Deloitte Access Economics

Australia’s health and medical research workforce

Expert people providing exceptional returns

The Australian Society for Medical Research

19 October 2016

Deloitte.

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Dr Roger Yazbek
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19 October 2016

Dear Roger,

Australia's health and medical research workforce: Expert people providing exceptional returns

Please find attached our final report which quantifies the value of the NHMRC funded health and medical research workforce in Australia. The results highlight the associated impact on Australia's ability to respond to future health challenges through medical research associated with declines in the workforce, and conversely, the increased returns if funding for health and medical research increased.

Please contact me if you would like to discuss any aspect of the report – we would be happy to elaborate as needed.

Yours sincerely,

Lynne Pezzullo
Lead Partner, Health Economics and Social Policy, Deloitte Access Economics Pty Ltd
Office Managing Partner, Canberra, Deloitte Touche Tohmatsu

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Glossary

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
ASMR	Australian Society for Medical Research
BCR	benefit-cost ratio
CVD	cardiovascular disease
DALY	disability adjusted life year
DWL	deadweight loss
FTE	full time equivalent
HSE	health system expenditure
MRFF	Medical Research Future Fund
NHMRC	National Health and Medical Research Council
PSP	personnel support package
R&D	research and development
VSLY	value of a statistical life year

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Abstract

Over a number of years, ASMR has observed, with deep concern, the erosion of Australia's health and medical research workforce. A large proportion of this workforce is supported by the National Health & Medical Research Council (NHMRC), the peak funding body for Australian health and medical research. However, five years of static investment into the NHMRC has resulted in falling grant funding rates and a decline in the NHMRC-funded workforce; this trend endangers the capacity of NHMRC investment to continue producing exceptional health and economic returns [Access Economics 2008b] and will equate to major negative impacts on the ability of the workforce to respond to the escalating and unsustainable healthcare crisis Australia now faces.

This report sought to describe the dynamics and quantify the value of the NHMRC-funded health and medical research workforce in Australia. Furthermore, the report calculates the health and economic gains attributable to the NHMRC-funded workforce under various contrasting scenarios, including changes to workforce size and investment models. The methodology used within the report has been described and validated elsewhere [Access Economics 2008b], with slight adjustments.

Workforce Dynamics. The findings of this report show that the estimated NHMRC-funded health and medical research workforce output has increased considerably over the past decade. Australia's share of world health and medical research output and the NHMRC's share of Australian output increasing from 2.5% and 21.9% in 2002 to 3.8% and 39.6% in 2012, respectively. Over the same period, the full-time equivalent (FTE) workforce increased from 2,925 to 8,110. Since 2012, the number of full-time researchers has declined, while the number of part-time researchers has risen.

- The total NHMRC workforce, started to fall in 2013, representing the first fall observed since 2000, with a 16% decrease in the number of FTE researchers supported by the Project Grant scheme.

The data reflects marked changes to the NHMRC-funded workforce, which may cause significant complications for the sector's ability to continue to maintain output and deliver health and economic benefits to the community.

The value of the NHMRC-funded health and medical research workforce. The report determined that:

- Each $1 invested into the NHMRC-funded health and medical research workforce (between 2000-2015) returned $3.20, **equating to a net benefit, over a period of 15 years, of $23.4 billion**.
- Higher returns were demonstrated for particular health conditions, including cardiovascular disease ($9.80 per dollar invested) and cancer ($3.70 per dollar invested).
- The above results highlight the exceptional value of investing in the NHMRC-funded health and medical research workforce.
- Modelling of hypothetical scenarios where the NHMRC-funded health and medical research workforce expanded or contracted (by 5, 10, 20 or 40%) revealed that, compared to base case, an expansion or contraction of 40% would respectively

increase or decrease net health and economic benefits by more than $11 billion over the 15 year period.

Future investment projections. To analyse the future returns from the NHMRC-funded health and medical research workforce, a number of scenarios were considered for the period of 2016-2025: (i) if investment into NHMRC was fixed as a share of total projected Health System Expenditure (HSE) (0.55%, the current NHMRC investment as a percentage of total HSE), (ii) if investment into NHMRC increased to 3% of total HSE by 2025, and (iii) if investment into NHMRC remained static in real terms, equating to a decrease as a percentage of HSE by 2025 (0.34%).

- Relative to the base case (0.55% scenario), which is expected to yield total net benefits of $17.3 billion, **total net benefits increased substantially to $58.7 billion under the 3% investment model**, while static funding in real terms resulted in $13.2 billion of benefits ($4.1 and $45.5 billion less relative to the base case and under the 3% investment model, respectively).

In conclusion, the data in this report highlight the major changes currently occurring in the NHMRC-funded workforce and provide evidence of the exceptional health and economic returns of investing in Australia's productive and highly talented research workforce. The data suggest that Australia still has capacity to provide greater output and benefits as a result of investing further in the NHMRC and the workforce it supports.

Executive summary

There are clear associations between investment in health and medical research and development (R&D) and health outcomes. Work by Access Economics (2003; 2008a; and 2008b) and Deloitte Access Economics (2014; 2012; 2011) has identified the returns to health and medical R&D funding between 2000 and 2010 for a number of conditions, as well as extrapolating health and medical R&D funding out to 2025 and considering the future returns of increasing investment in R&D. However, it is less clear what impact the changing health and medical research workforce, and the distribution of full time versus part time workers, between 2000 and 2015 has had on health outcomes.

Evidence suggests that the part time share of the health and medical research workforce has been increasing relative to the total workforce over time (NHMRC[1], 2016b). The analysis presented in this report quantifies the health and economic returns for NHMRC funded health and medical research.

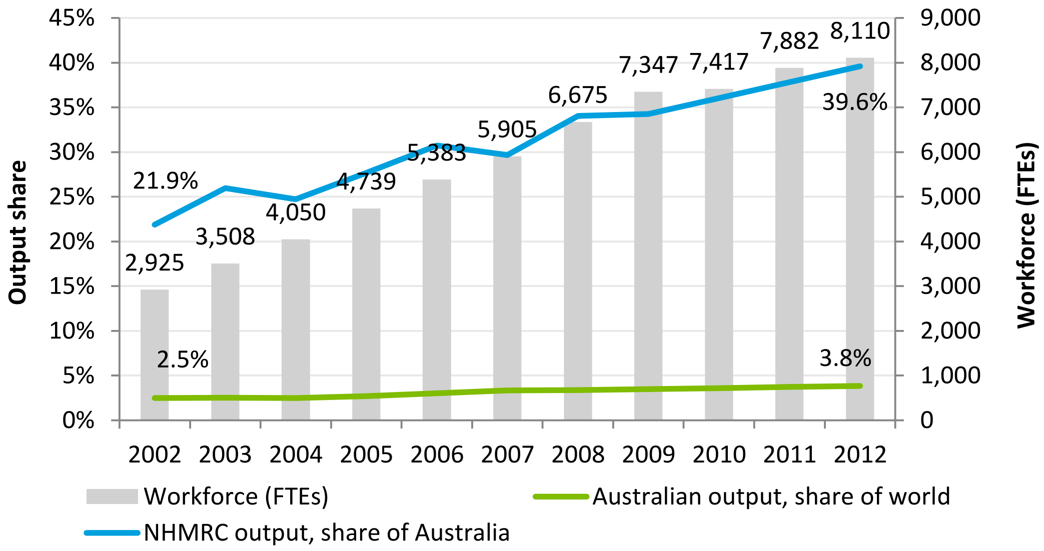
Workforce output and expenditure

A key component of the modelling includes estimating the shares of NHMRC funded health and medical research workforce output over the period 2000 to 2015. Output was measured using bibliometric data on health and medical research publications and citations. Data from the bibliometric analysis did not allow output to be disaggregated by full time and part time workforce status. As such, output shares were estimated for the workforce as a whole.

> Based on bibliometric analysis, Australia's share of world health and medical research output was estimated to be 3.8% in 2012, up from 2.5% in 2002. The NHMRC's share of Australian output has also increased, from 21.9% in 2002 to 39.6% in 2012 (Chart i). Over the same period, the full time equivalent (FTE) workforce increased from 2,925 to 8,110. This strong increase suggests that Australia may still have capacity to provide additional output and receive additional benefits as a result.

[1] National Health and Medical Research Council

Chart i: Health and medical research output shares, 2002-2012



Source: Deloitte Access Economics calculations.

Approximately 70%, or $7.1 billion, of NHMRC expenditure was associated with the workforce between 2000 and 2015. This directly corresponds to funding for fellowships, scholarships and project grants reported by the NHMRC. Expenditure on fellowships, scholarships and project grants does not exactly equate to the cost of labour – for example, this could still include equipment or other overheads funded through project grants. However, this funding data is best available and was used to derive relationships between NHMRC funding, the FTE workforce and its output. Overall, each $1 million of funding was estimated to result in approximately 11.6 publications when assessing these relationships historically (2000 to 2015). In comparison, each $1 million of funding over the next years is expected to result in approximately 10.1 publications. This is primarily driven by FTEs becoming more expensive on average, while output per FTE worker is not expected to substantially increase over this period.

Methodology for estimating benefits, costs and benefit-cost ratio

The share of the NHMRC funded output in each year (average of approximately 28% between 2000 and 2015), multiplied by the Australian share of world output (average of approximately 3% between 2000 and 2015), and the value of benefits attributed to health and medical R&D (assumed to be 50% in the base case), provides an estimate of the share of total gains attributable to the workforce in each year.

The gains that were attributable to the NHMRC funded health and medical research workforce included the value of:

- wellbeing gains – a reduction in the loss of healthy life due to morbidity and the loss of healthy life due to premature death;
- avoided health system costs, which includes reduced costs of running hospitals and other health services, the labour costs, pharmaceuticals, allied health care and other health care costs such as ambulances and health devices;

- avoided indirect costs, which includes productivity gains, avoided carer costs, and other costs such as avoided deadweight loss (DWL) associated with government transfers (including taxation and welfare); and
- commercialisation gains which are a direct result from R&D funding.

The total value of wellbeing gains was estimated by establishing the trend in the disability adjusted life year (DALY) rate per 1,000 population, and then comparing the reduction in DALYs from a base case. For this study, the base case was total DALYs for 2000.

The total value of health system and indirect benefits associated with expenditure between 2000 and 2025 were estimated by establishing the cost of a DALY on health system costs and indirect costs, and then estimating the discounted value in 2016 prices. The share of total gains was applied to the total estimated value of all health gains between 2040 and 2065, separated to 2040 to 2055 for historical returns, and 2056 to 2065 for the forward looking investment model. Costs were taken as the total real expenditure between 2000 to 2015 for the historical workforce returns, and 2016 to 2025 for the forward looking investment model.

Sensitivity analysis was conducted on the workforce, health benefits that are attributable to R&D returns and the forward looking investment model.

Estimated benefits of the NHMRC funded health and medical research workforce historically

In the base case, the benefit-cost ratio (BCR) associated with the NHMRC funded health and medical research workforce between 2000 and 2015 was estimated to be 3.2. As a comparison, Access Economics (2008b) estimated that the BCR of NHMRC funded health and medical research was 3.1 between 1993 and 2007, which triangulates reasonably well with the result presented here – noting that there are differences in methodologies. Table ii presents the benefits, costs and BCR for all NHMRC funded research (all causes), cardiovascular disease (CVD, including stroke), cancer, chronic respiratory, injuries, and all other conditions.

Table ii: Historical benefits, costs and BCR of workforce returns in the base case, detailed causes

Condition	Benefits ($b)					Costs ($b)	Net benefit ($b)	BCR
	BOD	*Direct*	*Indirect*	*Comm.*	*Total*			
All causes	20.3	2.7	3.2	7.5	33.8	10.5	23.4	3.2
CVD (including stroke)	8.2	0.6	0.5	0.7	10.0	1.0	9.0	9.8
Cancer	4.5	0.2	0.2	1.2	6.0	1.6	4.4	3.7
Chronic respiratory	0.9	0.1	0.2	0.3	1.5	0.4	1.1	3.8
Injuries	1.0	0.1	0.4	0.3	1.8	0.3	1.5	5.2
Other	5.7	1.7	2.0	5.1	14.5	7.1	7.4	2.0

Source: Deloitte Access Economics calculations. Comm. = Commercialisation.

Sensitivity analysis was conducted on this result by increasing or decreasing the number of FTEs in the health and medical research workforce by values of -40%, -20%, -10%, -5%, 5%, 10%, 20%, and 40%.

The sensitivity analysis suggested that the net benefits of the workforce's research may range between $221,000 in the low scenario and $257,000 in the high scenario. In the base case, the net benefits per FTE worker were estimated to be around $257,000. This represents substantial value for money and highlights the importance of the health and medical research workforce between 2000 and 2015.

Expected benefits of the NHMRC funded health and medical research workforce in the future

To model the future returns to NHMRC funded health and medical research output going forward, it was necessary to model the relationships between funding, workforce and output over time. Two measures were developed to project these relationships. These were:

- the number of FTEs per $1 million of funding; and
- output (in terms of the number of publications) per FTE worker.

Both of these measures were projected using a logarithmic trend. The established trends provided a base case and allowed the model to solve relationships between funding, workforce and output over time. For example, given a certain level of funding in the future, it was possible to estimate the workforce, and then derive the output of the workforce. The same approach was taken to estimate the benefits as in the historical model.

In the forward looking analysis base case, NHMRC funding was assumed to be constant as a fixed share of total health system expenditure (HSE) between 2016 and 2025 – approximately 0.55%. For the base case, the net benefits per FTE worker were estimated to be $172,000. This is lower than the historical analysis due to discounting, and if future benefits were valued the same as benefits today, the net benefit per FTE worker would be largely comparable across the time periods.

Table iii presents the benefits, costs and BCR for all NHMRC funded research (all causes) and other selected conditions.

Table iii: Future benefits, costs and BCR of workforce returns in the base case, detailed causes

Condition	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	BOD	*Direct*	*Indirect*	*Comm.*	*Total*			
All causes	14.7	2.0	2.3	8.6	27.6	10.3	17.3	2.7
CVD (including stroke)	5.4	0.4	0.3	0.8	6.9	1.0	5.9	6.8
Cancer	3.5	0.2	0.2	1.3	5.1	1.5	3.6	3.3
Chronic respiratory	0.7	0.1	0.2	0.3	1.3	0.4	0.8	3.1
Injuries	0.8	0.1	0.3	0.3	1.5	0.4	1.1	3.8
Other	4.3	1.2	1.4	5.8	12.8	7.0	5.8	1.8

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

Sensitivity analysis was conducted on this result by increasing the NHMRC funding as a share of total HSE – which would have a similar effect to the Medical Research Future Fund (MRFF) – or by holding NHMRC funding constant in real terms.

