malaria research and treatment in Malaysia (for example, see Barber et al, 2012 and Williams et al, 2011), which has significantly reduced deaths arising from plasmodium knowlesi and plasmodium vivax. These benefits have been included as Asia-Pacific benefits, and have been added to data from the WHO's South-East Asian region.

In 2013, the WHO recorded 790 malaria deaths, and 1.6 million cases of malaria in the South East Asian region[8]. However, the WHO estimates that there were 41,000 deaths, and 24 million cases of malaria (WHO, 2014a). This discrepancy is likely to be, at least in part, a function of limited access to health care. For the purposes of this assessment, the number of reported malaria deaths and cases has been used, noting that this is a very conservative estimate.

For the purposes of this assessment, benefits have been assumed to accrue for 20 years. It has further been assumed that the impact of the changes to the WHO guidelines will not be fully implemented in countries in the Asia-Pacific until 2015, in line with the approach adopted in Deloitte Access Economics (2012).

The parameters that were used to calculate the reduction in mortality from severe malaria as a result of Menzies' work are summarised in Table 4.2.

Table 4.2: Parameters for severe malaria calculations

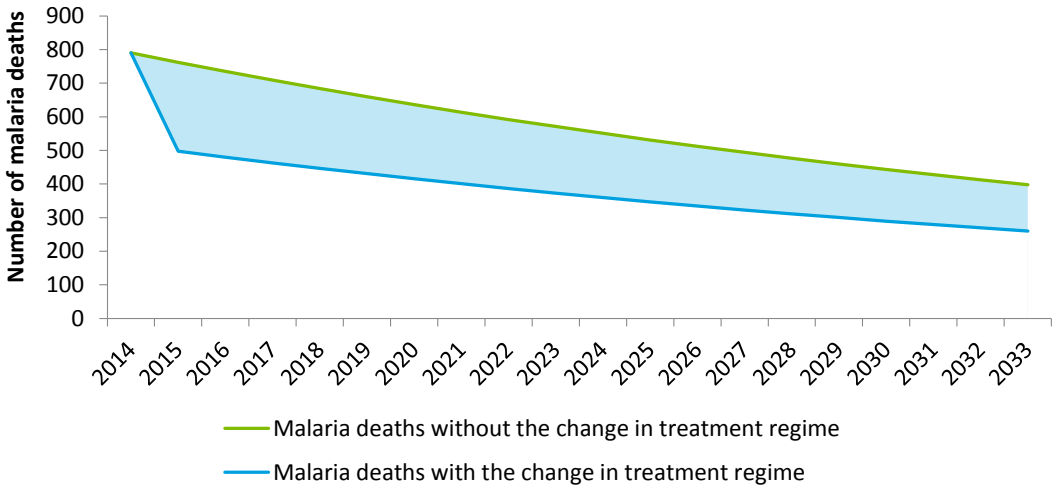
Parameter	Value	Source
Annual malaria deaths in SE Asia	790	WHO 2014a
Annual malaria deaths in Australia	2.5	Begg et al, 2007
Malaria cases in SE Asia	1.6 million	WHO 2014a
Annual decline in incidence of malaria over 2004-2013	3.5%	WHO 2014a
Reduction in mortality from severe malaria	34.7%	Dondorp et al, 2005
First year of benefits	2015	Deloitte Access Economics, 2012

Source: Deloitte Access Economics.

Based on these parameters, Menzies research is estimated to avoid 3,702 deaths from malaria over 2014-2033 in the Asia-Pacific, and 17 deaths in Australia. The reduction in deaths in the Asia-Pacific is shown in Chart 4.1.

[8] This includes deaths that occurred in Malaysia, due to Menzies' work in this country.

Chart 4.1: Reduction in mortality from severe malaria (Asia-Pacific)



Source: Deloitte Access Economics calculations.

4.2.2 Treatment of multi-drug resistant malaria

Research undertaken by Menzies has demonstrated the treatment of uncomplicated multi-drug resistant malaria with DHA-piperaquine results in a significantly lower parasitological failure rate at day 42 (13%) than treatment with artesunate-amodiaquine (45%). The research has also demonstrated that the DHA-piperaquine reduced the risk of anaemia (Hasugian et al, 2007).

> This study made a substantial contribution to the body of evidence supporting the application of DHA-piperaquine for the treatment of uncomplicated multi-drug resistant malaria.

A recurrence of malaria can be the result of either parasitological failure or re-infection. **The economic benefits of a reduction in the recurrence of malaria have been calculated for the Asia-Pacific region.** The parameters and methodology for this calculation are set out in the following paragraphs.

To be conservative it has therefore been assumed that the change in treatment regime results in a reduction in cases for a given year rather than a cure. The value is then the reduced burden of disease of a single episode of malaria, for each malaria sufferer who receives the alternate treatment.

In line with the methodology adopted in the 2012 report, the benefits of this research have been restricted to plasmodium vivax only, and do not include benefits from better treatment of plasmodium falciparum. Based on the WHO's *World Malaria Report*, it is assumed that 46%[9] of malaria cases in the Asia-Pacific are plasmodium vivax (WHO, 2014a).

[9] This is calculated from 2013 data for the South-East Asia region: out of 24,000 estimated cases of malaria, it is estimated that 11,000 are plasmodium vivax (WHO, 2014a).

The disease weight and duration for malaria is taken from the underlying modelling used in Mathers et al (1999). These are 0.175 and 0.01, respectively.

The remaining assumptions for this valuation are consistent with the methods used to assess the reduced mortality from severe malaria. The parameters used to calculate the benefit in reduced recurrence of plasmodium vivax malaria in Asia-Pacific are summarised in Table 4.3.

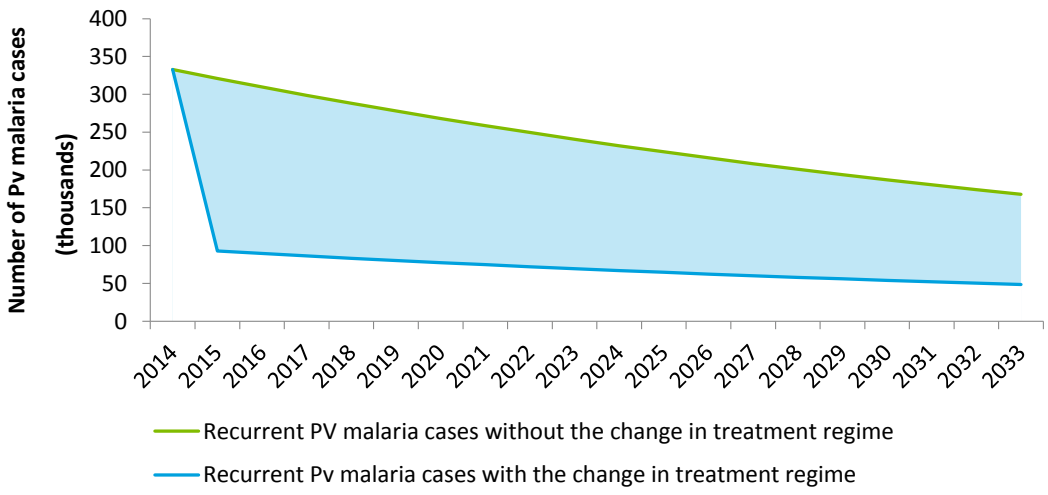
Table 4.3: Parameters for recurrence of plasmodium vivax calculations

Parameter	Value	Source
Malaria cases in SE Asia	1.6 million	WHO 2014a
Percentage of malaria cases from plasmodium vivax	45.8%	WHO 2014a
Annual decline in incidence of malaria over 2004-2013	3.5%	WHO 2014a
Disease weight for malaria episodes	0.175	Mathers et al, 1999
Duration	0.01	Mathers et al, 1999
First year of benefits	2015	Deloitte Access Economics, 2012

Source: Deloitte Access Economics.

In the absence of better treatment, the number of recurrent cases of plasmodium vivax malaria in the Asia-Pacific region is forecast to total 4.8 million over 2014-2033. With improved treatment, the forecast number of cases over the same period falls to 1.6 million. This is shown in Chart 4.2.

Chart 4.2: Reduction in recurrence of malaria (Asia-Pacific)



Source: Deloitte Access Economics calculations.

4.2.3 Treatment of malaria in pregnancy

Research undertaken by Menzies has demonstrated that the treatment of pregnant women with DHA-piperaquine in the second and third trimesters reduced the rate of vertical transmission from 3.2% to 0.2% when compared to the currently accepted treatment

regime of chloroquine/quinine (Poespoprodjo et al, 2011). It also found that the proportion of babies born with LBW from mothers with malaria dropped from 20% to 12%, following treatment with DHA-piperaquine (Poespoprodjo et al, 2015).

> Following on from this study, Indonesia changed national policy to DHA-piperaquine for pregnant women.

The economic benefits of a reduction in mild disability among babies as a result of LBW have been calculated for Indonesia, with the benefits recorded as Asia-Pacific benefits. The parameters and methodology for this calculation are set out in the following paragraphs.

In Indonesia there were 343,527 reported cases of malaria in 2010 (WHO, 2014b). As noted earlier, this is likely to be an underestimate of the total cases of malaria in Indonesia. For the purposes of the assessment, however, the lower estimate of malaria incidence has been applied, as it is assumed that this is the proportion of cases that were able to access health care. The fertility rate for Indonesian mothers is 2.3 children per mother (WHO, 2015b), and it was assumed that this fertility rate was the same between mothers with and without malaria.

The proportion of LBW babies who are born with a mild disability was assumed to have remained constant at 5%, in line with the assumptions used in Deloitte Access Economics (2012).

The disability weight used for this calculation is the weight used by Mathers et al (1999) of mild disabilities resulting from LBW. This is a proxy based on the disability weight of mild to moderate early acquired hearing loss, which is consistent with the approach used in Stouthard et al (1997). Duration of mild disability was assumed to be equal to the average lifespan of a child born in Indonesia, which is 71 years (WHO, 2015b).

Table 4.4 summarises the other parameters which were used to calculate the health benefits of Menzies' research in Indonesia.

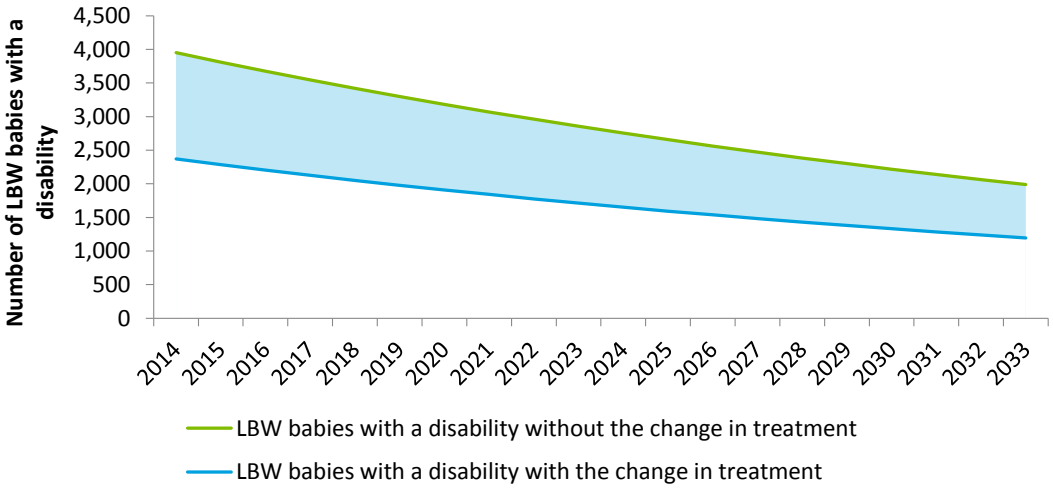
Table 4.4: Parameters for low birthweight babies calculations

Parameter	Value	Source
Proportion of babies born with LBW, prior to treatment	20%	Poespoprodjo et al, 2015
Proportion of babies born with LBW, with treatment	12%	Poespoprodjo et al, 2015
Fertility rate for Indonesian mothers with malaria*	2.3	WHO, 2015b
Disease weighting for mild disabilities resulting from LBW	0.11	Mathers et al, 1999.
Incidence of mild disability resulting from LBW	5%	Deloitte Access Economics, 2012
Life expectancy (Indonesia, child born in 2013)	71	WHO, 2015b
First year of benefits	2014	Deloitte Access Economics, 2012

Source: Deloitte Access Economics.
Notes: * assumed to be the same across mothers with and without malaria.

In the absence of better treatment, the number of LBW babies with mild disability in Indonesia as a result of vertical transmission of malaria is forecast to total 57,310 over 2014-2033. With improved treatment, the forecast number falls to 34,386 over the same period. This is shown in Chart 4.3.

Chart 4.3: Reduction in LBW babies born with a disability (Asia-Pacific)



Source: Deloitte Access Economics calculations.

The combined impact of Menzies' malaria research has a NPV of $0.8 million to Australia, and $436.9 million to the Asia-Pacific, in 2015.

4.2.4 Recent malaria research that is not quantified

In Ethiopia, Menzies researchers helped to conduct a randomised trial comparing artemether-lumefantrine and chloroquine with and without primaquine for treatment of uncomplicated vivax malaria in the country. The study found fewer recurrences in malaria

associated with chloroquine than artemether-lumefantrine while the efficacy of both regimens was improved by the addition of primaquine (Thriemer et al, 2014)

Menzies has also conducted international research into the impact of dosing regimens on antimalarial efficacy with positive results for children with malaria. Findings led to an increase in dosage rates of DHA-piperaquine and artemether-lumefantrine for children and to a reduction in the incidence of treatment failure, in one case halving the risk of treatment failure and ensuring the cure of at least 95% of young children (WWARN 2013; 2015).

In addition, Menzies has undertaken detailed research into vivax malaria in Indonesia via a clinical audit of deaths attributable to the disease in southern Papua. The audit provided insight into the epidemiology of mortality attributable to vivax malaria by using hospital surveillance to track the incidence, and causes, of deaths of patients with vivax monoinfection between 2004 and 2009. The study found that while vivax malaria was only the primary cause of death in 6 cases, it was an important indirect cause of death in patients with co-morbidities such as malnutrition, sepsis syndrome and chronic diseases (Douglas et al, 2014).

4.3 Melioidosis

Melioidosis is a potentially fatal, clinical disease caused by the bacterium burkholderia pseudomallei, which is found in wet soil and surface water in tropical areas, usually after heavy rainfall. Burkholderia pseudomallei bacteria live below the soil's surface during the dry season but after heavy rainfall are found in surface water and mud and may become airborne. Melioidosis occurs in tropical areas throughout the world, particularly in Southeast Asia and northern Australia – most often in the Top End of the NT, far north Queensland (QLD) and the Kimberley region of Western Australia (WA) (Healthy Living NT, 2015). Melioidosis is hyper-endemic in the Top End of the NT and in parts of north-eastern Thailand as it is the commonest cause of fatal community-acquired septicaemic pneumonia (Currie et al, 2000).