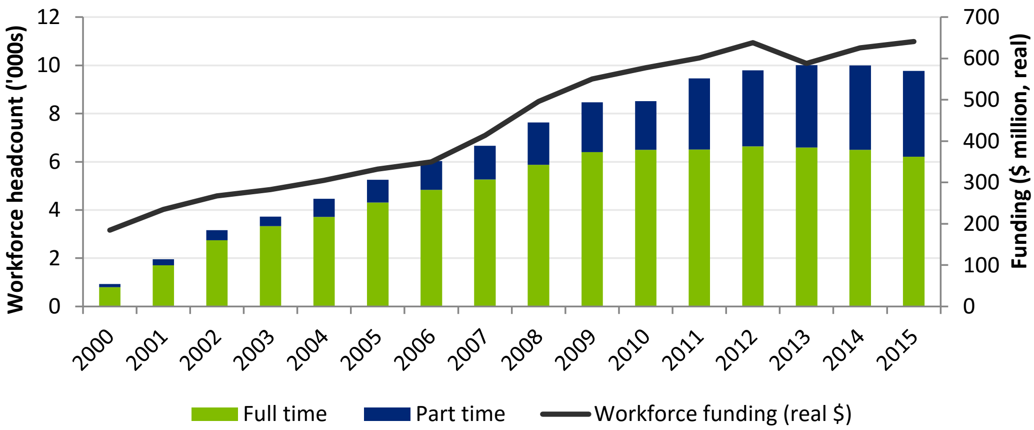
For the increased investment scenario, NHMRC funding was assumed to grow to 3% of total HSE by 2025 from 0.55% in 2015. The net benefit per FTE worker was largely unchanged in this scenario, although the total net benefits changed substantially. The net benefits under this scenario were $58.7 billion, rather than $17.3 billion under the base case.

For the static real funding scenario, NHMRC funding was assumed to decline from around 0.55% of total HSE to 0.34% of total HSE by 2025. Again, the net benefit per FTE worker was largely unchanged, although the net benefits were substantially reduced compared to the base case. The net benefits under this scenario were $13.2 billion.

Conclusions

The NHMRC funded health and medical research workforce is becoming increasingly part time, likely due in part to relatively static real funding in recent years (Chart ii). The workforce may also be becoming more part time due to underlying demographics of the workforce (i.e. the average of the cohort is moving closer to retirement over time, which may lead to a greater desire for shorter working hours) or due to other factors such as a more competitive funding environment.

Chart ii: Workforce composition (headcount), and real funding, 2000 to 2015



Source: Deloitte Access Economics analysis based on NHMRC (2016a; 2016b).

However, despite the possible reasons for the declining workforce, the results presented in this report suggest that there are still substantial benefits that may be realised by increasing health and medical research funding in Australia. Furthermore, if declines in the workforce were allowed to continue with other factors constant, over time Australia's ability to respond to chronic disease, pandemics and other health threats would be diminished, due to lower levels of innovation. **As shown by this report, static real funding relative to a modest investment program indicates that net benefits will be around $4.0 billion lower over the next 10 years**, while more aggressive investment could result in net benefits that are considerably higher.

Importantly, this report finds that there are still substantial wellbeing gains, direct and indirect benefits that may be realised from increased funding in the health and medical research workforce in Australia. However, given the NHMRC is conducting strategic reviews of its workforce funding models, these issues should be revisited once more useable data is available to establish the effect of changing workforce compositions.

There are two pertinent recommendations for this sector given the findings of this report:

1. There should be an immediate investment into the NHMRC's Medical Research Endowment Account to mitigate the decline in the health and medical research workforce and put the sector back on a sound footing.
2. The success of the Medical Research Future Fund needs to be ensured by creating a long term investment strategy for the NHMRC Medical Research Endowment Account with the purpose of generating a predictable and sustainable health and medical research ecosystem. This will ensure continued health and economic gains which will assist to mitigate the rising and unsustainable cost of health care and the burden of disease Australia is facing.

Deloitte Access Economics

1 Background

There are clear associations between investment in health and medical R&D and health outcomes. Work by Access Economics (2003; 2008a; and 2008b) and Deloitte Access Economics (2014; 2012; 2011) has identified the returns to health and medical R&D funding between 2000 and 2010 for a number of conditions, as well as extrapolating health and medical R&D funding out to 2025 and considering the future returns of increasing investment in R&D.

In 2003, Access Economics first developed a methodology to assess the historical return on investment to health R&D in Australia over the period 1960-1999. The report was commissioned by the Australian Society for Medical Research (ASMR) and was titled *Exceptional Returns: The Value of Investing in Health R&D in Australia* (Access Economics, 2003). The *Exceptional Returns* study estimated the life expectancy and quality of life gains experienced by Australians over the period, in terms of reductions in DALYs, and placed a dollar value on these gains using the concept of the value of a statistical life year (VSLY). Only a proportion of these gains could be attributed to Australian R&D, so the analysis depended critically on two parameters:

- the proportion of gains attributable to R&D rather than other factors, such as improvements in environmental factors (for example, sanitation) or public policies (for example, health awareness or promotion programs); and
- the proportion of gains attributable to Australian health R&D rather than health R&D from overseas.

A similar analysis was undertaken in 2008 for the NHMRC (Access Economics, 2008b), which used largely the same methodology as the 2008 ASMR report (Access Economics, 2008a), although that work was extended to specifically examine NHMRC funded R&D.

The returns estimated in each of these studies differs slightly due to varying methodologies; when estimating the returns to NHMRC funded health and medical research, Access Economics (2008b) reported that the BCR of NHMRC funded health and medical research was 3.1 between 1993 and 2007 – **implying that every $1 of NHMRC funding return $3.10 in benefits over that period**.

While past research has found that investment in funding contributes to health outcomes, none of that work has included a dynamic workforce, and consequently, it is less clear what impact the changing health and medical research workforce, and the distribution of full time versus part time workers, between 2000 and 2015 has had on health outcomes. Evidence suggests that the part time aspect of the health and medical research workforce is increasing its share of the total workforce – from approximately 13% in 2002 to 35% in 2014 (NHMRC, 2016). It is not clear why the part time workforce has increased so substantially over this period; broadly, this may represent funding issues or the underlying demographics of the workforce (i.e. the average of the cohort is moving closer to retirement over time (NHMRC, 2016b), which may reflect an increased desire to reduce working hours). Moreover, recent evidence suggests that the overall headcount and FTEs are declining given more competitive funding environments (NHMRC, 2016b).

This report quantifies the health and economic returns for NHMRC funded health and medical research, taking into account effects of a changing workforce, and quantifying this effect.

This current report examines the BCR of R&D investment by the NHMRC from 2000 to 2015, and extends this analysis from 2016 to 2025 using two investment scenarios. As such, this report primarily draws on the methodology developed for the 2008 and 2011 reports (Access Economics, 2008b; Deloitte Access Economics, 2011), and extends the analysis to model a dynamic workforce and the associated returns. Similar to the 2011 report, this report highlights the benefits of R&D for a select few conditions including CVD, cancer, chronic respiratory, injuries, and all other conditions. The analysis also considers the returns from overall expenditure in addressing the overall burden of disease in Australia.

2 Methodology

As outlined, this report quantifies the health and economic returns for NHMRC funded health and medical research, including quantifying the effect of a changing workforce.

A number of key modelling parameters are required to estimate the returns to the workforce. This chapter outlines the parameters and data required. To summarise, it was necessary to:

- quantify NHMRC funded health and medical R&D, the FTE workforce, and its associated output (Sections 2.1, 2.2, and 2.3);
- identify relationships between funding, the FTE workforce and its associated output (section 2.4); and
- extrapolate relationships in funding, the FTE workforce and its associated output to 2025 (section 2.5).

2.1 Attributing health gains to NHMRC funded health and medical R&D

Only a portion of wellbeing gains can be attributed to NHMRC funded health and medical R&D as there are many other factors that impact health that are not related to R&D. These include improved income, education programs, better food and improved environment. Health and medical R&D undertaken outside Australia has also had a significant impact on the health of Australians, so this impact must be removed if a true representation of the benefits from NHMRC funded R&D is to be made.

Consequently, modelling the benefits for Australian health critically depends on the following parameters:

- the proportion of health gains attributable to world health and medical R&D rather than other factors that impact health;
- the contribution of Australian health and medical R&D to the total health gains attributable to world R&D; and
- the proportion of Australian health and medical R&D gains derived from NHMRC funded R&D.

These parameters are discussed below.

2.1.1 Proportion of health gains attributed to world health and medical R&D

Access Economics (2008a; 2008b) used the base case assumption that health and medical R&D is responsible for 50% of the improvements in healthy lifespan. This was based on research quoted in Cutler and Kadiyala (2003), who estimated that about one third of the reduction in mortality from CVD is due to invasive treatments, one third stems from pharmaceuticals and the remaining third from behavioural changes. However, benefits from research in some areas are less immediately apparent, particularly if research and higher medical expenditure have little impact on mortality or morbidity, such as in the case of musculoskeletal conditions (Hanney et al, 2004).

Several papers have been written about the issue of how to attribute health gains to R&D. Buxton et al (2004), for instance, reviewed key studies related to the impact of health and medical research – including the Access Economics (2003) study – concluding that estimating the economic value of health research to society is complex. This includes the need to identify and value the relevant research inputs, accurately ascribing the impact of the research and appropriately valuing the attributed economic impact. Weiss (2007) argued that in order to calculate the clinical return on an investment in medical research, three outcomes need to be measured: awareness, implementation and patient benefit. However, the ability to provide this information is limited at present. As such, no better estimate of the actual percentage of health gains attributable to total R&D has been made.

Consequently the base case assumption of 50% can still be seen as appropriate given the complexity of the issue and the lack of alternative estimates. A recent study for the Australian Academy of Science (2016) used the lower bound 33%, while other authors in the US have suggested that a number of reports maintain the one third splits outlined above (Lauer and Hodes, 2011). As there is still some uncertainty about the range of health benefits attributable to health R&D, this report also considers, in sensitivity analysis, the effects of using 33% and 67% parameter values based on ranges determined by Cutler and Kadiyala (2003).

2.1.2 Proportion of world health and medical R&D attributable to Australian and NHMRC R&D

There is no denying that the majority of Australia's health gains have come from R&D undertaken within Europe and North America. This is shown by the amount of resources used to undertake health and medical R&D in these regions, and the number of journal articles that are created from this research.

However, Australia has also made considerable achievements in health and medical R&D. Australia produces 3% of the Organisation for Economic Co-operation and Devleopment's health and research output despite having only 0.3% of the world's population (Grant, 2004). Between 2001 and 2010, Australia ranked sixth in the world by citations per publication (McKeon et al, 2013). Australian scientists have received seven Nobel prizes for Medicine or Physiology, while the impact of our health and medical R&D ranks consistently in the top eight countries across a range of fields.

This report examines R&D output using bibliometric analysis of health and medical research publications from NHMRC, Australia and the world. The dynamics of publication output over time can be used to track the performance of NHMRC and Australian research, and its overall contribution to the health benefits flowing from R&D. The bibliometric analysis is discussed in the next section.

2.2 Measuring NHMRC, Australian and world output – bibliometric analysis

In order to derive the contribution of NHMRC health and medical research, it was first necessary to determine measures of research output for NHMRC, Australia, and the world. It was also necessary to identify how research output has evolved over time and any apparent trends. This allowed projections to be made into future periods.

Bibliometric analysis involves the use of publication and citation data in the assessment of research performance (Pollitt et al, 2011). In this report, bibliometrics has been applied to Australian research output generally, and to research supported specifically by NHMRC funding.

Bibliometric analysis undertaken by the NHMRC (Butler et al, 2005; Butler and Henadeera, 2009; NHMRC, 2013) found that the Australian share of health and medical research output has increased steadily during the period 1999 through 2009, rising from 2.8% (1999-2003) to **3.1%** (2005-2009) (Table 2.1). Similarly, NHMRC funded research has grown to 20,960 publications in 2005-2009, more than **0.9%** of world health and medical research output.

Table 2.1: Health and medical research publications and Australian/world proportions

	1999-2003	2002-2006	2005-2009
Publications			
NHMRC	10,813	12,458	20,960
Australia	42,621	47,799	68,657
World	1,543,086	1,622,169	2,237,732
Publications: proportion of Australia			
NHMRC	25.37%	26.06%	30.53%
Publications: proportion of world			
NHMRC	0.70%	0.77%	0.94%
Australia	2.76%	2.95%	3.07%

Source: Butler et al, 2005; Butler and Henadeera, 2009; NHMRC, 2013.

NHMRC funded health and medical research has displayed continued strength, with key observations including (NHMRC, 2013):

- 20,960 NHMRC supported publications accounted for nearly 31% of all Australian health and medical research output in 2005-2009;
- The number of health and medical research publications that have NHMRC support was 68% higher in 2005-2009 than in 2002-2006, whereas the total Australian health and medical research publications increased by 44% during the same period;
- NHMRC supported publications received 60% more citations than the world average;
- NHMRC funding supported nearly half of the Australian health and medical research publications that are in the top 1% of cited publications in the world; and
- Citation impact was highest for research arising from Program Grants (92% above the world benchmark) and Research Fellowships (81% above the world benchmark).

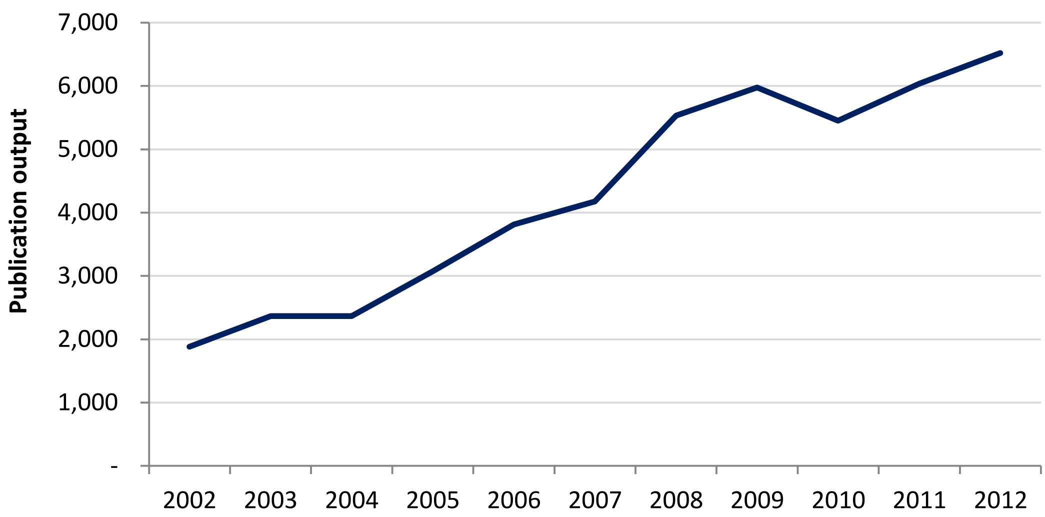
Table 2.1 provides research output statistics aggregated across three distinct time periods: 1999-2003, 2002-2006, and 2005-2009. However, a more granular analysis is required to model changes in workforce on output, and to make projections of output into the future. Accordingly, Deloitte Access Economics developed annual data for health and medical research output for NHMRC, Australia and the world, as outlined in the sub-sections below.

2.2.2 NHMRC supported publication output

The number of NHMRC supported health and medical research publications in each year between 2002 and 2009 was determined using data from bibliometric analysis undertaken by the NHMRC (Butler et al, 2005; Butler and Henadeera, 2009; NHMRC, 2013). These were further extended to 2012 using publication data provided through a special data request to the NHMRC.