People most at risk are those with conditions such as diabetes, which is the greatest risk factor, followed by heavy alcohol consumption, kidney disease, lung disease, cancer, and those on immunosuppressive therapy. The majority of infections occur when skin abrasions or wounds come into contact with wet soil or water contaminated with the bacterium, and very rarely through swallowing contaminated water, or through breathing in fine droplets of such water (Currie et al, 2000).

The Australian Government's *White Paper on Developing Northern Australia* (Australian Government, 2015) notes that tropical diseases such as melioidosis have the potential to have a high impact on health in Australia. Building and construction activity associated with new economic development increases the environmental exposure to melioidosis (as soil is disturbed and releases burkholderia pseudomallei into the air). Rising rates of risk factors for melioidosis among the NT population, such as kidney disease, diabetes and unsafe levels of alcohol consumption, also increase the risk of melioidosis among the NT population (ABS, 2012a).

Most cases of melioidosis are 'acute cases' that have a sudden onset of between 1-21 days after an apparent exposure to soil or muddy water, and can present as pneumonia with fever, cough and difficulty breathing or as blood poisoning with fever, confusion and shock. Acute melioidosis can be very severe, and almost always requires hospital inpatient management, with deaths occurring in Australia each year as a result of the disease. Melioidosis can present as a rapidly fatal septicaemic illness and burkholderia pseudomallei is now considered a potential biothreat agent, however there are major gaps in the understanding of the disease's global distribution, epidemiology and pathogenesis (Currie et al, 2010).

Menzies research has contributed to the body of evidence that improved early diagnosis and improved treatment of melioidosis with new antibiotics and granulocyte-colony stimulating factor (G-CSF) in severely ill cases. In 1998, a clinical trial was published that suggested that a subgroup of patients with severe pneumonia may benefit from the administration of recombinant human G-CSF (Nelson et al, 1998).

In response to this study, intensivists and infectious disease specialists at Royal Darwin Hospital with Menzies staff reviewed the literature about animal and human studies of the use of G-CSF for treating sepsis and it was decided that G-CSF would be added to the means of treating septic shock in a specific attempt to reduce the mortality rate (95%) associated with septic shock due to melioidosis.

In 2004, Menzies staff in conjunction with Flinders University reported a decrease in mortality rates from 95% to 10% as a result of improved early diagnosis and improved treatment of melioidosis with new antibiotics and G-CSF in severely ill cases (Cheng et al, 2004).

The economic benefits of a reduction in mortality from melioidosis were calculated for the Top End population of the NT[10].

Cheng et al (2004) established the incidence of melioidosis in northern Australia (this area extends outside of the NT and includes WA and QLD), to be 5.8 per 100,000 people. The economic modelling calculated the incidence of melioidosis in the Top End and northern Australia separately. The results for the Top End were subtracted from the northern

[10] According to the ABS (2003), this includes the Darwin Statistical Division, the Darwin Region, and the East Arnhem region.

Australia results. The parameter values which were used to establish the economic benefits of an improvement in mortality rates for melioidosis are summarised in Table 4.5.

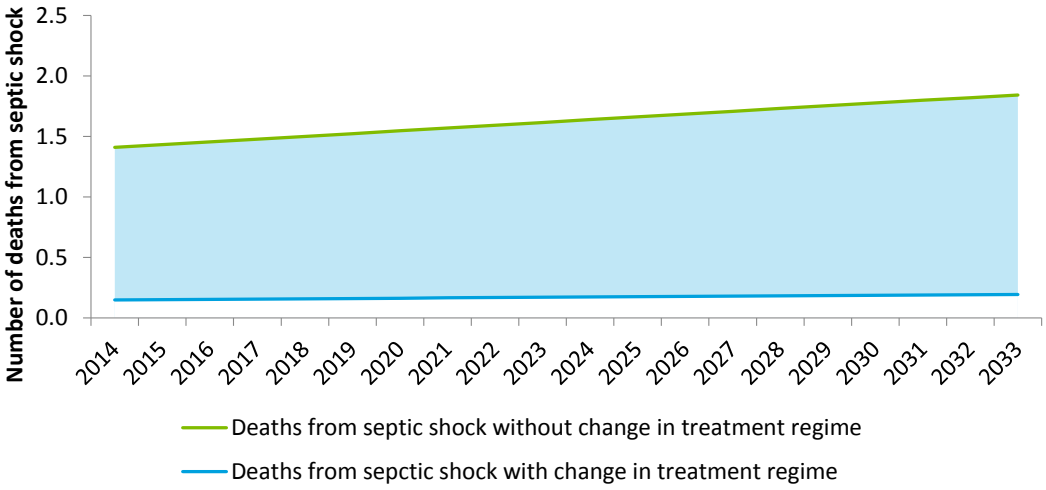
Table 4.5: Parameters for deaths from septic shock calculations

Parameter	Value	Source
Annual incidence of melioidosis in northern Australia	0.0058%	Cheng et al, 2004
Cases of melioidosis with septic shock	15%	Pitman et al, 2015
Prior rates of death from septic shock	95%	Cheng et al, 2004
New rates of death from septic shock	10%	Cheng et al, 2004

Source: Deloitte Access Economics.

Based on these parameters, it was estimated that Menzies research would contribute to a reduction in 29 deaths over the period 2014-2033 across the Top End population of the NT. This is shown in Chart 4.4.

Chart 4.4: Reduction in deaths from septic shock (Northern Territory)



Source: Deloitte Access Economics calculations.

The NPV of this reduction in mortality is $1.4 million to the NT, and $8.1 million to Australia, in 2015.

4.3.1 Recent melioidosis research that is not quantified

Menzies undertook a variety of melioidosis research projects, which focused on better understanding the disease's origins as well as its treatment. Associated studies have been briefly summarised below.

In Kaestli et al (2011), a study was undertaken to better understand the ecology of burkholderia pseudomallei, in particular the predictors for burkholderia pseudomallei occurrence and the impacts of the bacterium on native and exotic grasses. The study found that the bacterium occurred not only in the rhizosphere of various grasses, as previous

literature had hinted at, but also occurred endophytically in grasses as well, suggesting more widespread colonisation than initially thought.

In Chalmers et al (2014), researchers investigated the relationship between melioidosis and end-stage renal disease in northern Australia. Using the most recent 15 years of population and dialysis data, researchers compared incidence rates of melioidosis in dialysis and non-dialysis patient samples. The study found that dialysis patients exhibited a higher incidence rate of melioidosis compared to the rest of the population, supporting the implementation of an antibiotic prophylaxis guideline for dialysis patients to potentially reduce the burden of disease during the wet season.

In Houghton et al (2014), a study of antibody-based tests was conducted to determine whether a prototype lateral flow immunoassay (LFI) could be used to more rapidly diagnose melioidosis than the current gold standard. The research found that the LFI could successfully detect burkholderia pseudomallei, demonstrating an analytical reactivity of 98.7% when tested against a large panel of burkholderia pseudomallei isolates. Researchers in Thailand and Australia are currently conducting preclinical analysis of the LFI to compare its performance with alternative methods of diagnosis and optimise its use for further evaluation.

In Hantrakun et al (2015), cost-effectiveness analysis was undertaken of treatment options for acute melioidosis in Thailand. The study found that treatment of severe cases with an antimicrobial agent (meropenem) is likely to be cost-effective in Thailand. However, empirical meropenem treatment is less likely to be cost-effective for all acute cases unless the reduction in mortality is much higher.

In Kaestli et al (2015), a study was conducted into whether anthropogenic manipulations, such as irrigation or fertilisers, were responsible for the occurrence of burkholderia pseudomallei in domestic gardens. The study found that while the effect of fertiliser application on burkholderia pseudomallei was contingent on other environmental factors, irrigation had a direct impact on increasing burkholderia pseudomallei occurrence.

In Pitman et al (2015), researchers reviewed the efficacy of international melioidosis treatment guidelines, with respect to intravenous therapy duration, using a retrospective cohort study. The study found that patients who received a minimum intensive phase duration, as specified by local guidelines and extended according to clinical progress, were less likely to experience melioidosis relapse, despite poor adherence to eradication therapy. While findings validated local guidelines that ensured low rates of relapse of melioidosis in the Top End of the NT, researchers suggest that further research and investigation will need to be undertaken to validate its applicability in other, developing regions.

In Yip et al (2015), a study was undertaken to investigate the resilience of burkholderia pseudomallei in atypical environments. The study focused on six patients who had acquired burkholderia pseudomallei infection in central Australia, most likely following instances of atypically intense rainfall. The study found that burkholderia pseudomallei could survive in desert environments outside the traditionally recognised endemic regions of the wet tropics, suggesting that greater caution is warranted of melioidosis occurring beyond its traditional locus of occurrence.

4.4 Acute Rheumatic Fever and Rheumatic Heart Disease

Acute rheumatic fever (ARF) is an illness caused by a bacterial pathogen called Group A streptococcus (GAS). An episode of ARF may lead to residual heart valve damage. Recurrent episodes of ARF can then lead to chronic damage to the valves in the heart caused by repeated swelling and stretching of the valves, known as rheumatic heart disease (RHD). Prevention of recurrent episodes of ARF is important to minimise further valve damage, worsening of RHD and preventing the heart valves from becoming severely defective. Recurrent episodes may cause heart failure, other complications such as stroke and endocarditis, and lead to the need for cardiac surgery, or result in early death (RHDAustralia, 2015).

The incidence of ARF, although rare in most industrialised countries, remains high in many populations living in poverty. RHD remains the major cardiac disease of children and young adults in many less developed countries. This is due to the fact that ARF is more often seen in people who live in poor, crowded conditions, and that first episodes of ARF most commonly occur between the ages of 5 and 15 years (Mackay and Mensah, 2004). The disease burden rates of ARF and RHD among Indigenous Australians are amongst the highest in the world. Indigenous and Pacific Islander populations living in remote northern and central Australia are at high risk of developing ARF, as well as some migrants from high risk countries (RHDAustralia, 2015).

> Efforts led by Menzies researchers resulted in the introduction of the Rheumatic Heart Disease Control Program in the NT. This work subsequently led to the National Rheumatic Fever Strategy, which includes funding for control programs in the NT, QLD and WA and the establishment of a national coordination unit, RHDAustralia, housed within Menzies.

The economic benefits of a reduction in recurrent episodes of ARF and associated reductions in RHD were calculated for the Indigenous populations of the NT and the whole of Australia. The parameters and methodology for these calculations are set out in the following paragraphs.

The available data suggest that recurrence rates of ARF have approximately halved in recent years. Approximately 40% of all ARF episodes in 1997-2000 were recurrences, compared to 24% in 2005-2010 (Deloitte Access Economics, 2012; AIHW[11] 2013). The proportion of people with ARF suffering a recurrence in the first three years (the time of greatest recurrences) reduced from 12.9% in 1997-8 to 6.3% in 2005-2007 (Deloitte Access Economics, 2012).

As recurrence rates of ARF have approximately halved over the decade to 2010, it is assumed that corresponding rates of rheumatic heart disease will also approximately halve in each subsequent decade.

[11] Australian Institute of Health and Welfare.

The disease weight for RHD of 0.247 was obtained from Mathers et al (1999) by taking the average of treated and untreated RHD. The parameters that were used to calculate the economic benefits of a reduction in ARF recurrences are summarised in Table 4.6.

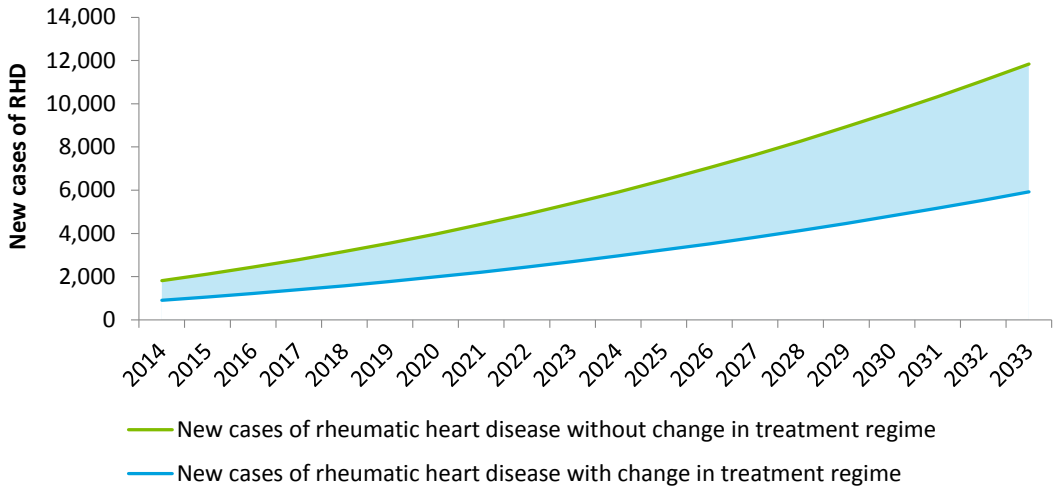
Table 4.6: Parameters for rheumatic heart disease calculations

Parameter	Value	Source
Reduction in the rate of RHD per decade	50%	Deloitte Access Economics, 2012
Prevalence of RHD in the NT Indigenous population	2%	CRCAH, 2015
Disease weight for RHD	0.247	Mathers et al, 1999
Australian Indigenous population to 2033*	N/A	ABS, 2014b

Source: Deloitte Access Economics research.
Note: * To align with the methodology adopted in Deloitte Access Economics (2012, Australia was limited to SA, WA and QLD.

Based on these parameters, by 2033 it was estimated that Menzies research would contribute to reducing RHD prevalence by 2,695 cases in the NT, and 22,124 cases in Australia. The reduction in prevalence for the NT is shown in Chart 4.5

Chart 4.5: Reduction in rheumatic heart disease prevalence (Northern Territory)



Source: Deloitte Access Economics calculations.

The NPV of this reduction in RHD is $0.8 million for the NT, and $6.7 million for Australia, in 2015.

4.4.1 Recent ARF and RHD research that is not quantified

As part of its work under RHDAustralia, Menzies has developed a range of education activities and resources for patients, families and clinicians to improve preventive treatment and management of ARF and RHD. Menzies' clinical practice resources include the development of a diagnostic application, based on the Australian Guideline for Prevention, Diagnosis and Management of ARF/RHD, for use by clinicians who have had

limited previous exposure to the disease. Menzies has also developed video resources on benzathine penicillin administration and targeted workshops. Resources created for RHD patients and the wider community include the development of a Facebook application and other social-media based community outreach initiatives, the production of a quarterly newsletter, and the use of public service announcements to spread awareness across high risk communities.

Menzies' research into health services for RHD also resulted in the development of an ARF/RHD Nurse Practitioner (NP) framework, which outlines the professional requirements for the role and endorses a NP to function autonomously in their field of practice alongside other healthcare providers. The framework was designed to identify a complementary role for the NP in the current model of service for ARF and RHD management and to address issues such as:

- delays in service delivery;
- gaps in the continuum of care; and
- lack of knowledge and experience of ARF and RHD for community members, patients and clinicians.

4.5 Oral disease

The most common consequences of oral disease are pain, infection and tooth loss, as well as causing difficulties with chewing, swallowing and speech, disrupting sleep and productivity and having a significant impact on self-esteem, psychological and social wellbeing, employment, interpersonal relations, and quality of life (NACOH[12], 2004).

A significant number of health conditions and diseases are associated with oral disease, including a number of chronic diseases, such as cardiovascular disease, cerebrovascular disease, diabetes, preterm and LBW babies, aspiration pneumonia, blood borne diseases, infective endocarditis, otitis media, hepatitis C, HIV, infective endocarditis, aspiration pneumonia and nutritional deficiencies in children and older adults (AHMAC[13], 2001).

There is a strong link between socio-economic status and health, reflected in patterns of oral health and disease in Australia, with children in low socio-economic groups experiencing almost twice as many dental caries as those in high socio-economic groups (NACOH, 2004; AHMAC, 2001). Even higher rates are seen among Australian Indigenous children. A study on the oral health of Indigenous children by the Dental Statistics and Research Unit of the AIHW in 2007 found that (Jamieson et al, 2007):

- a higher percentage of Indigenous children had experienced dental caries than other Australian children at all ages between 4 and 14 years;
- Indigenous children had consistently higher levels of dental caries (decay) in the deciduous and permanent dentition than their non-Indigenous counterparts;
- Indigenous children most affected were those in socially disadvantaged groups and those living in rural/remote areas;

- trends in Indigenous child dental caries prevalence indicate that dental caries levels are rising, particularly in the deciduous dentition; and
- Indigenous children aged under five years had almost one and a half times the rate of dental-related hospitalisations as other Australian children.

In addition, as good oral health in childhood contributes to better teeth and gums in adulthood (via less decay and the loss of fewer natural teeth), these rates in Indigenous children will impact them throughout their adult lives (AIHW, 2014a).

> To address these issues, Menzies' researchers have developed, implemented and evaluated the effectiveness of a community-oriented primary health care intervention to prevent dental decay among Indigenous pre-school children in the NT.

The economic benefits of a reduction in dental caries among Indigenous children in the NT were calculated. The parameters and methodology used for these calculations are set out in the following paragraphs.

The controlled trial involved a dental health program in which fluoride varnish was applied to children's teeth, training provided to staff, and health promotion activities conducted to educate children and their families about brushing teeth and drinking water. The trial found that children in remote communities would benefit from a broader range of preventive services, and corroborated findings in other studies of fluoride varnish's effectiveness in preventing dental caries in children (Slade et al, 2011).

The most recently available data on the percentage of Indigenous children with dental caries was provided in Jamieson et al (2007), which estimated that in 2007 63.1% of Indigenous children had dental caries. Of these children, the average number of dental caries was four per child (Slade et al, 2011). Menzies research found that 36% of the target population were responsive to the new treatment programs, and that the average reduction in the responsive population was 3.5 caries per child (Slade et al, 2011).

According to Begg et al (2007), the appropriate disease weight for dental caries is 0.014, and the duration is 0.21 years. The parameters which were used to calculate the economic benefits of a reduction in dental caries are summarised in Table 4.7.

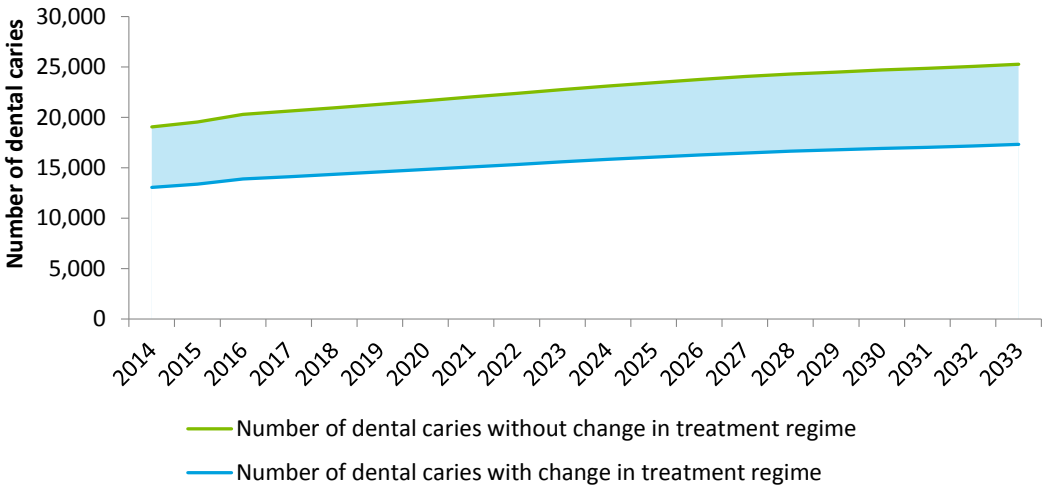
Table 4.7: Parameters for dental caries calculations

Parameter	Value	Source
Percentage of Indigenous children with dental caries	63.1%	Jamieson et al, 2007
Average number of dental caries per Indigenous child	4	Slade et al, 2011
Disease weight	0.014	Begg et al, 2007
Duration	0.21	Begg et al, 2007
Percentage of target population responsive to treatment	36%	Slade et al, 2011
Average reduction in caries in responsive population	3.5	Slade et al, 2011

Source: Deloitte Access Economics research.

Based on these parameters, Menzies research is estimated to have avoided 142,816 dental caries in NT Indigenous children over the period 2014-2033. This is shown in Chart 4.6.

Chart 4.6: Reduction in dental caries (Northern Territory)



Source: Deloitte Access Economics calculations.

The economic value of this reduction in caries to the NT population is $1.1 million in 2015.

Since 2012, Menzies staff who had been focused on oral health have directed their efforts toward otitis media research (see Section 4.11). As such, non-quantified recent research work on oral health has not been included in this report.

4.6 Improved quality of primary health care for chronic disease

Australian Indigenous people experience significantly higher levels of chronic diseases than other Australians. Prevalence rates of chronic diseases such as asthma, ear disease, hearing loss, heart disease and diabetes are all significantly higher among the Indigenous population, compared to the non-Indigenous population (ABS, 2013c). Reducing the incidence of these illnesses within the population has been identified as a major challenge in advancing the health of Indigenous communities by the Australian Governments.

Best practice in chronic disease management has been linked to the implementation of multidisciplinary, cross-cultural teams skilled in health education, clinical care, health promotion and Indigenous knowledge. However, such practice does not yet occur in many parts of rural and remote Australia where there are specific challenges such as: limitations in policy frameworks, high staff turnover, limited preventative activity targeted towards adults and limited infrastructure (Department of Health and Ageing, 2010).

To address this matter, Menzies instituted the ABCD National Partnership in 2002, to consider options for quality improvements to chronic disease control in primary care settings. This was instituted amid a growing body of evidence suggesting that system-oriented approaches were important to the improvement of quality of care in primary health care settings.

ABCD was developed as a continuous quality improvement initiative seeking to meet the needs of Indigenous primary health care services in the NT. The program works with health centres to improve the delivery of care using a structured and collaborative approach to assess clinical performance against best practice guidelines. It also works to improve aspects of health centre systems that are needed to support best practice, such as clear staff roles and responsibilities, data and clinical management systems and the availability of best practice guidelines.

In 2009 the ABCD team, with seed funding from the CRCAH, established One21Seventy – a National centre for Quality Improvement in Indigenous Primary Health Care. One21Seventy is a not-for-profit organisation promoting quality improvement in the Indigenous community controlled health sector.

> To date, the improvement in the delivery of primary health care services from One21Seventy has resulted in improvements in diabetes management across Indigenous communities in NT and the rest of Australia.

The economic benefits of an improvement in the management of diabetes among the Indigenous population of the NT and Australia were calculated. The parameters and methodology used for these calculations are set out in the following paragraphs.

Results from the improved management systems have shown a notable improvement in the proportion of Indigenous people with diabetes that are controlling their blood glucose levels at either ideal or acceptable levels according to glycated haemoglobin (HbA1c) levels. Across the entire sample population, HbA1c levels had fallen by 4% (Bailie et al, 2007).

A study by the United Kingdom Prospective Diabetes Study (UKPDS) Group found that an 11% reduction in HbA1c levels across a population results in a 25% reduction in the incidence of micro vascular complications such as retinopathy, neuropathy and nephropathy (UKPDS, 1998).

The ABS' 2012-13 Australian Aboriginal and Torres Strait Islander Health Survey established the prevalence rate of diabetes among the Indigenous population to be 12.6%, and the prevalence rate of kidney disease to be 17.9%, based on biomedical results (ABS, 2014a). Of the Indigenous people with kidney disease, the AIHW (2011) has estimated that 78% of these people also have diabetes.

A study led by Menzies researchers (Maple-Brown et al, 2007) established the prevalence of diabetes-related complications such as retinopathy and neuropathy among the adult Indigenous population of Darwin who had diabetes. The estimated prevalence was 21% for retinopathy, and 9% for neuropathy. This drew on results from the Darwin Region Urban Indigenous Diabetes (DRUID) Study of 1,004 volunteers aged 15 years and over. The

prevalence of these complications was established using a questionnaire and verified by clinical examination.

Disease weights for retinopathy, neuropathy and kidney disease were obtained from the Australian burden of disease studies (Begg et al, 2007; Mathers et al, 1999) who based their estimates on results from the Dutch study undertaken by Stouthard et al (1997):

- retinopathy (0.254) was calculated as a weighted average across mild and moderate vision loss from the Dutch study, as retinopathy is a disease that results in vision loss;
- neuropathy (0.19) was adopted from the Dutch study; and
- kidney disease (0.29) used the Dutch weight for diabetic nephropathy, which refers to damage to the kidney.

The parameters used to calculate the economic benefits associated with improvements in primary care delivery models are summarised in Table 4.8.

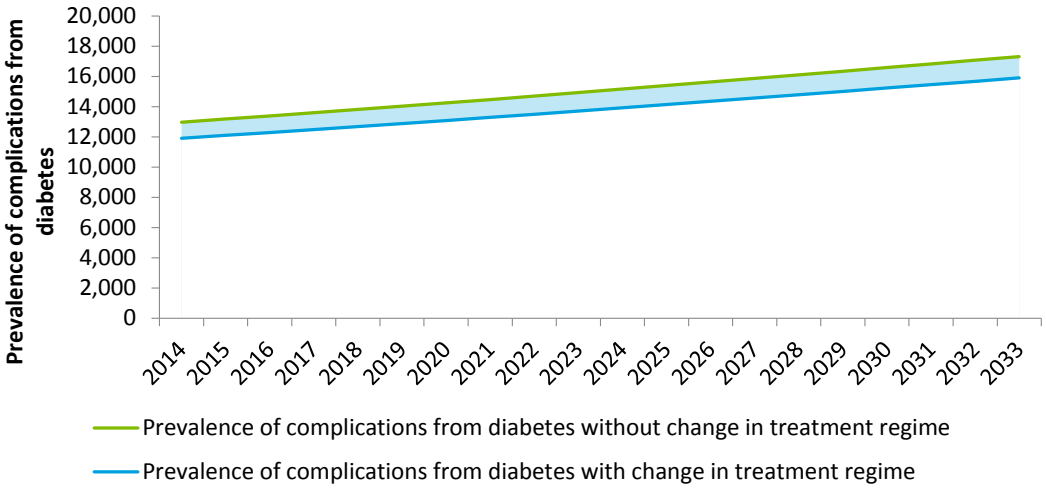
Table 4.8: Parameters for diabetes complications calculations

Parameter	Value	Source
Prevalence of diabetes among Indigenous people	12.6%	ABS, 2014a
Prevalence of kidney disease among Indigenous people	17.9%	ABS, 2014a
Prevalence of retinopathy among Indigenous people with diabetes	21%	Maple-Brown et al, 2007
Prevalence of neuropathy among Indigenous people with diabetes	9%	Maple-Brown et al, 2007
Prevalence of diabetes among Indigenous people with kidney disease	78%	AIHW, 2011
Reduction in HbA1c levels in Indigenous population	4%	Bailie et al, 2007
Reduction in HbA1c levels that leads to 25% reduction in complications	11%	UKPDS, 1998
Disease weight – retinopathy	0.254	Begg et al, 2007
Disease weight – neuropathy	0.190	Mathers et al, 1999
Disease weight – kidney disease	0.290	Mathers et al, 1999

Source: Deloitte Access Economics research.

Based on these parameters, by 2033 Menzies research is estimated to have reduced NT prevalence of retinopathy by 3,847 cases, prevalence of neuropathy by 1,649 cases, and prevalence of kidney disease by 19,527 cases. For Australia, the respective reductions in total are 39,836, 17,073 and 203,439. The combined impact of the reduction for the NT is shown in Chart 4.7.

Chart 4.7: Reduction in diabetes complications (Northern Territory)



Source: Deloitte Access Economics calculations.

The economic value of this reduction in prevalence is $14.6 million in the NT, and $135.4 million for Australia, in 2015.

4.6.1 Recent research that is not quantified

Under the ABCD program, Menzies has conducted extensive research into the quality of primary health care for Indigenous people across the country with the aim of improving care quality and capacity. Key research findings showed that wide variations exist between health centres and between jurisdictions in quality of care for Indigenous Australians. Researchers identified variations in levels of delivery of guideline-scheduled preventive services, ranging from 5% to 74%, as well as in diabetes care with adherence ranging from 22% to 83% (Bailie et al, 2015). Significant variations were also observed for care in maternal health, mental health and rheumatic heart disease.

Menzies has also undertaken research into continuous quality improvement (CQI) programs and their system-wide efficacy with a particular focus on diabetes care. In Matthews et al (2014), researchers analysed over 10,000 clinical audit records to assess quality of care for patients with Type 2 diabetes. The study found that longer term commitment to a CQI program was highly beneficial for quality of care with changes such as improved regularity of patient attendance and greater collaboration in care coordination in remote areas likely to improve system-wide delivery of care.