The annual NHMRC research output is shown in Chart 2.1. With the exception of a decline in 2010, NHMRC supported publication output has shown a clear upward trend, and has grown by 14.0% per year on average over 2002-2012. This exceeds both average growth in world output (5.6%) and Australian output (10.2%) over the same period (see sections below). In 2012, NHMRC supported research resulted in 6,522 health and medical research publications, up from 1,881 in 2002.

Chart 2.1: NHMRC supported health and medical research publications, 2002-2012



Source: NHMRC special request and Deloitte Access Economics calculations.

2.2.3 Australian publication output

NHMRC (2013) provides the number of Australian publications for each year in the period 2005-2009 (see Table 2.2), which was extended to 2012 using special request data from the NHMRC. However, annual data were not available for the period 2002-2004. In order to disaggregate this period, the annual publication numbers for 2005-2009 were benchmarked against data from PubMed[2], which comprises more than 26 million citations for biomedical

[2] See http://www.ncbi.nlm.nih.gov/pubmed

literature including from life science journals and books. Table 2.2 shows the number of journal articles on PubMed published each year between 2005 and 2009 as revealed by a search for Australian publications.[3]

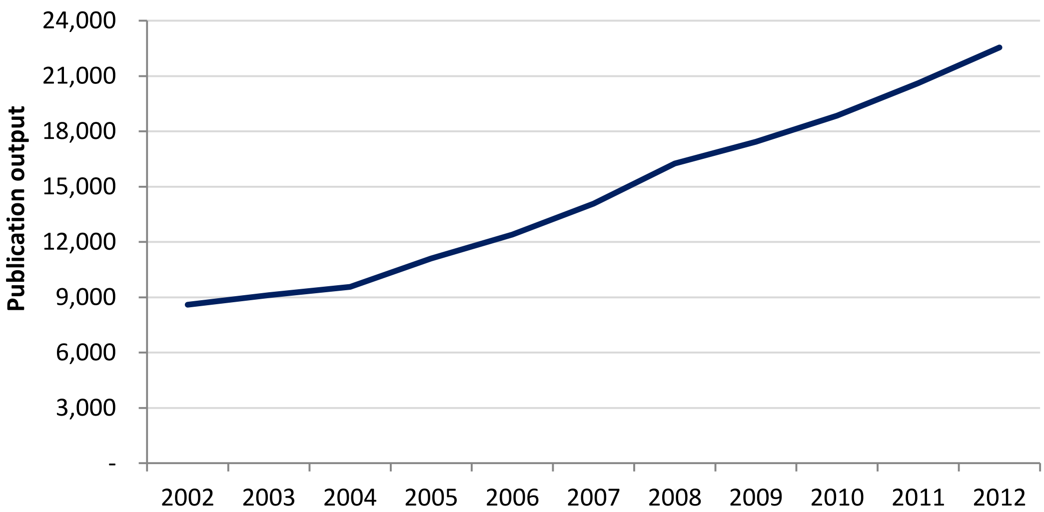
Table 2.2: Australian health and medical research publications 2005-2009

	2005	2006	2007	2008	2009	Total
Australian publications						
NHMRC (2013) data	11,098	12,405	14,076	15,508	15,570	68,657
Share of total	16.16%	18.07%	20.50%	22.59%	22.68%	100.00%
PubMed data	13,595	14,851	15,707	16,882	17,997	79,032
Share of total	17.20%	18.79%	19.87%	21.36%	22.77%	100.00%

Source: NHMRC, 2013; PubMed.

It was found that the annual decomposition of total publications across the five year period was approximately similar between NHMRC (2013) and PubMed. Accordingly, for the periods where NHMRC data does not provide annual disaggregation, we used ratios obtained from PubMed to derive the number of Australian publications in any given year. These ratios were applied against the aggregate Australian publication output for the periods 1999-2003 and 2002-2006 to derive annual output over 2002-2004. The number of Australian publications disaggregated by year is shown in Chart 2.2 for the period 2002-2012. Over this period, the number of Australian publications has grown by 10.2% per year on average.

Chart 2.2: Australian health and medical research publications, 2002-2012



Source: Deloitte Access Economics calculations.

[3] It was not possible to precisely identify all Australian publications on PubMed, since this would require a detailed analysis of publication authors and their affiliations. Deloitte Access Economics' analysis was based on searching for the keyword "Australia" in journal articles. As such, the results are likely to include some publications from outside Australia, and hence the number of publications derived from PubMed is higher than that reported by NHMRC (2013). However, PubMed data were only used to determine the overall proportions of publication numbers from year to year and we expect that our search yielded a reasonable proxy for this.

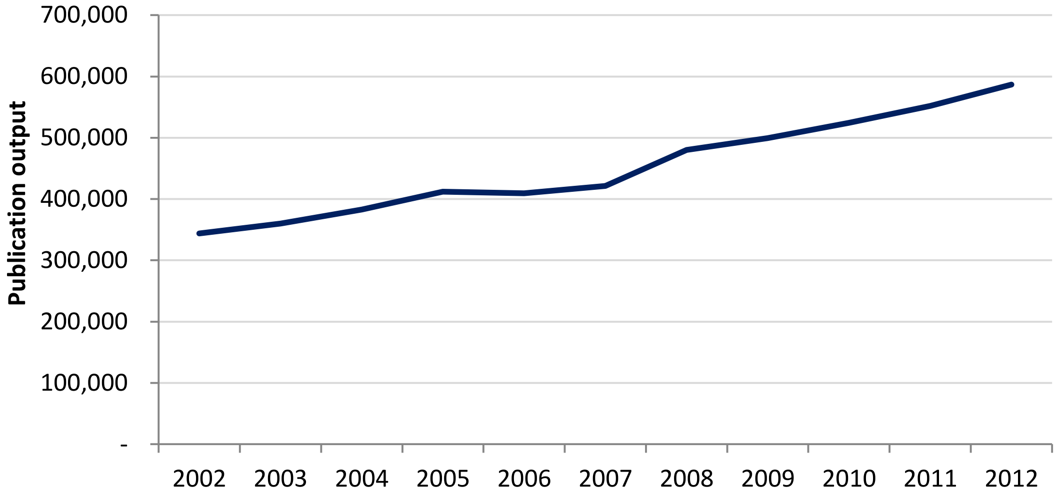
2.2.4 World publication output

The number of annual world health and medical research publications for the period 2005-2012 was obtained from NHMRC special request bibliometric data. However, annual data were not available for the period 2002-2004. To derive these data, Deloitte Access Economics benchmarked known annual data for 2005-2012 against the number of annual journal articles reported in PubMed. It was found that the ratio of world publications reported by the NHMRC to those provided by PubMed was 67.8% on average over the period 2005-2009 (with a standard deviation of 1.8%). It was assumed that this ratio also holds for years where NHMRC data is not available.

The number of journal articles in PubMed is higher than that reported in NHMRC data. This is because the NHMRC results are based on a more restrictive bibliometric analysis of specific research subject categories that implicitly exclude many publications. Replicating this analysis for each individual year is outside the scope of this report. However, we note that the ratio of NHMRC to PubMed publications has a low standard deviation (1.8%). It was hence assumed that the share of PubMed publications that would have been excluded by NHMRC's methodology remains approximately constant over time.

The estimated world health and medical research publication output for each year in 2002-2012 is shown in Chart 2.3. World output has grown by an average of 5.6% per year over the period. It was estimated that world health and medical research output reached 586,820 publications in 2012 (NHMRC special request data).

Chart 2.3: World health and medical research publications, 2002-2012



Source: NHMRC special request data.

2.2.5 NHMRC and Australian research output shares

The previous sections used bibliometric analysis to develop output measures for NHMRC, Australian and world health and medical research. This section uses these data to develop output shares representing:

- the contribution of Australian health and medical R&D to the total health gains attributable to world R&D; and

- the proportion of Australian health and medical R&D gains derived from NHMRC funded R&D.

These shares can be used to model how NHMRC health and medical research is contributing to health benefits for people in Australia over time. The estimated shares are shown in Table 2.3 together with the underlying output measures.

Table 2.3: Health and medical research output and output shares, 2002-2012

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Output (publications)											
NHMRC	1,881	2,367	2,367	3,071	3,812	4,175	5,532	5,975	5,454	6,040	6,522
Australia	8,594	9,108	9,569	11,098	12,405	14,076	16,254	17,431	18,854	20,611	22,543
World	343,781	360,007	383,089	412,243	409,200	421,467	479,920	499,638	524,171	552,007	586,820
Output shares											
NHMRC: Australia	21.9%	26.0%	24.7%	27.7%	30.7%	29.7%	34.0%	34.3%	36.1%	37.8%	39.6%
Australia: World	2.5%	2.5%	2.5%	2.7%	3.0%	3.3%	3.4%	3.5%	3.6%	3.7%	3.8%

Source: Deloitte Access Economics calculations based on NHMRC (2013).

The NHMRC share of Australian health and medical research output has been increasing over time, from 21.9% in 2002 to 39.6% in 2012. This increase is driven by the high growth rate of NHMRC supported publications (14.0% per year, on average) relative to Australian publications more broadly (10.2%).

Australia's share of world health and medical research output has also increased, from 2.5% in 2002 to 3.8% in 2012. This is because the growth rate of Australian publications (10.2% per year, on average) has been higher than growth of publications globally (5.6%).

> Based on bibliometric analysis, Australia's share of world health and medical research output was estimated to be 3.8% in 2012, up from 2.5% in 2002. The NHMRC's share of Australian output has also increased, from 21.9% in 2002 to 39.6% in 2012.

2.3 NHMRC funding and workforce

NHMRC funding and workforce data were obtained from recent publications from the NHMRC (2016a; 2016b). These were required to establish relationships in these data and with output data.

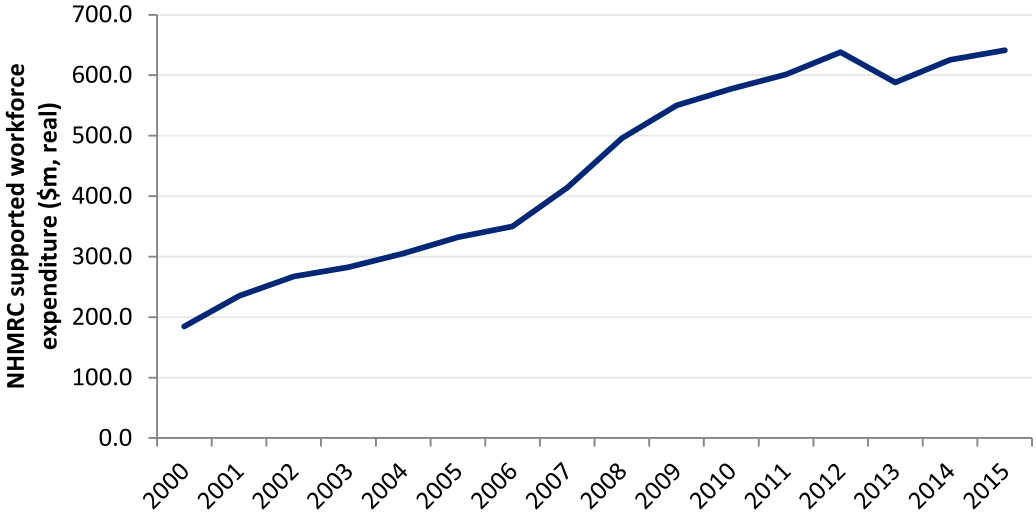
2.3.1 NHMRC funding

As not all NHMRC funding is designated to support the workforce, it was necessary to identify funding that directly supports salaries of the workforce, and funding that is allocated to specific conditions. The former was needed to establish relationships between the funding and workforce, while the latter was required to determine the costs associated with each cause when considering wellbeing gains (chapter 3).

2.3.1.1 NHMRC funding to support the health and medical research workforce

As outlined, establishing funding which supports the health and medical research workforce is a key component of the modelling to estimate the returns to the workforce. NHMRC (2016) published a range of detailed data that reports on funding by grant and program types. Chart 2.4 presents the real expenditure that supports researchers over the 15 years between 2000 and 2015. This includes funding that directly supports researchers with salary from scholarships or fellowships, as well funding through grants. Over the last 15 years, expenditure has increased in real terms although this has become more stable over the past 4 years (in 2015-16 dollars).

Chart 2.4: NHMRC real expenditure, $ million, 2000-2015

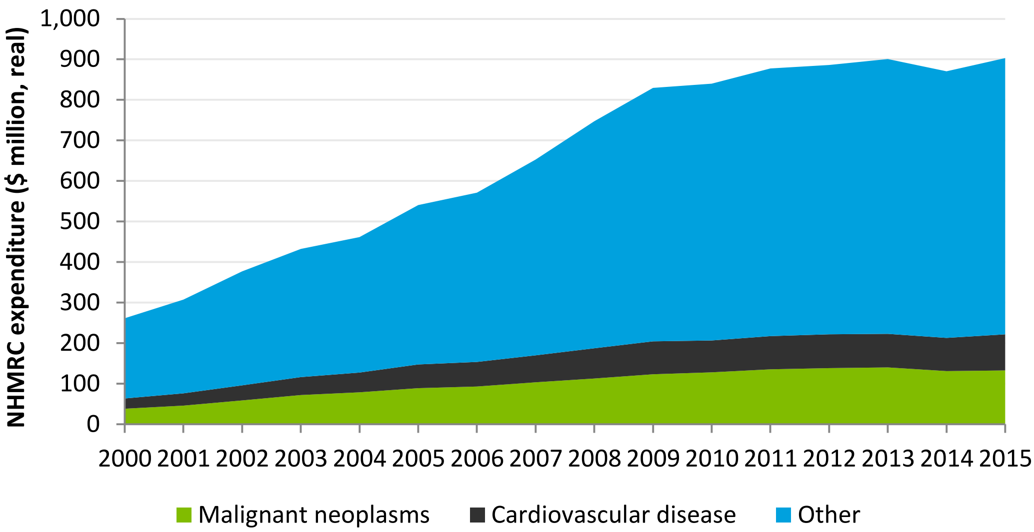


Source: Deloitte Access Economics calculations based on NHMRC (2016a).

2.3.1.2 Funding by condition

Establishing funding by condition is a key component of the modelling to estimate the costs over time, and to estimate the returns of the workforce by condition. NHMRC (2015) published a range of detailed data that reports on funding by condition for broad cause levels. Chart 2.5 presents the expenditure by condition between 2000 and 2015. Over the last 15 years, expenditure has increased from around $261.5 million to $903.1 million (in 2015-16 dollars). Expenditure on CVD and cancers (malignant neoplasms) has been relatively stable since 2009. Expenditure for all conditions has grown substantially over the period.

Chart 2.5: NHMRC supported expenditure by condition



Source: Deloitte Access Economics calculations based on NHMRC (2015).

2.3.2 NHMRC workforce

Workforce data were provided in terms of the headcounts of part time and full time workers for each year between 2002 and 2014 (NHMRC, 2016). However, the number of workers by headcount does not completely describe total workforce 'effort', since time spent at work varies by full time and part time status. In order to develop a standardised measure for workforce, Deloitte Access Economics converted headcounts into the number of FTE workers. This was done by utilising average weekly hours worked by Australian professionals,[4] by full time and part time status (ABS[5], 2016). Australian professionals is the most representative time series data identified for the Australian health and medical research workforce.