Work has also been conducted more specifically into the evaluation of health promotion in Indigenous populations. In McCalman et al (2014), a systematic literature search was conducted of Indigenous health promotion tools to assess the scope of their implementation and effectiveness. The study found that while promotion tools were widely available, information about the quality of impact was limited, providing a strong impetus for future research to focus on efficacy rather than development. In O'Donoghue et al (2014), a study was undertaken to test the suitability of audit and feedback (A&F) as an evaluation technique of health promotion activities in the NT. Researchers found that

A&F was a feasible tool for health promotion evaluation on both an individual and organisational level, which could be used to facilitate more practical engagement and understanding of health promotion strategies.

On a broader scale, Menzies' researchers have also conducted program evaluations, including a three-year place-based evaluation of the Department of Health's Indigenous Chronic Disease Package. The evaluation included 24 sentinel sites across Australia and entailed comprehensive data collection, in-depth stakeholder engagement with local Indigenous people and capacity building in community health providers. For their work on this project, Menzies received the 2015 Australian Evaluation Society's Indigenous Evaluation Award for Excellence in Evaluation.

4.7 Pyoderma and scabies

Pyoderma is a generic term used to describe a clinical diagnosis of superficial bacterial skin infection whereas scabies is an infestation of the skin by the scabies mite *Sarcoptes scabiei.* In high-prevalence areas, poverty and overcrowded living conditions are important underlying social determinants. Pyoderma generally arises as primary infections of the skin known as impetigo or as secondary infections of other lesions such as scabies or insect bites. The usual bacterial causes are Group A streptococci or Staphylococcus aureus (Andrews et al, 2009a).

Controlling pyoderma and scabies could be an important primary health intervention to reduce serious bacterial infections in childhood, and may be associated with significant longer term benefits. Group A streptococcal pyoderma leads to acute post-streptococcal glomerulonephritis and underlies most cases of invasive Group A streptococcal infections, especially in tropical regions. Links between scabies, pyoderma and high rates of ARF in remote Indigenous communities in the NT have also been postulated (Andrews et al, 2009a).

In 2005, the WHO estimated that the prevalence of pyoderma among children aged 15 years and under in lesser developed countries was 111 million (WHO, 2005). Since that time, Menzies and others have conducted a systematic review of 66 publications (89 studies) spanning published and grey literature from 1970-2014 and have estimated that 167 million children have pyoderma worldwide at any one time (Bowen et al, 2015). The pooled prevalence, taking account of variability in study size using a random effects model, was 16.6% among children aged less than 15 years and 4.9% amongst adults. The median childhood prevalence amongst children living in impoverished populations within Australia, New Zealand and North America (25 studies) was 19.4%. Scabies prevalence amongst children was estimated from 57 studies in 27 countries to be 3.3%. In Oceania (14 studies), median scabies prevalence was 16%. The prevalence of pyoderma and scabies were closely correlated indicating that interventions targeted against scabies are highly likely to also reduce pyoderma.

Menzies and others have collaborated with communities in the NT, within the Asia-Pacific region, and with government authorities over a long period of time to develop strategies for tackling skin infections at a community level. Work conducted by Menzies from 2004-2007, targeting pyoderma and scabies among Indigenous children in the NT, identified a very high disease burden in the first year of life – 69% and 63%, respectively (Clucas et al, 2008) - and found value in implementing measures of regular surveillance and routine service delivery in significantly reducing pyoderma prevalence (Andrews et al, 2009a). A randomised controlled trial conducted from 2009-2012 demonstrated that an easily administered oral antibiotic resulted in treatment success for 85% of children with pyoderma and was an effective alternative to a painful injection (Bowen et al, 2014). A trial of three alternative approaches to scabies control in Fiji, from 2012-2013, in which Menzies was involved, then demonstrated an oral ivermectin-based mass drug administration (MDA) program achieved a 94%[14] reduction in scabies prevalence (Romani et al, 2015). These studies form the evidence base for major impacts on pyoderma and scabies worldwide.

The economic benefits of a reduction in pyoderma and scabies prevalence among NT Indigenous children aged 15 years and under were estimated. The parameters and methodology used for this estimation are set out in the following paragraphs.

Menzies' research has demonstrated the effectiveness of alternative oral treatment of pyoderma (Bowen et al, 2014), by using trimethoprim-sulfamethoxazole for five days, which is now incorporated into the Central Australian Rural Practitioners Association (CARPA) Standard Treatment Manual as an alternative to injectable benzathine penicillin (CARPA, 2014). As a palatable, pain free, practical and easily administered alternative which achieved treatment success in 84.7% of recipients (Bowen et al, 2014), implementation of the five day oral treatment regimen pioneered by Menzies has the potential to significantly increase treatment uptake above that seen previously in similar settings.

The previous report on Menzies' contribution was based on the outcomes of the 2004-2007 study (Andrews, 2009a) where pyoderma prevalence dropped from 46.7% at baseline to a median of 32.4% during the follow up period, an absolute reduction of 14.3% that was predominantly attributed to increased treatment (Andrews et al, 2009a). New data from Menzies, which comes from the systematic review of pyoderma disease burden (Bowen et al, 2014) suggests that this new treatment is likely to be much more acceptable for children with pyoderma. The study implemented routine screening undertaken by trained local communities and treatment was recommended and provided. The study also noted the importance of local action delivered through basic primary health services and the key role played by local community workers in conducting surveillance for skin infections.

For scabies treatment, Menzies' researchers have previously demonstrated that uptake of topical antibiotic treatment (5% permethrin) within households of scabies cases was very low (44%) but that the odds of remaining scabies-free was almost six times greater among

[14] The 95% confidence interval for this estimate is 83%-100%.

individuals belonging to a household where all people reported treatment uptake (La Vincente, 2009). In collaboration with others, Menzies' researchers have now demonstrated the relative efficacy of three different approaches to scabies control that were randomly assigned to three island communities in Fiji (Romani et al, 2015). With universal uptake, an ivermectin-based MDA program resulted in a 94% relative reduction in scabies prevalence from 36.6% at baseline to 1.9% at 12 months follow-up and a 67% relative reduction in pyoderma prevalence from 24.6% at baseline to 11.3%.

Pyoderma prevalence post-intervention assumes an 80%[15] treatment uptake of the five day oral antibiotic regimen at 84.7% treatment efficacy, which differs from the more conservative estimate of baseline prevalence that was used in the 2012 report. Scabies incidence post-intervention uses the lower bound of the 95% confidence interval from the study by Romani et al (2014), which reports an 83% efficacy rate. This is a more conservative estimate of scabies prevalence at 12 months post-implementation of an ivermectin-based MDA, noting the estimated baseline prevalence is substantively lower than that observed in the Fiji trial (16% compared with 32%).

In 2011, the ABS' *Health and Welfare of Australia's Aboriginal and Torres Strait Islander Peoples* (ABS, 2011) estimated that 25% of Indigenous people lived in a remote area (compared to 32% in major cities, and 43% in regional areas). Menzies' work has been targeted at remote Indigenous communities in the NT, as pyoderma prevalence is highest in these areas (Andrews et al, 2009a; Clucas et al, 2008).

In line with the methodology adopted in the 2012 report, the disease weight for eczema has been used as a proxy for pyoderma, as no disease weight for pyoderma could be located in the academic literature. The disease weight for eczema used in Begg et al (2007) was 0.054. The same disease weight has also been applied to scabies.

Table 4.9: Parameters for pyoderma calculations

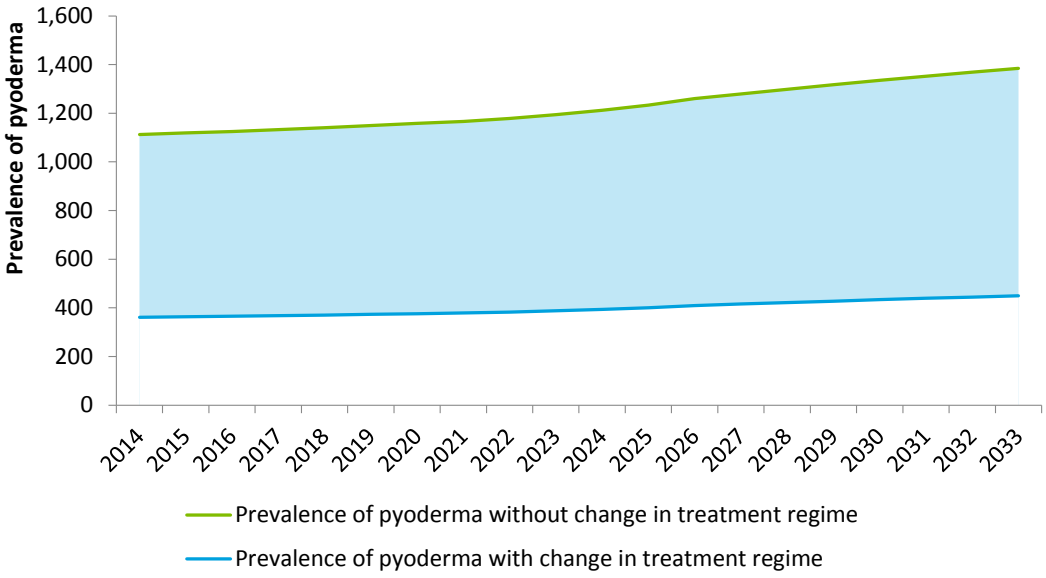
Parameter	Value	Source
Percentage of Indigenous people living in remote areas	25%	ABS, 2011
Percentage of Indigenous children with pyoderma	19.4%	Bowen et al, 2015
Incidence of pyoderma after intervention, assuming 80% oral treatment uptake and 84.7% efficacy	6.3%	Andrews et al, 2009a; Bowen et al, 2014
Percentage of Indigenous children with scabies	16%	Bowen et al, 2015
Incidence of scabies after intervention, assuming 83% efficacy at 12 months following ivermectin-based MDA	2.7%	Romani et al, 2014; Andrews et al, 2009a
Disease weight of eczema	0.054	Begg et al, 2007

Source: Deloitte Access Economics research.

Based on these parameters, it is estimated that Menzies research will contribute to a reduction in pyoderma prevalence of 16,556 cases and a reduction in scabies prevalence of 16,809 cases by 2033. Across Australia, there is estimated to be a reduction of 198,075 pyoderma cases and 201,099 scabies cases by2033. The impact of this reduction for the NT is shown in Chart 4.8 and Chart 4.9.

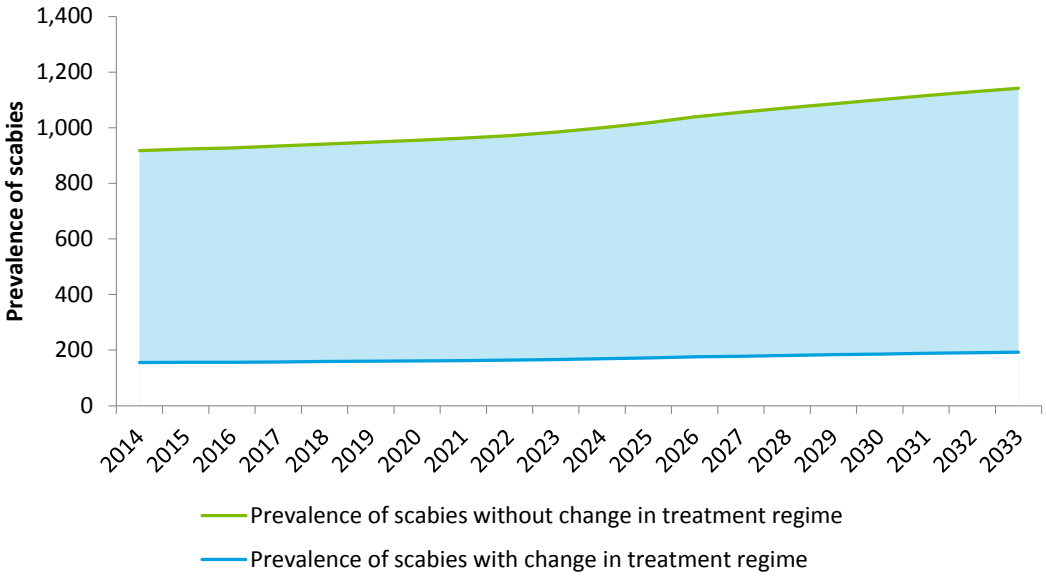
[15] Personal communication with Professor Ross Andrews (8 September 2015).

Chart 4.8: Reduction in pyoderma (Northern Territory)



Source: Deloitte Access Economics calculations.

Chart 4.9: Reduction in scabies (Northern Territory)



Source: Deloitte Access Economics calculations.

The economic benefit of this reduction in cases of pyoderma and scabies is $5.6 million for the NT, and $58.1 million for Australia, in 2015.

4.7.1 Recent pyoderma research that is not quantified

Future work by Menzies' researchers on pyoderma will focus on the relationship between rheumatic fever and pyoderma with an aim to reduce rheumatic fever via early treatment of skin sores, as well as further research on treatment duration.

4.8 Diabetes mellitus in pregnancy

Diabetes mellitus in pregnancy, or gestational diabetes mellitus (GDM), refers to diabetes that begins during pregnancy and is closely linked to obesity in pregnant women. GDM can occur in at least 5% of all pregnancies and is a condition that increases the risk of foetal and maternal morbidity and mortality (Friel, 2014). If poorly controlled in the later stages of pregnancy, GDM can increase the chance of adverse perinatal outcomes such as:

- foetal macrosomia, which is distinguished by above average foetal weight (> 4,000g) and can result in birth difficulty;
- pre-eclampsia, which is characterised by high blood pressure and protein in the urine and if left untreated, can result in organ failure in the mother and growth restriction of the child;
- shoulder dystocia, which may result in damage to the upper brachial plexus nerves due to obstructed labour and result in the development of neonatal conditions such as Erb's palsy and foetal hypoxia; and
- spontaneous abortion.

Treatment of GDM has been associated with reductions in the risk of these outcomes. In randomised trials undertaken by Crowther et al (2005) and Landon et al (2009), treatment was found to reduce the risk of foetal macrosomia, pre-eclampsia and shoulder dystocia. In Landon et al (2009), a reduction in the likelihood of caesarean delivery was also identified, as a result of reduced macrosomia. While studies suggest that GDM is likely to have adverse impacts on children in later stages of their life, there has been no significant evidence that GDM treatment reduces the future likelihood of obesity or diabetes in the child (Donovan et al, 2015; Gillman et al, 2010; McLean et al, 2006).

GDM is particularly prevalent in pregnant women in the NT, which has a rate of GDM per 1,000 women who give birth that exceeds that of all other states and territories in Australia (NT Department of Health, 2014). Indigenous mothers are particularly susceptible to GDM, with 8.7% of Indigenous mothers in the NT experiencing complications with GDM in pregnancy in comparison to 6% of non-Indigenous mothers in the NT (AIHW, 2014b).

To address this matter, Menzies has undertaken three streams of work as part of its NT Diabetes in Pregnancy Partnership Project, which commenced in 2012 and include:

- Pregnancy and Adverse Neonatal Diabetes Outcomes in Remote Australia (PANDORA), a detailed research project that focuses on assessing the rates and characteristics of GDM outcomes;

- the development of a Clinical Register for use by health professionals; and
- the review of current models of care to improve health service delivery for women with GDM.

More recently, Menzies has also rolled out this project in Upper North QLD.

> As part of their work with in developing a clinical register and improving models of care, Menzies' contributions have resulted in more women being diagnosed with pregnancy in diabetes – both GDM and pre-existing type-2 diabetes mellitus. This has allowed for earlier intervention in the treatment and control of diabetes, resulting in better maternal and neonatal outcomes in both the NT and Upper North QLD.

The economic benefits of improved, and subsequently increased, diagnoses of GDM in pregnant women in the NT and Upper North QLD have been calculated. The parameters and methodology used for this estimation are set out in the following paragraphs.

Menzies' work on improved diagnosis of GDM resulted in an increase in the number of cases diagnosed since 2012, from 7% to 11% of women aged 15-40 who gave birth. These estimates were derived from commercial-in-confidence data obtained from Menzies, in addition to data from the 2012 Mothers and Babies report (AIHW, 2014b) and the 2011 NT Mothers and Babies report (NT Department of Health, 2014).

The benefits of treatment of GDM from Crowther et al (2005) and Landon et al (2009) were used to calculate the average estimate of a reduction in pre-eclampsia of 6%. A reduction of 7.9% in caesarean deliveries was obtained from Landon et al (2009).

In lieu of a disability weight for pre-eclampsia, the disability weight for hypertension was used as a proxy, given the similarity between the symptoms of both conditions. The disability weight for hypertension and for caesarean delivery in Begg et al (2007) was 0.117 and 0.349 respectively. The parameters used to establish the economic benefits of improved diagnoses are summarised in Table 4.10.

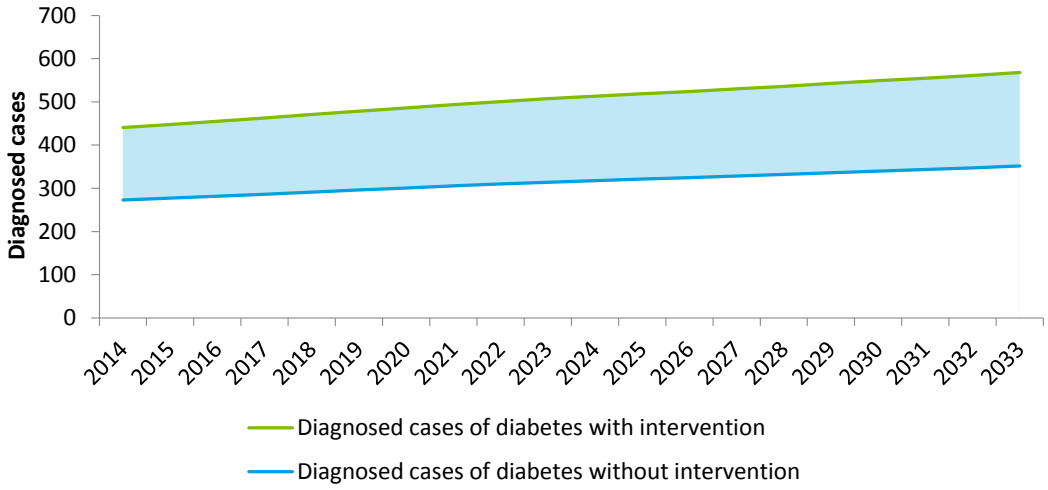
Table 4.10: Parameters for gestational diabetes mellitus calculations

Parameter	Value	Source
Prevalence of GDM	7%	AIHW, 2014b; NT Department of Health, 2014
Prevalence of GDM after improved diagnosis	11%	AIHW, 2014b; NT Department of Health, 2014; unpublished data
Reduction in pre-eclampsia	6%	Crowther et al, 2005; Landon et al, 2009
Reduction in caesarean delivery	7.9%	Landon et al, 2009
Disability weight of hypertension	0.117	Begg et al, 2007
Disability weight of caesarean delivery	0.349	Begg et al, 2007

Source: Deloitte Access Economics research.

By 2033, it is estimated that Menzies' contributions will have helped to diagnose 216 additional cases of GDM in the NT, and 248 additional cases of GDM in Upper North Queensland. The impact is shown for the NT in Chart 4.10.

Chart 4.10: Increase in GDM diagnosis (Northern Territory)



Source: Deloitte Access Economics calculations.

The economic benefit of this reduction in cases of pre-eclampsia and caesarean delivery in mothers with gestational diabetes mellitus is $0.01 million for the NT, and $0.02 for Australia, in 2015.

4.8.1 Recent diabetes research that is not quantified

Menzies has been involved in additional research on diabetes management in Indigenous populations, including the DRUID study, a cohort study looking at the incidence of diabetes, heart disease, stroke, kidney disease and related diseases in Indigenous adults. Findings from the DRUID study will inform both diabetes and heart disease risk factor assessments with the aim of improving early detection of these diseases, improving treatment and clinical outcomes.

4.9 Protracted bacterial bronchitis

Protracted bacterial bronchitis (PBB) is a common disease amongst the paediatric population that is caused by the chronic infection of the conducting airways and impairment of muco-ciliary clearance (Craven and Everard, 2013). PBB is the most common cause of chronic wet cough and can be characterised by persistent coughing, wheezing, noisy breathing and interrupted sleep. Due to similarities between symptoms of PBB and asthma, PBB has often been misdiagnosed as the latter and overlooked in both treatment and research (Chang et al, 2008).

Menzies' work in respiratory paediatrics in the Child Health Division has been pivotal to increased awareness and treatment of this disease. Menzies was responsible for

diagnostically categorising PBB in 2006 and identifying a cure for the condition. Menzies' work has since contributed to national management of PBB.

> Menzies' diagnosis of PBB in 2006 has helped to raise national awareness of the disease. Menzies' research has also made a valuable contribution to the treatment of the disease, identifying that a two-week course of antibiotics, amoxicillin clavulanate, can be administered to patients with PBB to resolve the condition (Marchant et al, 2012).

The economic benefits of increased resolution of PBB in children under the age of 15 in the NT and Australia have been calculated. The parameters and methodology used for this estimation are set out in the following paragraphs.

In their study, Marchant et al (2012) undertook a randomised controlled trial of amoxicillin clavulanate in children with chronic wet cough to determine the effects of antibiotic treatment on the condition. As the majority of children with chronic wet cough have PBB, the researchers deemed the effects of treatment to be similarly translatable. Following 14 days of treatment, the study compared the cough scores of the children with their baseline scores. Researchers found that cough resolution rates were significantly higher in children who had received amoxicillin clavulanate (48%) compared to those who had received a placebo (16%), representing a 32% increase in the treatment of the disease.

Due to previous under-diagnosis and common disagreement over standardised definitions for 'chronic', the prevalence of chronic wet cough, and by extension PBB, is not currently known (Chang et al, 2012). An estimate was taken from Carter et al (2006), which conducted a cross sectional survey of 2,397 Seattle middle school students aged between 11-15 years old to determine prevalence of chronic productive cough. The study identified that 7.2% of the sample population had chronic productive cough.

A disability weight has not been officially calculated for PBB. As such, the disability weight for acute bronchitis was used as a proxy for PBB, given the strong association between both diseases. The disability weight for acute bronchitis, as reported in Begg et al (2007), is 0.132. The disability weight was adjusted to account for the duration of the condition from Marchant et al (2012). The parameters discussed are summarised in Table 4.11.

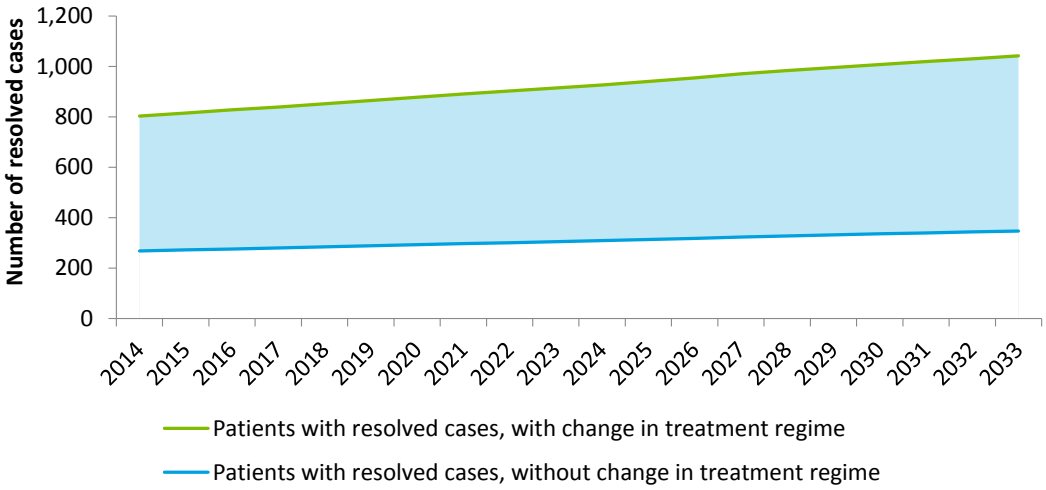
Table 4.11: Parameters for protracted bacterial bronchitis calculations

Parameter	Value	Source
Increase in resolution of PBB	32%	Marchant et al, 2012
Prevalence of PBB in children	7.2%	Carter et al, 2006
Disability weight for acute bronchitis	0.132	Begg et al, 2007

Source: Deloitte Access Economics research.

By 2033, it is estimated that Menzies' research will have resolved PBB in 16,283 patients with PBB in the NT, and 1,318,437 patients in Australia. The impact of this is shown for the NT in Chart 4.11.

Chart 4.11: Increase in resolved cases of PBB (Northern Territory)



Source: Deloitte Access Economics calculations.

The benefits of increased resolution of PBB are $1.1 million to the NT, and $91.5 million to Australia, in 2015.

4.9.1 Recent respiratory research that is not quantified

Menzies has also undertaken other initiatives in respiratory research, which have not been quantified in this report. Menzies has led the Centre of Research Excellence (CRE) in Lung Health of Aboriginal and Torres Strait Islander Children, a five year program of research and capacity building aimed at preventing and treating lung disease in children before irreversible lung damage is caused. The program will run from 2012-2017 with the funding of the NHRMC. The CRE involves the collaboration of researchers from a number of other institutes such as the Children's Medical Research Institute, the University of Queensland and Wollongong University.

4.10 Cancer research

Indigenous Australians experience higher rates of cancer incidence and mortality than non-Indigenous Australians (AIHW, 2013). In addition, Indigenous Australians have been shown to experience lower rates of cancer survival, and greater prevalence of cancer-related modifiable risk factors. Leading cancers affecting Indigenous people include the following (AIHW, 2013):

- lung cancer;
- breast cancer in females;
- bowel cancer;
- cervical cancer;
- liver cancer;

- prostate cancer; and
- cancer of unknown primary site.

Research has shown that while Indigenous Australians may be less likely to develop certain cancers than non-Indigenous Australians, leading cancers affecting Indigenous Australians tend to have poor prognosis but are largely preventable (Cunningham et al, 2008). Higher prevalence of risk factors such as smoking, chronic infections and risky alcohol consumption are likely to contribute to the development of certain cancers. However, the problem may be further exacerbated by limited preventive care, as evidenced by low participation in cancer screenings, and inadequate health service coverage, resulting in poor engagement of Indigenous patients and delayed treatment (Cunningham et al, 2008).

In response to these health disparities, Menzies has undertaken significant research over the years into cancer treatment and management for Australia's Indigenous population. Between 2002 and 2014, Menzies has received over $7 million in funding to conduct research into areas such as the impact of co-morbidities on cervical cancer in Indigenous women, improving systems and quality of cancer care in Indigenous primary health care settings and social and system determinants of Indigenous health (NHRMC, 2014).

In recognition of the high priority of cancer on the Indigenous health agenda, Menzies established two major Indigenous care focused initiatives in 2013:

- DISCOVER-TT, which is aimed at addressing knowledge gaps relating to Indigenous-specific models of cancer care, health services and care needs; and
- The Strategic Research Partnership to improve cancer control for Indigenous Australians program, designed to consolidate DISCOVER-TT's capacity via additional funding and bring together researchers, advocates, policy-makers and other like minds through strategic research and funding partnerships.

> Menzies' research into Indigenous-specific treatment and care of cancer has made significant contributions to Australian knowledge regarding Indigenous health relating to cancer and provided valuable insights into how Indigenous health outcomes may be improved.

The economic benefits of Menzies' cancer research to Australia have been calculated. The parameters and methodology used for this estimation are set out in the following paragraphs.

The NHRMC (2014) provides a comprehensive dataset on funding grants, past and pending, pertaining to cancer research for the years 1994-2019. Figures for the calendar years 2002 and onward, which relate to cancer research projects that Menzies has undertaken using NHRMC funding were obtained from this dataset.

An estimate for the return on investment yielded by Menzies' cancer research was obtained from Glass et al (2008), which calculated the economic value of cancer research and development in Australia using return on investment analysis. The report estimated that the average return on investment to cancer research and development in Australia was 239%. The parameters discussed have been summarised in Table 4.12.

Table 4.12: Parameters for cancer research calculations

Parameter	Value	Source
Grants received for Menzies' cancer research	$8.4 million (a)	NHRMC, 2014
Estimate for return on investment in cancer research	239%	Glass et al, 2008

Source: Deloitte Access Economics research. (a) This is the sum of cancer research grants over the period 2002-2019.

As it is not possible to separate the NT research from the rest of Australia research, and as the funding is provided by the Australian Government, the benefits of cancer research have been assumed to accrue to the rest of Australia.

> The benefits of cancer research undertaken by Menzies are $19.2m to Australia in 2015.

This estimate of the economic value of Menzies' cancer research is assumed to capture the value of all Menzies' cancer research. As such, non-quantified aspects of Menzies' cancer research are not discussed.

4.11 Otitis media

Otitis media is a condition that is distinguished by bacterial or viral infection, and inflammation of the middle ear. Otitis media encompasses a spectrum of disease, ranging from mild (otitis media with effusion) to severe (chronic suppurative otitis media, CSOM). The condition most commonly occurs in young children between the ages of 3 months and 3 years and is often accompanied by symptoms of earache, fever, nausea, vomiting and diarrhoea (Miyamoto, 2012). Hearing loss may also occur if there is fluid in the middle ear space and, while temporary, may increase in duration and severity if otitis media becomes chronic in the patient.