Table 2.4 shows headcounts and the estimated number of health and medical research FTEs for each year, by part time and full time status. The table also shows the average weekly hours worked by full time and part time professionals, which were used to convert headcounts into FTEs.

Average hours worked by full time professionals have been falling over the period, from 45.2 hours per week in 2002 to 43.6 hours in 2014. In contrast, part time professionals have experienced a slight increase in the average working week, from 19.6 hours in 2002 to 20.4 hours in 2014.

[4] Professionals are defined in the Australian and New Zealand Standard Classification of Occupations (ABS, 2013). These include arts and media professionals; business, human resource and marketing professionals; design, engineering, science and transport professionals; education professionals; health professionals; ICT professionals; and legal, social and welfare professionals.

[5] Australian Bureau of Statistics.

Table 2.4: Health and medical research workforce, 2002-2015

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
NHMRC workforce headcount														
Full time	2,744	3,337	3,712	4,311	4,836	5,271	5,878	6,401	6,492	6,509	6,642	6,596	6,502	6,214
Part time	417	390	758	948	1,195	1,390	1,749	2,074	2,021	2,947	3,154	3,413	3,499	3,563
Total	3,161	3,727	4,470	5,259	6,031	6,661	7,627	8,475	8,513	9,456	9,796	10,009	10,001	9,777
Average weekly hours worked by professionals														
Full time	45.2	45.0	44.8	44.8	44.4	44.0	44.0	43.8	43.9	43.7	43.7	43.8	43.6	43.5
Part time	19.6	19.8	20.0	20.2	20.4	20.1	20.1	20.0	20.1	20.4	20.4	20.4	20.4	20.7
NHMRC workforce FTEs														
Full time	2,744	3,337	3,712	4,311	4,836	5,271	5,878	6,401	6,492	6,509	6,642	6,596	6,502	6,214
Part time	181	171	338	428	547	634	797	946	925	1,373	1,468	1,593	1,639	1,695
Total	2,925	3,508	4,050	4,739	5,383	5,905	6,675	7,347	7,417	7,882	8,110	8,189	8,141	7,909
Proportion of total FTEs (%)														
Full time	93.8	95.1	91.7	91.0	89.8	89.3	88.1	87.1	87.5	82.6	81.9	80.5	79.9	78.6
Part time	6.2	4.9	8.3	9.0	10.2	10.7	11.9	12.9	12.5	17.4	18.1	19.5	20.1	21.4

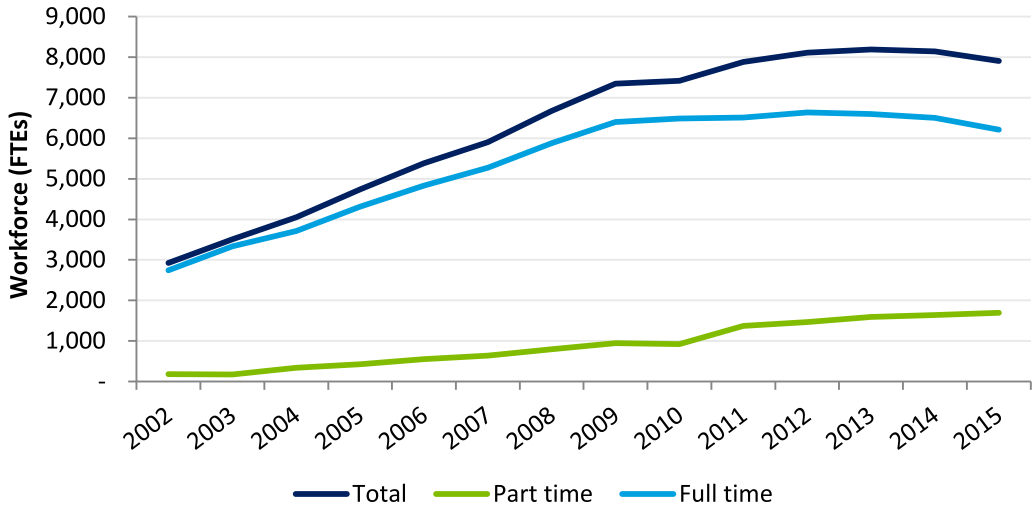
Source: ABS (2016); NHMRC (2016); Deloitte Access Economics estimates.

Note: FTEs were estimated as the total hours worked by full time and part time workers, divided by the average hours worked by full time workers in a given year. This calculation was based on average weekly hours worked by professionals as reported by ABS (2016).

Chart 2.6 shows the estimated number of FTEs associated with full time and part time workers between 2002 and 2014. The number of FTEs comprising full time workers showed steady growth of 13% per year on average over the period 2002 to 2009. However growth slowed markedly from 2009 onwards, and the number of FTEs from full time workers decreased from 2013 onwards.

Over the same period, FTEs comprising part time workers have increased at a faster rate, with average growth of 30% per year between 2002 and 2009. The number of part time FTEs continued to increase after 2009, recording growth of nearly 49% between 2010 and 2011. From 2013, there has been very limited growth in part time FTEs, growing only 4.4% over the entire period.

Chart 2.6: Health and medical research workforce (FTEs), 2002-2015

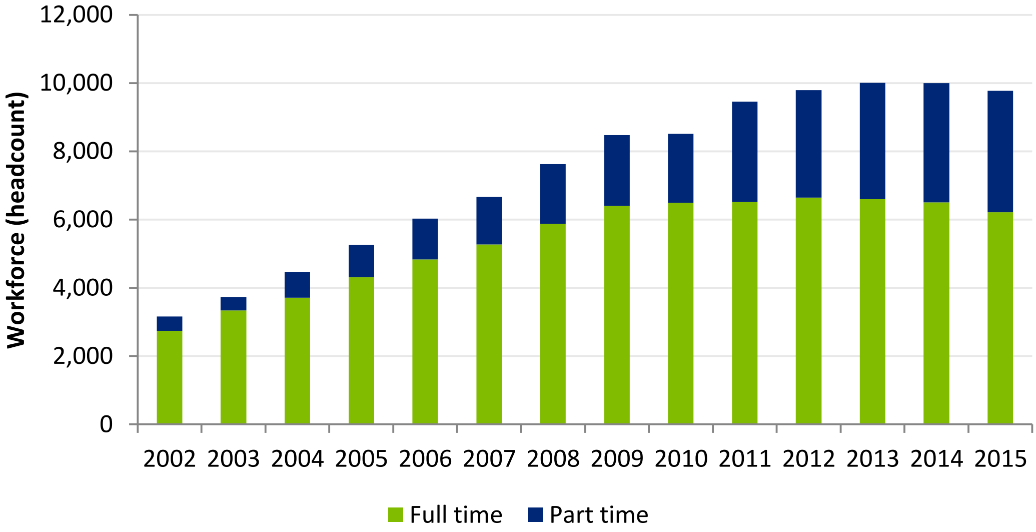


Source: NHMRC (2016).

The total number of FTEs (the sum of full time and part time FTEs) grew each year from 2002 to 2013. However, growth slowed in later years, and total FTEs declined by 2.3% between 2013 and 2015. The decrease in total FTEs occurred because the number of full time workers fell in 2014 and 2015 while the number of part time workers did not increase sufficiently to make up for the lost full time hours. This reflects a changing workforce composition, with an increasing number of part time workers relative to full time workers.

Chart 2.7 shows the workforce's composition by the number (headcount) of full time and part time workers. The number of full time workers has plateaued and declined in the years after 2009, however the number of part time workers has continued to rise – albeit at a much lower rate. Total headcount has therefore been stagnant since 2012, and is expected to continue its downward trend. Indeed, the share of full time workers has fallen from 86.8% in 2002 to 65.0% in 2014.

Chart 2.7: Health and medical research workforce composition (headcount)



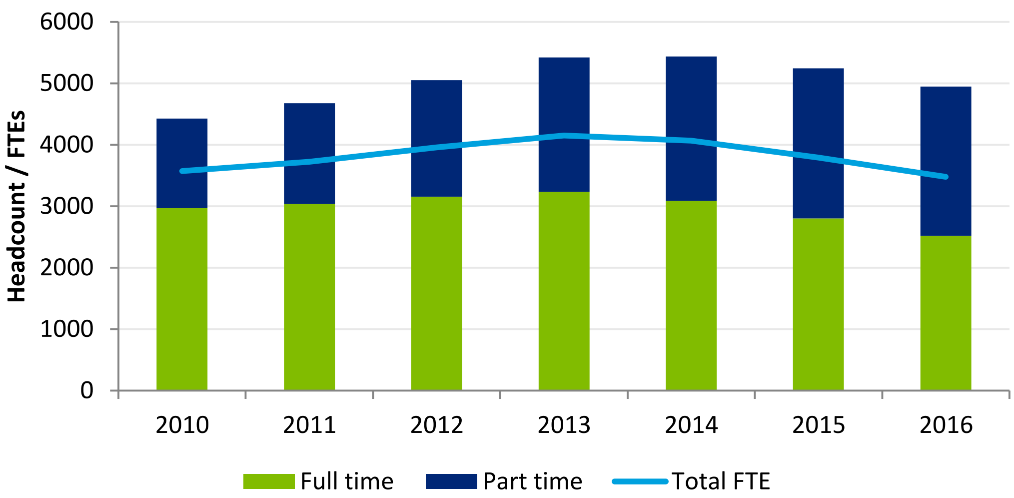
Source: NHMRC (2016).

2.3.2.2 NHMRC special request workforce data

In addition to the publicly available workforce data provided by NHMRC (2016), Deloitte Access Economics also considered workforce data obtained from a special request to the NHMRC in order to validate the findings.

These special request data relate to the number of personnel support packages (PSPs) under the NHMRC project grant scheme, which accounts for around 60% of total expenditure for the NHMRC supported workforce (NHMRC, 2016). These data (shown in Chart 2.8) reflect the number of PSPs receiving funding from project grants in any given year. That is, the data represents the actual project grant funded workforce.

Chart 2.8: Total PSPs receiving funding from project grants (headcount and FTEs)



Source: NHMRC special request data.

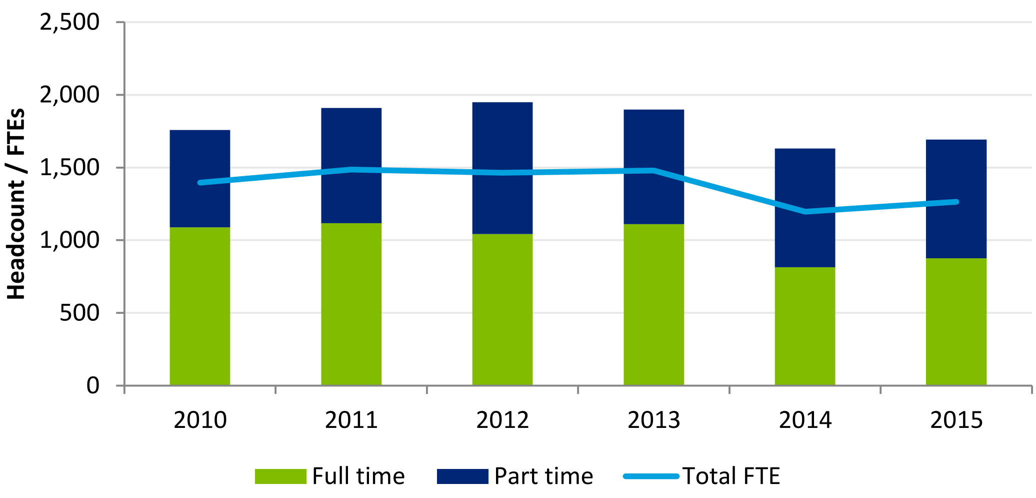
As shown in Chart 2.8, the number of FTEs supported by project grants declined each year from 2013 to 2016, with a total decline of 16.2% over this period. The current year (2016) contained the lowest number of FTEs (3,480) and the highest share (49%) of part-time PSPs since 2010. This trend was observed across all PSP levels.

These data support findings for the total NHMRC workforce, as outlined in the previous section, where it was found that total workforce headcounts and FTEs started to decline from 2013 (NHMRC, 2016).

The special request data also provided the number of new project grant supported personnel receiving funding in each year ('workforce flow'), disaggregated by full time and part time status. As shown in Chart 2.9, and similar to earlier findings, the workforce flow experienced a marked drop of approximately 19% between 2013 and 2014 in terms of FTEs. This was mainly driven by a drop in the number of funded full time applications from 1,111 in 2013 to 813 in 2014.

While the number of funded part time applications increased slightly from 787 to 817, this was not sufficient to offset the decrease in funded full time applications which caused the number of FTEs to decline. The number of funded full time applications increased slightly from 813 in 2014 to 876 in 2015, which increased the total headcount and number of FTEs in that year relative to 2014, but this was still lower than 2013 levels.

Chart 2.9: Flow of NHMRC project grant supported workforce (headcount and FTEs)



Source: NHMRC special request data.

The composition of new project grant supported personnel has also changed over time, with the share of full time applications falling from 62% in 2010 to 52% in 2015. Again, this reflects trends seen in the total NHMRC supported workforce data as described in the previous section.

Overall, the special request data for project grants supports findings for the total NHMRC workforce.

2.4 Associations between NHMRC funding, workforce and output

It was estimated that every $1 million of funding provides an additional 12.7 health and medical research FTEs. Every additional FTE is estimated to increase output by 0.9 publications. Overall it is estimated that every $1 million of funding leads to an increase in output of 11.6 publications, on average (or approximately $86,008 per publication).

The impact of NHMRC funding on output (and hence benefits) was modelled using a two-step relationship:

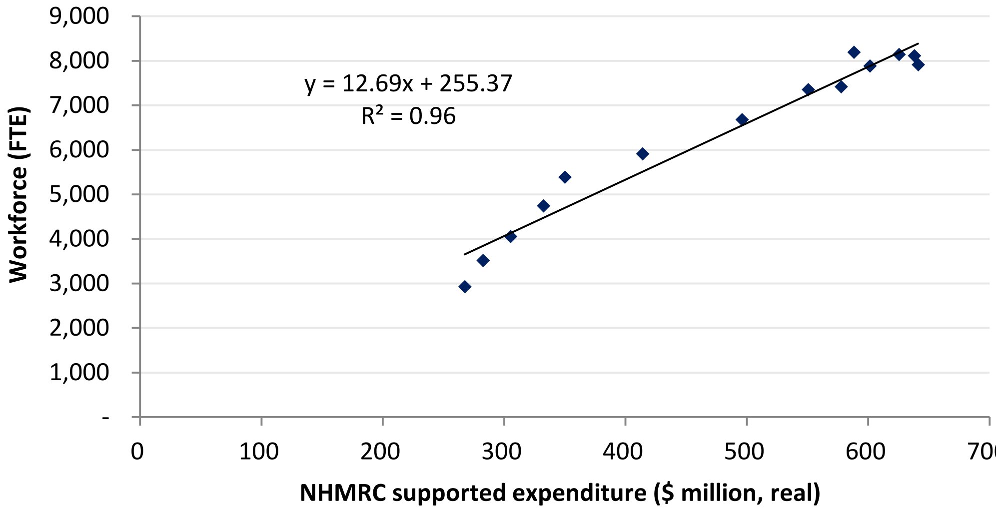
3. the impact of NHMRC funding was modelled on workforce (FTEs); and
4. the impact of workforce was modelled on output.