Although otitis media commonly occurs in the Australian population, Indigenous children are particularly vulnerable to developing otitis media. According to Verhoeff et al (2006), the medical literature reports some of the highest rates of CSOM for Indigenous children in Australia. In response to this issue, Menzies has undertaken significant research into improved management and treatment options for otitis media in Indigenous communities. Menzies' research has contributed to a range of benefits, including the development of improved clinical care guidelines on the management of the condition and the identification of an improved vaccination for otitis media in children (Leach et al, 2014).

> Menzies' research into otitis media has yielded significant improvements in management and care for Indigenous patients through the development of improved clinical care guidelines and increased efficacy in vaccinations for child patients.

The economic benefits of Menzies' research into otitis media vaccinations for Indigenous children aged 15 and under in remote communities were calculated. The parameters and methodology used for this estimation are set out in the following paragraphs.

In Leach et al (2014), a study was conducted to assess the impacts of administering the 10-valent pneumococcal Haemophilus influenzae protein D conjugate vaccine (PHiD-CV10) in comparison to the effects of the 7-valent pneumococcal conjugate vaccine (PCV7), to treat otitis media. Community surveillance was conducted of children with otitis media in remote Indigenous communities, comparing children less than 36 months of age who had received a primary course of at least two doses of PCV7 or PHiD-CV10. The study identified a distinct decrease in the prevalence of any otitis media in children who had been administered the PHiD-CV10 when compared to those who had been vaccinated with the PCV7, in all age groups.

Weighted averages were calculated to derive prevalence rates for the age bands of less than one year old, between one and two years old, and two years old and above. Based on these age bands, the study reported a 19% decrease in prevalence amongst children aged less than one, a 17% decrease amongst children aged between one and two and a 6% decrease in children aged two and above.

In Morris et al (2007), researchers identified estimates for prevalence rates for variations on otitis media, including the estimated prevalence of CSOM in children. The study identified that 15% of its sample had CSOM. An estimate of the percentage this constituted of cases of otitis media was calculated to be 17%. According to a report by the WHO (2004) on CSOM, at least 50% of cases of CSOM can result in mild to moderate conductive hearing loss.

As with pyoderma, it is estimated that 25% of Indigenous people live in remote areas (ABS, 2011). This proportion has been used for this analysis as remote Indigenous communities constitute the focus of Menzies' work in otitis media and were the target population for trial undertaken by Leach et al (2014).

The disability weights for otitis media and deafness resulting from otitis media have been taken from Mathers et al (1999). The weight for chronic otitis media is 0.110 and 0.233 for deafness. The parameters discussed have been summarised in Table 4.13.

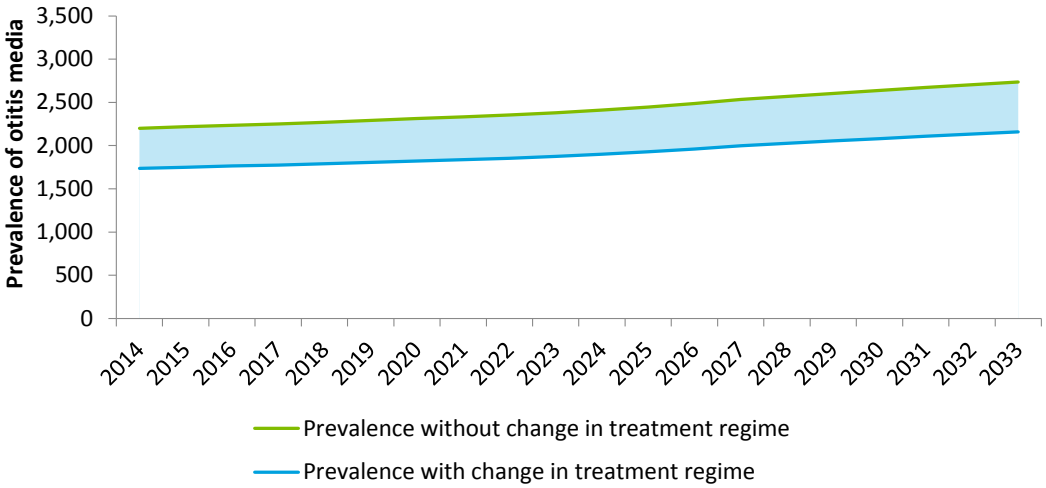
Table 4.13: Parameters for otitis media calculations

Parameter	Value	Source
Reduction in prevalence in children <1 year old	19%	Leach et al, 2014
Reduction in prevalence in children >1 and <2 years old	17%	Leach et al, 2014
Reduction in prevalence in children ≥ 2 years old	6%	Leach et al, 2014
Percentage of Indigenous people living in remote areas	25%	ABS, 2011
Percentage of otitis media cases resulting in CSOM	17%	Morris et al, 2007
Percentage of cases of CSOM resulting in hearing loss	50%	WHO, 2004
Disability weight for chronic otitis media	0.11	Mathers et al, 1999
Disability weight for deafness associated with otitis media	0.233	Mathers et al, 1999

Source: Deloitte Access Economics research and calculations.

By 2033, it is estimated that Menzies research will have helped reduce the prevalence of chronic suppuratives otitis media by 9,356 cases in the NT and 106,437 cases in Australia. The impact of this research for the NT is shown in Chart 4.12.

Chart 4.12: Reduction in prevalence of otitis media (Northern Territory)



Source: Deloitte Access Economics calculations.

The benefits of Menzies' research into otitis media are $2.0 million to the NT, and $24.0 million to Australia, in 2015.

4.11.1 Non-quantified otitis media research

As part of the Department of Health's Care for Kids' Ears campaign, Menzies has helped to develop educational resources for clinicians, health practitioners and teachers with the aim of improving understanding and awareness of otitis media. Menzies has also been focused on improving capacity building, training skills and health service delivery in the area of otitis media management. The effects of this work on quality of service in Medicare Locals are currently being evaluated by the National Aboriginal Community Controlled Health Organisation. Menzies' work in otitis media led the NHMRC to declare its research program as a Centre of Research Excellence.

4.12 Higher degree graduates

In addition to the health and policy and program improvements that may arise to the NT and broader communities from the research being conducted by students at Menzies (discussed above), there are many benefits that accrue to both the individual and community as a whole from higher education.

The main expected benefit of a research higher degree education[16] is the increased productivity for both the individual (reflected in higher lifetime earnings) and for the entire labour force as a result of having more skilled resources available. In the absence of such data, there are also likely to be other intangible benefits to the individual such as self-esteem, status and the enjoyment of learning. For society overall, it is broadly recognised

[16] Higher degrees by coursework have been excluded from this assessment of the impact of knowledge and skills as these students could have conducted their degree at an alternative institution. As such, Menzies does not offer any particular advantage beyond what was accessible elsewhere.

that there are spillover benefits from research training. Benefits typically include social consequences such as improved law and order, and improvements in the 'quality' of society (for example, involvement in voluntary community activities).

Estimates of the magnitude of benefits to society from research higher degrees are contentious and difficult to quantify[17]. For example, with respect to increased productivity, it is difficult to estimate the proportion of the benefit derived from increased productivity as a result of a research higher degree that is claimed by the individual in the form of earnings versus what spills over to society.

For the individual, it is also difficult to quantitatively measure the benefits of undertaking a higher degree course. In the absence of data the dollar cost of Australian Government funding is used as a proxy for benefits to the individual and society of undertaking the higher degree course. This is a simple assumption that ignores other costs to the student such as the opportunity cost of not being in the full-time labour force as well as the cost of materials and books, where there is substantial uncertainty in cost estimation. However, the student funding cost represents a defensible minimum benefit estimate since the student would not proceed – according to economic principles of rationality and information – if the net cost exceeded the net benefit.

The Australian Government provides funding of $25,849 per year for 3 years[18], the current total funding provided for undertaking a higher research degree at the Menzies is therefore $77,547 (noting that this is using the current funding level for all degrees commenced and completed during 2002-2014, rather than taking into account potential changes in real funding levels over this period). Based on this approach, the total economic value of the 67 completed higher degrees is $2.8 million ($NPV_{7\%}$) over the next 20 years.[19] Again, this is likely to be a very conservative estimate.

[17] For discussion see Industry Commission 1997, *Industry Commission Submission to the Review of Higher Education Financing and Policy*, Industry Commission, Canberra, July.
[18] Personal communication: David Scholz, 30 July 2015.
[19] Note: Scholarship moneys are not included in this estimate because these represent a living expense rather than real expenditure on education.

5 Qualitative impacts

This section describes various areas of Menzies' research where economic benefits were not able to be quantified, largely due to lack of data on impacts.

5.1 Tobacco control

Tobacco smoking is particularly prevalent in the Indigenous population, with statistics suggesting that almost 50% of Indigenous adults smoke (ABS, 2014a). Harm caused from smoking represents a significant cause of chronic disease and death in Indigenous populations, contributing to comorbidities and other conditions. In response to this issue, Menzies has conducted research into the prevalence of smoking among Indigenous people in the NT, with a particular focus on monitoring tobacco consumption and trends.

In 2012, Menzies commenced a large national research project, called Talking About the Smokes, aimed at providing longitudinal analysis of pathways to smoking and quitting for Indigenous people. The project encompassed baseline and follow-up surveys from 2012-2014 and identified key findings about quitting and second-hand smoke. Additional work that Menzies has undertaken in this field include the development of a pilot project to monitor tobacco consumption among Indigenous communities, advocacy and public work on policies to decrease smoking rates and assisting with the establishment and evaluation of a ban on smoking in NT prisons.

Future research undertaken by Menzies in tobacco control will focus on the impact of social media on reducing smoking rates, with the aim of identifying possible social media interventions via viral campaigns and influential social media users.

5.2 Centre for Child Development and Education

The Menzies Centre for Child Development and Education (CCDE) was established in 2010 to research education, from early childhood through to secondary school, and collaborate with child protection, health services and juvenile detention on important issues of childhood development. As part of the Centre's work, Menzies has been involved in a number of different initiatives.

Menzies has been involved in testing the efficacy of interventions in childhood development, focusing on adapting mainstream approaches to remote Indigenous communities rather than undertaking research and initial model development. Menzies has helped develop a life skills curriculum with the NT government, which it is currently in the second year of piloting, as well as a parenting intervention program, focused on parents of preschool/primary school students with difficulties, which has reported positive impacts on school attendance rates.

Menzies has also undertaken epidemiological research, including a data linkage program focused on establishing confidential linkages between individual data across service delivery sectors, such as healthcare and education, to encourage greater collaboration and coordination.

Menzies has been involved in a suicide prevention research stream, which investigates outcomes for people hospitalised with deliberate self-harm in terms of repeat hospitalisations, and premature mortality and associated levels of health service utilisation. The stream's objectives, to link hospital admissions data with primary care data and Indigenous medical services, aims to enable health services to track and follow up on patient outcomes.

Menzies has also helped to develop a number of discussion papers for the NT government on a range of topics relating to child development and education, including early development issues, disadvantage in NT Indigenous populations and evidence for effective early interventions.

5.3 Nutrition

Poor nutrition and dietary habits have been long observed in Indigenous communities in Australia, with previous trends of undernutrition in Indigenous children now giving way to higher rates of obesity in adults (Gracey, 2007). Approximately 40-45% of Indigenous adults are either overweight or obese, the high prevalence of which has driven increases in co-morbidities such as cardiovascular disease, type 2 diabetes mellitus and chronic renal disease. Poor nutrition amongst Indigenous people can be attributed to a number of complex factors, including the "Westernisation" of Indigenous diets, which were originally low in fat, salt and sugar, and lifestyles and high rates of risk factors such as excessive alcohol and tobacco consumption. These factors have been further compounded by other social influences, including poverty and educational disadvantage, which limit access to, and knowledge of, nutritious foods and healthy dietary practices (Gracey, 2007).

In response to this issue, Menzies has focused on furthering knowledge of Indigenous dietary patterns, and advocating for better nutritional policies in remote Indigenous communities. As part of its data collection efforts, Menzies has collected weekly store sales data for 20 communities over three years to track the price and content of food purchases by Indigenous Australians, enabling the identification of long-term trends in problem areas. Menzies has also conducted analysis on food prices, particularly on the differential between the cost of food in remote and urban areas.

In addition to this research, Menzies has also been involved in a number of trials aimed at improving nutritional welfare through targeted interventions and initiatives. The Shop@RIC Stores Healthy Options Project, which analyses the impact of a 20% reduction in the price of healthy foods, has yielded positive preliminary results, with further analysis of findings to come.

Another initiative, in partnership with the George Institute, Goodman Fielder, the NT Department of Health, Outback Stores and the Arnhem Land Progress Aboriginal Corporation, has focused on reducing the intake of salt among 30 communities by introducing salt-reduced bread, developed by Goldman Fielder.

The Good Foods Systems Project is another initiative which was developed in conjunction with 70 different stakeholders and focuses on encouraging the community to identify gaps in healthy eating service delivery. Results have led to the implementation of a number of

changes in store practices, such as confectionary free counters and an increase in the variety of fruit and vegetables.

School-based nutrition intervention represents another Menzies initiative that is still in its early stages. A pilot program was well-received in the community and will potentially be funded by an NHMRC grant.

5.4 Kidney disease

Kidney disease represents a significant cause of mortality among Indigenous Australians who experience mortality rates that are eight to 10 times higher than those of other Australians. Furthermore, Indigenous patients face particular problems, such as high costs of management (the majority of those on dialysis receive haemodialysis, the most expensive form of dialysis) and housing issues caused by the need to relocate from their homes in remote areas to urban areas for treatment (AIHW 2011). As such, Menzies has been heavily involved with research and development on improving disease management for Indigenous patients with a particular focus on preventative intervention and improving the quality of health service delivery.

One such project has involved the development of cross cultural resources, including educational vignettes, a facilitator's guide and cultural training, to improve communication between Indigenous Australians and health service providers. Menzies has also been involved in evaluations of relevant programs to assess their efficacy, including the evaluation of the Renal Case Management Program, a chronic kidney disease management plan that was implemented in 2007 by the NT and Australian Government.

In addition, Menzies has been involved in a cost-effectiveness analysis of service delivery models as part of the dialysis models of care project, aimed at improving understanding of the health, social and economic impacts of dialysis services available in the NT. Menzies has also conducted research into improving kidney transplant outcomes, aiming to both improve health and reduce barriers to transplant access for Indigenous Australians.