This establishes a causal pathway between NHMRC funding, total workforce and output of the health and medical research sector. The two steps involved in the modelling are discussed below. This section concludes with a discussion of the composition of the health and medical research workforce.

NHMRC funding and workforce

The relationship between workforce and NHMRC supported expenditure was modelled using a bivariate regression analysis over the period 2002 to 2014. It was found that workforce is strongly correlated to expenditure (see Chart 2.10). It was estimated that every $1 million of expenditure results in an additional 12.7 health and medical research FTEs (giving a cost of approximately $78,832 per FTE).

Chart 2.10: Relationship between workforce and NHMRC supported expenditure



Source: Deloitte Access Economics analysis.

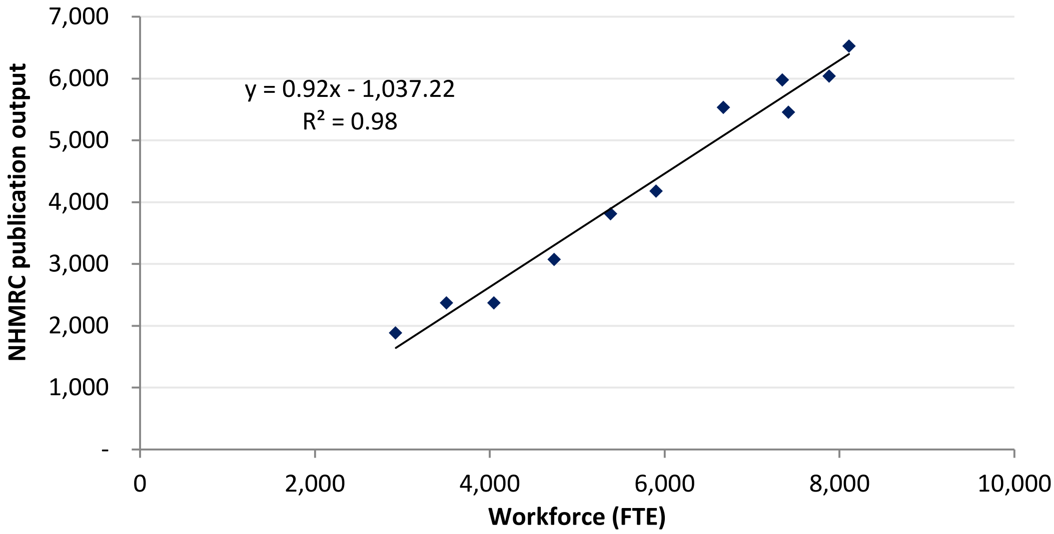
It is noted that NHMRC special request data relating to the project grant supported workforce (as described in Section 2.3.2) produces similar estimates. Using these data, together with project grant funding statistics, it was estimated that every $1 million of project grants expenditure results in between 12.7 and 14.3 additional FTEs.

Output and workforce

Having established the relationship between funding and workforce, this step considers how output relates to the number of health and medical research FTEs. Although workforce data were provided for the period 2002 to 2015, NHMRC output data were only available for 2002 to 2012 based on bibliometric analysis (see Section 2.2). Accordingly, the relationship between workforce (FTEs) and output was modelled over the period 2002 to 2012, using a bivariate regression analysis.

Chart 2.11 shows a strong, linear relationship between publication output and workforce. It is estimated that every additional FTE increases output by 0.9 publications in a year.

Chart 2.11: Relationship between NHMRC output and workforce



Source: Deloitte Access Economics analysis.

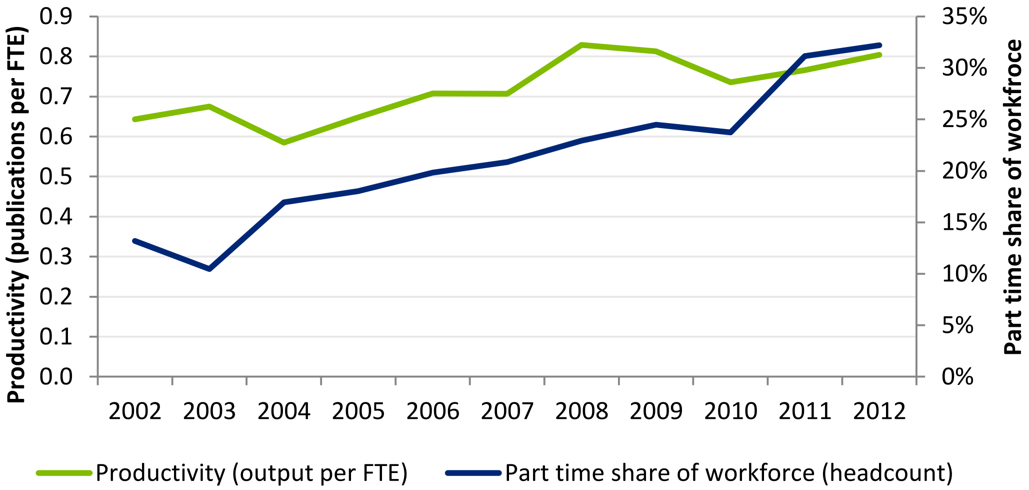
NHMRC special request data for the project grant supported workforce (as described in Section 2.3.2) gives similar results. Using these data, together with project grant research output statistics, it was estimated that every additional project grant supported FTE increases output by between 0.8 and 0.9 publications

2.4.2 NHMRC workforce composition

The health and medical research workforce is undergoing substantial transformation. Growth in the number of full time workers has been negative in recent years while the number of part time workers continues to increase (see Section 2.3.2). Changes to workforce mix may have implications for the research industry's ability to continue growing output and delivering high quality publications.

Chart 2.12 shows workforce productivity (measured by output per FTE) and the share of the health and medical research workforce comprising part time workers (by headcount). The part time share of the workforce has increased substantially over the period - from 13.2% in 2002 to 32.1% in 2012. Over the same period, productivity has increased from 0.6 publications per FTE in 2002 to 0.8 in 2012.

Chart 2.12: Workforce productivity and composition, 2002-2012



Source: Deloitte Access Economics calculations.

Overall, the impact of changing workforce composition on productivity is difficult to identify with available data. It is important to note that productivity will be affected by many factors apart from workforce composition. For example, the total number of FTEs has increased over the period 2002 to 2012, and the number of full time workers has also grown (see section 2.3.2). The growing workforce has, in turn, resulted in increased output (see section 2.2.5). It is likely that growth in the number of FTEs and full time workers has had an effect on workforce productivity, which may have partially offset any negative impacts from the increase in the part time share of the workforce. Consequently, it is not clear how productivity would have evolved over time if the workforce composition had remained unchanged.

In section 2.3.2, it was found that the share of full time workers decreased from approximately 76% in 2010 to 65% in 2014. Indeed, the total number of full time personnel actually decreased from 2013 onwards, representing the first observed decrease since 2000. In contrast, the number of part time personnel has consistently increased year-on-year since 2003. As a result, the number of FTEs was estimated to decrease for the first time in 2014, and the observed decrease was larger in 2015. Based on NHMRC data relating to the project grant supported workforce, these trends in workforce composition and total FTEs likely continued to 2016 and may remain into the future (see Section 2.3.2).

However, there was insufficient output data beyond 2012 to quantify the effects on output of changing workforce composition. This was the case for both the total NHMRC supported workforce (when compared to total output) as well as for data relating to the project grant supported workforce (when compared to project grant output). It is possible that data from future bibliometric analysis will more clearly show the effects of changing workforce mix on output, especially if growth in full time workers continues to slow and the number of part time workers continues to increase under current trends.

Furthermore, consideration should be given to the increasingly competitive nature of the funding environment, and the effects that increasing team size has on the productivity per worker (as defined by publication output). For example, increased team size has declining marginal productivity (Cook et al, 2015), and there has been a trend towards longer grants (NHMRC, 2016b). Also, there is likely to be an optimal team size in terms of knowledge spill over and productivity. Cook et al (2015) found that the optimal team size involves a chief investigator with a small research group. Finally, there has been a push towards increasing publication output in recent times, but not necessarily quality, given the increasing existence of open access journals and online publishing. Moreover, recent NHMRC consultations have shown researchers are becoming increasingly discouraged, which could lead to reduced output going forward (NHMRC, 2016b). All of these factors need careful consideration, and the results of the output analysis should be interpreted with this in mind. That said, it was not possible to quantify the effects of these changes on the NHMRC funded output given the lack of available data.

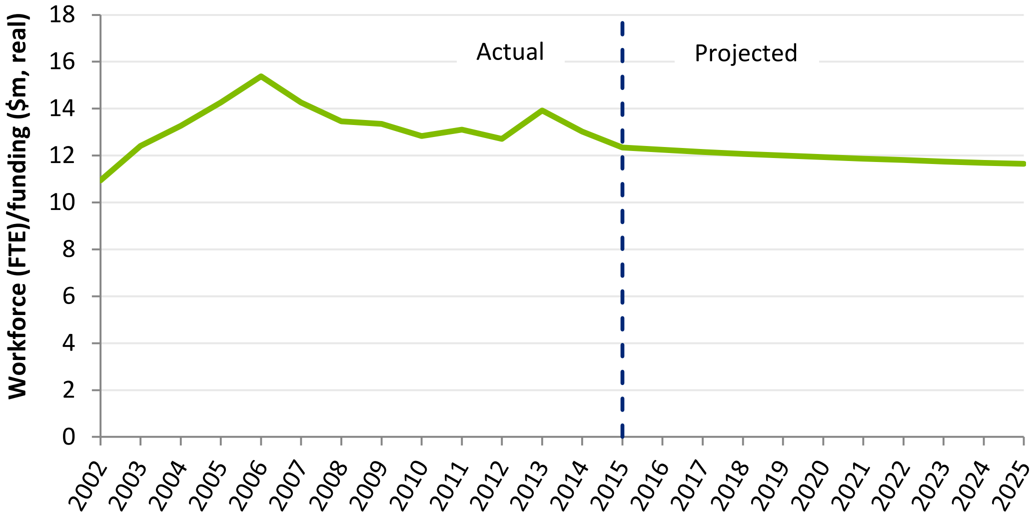
2.5 Projection of funding, workforce and output

To model the future returns to the NHMRC funded health and medical research workforce, it was necessary to model the relationships between funding, workforce and output over time. This was also necessary to establish the base case of output for the years following 2012.

To project these relationships, two measures were developed. These were the number of FTEs per $1 million of funding, and output (in terms of the number of publications) per FTE worker.

Chart 2.13 shows the actual and projected number of FTE workers for every $1 million of funding (in real terms). The actual data indicates that FTEs were becoming less expensive on average (perhaps due to a higher share of more junior researchers or declining fixed costs associated with infrastructure), between 2002 and 2006, although this trend has reversed in recent years. To project this relationship over time, a logarithmic trend function was fitted to the data from 2006 to 2015 since there appears to be a structural break at this period, and the estimated growth from the logarithmic trend was then applied out to 2025. From this data, it is expected that the ratios between funding and number of FTE workers will continue to decline to 2025 given static funding (in real terms).

Chart 2.13: Number of FTE workers for every $1 million funding in real terms



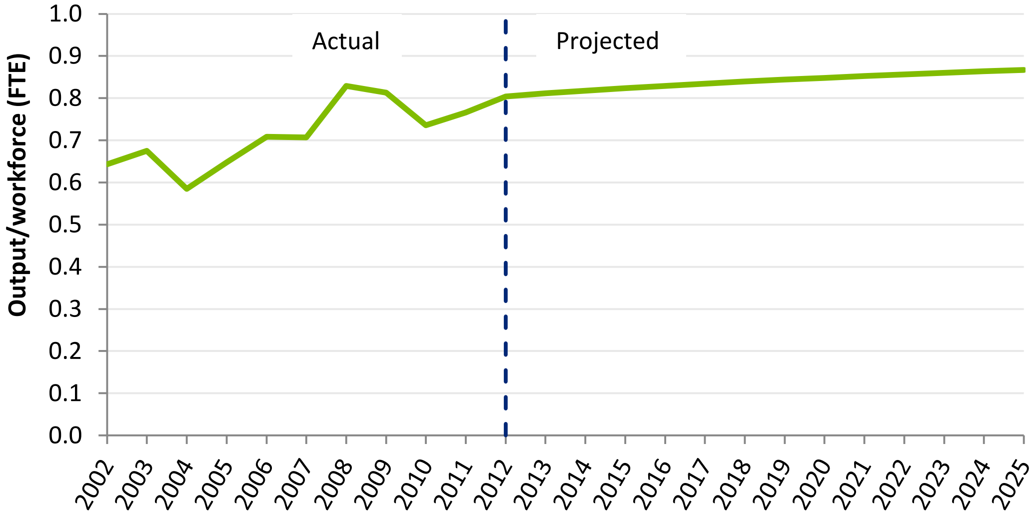
Source: Deloitte Access Economics calculations.

Chart 2.14 shows the actual and projected output (in terms of number of publications) per FTE worker. This chart shows that the average FTE worker may have become more productive over 2002 to 2012. To project this relationship over time, a logarithmic trend function was fitted to the data from 2002 to 2012, and the estimated growth from the logarithmic trend was then applied out to 2025. From this data, it is expected that the average FTE worker will have a slightly increased productivity in 2025 than they did in 2012 – producing around 0.07 more publications each year.

The slower increase in productivity in the future may make sense given the decrease in FTEs observed in 2014 and 2015 (section 2.3.2). However, it is not clear if this relationship would hold if additional output data were available.

The underlying data is based on outdated data, and consequently, the relationship showing a slow increase in productivity may be overstated. That is, if output data for 2014 and 2015 were available, the data may show that productivity is improving at an even slower rate than predicted, or even declining, especially given the increasing share of part time workers and the more competitive funding environment – i.e. where it is harder for researchers to obtain funding and more time is used to obtain research funding. The logarithmic trend will partly correct for this, by limiting the growth in productivity over time.

Chart 2.14: Publication output per FTE worker



Source: Deloitte Access Economics calculations.

Noting the caveats surrounding the workforce and output data, these trends establish a base case and allow the model to solve relationships between funding, workforce and output over time. For example, given a certain level of funding in the future, it is possible to estimate the workforce, and then derive the output of the workforce.

3 Quantifying the change in health outcomes

To measure the gains in wellbeing over time, this study has used a framework known as a 'burden of disease' analysis. This was originally developed by the World Bank in its global burden of disease study to inform global health planning (Murray and Lopez, 1996) and has subsequently been widely used and improved in a number of Australian and international settings.

Burden of disease analysis aims to calculate the size and impact of health problems derived from disease and injury across a population. It uses measured incidence, prevalence, duration, mortality and morbidity to quantify a summary measure of population health known as DALYs.