5.5 Mental health

Indigenous Australians are disproportionately vulnerable to mental health issues and disorders. In addition to higher rates of depression and psychological distress, the suicide rates of Indigenous people for the period 2001-2010 were twice as high as that of non-Indigenous Australians (ABS, 2012). In the NT, this discrepancy is particularly high with a youth suicide rate that is 3.5 times greater than the national average and an overall rate that is twice the national rate (Legislative Assembly of the NT, 2012).

In response to this issue, Menzies has been involved in a number of mental health programs aimed at addressing, and improving the communication of, Indigenous mental health needs both in the NT and in the rest of Australia. The Australian Integrated Mental health initiative (AIMhi) is one such program of research dedicated to developing culturally-relevant tools for Indigenous service providers and communities to help recognise and overcome mental health problems. In the last five years, AIMhi has grown to encompass greater collaboration with the alcohol and other drugs workforce to help embed strategies

in serve providers as well as in communities, contributing to CARPA guidelines and best practice protocol on mental health treatment.

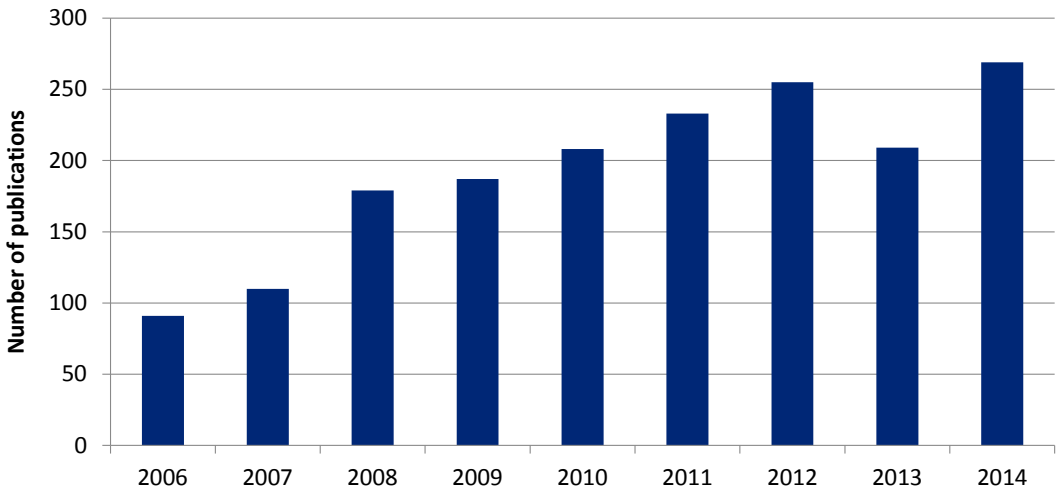
Under AIMhi, Menzies has advanced a number of e-mental health support services, including development of the Stay Strong app, a digital adaptation of the AIMhi Stay Strong Care Plan, designed to be used by health care providers. The application is intended to replace paper-based therapy and deliver low-intensity cognitive behavioural therapy to Indigenous clients in an accessible and engaging manner. As of August 2015, 200 service providers have been trained in the use of the application in the NT. Approximately 20 service providers have been trained in NSW and a further 20 in QLD. While findings have yet to be released on the efficacy of the app, research by Dingwall et al (2015) indicate that e-mental health interventions are likely to be acceptable, appropriate and feasible for delivery by remote health service providers, as they require minimal training and can be customised for cultural accessibility.

In addition, Menzies has also worked with remote Indigenous schools to introduce resilience training into the curriculums of children in year nine. The training, designed to provide early intervention for suicide prevention, has been piloted over the past few years and will continue for the next four years. The program promotes wellbeing and seeks to diminish healthcare costs relating to mental health, chronic disease and suicide prevention.

5.6 Academic publications

While it is not possible to place a value on the academic publications produced by Menzies' researchers, these publications generate value through contributing to the body of knowledge, promoting knowledge transfers and promoting both Menzies and NT as a health science research hub. As shown in Chart 5.1, the number of publications authored by Menzies researchers has increased from 91 in 2006 to 269 in 2014.

Chart 5.1: Number of publications by Menzies staff (2006-2014)



Source: Data provided by Menzies School of Health Research.

6 Overall impacts

This section of the report summarises the costs and benefits from the previous section, assesses them using cost-benefit analysis, and conducts sensitivity analysis on the results.

6.1 Cost-benefit analysis methodology

A cost-benefit analysis (CBA) involves the estimation of costs and benefits over a number of years, with future benefits and costs discounted to the present using a discount rate. The NPV of the costs and benefits of a particular intervention program are compared to determine a net benefit (or cost) along with a benefit-cost ratio (BCR), which is the 'breakeven point' – anything above this point is a net benefit. The BCR is calculated as the ratio of the sum of the discounted benefits of Menzies' benefits, relative to the cost of Menzies research. The breakeven point for the BCR is 1, in that a BCR between 0 and 1 represents a net cost, while a BCR above 1 represents a net benefit.

The benefits estimated are conservative as many of the future benefits of Menzies' work are yet to be realised. The methodology may also be conservative because it only includes the value of wellbeing gains that accrue to the individual as benefits. For example, other health sector benefits of averting DALYs accrue to governments (for example, health expenditure saved), to firms (to the extent that they bear part of the productivity losses associated with disease and injury) and to the rest of the society (for example, the value of informal care from family and friends).

A Monte Carlo analysis was applied to test the sensitivity of the net benefit to variations in key model inputs, such as the VSLY and the discount rate. The results of the sensitivity analysis are presented in Section 6.3.

6.2 Results of the cost-benefit analysis

The total costs and benefits associated with Menzies activities are shown in Table 6.1. The costs are based on the estimates presented in Section 2, while the benefits reflect the sum of the benefits in Sections 3 and 4.

> In total, in NPV terms and 2015 dollars, the net benefit from Menzies research over the period 2002 to 2033 is $168.4 million for the NT (with a BCR of 2.2), $273.0 million for Australia (a BCR of 1.69) and $424.9 million for the Asia-Pacific region (a BCR of 36.2).

Table 6.1: Summary of results (2015)

	NT $NPV_{7\%}$ $2015m	Australia $NPV_{7\%}$ $2015m	Asia-Pacific (a) $NPV_{7\%}$ $2015m
Costs	**$140.67**	**$392.92**	**$12.07**
Benefits			
Direct economic contribution	$202.76	$228.79	
Indirect economic contribution	$79.61	$89.53	
Education		$2.81	
Health benefits			
Malaria		$0.84	$436.92
Melioidosis	$1.44	$8.10	
Rheumatic heart disease	$0.84	$6.71	
Oral disease	$1.05	$1.05 (b)	
Quality improvement for primary care of chronic disease	$14.60	$135.37	
Pyoderma and scabies	$5.64	$58.09	
Gestational diabetes	$0.01	$0.02	
Protracted bacterial bronchitis	$1.13	$91.48	
Cancer research		$19.17	
Otitis media	$2.03	$23.96	
Tobacco control		Not quantified	
Child development and education		Not quantified	
Nutrition		Not quantified	
Kidney disease		Not quantified	
Mental health		Not quantified	
Total benefits	**$309.10**	**$665.92**	**$436.92**
Net benefits	**$168.43**	**$273.00**	**$424.85**
Benefit cost ratio	**2.20**	**1.69**	**36.20**

Note: (a) 'Australia' refers to Australia including the NT, and 'Asia-Pacific' refers to the region excluding Australia. (b) The health benefits of improved treatment of oral disease derive solely from the NT.

The results in Table 6.1 encompass previously estimated costs from the previous report for 2002-2030, and the additional valuations in this report, which have all been adjusted to 2015 dollars. The results suggest that between 2002 and 2033, Menzies' activities will generate significant economic benefit to the NT and the Asia-Pacific regions, and a modest net benefit to Australia. Menzies' activities contributed $168.4 million in benefits to the NT, the majority of which can be attributed to direct and indirect contributions made by Menzies to the NT economy.

Menzies' direct and indirect contributions to the Australian economy in total amounted to $273.0 million, the majority of which were due to the significant health benefits from Menzies' research. As Menzies' activities did not generate any direct or indirect economic contributions to the Asia-Pacific region, the entirety of its contribution in this area came

from health benefits, namely from Menzies' work in malaria treatment and management in the Asia-Pacific.

6.3 Sensitivity analysis

There are a number of assumptions in this analysis that, in practice, may vary either side of the estimate used. It is therefore important to sensitivity test assumptions to ensure the robustness of the final estimates.

The key assumptions which will be used in the sensitivity testing are:

- the VSL and VSLY in the Asia-Pacific – the VSL and VSLY in a given country is a reflection of economic prosperity, and given the level of economic development in the Asia-Pacific the application of an Australian measure may overestimate the impact;
- the number of cases and deaths from malaria in the Asia-Pacific – very conservative estimates of the number of cases of malaria receiving treatment have been applied to the above assessment; and
- the discount rate – at 3% and 11% as per PM&C guidelines.

The following sensitivity tests use Monte Carlo analysis. This approach makes it possible to vary all of the estimates discussed above simultaneously to explore the effect of their potential interactions on the impact of Menzies activities. This involves performing 10,000 simulations of the economic impact model using different values, and combinations of values for the estimates adopted. This analysis makes it possible to determine the robustness of the results reported above. It is important to note that as benefits from 2002-2010 have been included from previous analysis, sensitivity analysis has only been conducted on benefits derived for 2011-2033.

Table 6.2 summaries the range and distribution applied for each estimate for the sensitivity analysis.

Table 6.2: Ranges and distributions applied to the estimates for sensitivity analysis

Estimates	Minimum	Most likely	Maximum
VSL in the Asia-Pacific	$1.1 million	$2.6 million	$4.2 million (Australian VSL)
VSLY in the Asia-Pacific	$45,500	$113,750	$182,000 (Australian VSLY)
Estimated numbers of deaths from malaria that receive treatment	790	10,645	20,500 (half of WHO estimates)
Estimated number of causes of malaria that receive treatment (a)	1.6 million	13 million	24 million
Discount rate	3%	7%	11%

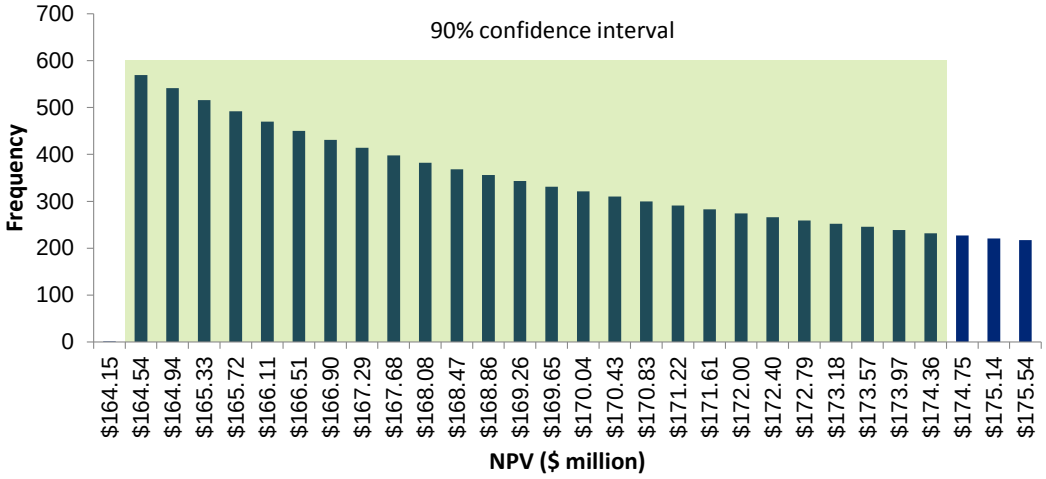
Note (a): In 2013, the WHO (2014a) recorded 1.6 million cases of malaria in the South East Asian region but estimated that there were 24 million cases of malaria. These totals have been used as the upper and lower bounds of this estimate respectively.

6.3.1 Sensitivity analysis – Northern Territory

The sensitivity analysis found that the average economic contribution[20] of Menzies to the NT for the period from 2002 to 2033 was $168.9 million. The upper and lower bounds of this estimate are $175.5 million and $164.2 million, respectively.

Chart 6.1 illustrates the results of the sensitivity analysis and highlights the robust nature of the results reported in Section 6.2. Using a 90% confidence interval, the analysis suggests a likely economic contribution of Menzies' activities to the NT of between $164.5 and $174.6 million.

Chart 6.1: Sensitivity analysis of the economic contribution to the NT



Source: Deloitte Access Economics calculations using @Risk.

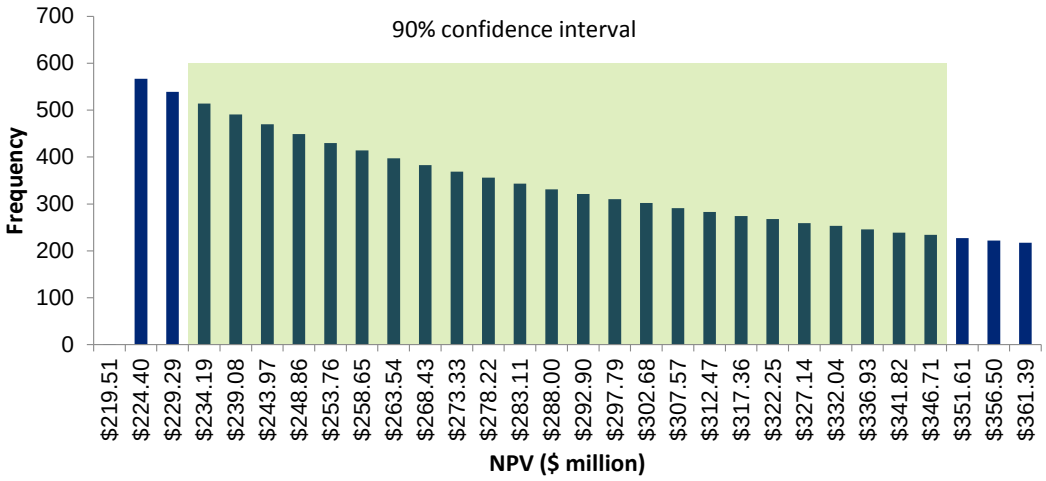
6.3.2 Australia

The sensitivity analysis found that the average economic contribution of Menzies to Australia for the period from 2002 to 2033 was $278.7 million. The upper and lower bounds of this estimate are $361.4 million and $219.5 million, respectively.

Chart 6.2 illustrates the results of the sensitivity analysis, and suggests a likely economic contribution to Australia from Menzies activities, with 90% probability, will be between $223.8 million and $350.3 million.

[20] The average value is calculated based on the sum of the values generated by the Monte Carlo sensitivity analysis divided by the number of iterations and as such, will differ from the results which are presented in Section 6.2.

Chart 6.2: Sensitivity analysis of the economic contribution to Australia



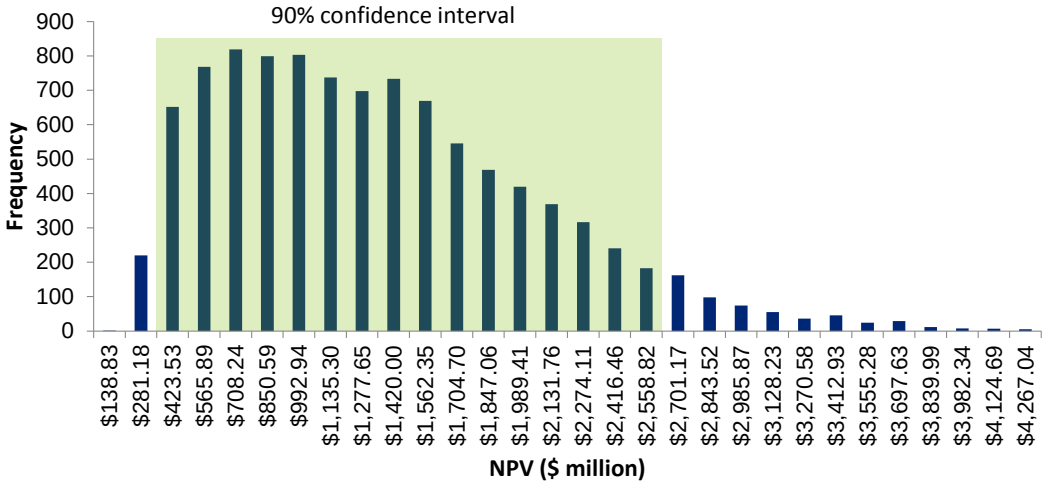
Source: Deloitte Access Economics calculations using @Risk.

6.3.3 Asia-Pacific

The sensitivity analysis found that the average economic contribution of Menzies to the Asia-Pacific for the period from 2002 to 2033 was $1.3 billion. The upper and lower bounds of this estimate are $4.3 billion and $138.8 million, respectively. However, the likelihood of such results is very low.

Chart 6.3 illustrates the results of the sensitivity analysis, and suggests a likely economic contribution to the Asia-Pacific from Menzies' activities will be between $349 million and $2.6 billion, given a 90% confidence interval. The range can be attributed to the high upper bound values tested for the estimated numbers of deaths from malaria that receive treatment and the estimated number of causes of malaria that receive treatment. As discussed in 4.2, these values, which were derived from the WHO (2014a) were excluded from this report's calculation of its base case in favour of more conservative estimates.

Chart 6.3: Sensitivity analysis of the economic contribution to the Asia-Pacific



Source: Deloitte Access Economics calculations using @Risk.

6.4 Comparison of results

Table 6.3 compares the results of the analysis in the current report, with the results of the analysis in the 2012 report.

Table 6.3: Comparison of results

	Total costs ($m)	Total benefits ($m)	Net benefit ($m)	BCR
Northern Territory				
Results in 2012	71.36	158.75	87.38	2.22
Results in 2015	140.67	309.10	168.43	2.20
Australia*				
Results in 2012	182.01	269.04	87.03	1.48
Results in 2015	392.92	665.92	273.00	1.69
Asia-Pacific				
Results in 2012	4.15	296.97	292.83	71.62
Results in 2015	12.07	436.92	424.85	36.20
Total				
Results in 2012	186.16	579.36	393.2	3.11
Results in 2015	404.99	1,102.85	697.86	2.72

Source: Deloitte Access Economics calculations; Deloitte Access Economics (2012). * Results for Australia in 2012 have been updated to include results for Northern Territory in 2012, in line with this report's new definition for Australia.

As shown in Table 6.3, the BCRs for the NT and Australia have remained relatively constant, while the BCRs for the Asia-Pacific and the total across all areas have fallen. However, the BCRs (36.20 and 2.72, respectively), still remain very strong. **The net benefits have increased substantially for all areas: increasing by 93% in the NT, 214% in Australia, 45% in the Asia-Pacific, and 77% across all three areas**.

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Appendix A: Consultation methodology and stakeholders

In developing this report, Deloitte Access consulted with stakeholders in order to review and triangulate the initial research undertaken by Deloitte Access Economics, and provide additional information that was not publicly available. Table A.1 provides a list of stakeholders who were consulted with.

Table A.1: Stakeholder list

Name	Role at Menzies
Alan Cass	Director, Menzies School of Health Research
Anne Chang	Head, Child Health Division
Bart Currie	Director, RHD Australia; Team leader, Tropical and Emerging Infectious Diseases
Christian James	Program Manager, RHD Australia
Claire Boardman	Deputy Director, RHD Australia
David Blair	Chief Operating Officer, Menzies School of Health Research
David Thomas	Head, Wellbeing and Preventable Chronic Disease Division
Derek Sarovich	Senior research officer
Gail Garvey	Division leader, Epidemiology and Health Systems
Gary Robinson	Director, Centre for Child Development and Education
Gillian Gorham	Program manager, Renal Health
Julie Brimblecombe	Senior research fellow
Kylie Dingwall	Postdoctoral research fellow
Louise Maple-Brown	Principal research fellow
Mark Mayo	Laboratory project manager and senior researcher
Nick Anstey	Head, Global Health Division; senior principal research fellow
Peter Morris	Deputy head, Child Health Division
Ric Price	Professor of global health; senior principal research fellow; staff specialist in infectious diseases and general medicine
Ross Andrews	Deputy Director, Menzies School of Health Research
Ross Bailie	Senior principal research fellow
Steve Tong	Principal research fellow
Tricia Nagel	Associate professor
Vijaya Joshi	Business manager

Prior to the consultations, stakeholders were provided with a consultation brief, which has been reproduced below.

Consultation brief

Date: [*Date*]

To: [*Stakeholder's name*]

From: Deloitte Access Economics

Subject: Modelling the social and economic impact of Menzies School of Health Research

Funding for health and medical research and development contends with competing demands for a limited pool of funding. Hence, it can be strategic for research organisations such as the Menzies School of Health Research (Menzies) to demonstrate *how* and *where* they generate value and the quantum of value generated.

Menzies has previously commissioned Deloitte Access Economics to estimate the social and economic contribution of Menzies School of Health Research to the Northern Territory, Australia and the Asia-Pacific. To this end, Menzies has re-engaged Deloitte Access Economics to undertake an update to this report, again, with the following objectives:

- To analyse and document the economic and social contribution of Menzies School of Health Research (Menzies) to the Northern Territory (NT), Australia and the Asia-Pacific.
- To provide a report for the NT government and philanthropic organisations documenting the economic and social contribution of the Menzies.

As part of this project, we are re-assessing the health benefits, or policy and program improvements that have been generated by Menzies' work.

We understand that you have been instrumental in the research work conducted by Menzies into [*Subject area*]. We would therefore like to cover a number of discussion points in a [*face to face meeting/phone call*], which would take approximately 45 minutes. The discussion points are:

- Could you please provide a brief description of the type of work that you are undertaking?
- What is the timeline for completing this work?
- Has your research to date resulted in a change in clinical practice either directly or through changes in health policies, or new programs?
- Prior to your research, what were the impacts of the clinical condition on the community and individuals?
- If Menzies had not undertaken/been involved in this research what would have happened?
- What is the anticipated outcome of any changes that have resulted from your research? When will the impacts of these changes be felt?

- How many people do you estimate will benefit from the outcomes of your research over the next decade? What is the nature of the expected benefits? For example, improved quality of life.
- Are there other potential future benefits that may be derived from your work?
- Are there considerations particular to Indigenous Australians or other vulnerable groups that we should take into account when assessing the health impacts?
- Can you think of other Menzies staff who we should be talking to about this project?
- Is there any other published material you would recommend we consider as part of this project?
- Is there anything else you would like to discuss?

Appendix B: Input-output methodology

The total economic activity generated by Menzies has both indirect and direct components.

As the name suggests, the **direct** component measures the economic activity that is directly associated with Menzies' direct activities, such as education and research. For example, labour is a key input in production, with the total salaries of workers representing an important direct measure of the activity generated by Menzies.

In contrast, the **indirect** activity component captures the economic activity generated by Menzies through the demand it generates for output from other industries. Estimation of these components relies heavily on the estimated input-output (IO) structure of the economy. This attachment outlines these calculations.

Conceptual framework

Every sector (or firm's) gross output can be expressed in terms of its uses:

$$y_i = \sum_{i=1}^{n} z_{ij} + d_i \qquad \text{(B1)}$$

where y_i is sector i's gross output, z_{ij} is sales of intermediate goods from sector i to sector j, and d_i is final demand for sector i's output. This framework can be further refined by the addition of IO coefficients, which measure the value of sector i's output that is required as an intermediate input in the production of one unit of sector j's gross output:

$$a_{ij} = z_{ij} / y_j \qquad \text{(B2)}$$

There is an economy-wide analogue to (B1) that takes the following form:

$$Y = AY + D \qquad \text{(B3)}$$

where Y is a vector of sector gross outputs with ith element y_i, D is a vector of sector final demands with ith element d_i and A is a matrix with ijth element a_{ij}.

This framework can be adapted to analyse the economic activity of Menzies. For convenience we partition the vector and matrix elements of (B3) into their Menzies (subscript L) and non-Menzies (subscript O) components:

$$\begin{bmatrix} Y_O \\ y_L \end{bmatrix} = \begin{bmatrix} A_{OO} & A_{OL} \\ A_{LO} & a_{LL} \end{bmatrix} \begin{bmatrix} Y_O \\ y_L \end{bmatrix} + \begin{bmatrix} D_O \\ d_L \end{bmatrix} \qquad \text{(B4)}$$

where Y_O is a vector of non-Menzies sector gross outputs, D_O is a vector of non-Menzies sector final demands, and A_{ij} the matrix/vector of IO coefficients for sectors included in i and j.

Estimates of the IO based on the ABS' Australia-wide IO table indicate that A_{LO} is effectively a zero vector. This reflects the fact that Menzies is a relatively small input in the gross output of much larger sectors represented in the IO tables. Similarly, the financial accounts of Menzies suggest that it uses anything that it makes itself as an input into its production processes, which suggests that a_{LL} is zero.

In light of these observations, the economy-wide system of equations (B4) can be written as two separate systems:

$$Y_O = A_{OO}Y_O + A_{OL}y_L + D_O \quad \text{(B5)}$$

$$y_L = d_L \quad \text{(B6)}$$

Equation (B5) can be used to derive the relationship between Menzies' sector gross output and non-Menzies' sector gross output:

$$Y_O = \left(I - A_{OO}\right)^{-1}\left(A_{OL}y_L + D_O\right) \quad \text{(B7)}$$

where I is an identity matrix.

The non-Menzies industry output that is tied to Menzies can be derived by setting the elements of the final demand vector for non-Menzies output to zero $\left(D_O = 0\right)$ in (B7):

$$Y_O^* = \left(I - A_{OO}\right)^{-1} A_{OL}y_L \quad \text{(B8)}$$

In particular, a one unit increase in Menzies' gross output $\left(y_L = 1\right)$ generates the following vector of non-Menzies sector outputs:

$$C_{OL} = \left(I - A_{OO}\right)^{-1} A_{OL} \quad \text{(B9)}$$

The ith element of C_{OL}, c_{iL} represents the increase in sector i's gross output required to meet the intermediate demands of a one unit increase in Menzies' gross output. These elements can be summed to estimate the increase in output required by all non-Menzies industries to accommodate a one dollar increase in gross output of Menzies. This implies that the economy-wide increase in gross output required to accommodate a one dollar increase in Menzies' output is then:

$$my_L = \sum_{i \in O} c_{iL} + c_{LL} \quad \text{(B10)}$$

where c_{LL} represents the increase in Menzies' gross output required to meet a one unit increase in Menzies gross output, which is 1 under the assumptions underlying (B6). The resulting estimate of my_L is the **gross output multiplier** of Menzies.

With the gross output multiplier calculated it is relatively easy to derive the other multipliers. The key is defining a set of coefficients that link value added, labour income and employment to gross output.

- The value added coefficient for the i[th] industry is $v_i = va_i / y_i$, where va_i is the i[th] sector's total value added.
- The labour income coefficient for the i[th] industry is $w_i = l_i / y_i$, where l_i is the i[th] sector's total labour expense.
- The employment coefficient for the i[th] industry is $e_i = fte_i / y_i$, where fte_i is the i[th] sector's number of FTE workers.

These coefficients imply the following total to direct effect multipliers for Menzies:

- **value added:** $mv_L = \left(\sum_{i \in O} v_i c_{iL} + v_L c_{LL} \right) / v_L$
- **labour income:** $mw_L = \left(\sum_{i \in O} w_i c_{iL} + w_L c_{LL} \right) / w_L$
- **employment:** $me_L = \left(\sum_{i \in O} e_i c_{iL} + e_L c_{LL} \right) / e_L$

These multipliers estimate the economy-wide change in value added, labour income and employment required to accommodate a one dollar increase in Menzies gross output divided by Menzies' value added, labour income and employment coefficients defined above.

Data analysis

The IO matrix for all the other sectors in the economy A_{OO} is derived from the latest Australian Bureau of Statistics (ABS) IO tables for Australia for reference year 2009-10. The cost structures of IO tables do not change appreciably over five or ten years, so that the IO coefficients derived from 2009-10 IO tables can be assumed to be approximately constant over such time scales.

Estimates of A_{OL} are derived from Menzies' data. In order to make use of these data they must be translated to the ABS IO classification, which were determined by Deloitte Access Economics based on commercial-in-confidence financial data provided for the purposes of this engagement.

Coefficients for value added and labour income are also derived from the ABS IO table for 2009-10. Again, the cost structures of IO tables do not change appreciably over five or ten years, so that the value added and income coefficients derived from 2009-10 IO tables can be assumed to be approximately constant over such time scales.

Coefficient estimates for employment rely on matching ABS Labour Force data for Australia for the 19 major Australian and New Zealand Standard Industrial Classification (ANZSIC) industries to the 114 ANZSIC industries reported in the ABS IO for 2009-10. This is achieved by assuming that labour inputs are paid the same average wage across sub-industries, which allows employment to be distributed across sub-industries according to the distribution of their labour income. Employment coefficients for Menzies are calculated using the gross output estimate derived from the annual report for 2013, which is deflated by the average annual growth rate of the Professional, Scientific and Technical Services industry to produce a 2009-10 gross output estimate.

Limitation of our work

General use restriction

This report is prepared solely for the use of the Menzies School of Health Research. 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 analysing and documenting the social and economic contribution of Menzies School of Health Research to the Northern Territory, Australia and the Asia-Pacific. You should not refer to or use our name or the advice for any other purpose.

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