The following sections outline the methods for quantifying gains in wellbeing and present the total number of DALYs averted for the period 2040 to 2065. The final section briefly summarises methods from Deloitte Access Economics (2011), which were used to quantify the direct health system benefits, indirect productivity and other benefits (such as averted DWL.

3.1 Methods for quantifying gains in wellbeing

To establish the net benefit estimates from NHMRC funded R&D, the projections of DALYs between 1993 and 2023 from Begg et al (2007) have been used, as well as DALYs from the earlier burden of disease report (Mathers et al, 1999).[6] The methodology that was used to project DALYs by Begg et al (2007) is discussed in the next section.

3.1.1 Estimating past, present and future wellbeing in Australia

Data from Begg et al (2007) was used to estimate the past, present and future DALYs in Australia between 1993 and 2023. The method in Begg et al (2007) transforms estimates of burden of disease and injury in the past, present and future into a set of standardised rate ratios. These rate ratios represent the growth rate of DALYs after the effect of population ageing has been removed.

The standardised rate ratios used to estimate DALYs between 1993 and 2023 for males and females by cause are shown in Table 3.1. Growth was projected from an initial starting point in 2003 so the ratio for 2003 represents the base from which the future and past rate ratios were estimated (ratios for 1993 were 'back-cast'). As data on the growth rate of DALYs were only available for four time periods (1993, 2003, 2013, and 2023), linear projections were

[6] At the time of writing this report, there was not sufficient detail published in the latest burden of disease and injury study in Australia for the year 2011 (AIHW, 2016) to update this analysis. Consequently, the data from Begg et al (2007) and Mathers et al (1999) have been retained for this report. Considering the changes between 2003 and 2011, the DALY rates per 1,000 population are broadly moving in the same direction, and so Begg et al (2007) was considered to still be representative.

used to fill in the data gaps, and to project the growth rate forward to 2065. DALY rate changes were restricted so that no DALYs could become negative.

Table 3.1: Standardised ratio of DALYs, 1993 to 2023

	Males				Females			
	1993	2003	2013	2023	1993	2003	2013	2023
Infectious and parasitic diseases	0.93	1.00	1.02	0.99	0.99	1.00	0.93	0.85
Acute respiratory infections	0.67	1.00	1.00	1.00	0.61	1.00	1.00	1.00
Maternal conditions	0.00	0.00	0.00	0.00	1.09	1.00	1.03	1.02
Neonatal causes	1.32	1.00	0.80	0.68	1.00	1.00	0.82	0.71
Nutritional deficiencies	1.12	1.00	1.03	1.02	1.03	1.00	0.99	0.98
Malignant neoplasms	1.20	1.00	0.85	0.70	1.16	1.00	0.88	0.74
Other neoplasms	1.03	1.00	0.83	0.68	0.94	1.00	0.89	0.81
Diabetes mellitus	0.87	1.00	1.15	1.32	0.89	1.00	1.18	1.40
Endocrine and metabolic disorders	1.88	1.00	1.08	1.03	0.89	1.00	1.16	1.31
Mental disorders	1.03	1.00	1.01	0.99	0.99	1.00	1.01	1.01
Nervous system and sense organ disorders	0.96	1.00	1.02	1.03	0.96	1.00	1.03	1.05
CVD	1.56	1.00	0.69	0.48	1.51	1.00	0.74	0.53
Chronic respiratory disease	1.22	1.00	0.83	0.73	1.04	1.00	0.96	0.93
Diseases of the digestive system	1.01	1.00	0.81	0.71	1.03	1.00	0.85	0.75
Genitourinary diseases	0.97	1.00	0.97	0.96	0.97	1.00	0.98	0.95
Skin diseases	1.00	1.00	1.00	0.99	1.00	1.00	1.00	0.99
Musculoskeletal diseases	0.98	1.00	1.03	1.05	0.97	1.00	1.02	1.02
Congenital anomalies	1.11	1.00	0.84	0.74	1.19	1.00	0.84	0.72
Oral conditions	0.99	1.00	1.02	1.03	0.98	1.00	1.01	1.02
Ill-defined conditions	1.70	1.00	0.83	0.73	1.31	1.00	0.93	0.89
Injuries	1.16	1.00	0.91	0.79	1.08	1.00	0.89	0.76
All causes	**1.18**	**1.00**	**0.90**	**0.81**	**1.11**	**1.00**	**0.93**	**0.87**

Source: Begg et al (2007).

There are two issues with projecting total DALYs by condition level data. The first issue with projecting total DALYs is the changing composition of the Australian population. Higher incomes, improved health care, healthier lifestyles, and decreased fertility are resulting in population ageing. As the total population prevalence and incidence of disease and injury is closely linked with ageing, the expected changes in the Australian population need to be taken into account when estimating total DALYs for a population. Within this study, DALY growth rates (as represented by the standardised ratio of DALYs) were multiplied by population projections (at the five year age cohort level and by gender) using ABS population projections (ABS, 2013a). This provided a total DALY estimate by age, gender and cause for each year between 2000 and 2065.

The second issue is that the counterfactual for standardised DALYs over time is not clear. For example, loss of wellbeing is expected to increase for conditions such as diabetes, nervous system and sense organ disorders, etc. **Research will not contribute to the increase in loss of wellbeing; rather, this would be due to behavioural change and risk factor patterns. Consequently, where the disease burden is expected to increase, these conditions are modelled using the observed decrease for all diseases.** This has the effect of attributing a likely benefit gain to 'other' conditions, while we can more directly attribute the gains due to health research for conditions such as CVD and cancers.

Finally, the total gains in wellbeing can be represented by the reduction in DALYs from a base case. In this study, the base case was total DALYs for 2000, which was constructed by 'back-casting' total DALYs from 2003 across age, gender and cause using the standardised ratio of DALYs displayed in Table 3.1.

DALY gains for these diseases were estimated as a proportion of the total gains in wellbeing for their disease classification group. Annual estimates of DALYs for the overarching disease classification groups were derived using the standardised ratios displayed in Table 3.2, and using linear projections to impute values from 2000 through to 2050.

3.2 Calculating the total DALYs averted

To estimate the total DALYs averted, results from Begg et al (2007) were used. As outlined in section 3.1, the rate of DALY changes over time were interpolated within periods and a linear extrapolation of the change over the period 2013 to 2023 was applied to the years after 2023. The linear extrapolation was adjusted slightly so that DALYs could not become negative (i.e. the best outcome is that DALYs due to a condition are eradicated over time).

The total aversion of DALYs per annum was then calculated by subtracting the DALYs at 2000 levels from projected DALYs up to 2065 for each of the key diseases. The aversion of DALYs generally increases out into the future for males and females for each of the key diseases reported. This suggests that, despite population increases and ageing, total DALYs for CVD, cancer, chronic respiratory and injuries are expected to be less than 2000 levels overall. However, for other conditions the aversion of DALYs is negative overall for males and females in the future. This can be interpreted as an increase in the burden of disease due to an increase in incidence and the 'at risk' population. **As mentioned, these conditions were therefore modelled using the observed decrease for all causes**.

Table 3.2 presents the estimates of the total DALYs expected to be averted between 2040 and 2065. This forms the baseline for establishing gains in wellbeing attributable to NHMRC funded health R&D in Australia.

Table 3.2: Total DALYs averted, 2040-2065, '000s

Condition	2040-2055	2056-2065
CVD	25,092.6	19,476.3
Cancer	13,685.0	12,741.3
Chronic respiratory	2,766.7	2,497.1
Injuries	3,195.2	2,895.7
Other	17,494.4	15,819.1
All causes	**62,233.9**	**53,429.5**

Source: Deloitte Access Economics calculations based on Begg et al (2007).

3.3 The value of gains in wellbeing

The gains in wellbeing presented in Table 3.2 are represented as DALYs avoided. However, to determine the net benefits from NHMRC funded R&D, 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 was calculated by multiplying the total number of DALYs averted per year by the VSLY.

The Department of Prime Minister and Cabinet provides a value of the VSLY (DPMC, 2014). The Department of Prime Minister and Cabinet recommends that a credible estimate for the VSL is $4.2 million and $182,000 for a VSLY (in 2014 dollars). Adjusting this value to account for inflation gives a VSLY of approximately $187,502 in 2016 dollars.

Applying this VSLY to the total number of DALYs averted per year for each of the key diseases and discounting the values back to 2016 levels enables estimation of the net present value of these wellbeing gains. Projected benefits are discounted to take into account society's preference to experience these benefits in nearer rather than more distant years, resulting in the value of these gains diminishing over time.

3.4 Quantifying avoided health system costs, indirect costs and commercial gains

There are many different types of benefits resulting from NHMRC funded R&D. First and foremost is the increase in wellbeing resulting from improved health outcomes now and in the future, which was outlined in the previous sections. From these health gains there are associated benefits, including the avoidance of direct HSE and the avoidance of indirect costs (such as productivity loss, other financial costs associated with reduced wellbeing, and DWL). In addition, there are commercial gains that result from NHMRC funded R&D. The methodology to establish the value of these benefits is presented in detail in Deloitte Access Economics (2011). The methodology is summarised briefly in the following paragraphs.

Avoided direct financial costs include the costs of running hospitals and other health services, the labour costs, pharmaceuticals, allied health care and other health care costs such as ambulances and health devices. In 2014, the Australian Institute of Health and Welfare (AIHW) estimated the expenditure on disease and injury for a range of conditions (AIHW, 2014). The conditions in the AIHW publication match the burden of disease study presented here, so it is possible to derive the average cost of a DALY on the health system. The avoided direct financial costs were estimated by multiplying the average health system cost per DALY for each condition by the expected total DALYs avoided within each year.

Avoided indirect costs include productivity gains, avoided carer costs, and other costs such as avoided DWL associated with government transfers (including taxation and welfare). The value of avoided lost productivity, carer costs and other costs have been derived from estimates made within burden of disease analyses previously undertaken by Deloitte Access Economics over a range of conditions. To derive the value of avoided indirect costs for each condition, the cost per DALY was multiplied by the expected total DALYs avoided within each year.

The value of commercial gains was assumed to be the same as in Deloitte Access Economics (2011), which found that for every $1 of R&D research, commercialisation gains were equal to $0.72.

The value of the averted direct health system costs and indirect costs were discounted back to current prices, and where relevant, commercialisation gains were also discounted back to current prices.

4 Historical net benefits from NHMRC health and medical workforce and R&D output

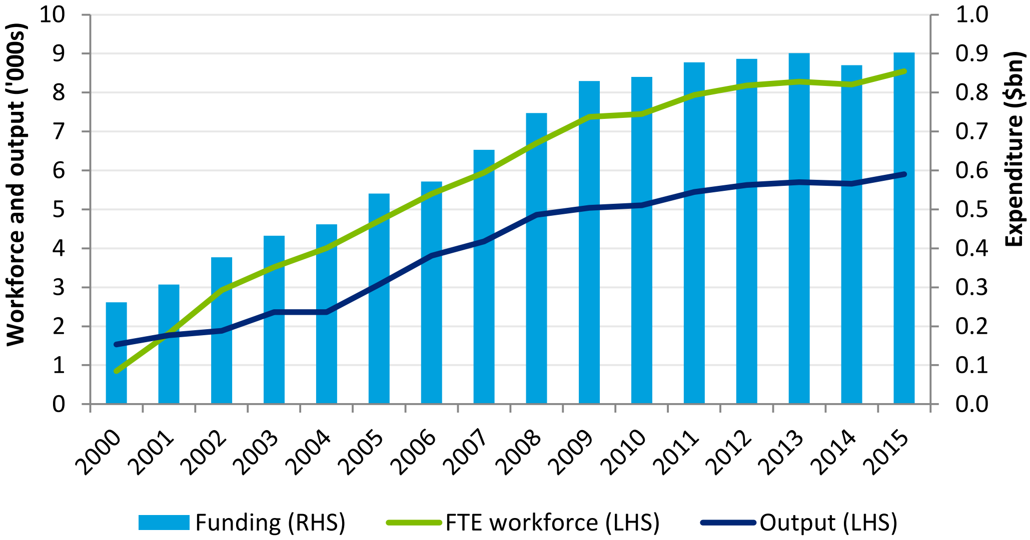
To analyse the historical returns from the health and medical research workforce, the funding and output data were considered over the period 2000 to 2015. Chapter 5 estimates the future projected returns from the health and medical research workforce for the period 2016 to 2025.

A number of scenarios were considered historically, including what would happen if the returns to health and medical R&D were lower, or if the workforce had of been higher or lower from 2000 to 2015. In the base case, NHMRC funding, FTE workforce data and output were taken as given over the 2000 to 2015 period. The results for the base case are presented in section 4.1, and the results for the sensitivity analysis are presented in section 4.2.

4.1 Methodology and results

To estimate the total returns to the health and medical research workforce during the period 2000 to 2015, workforce and funding data were collected from the NHMRC. Output data was also collected for the period 2000 to 2012 and then projected for the entire period using observed relationships in the workforce and funding data, and the output and workforce data, as presented in section 2.4. The output associated with the NHMRC funded health and medical research workforce relative to the total Australian output, and to world output, was derived to establish the attributable fraction for health and medical research output during the period 2000 to 2015. Chart 4.1 shows the estimated NHMRC funding, workforce and output during the period 2000 to 2015, respectively.

Chart 4.1: NHMRC funding, workforce and output, 2000-2015

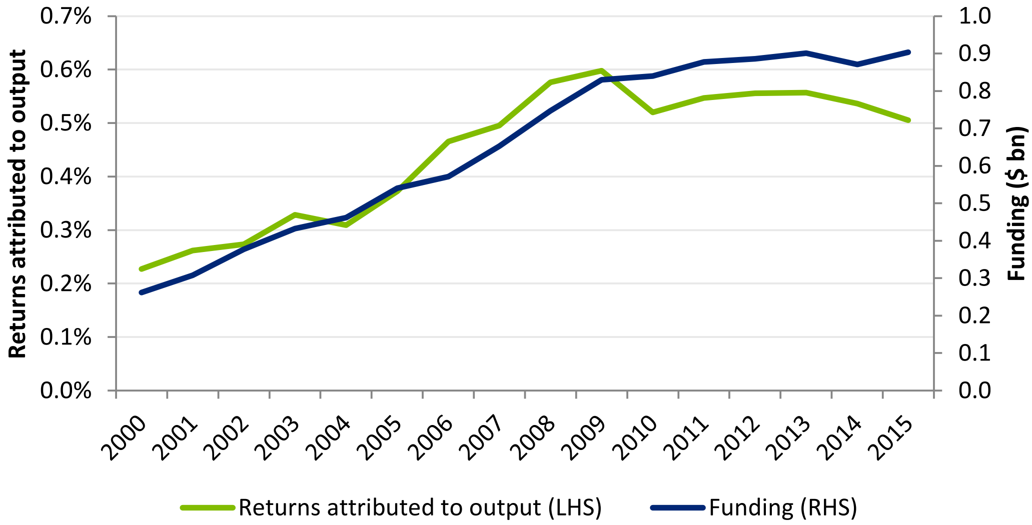


Source: Based on NHMRC (2013; 2016a) and Deloitte Access Economics calculations.

For the base case, the share of total health returns attributed to the NHMRC funded health and medical workforce were estimated by multiplying the total DALYs averted (relative to 2000) by the share of wellbeing gains that were attributed to the NHMRC health and medical research workforce – noting that there was assumed to be a 40 year lag to returns, on average. The share of wellbeing gains that was attributable to the workforce is shown in Chart 4.2 for the period 2000 to 2015. Funding is also shown in this chart to highlight the potential downturn in returns attributed to output that corresponds closely with static funding since 2009.

A key assumption underlying the returns attributed to the NHMRC health and medical research workforce in this chart is that 50% of health benefits are due to health and medical R&D (Cutler and Kadiyala, 2003). Sensitivity is conducted on this assumption in section 4.2.2.

Chart 4.2: Proportion of total health benefits attributed to NHMRC health and medical research workforce, 2000-2015



Source: Deloitte Access Economics calculations.

The benefits, costs and BCR of workforce returns for the base case between 2000 and 2015 are shown in Table 4.1, for all NHMRC funded research (all causes), CVD, cancer, chronic respiratory, injuries and other causes. Chart 4.3 presents the BCRs by cause graphically.

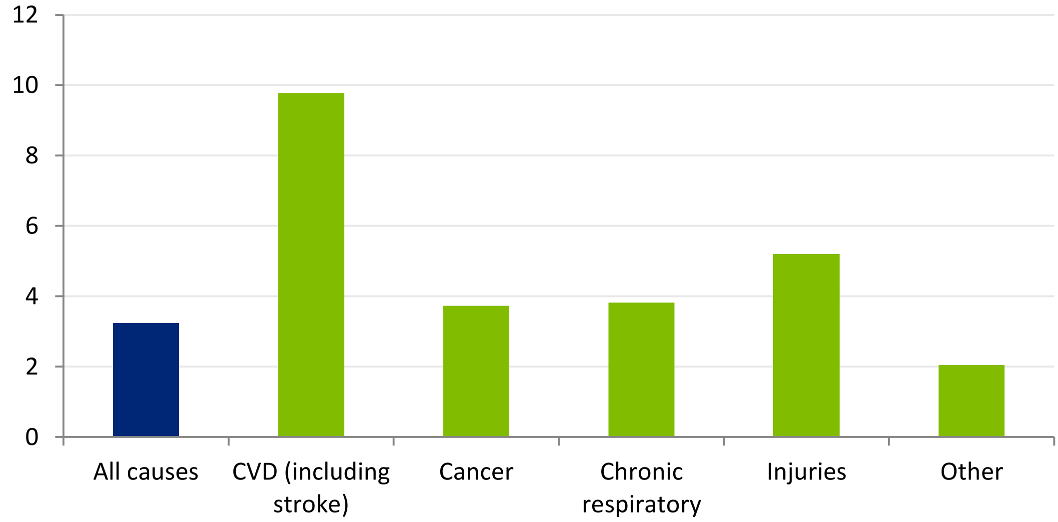
Table 4.1: Benefits, costs and BCR of workforce returns in the base case, detailed causes, 2000-2015

Condition	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
All causes	20.3	2.7	3.2	7.5	33.8	10.5	23.4	3.2
CVD (including stroke)	8.2	0.6	0.5	0.7	10.0	1.0	9.0	9.8
Cancer	4.5	0.2	0.2	1.2	6.0	1.6	4.4	3.7
Chronic respiratory	0.9	0.1	0.2	0.3	1.5	0.4	1.1	3.8
Injuries	1.0	0.1	0.4	0.3	1.8	0.3	1.5	5.2
Other	5.7	1.7	2.0	5.1	14.5	7.1	7.4	2.0

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

The total benefits of the NHMRC funded health and medical research workforce were estimated to be $33.8 billion between 2000 and 2015, while the cost of funding was only $10.5 billion (real 2015-16 dollars). The net gain was $23.4 billion, or roughly $257,000 per FTE worker. Greater returns are expected to occur for CVD and cancers than for other conditions. Overall, it was estimated that every $1 invested in the NHMRC funded health and medical research workforce returned $3.20, on average.

Chart 4.3: BCR of workforce returns in the base case, detailed causes, 2000-2015



Source: Deloitte Access Economics calculations.

4.2 Sensitivity analysis

To analyse the historical returns from the health and medical research workforce, a number of scenarios were considered. These scenarios considered what the returns to the NHMRC workforce would have been given:

- a 40% decline or increase in the FTE workforce;
- a 20% decline or increase in the FTE workforce;
- a 10% decline or increase in the FTE workforce; and
- a 5% decline or increase in the FTE workforce;

Sensitivity analysis was also conducted on the attribution of total health benefits to health and medical R&D. The parameters considered for this analysis were (Cutler and Kadiyala, 2003):

- health and medical R&D was assumed to cause 33% of the change in health outcomes; and
- health and medical R&D was assumed to cause 67% of the change in health outcomes.

The results of the sensitivity analysis for the workforce scenarios are presented in section 4.2.1, and the results of attribution of total health benefits to health and medical R&D are presented in section 4.2.2.

Overall, the sensitivity analysis results in large changes in expenditure and benefits, although the BCR of health and medical research is relatively stable across all sensitivity scenarios.

4.2.1 Workforce scenarios

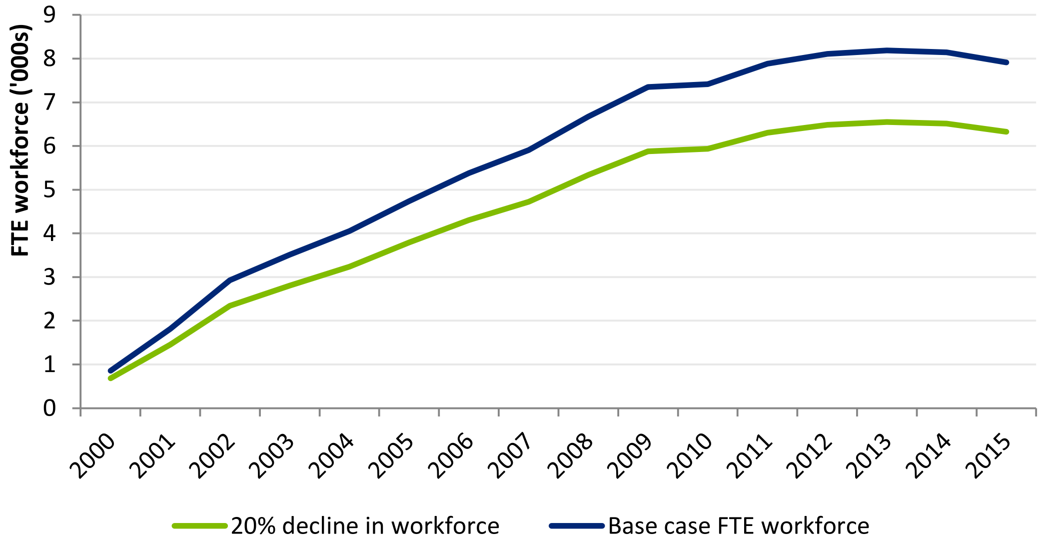
Section 2.4 established the associations between NHMRC health and medical research funding, the FTE workforce and its output (in terms of the number of publications produced). Recall that:

5. for every additional $1 million of funding, the FTE workforce would increase by 12.7 people; and

6. for every additional FTE worker, output would increase by 0.9 publications.

For these scenarios, the same workforce assumptions were used. Chart 4.4 shows the estimated decline in the health and medical research workforce between 2000 and 2015 for a 20% decline in the total number of FTEs.

Chart 4.4: Example workforce change for a 20% decline in the health and medical research workforce, 2000-2015



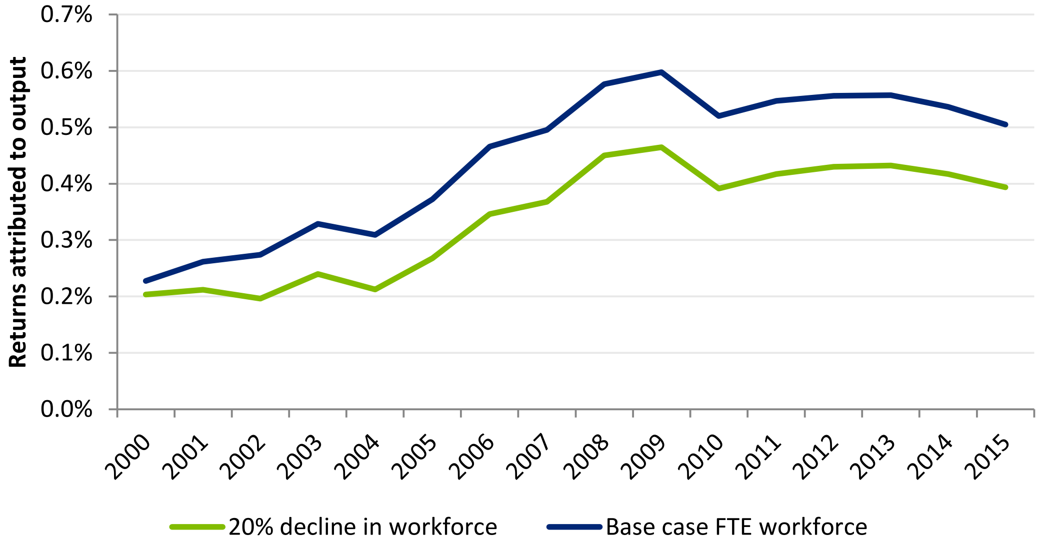
Source: Deloitte Access Economics calculations.

Fewer FTEs are associated with lower funding (assumption 1 above). Similarly, a decrease in the workforce would have been associated with decreased funding and output between 2000 and 2015.

In each workforce scenario, the share of total health returns attributed to the NHMRC funded health and medical workforce were recalculated given the decreased output. To recalculate Australian output, the output from other Australian sources was assumed to be constant, while the overall total declined by the same amount as the decline in NHMRC health and medical research output. The world output was also decreased by the same amount; however, given the small magnitude of NHMRC health and medical research output to world output, the world output was essentially very similar.

Chart 4.5 shows the share of total health benefits that were attributed to NHMRC health and medical research output for a 20% decline in workforce. As with the base case, the returns were assumed to occur 40 years after funding, on average.

Chart 4.5: Health benefits attributed to NHMRC health and medical research output for a 20% decline in workforce, 2000-2015



Source: Deloitte Access Economics calculations.

The health benefits attributed to NHMRC health and medical research output were estimated for each workforce scenario by multiplying the share of health returns that can be attributed to health and medical R&D by the total DALYs averted (relative to 2000) – which were outlined in section 3.2. The benefits, costs and BCR of workforce returns for each scenario are shown in Table 4.2 for all NHMRC funded research (all causes). Appendix A contains detailed results for all causes, CVD, cancers, chronic respiratory, injuries and all other conditions.

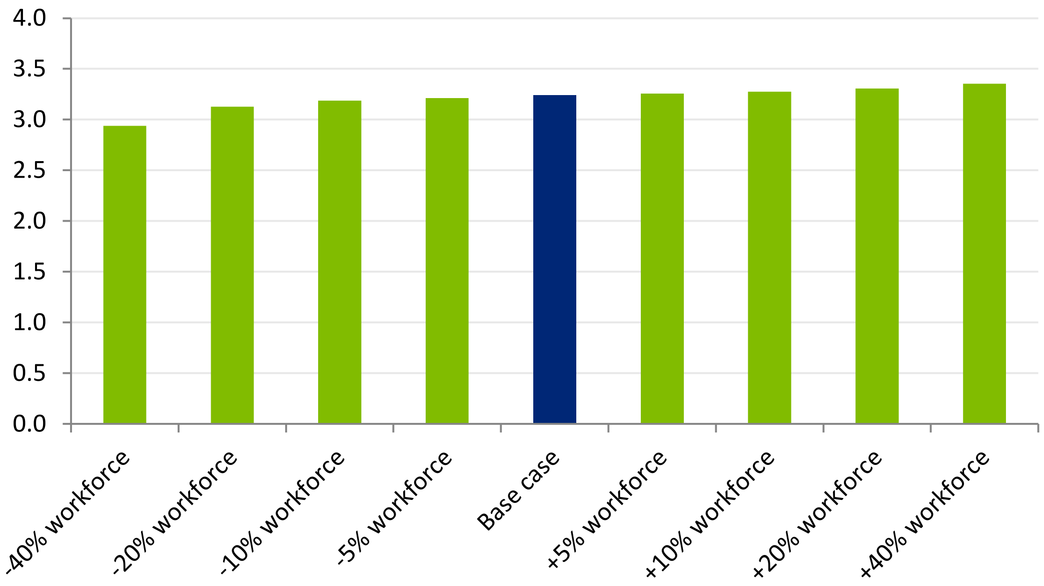
In the base case, total benefits associated with the output of the health and medical research workforce's output were estimated to be $33.8 billion, while costs were estimated to be $10.5 billion. The sensitivity analysis on workforce changes suggests a range of benefits between $18.3 billion and $49.3 billion, while the range for costs were estimated to be $6.2 billion and $14.7 billion for the low and high workforce scenarios, respectively. Overall, the BCR estimated for the base case represents a mid-range of the low and high workforce scenarios, with BCR increasing with increasing workforce. The BCRs for each of the workforce scenarios are shown graphically in Chart 4.6.

Table 4.2: Benefits, costs and BCR of workforce returns for each scenario, all causes, 2000-2015

Scenario	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
-40% workforce	10.7	1.4	1.7	4.5	18.3	6.2	12.1	2.9
-20% workforce	15.5	2.1	2.5	6.0	26.1	8.3	17.7	3.1
-10% workforce	17.9	2.4	2.8	6.8	30.0	9.4	20.6	3.2
-5% workforce	19.1	2.6	3.0	7.2	31.9	9.9	22.0	3.2
Base case	20.3	2.7	3.2	7.5	33.8	10.5	23.4	3.2
+5% workforce	21.5	2.9	3.4	7.9	35.8	11.0	24.8	3.3
+10% workforce	22.7	3.1	3.6	8.3	37.7	11.5	26.2	3.3
+20% workforce	25.1	3.4	4.0	9.1	41.6	12.6	29.0	3.3
+40% workforce	29.9	4.0	4.7	10.6	49.3	14.7	34.6	3.4

Source: Deloitte Access Economics calculations. Comm. = commercialisation

Chart 4.6: BCR of workforce returns by scenario, all causes, 2000-2015



Source: Deloitte Access Economics calculations.

The benefits and costs of workforce returns in each workforce scenario are presented relative to the base case in Table 4.3. Costs were estimated to decrease or increase by up to $4.2 billion, while for benefits this was estimated to be $15.6 billion.

Table 4.3: Benefits, costs and BCR of workforce returns relative to the base case, 2000-2015, all causes

Scenario	Benefits ($b)					Costs ($b)	Net benefits ($b)
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*		
-40% workforce	-9.7	-1.3	-1.5	-3.1	-15.6	-4.2	-11.3
-20% workforce	-4.8	-0.7	-0.8	-1.5	-7.8	-2.1	-5.6
-10% workforce	-2.4	-0.3	-0.4	-0.8	-3.9	-1.1	-2.8
-5% workforce	-1.2	-0.2	-0.2	-0.4	-1.9	-0.5	-1.4
Base case	-	-	-	-	-	-	-
+5% workforce	1.2	0.2	0.2	0.4	1.9	0.5	1.4
+10% workforce	2.4	0.3	0.4	0.8	3.9	1.1	2.8
+20% workforce	4.8	0.6	0.8	1.5	7.7	2.1	5.6
+40% workforce	9.6	1.3	1.5	3.1	15.4	4.2	11.2

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

Overall, the modelling results showed small variances in the BCR under each workforce scenario. The BCR ranged from 2.9 to 3.4 when considering -40% workforce scenarios through to +40% workforce scenarios. For the low workforce scenario, the net benefits per FTE worker were estimated to be around $221,000, while for the high workforce scenario, this was estimated to be just under $272,000. In the base case, the net benefits per FTE worker were estimated to be around $257,000.

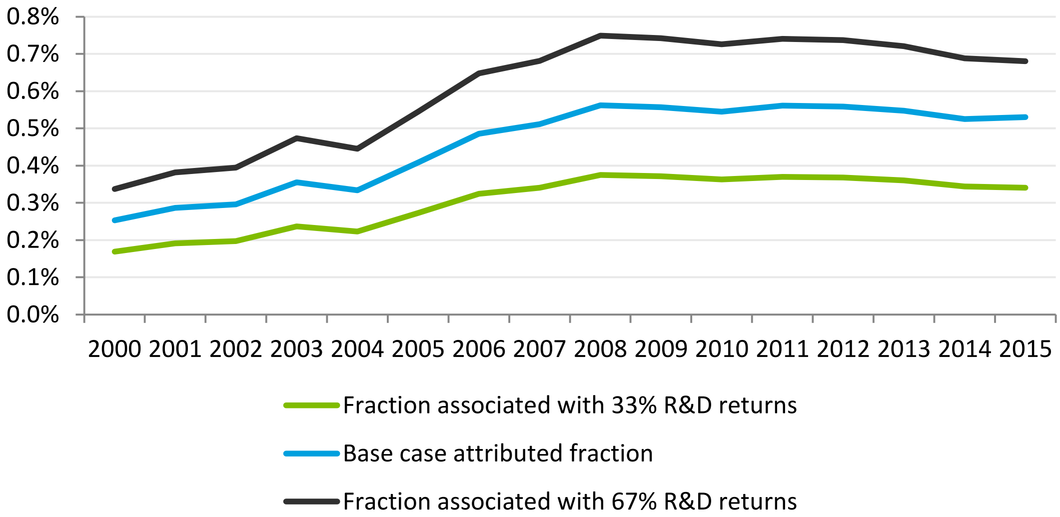
4.2.2 Attribution of health returns to R&D

Sensitivity analysis was also conducted on the attribution of health benefits to health and medical R&D. In the base case, it was assumed that 50% of all health benefits are attributed to health and medical R&D. The parameters considered for this analysis were (Cutler and Kadiyala, 2003):

- health and medical R&D was assumed to cause 33% of the change in health outcomes; and
- health and medical R&D was assumed to cause 67% of the change in health outcomes.

For each of these scenarios, the parameter affects the total benefits that are attributed to health and medical R&D as a linear transformation of the base case. Chart 4.7 presents the total health benefits that are attributed to NHMRC funded health and medical workforce research output for each year in the period 2000 to 2015.

Chart 4.7: Share of health benefits attributed to the NHMRC health and medical research workforce by R&D returns, 2000-2015



Source: Deloitte Access Economics calculations.

Table 4.4 shows the estimated health returns that may be attributed to the NHMRC funded health and medical research workforce for each of the scenarios listed.

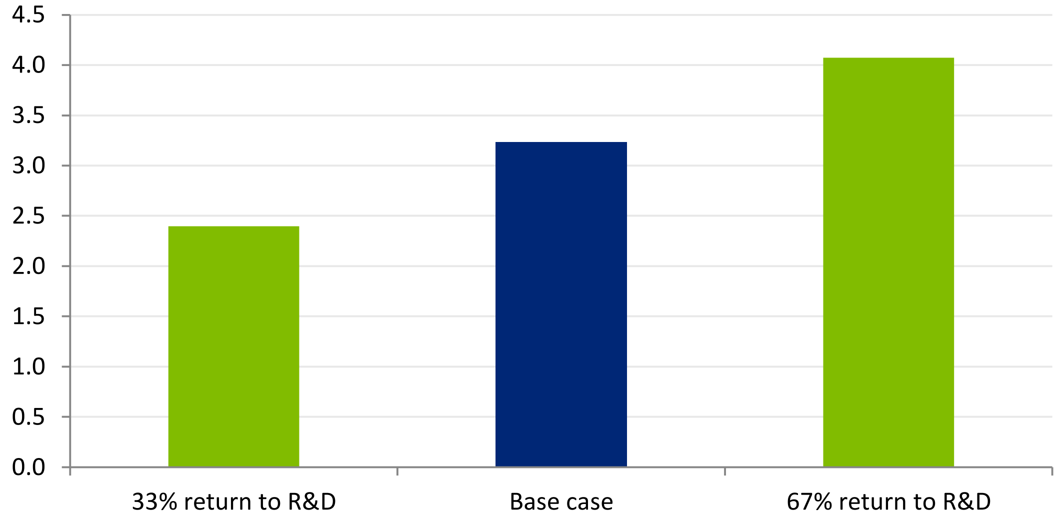
Table 4.4: Benefits, costs and BCR of workforce returns for each scenario, all causes, 2000-2015

Scenario	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
33% return to R&D	13.6	1.8	2.2	7.5	25.1	10.5	14.6	2.4
Base case	20.3	2.7	3.2	7.5	33.8	10.5	23.4	3.2
67% return to R&D	27.1	3.7	4.3	7.5	42.6	10.5	32.2	4.1

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

Overall, it was estimated that benefits would range between $25.1 billion and $42.6 billion during the period 2000 to 2015. The net benefits therefore range between $14.6 billion and $32.2 billion. For the estimated 90,849 workers over the entire period, the net benefits per FTE worker range between $161,000 and $354,000. For these scenarios it was estimated that every $1 invested in the health and medical research workforce by the NHMRC returns between $2.40 and $4.10. This is shown in Chart 4.8.

Chart 4.8: BCR of workforce returns by scenario, all causes, 2000-2015



Source: Deloitte Access Economics calculations.

5 Forward looking investment model

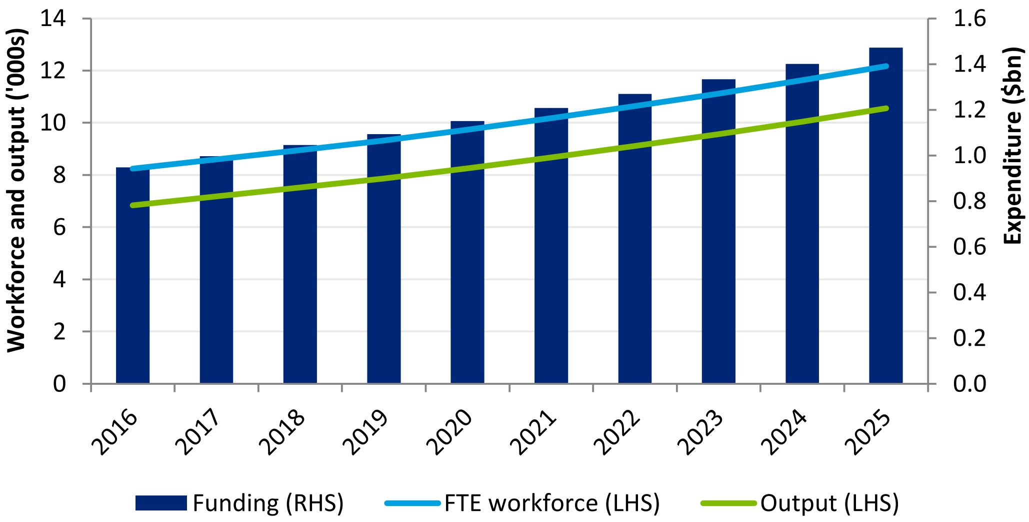
To analyse the future returns from the health and medical research workforce, the funding and output were considered over the period 2016 to 2025. A number of scenarios were also considered, including what would happen if the returns to health and medical R&D were lower, if funding increases as a share of total HSE between 2016 and 2025, or if funding was constant in real terms from 2015. In the base case, NHMRC funding, FTE workforce data and output were projected using relationships identified in chapter 2. The results for the base case are presented in section 5.1, and the results for the sensitivity analysis are presented in section 5.2.

5.1 Methodology and results

To estimate the future returns to the health and medical research workforce during the period 2016 to 2025, historical workforce, funding, and output data were projected using logarithmic trends – this was described in chapter 2. The output associated with the NHMRC funded health and medical research workforce relative to the total Australian output, and to world output, was derived in each year to establish the attributable fraction for health and medical research output during the period 2016 to 2025.

Chart 5.1 shows the projected funding, workforce and output during the period 2016-2025, assuming the NHMRC funding will maintain a fixed share of total HSE. Estimates of the total HSE over this period were modelled using a rolling six-year average of historical growth rates.

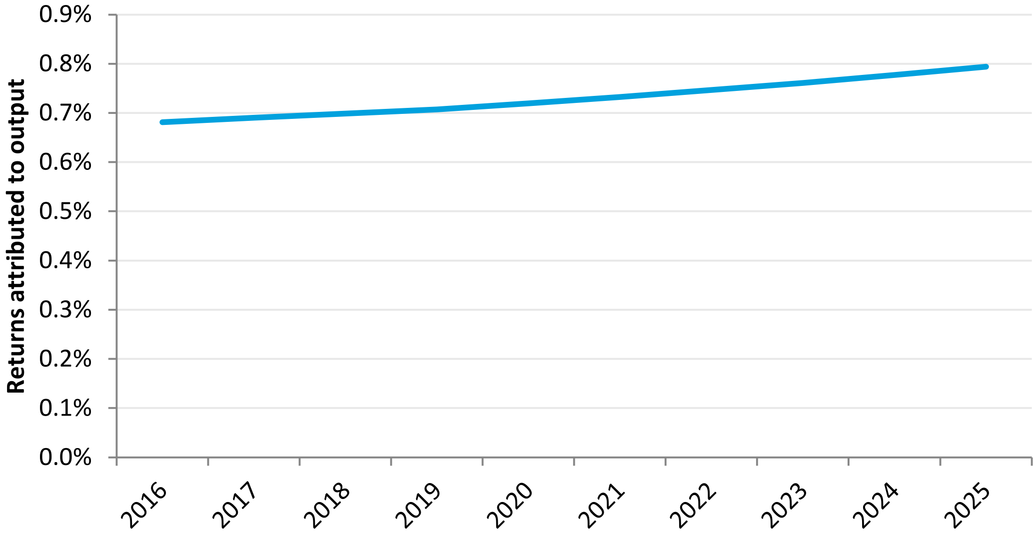
Chart 5.1: Projected NHMRC funding, workforce and output, 2016-2025



Source: Deloitte Access Economics calculations.

For the base case, the total benefits attributed to the NHMRC funded health and medical research workforce were estimated by multiplying the total DALYs averted (relative to 2000) by the value of benefits attributable to the NHMRC health and medical research workforce – noting that there was assumed to be a 40 year lag to returns, on average. The share of health benefits that were attributed to the NHMRC health and medical research workforce is shown in Chart 4.2. A key assumption underlying this chart is that 50% of health benefits are due to health and medical R&D (Cutler and Kadiyala, 2003). Sensitivity is conducted on this assumption in section 5.2.2.

Chart 5.2: Projected share of health returns attributable to the NHMRC health and medical research workforce, 2016-2025



Source: Deloitte Access Economics calculations.

The benefits, costs and BCR of workforce returns for the base case between 2016 and 2025 are shown in Table 5.1, for all NHMRC funded research (all causes), CVD, chronic respiratory, injuries and all other conditions. Chart 5.3 presents the BCRs by cause graphically.

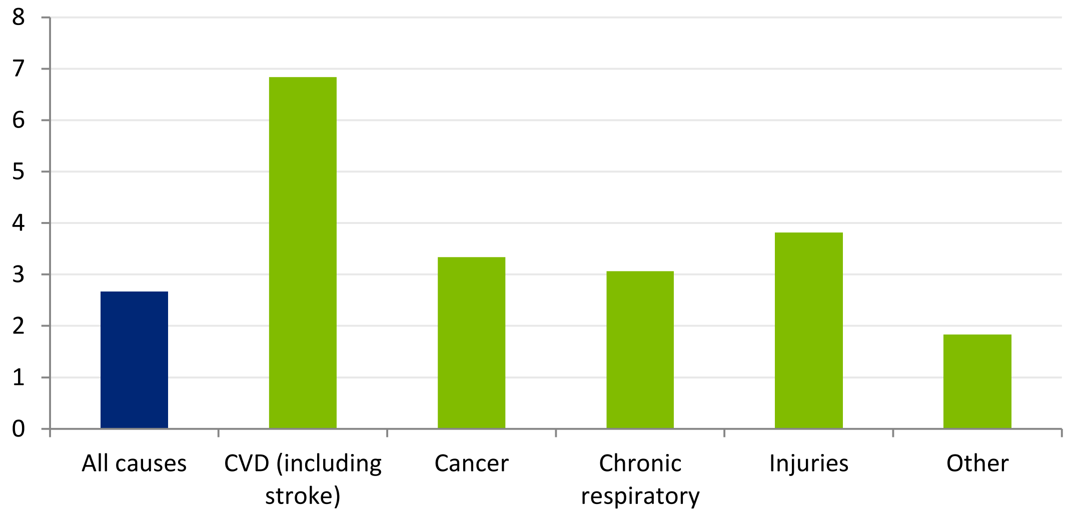
Table 5.1: Benefits, costs and BCR of workforce returns in the base case, detailed causes, 2016-2025

Condition	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
All causes	14.7	2.0	2.3	8.6	27.6	10.3	17.3	2.7
CVD (including stroke)	5.4	0.4	0.3	0.8	6.9	1.0	5.9	6.8
Cancer	3.5	0.2	0.2	1.3	5.1	1.5	3.6	3.3
Chronic respiratory	0.7	0.1	0.2	0.3	1.3	0.4	0.8	3.1
Injuries	0.8	0.1	0.3	0.3	1.5	0.4	1.1	3.8
Other	4.3	1.2	1.4	5.8	12.8	7.0	5.8	1.8

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

> The total benefits of the NHMRC funded health and medical research workforce are estimated to be $27.6 billion between 2016 and 2025, while the cost of funding is expected to be $10.3 billion (real 2015-16 dollars). The net gain would be approximately $17.3 billion, or roughly $172,000 per FTE worker. Overall, for every $1 invested in the NHMRC funded health and medical research workforce, it is expected that the returns will be $2.70, on average.
>
> The net benefit per FTE worker and BCR are lower than the historical analysis due to discounting. If future benefits were valued the same as benefits today, the net benefit per FTE worker would be largely comparable across the time periods. Greater returns are expected to occur for CVD and cancers than for other conditions.

Chart 5.3: BCR of workforce returns in the base case, detailed causes, 2016-2025



Source: Deloitte Access Economics calculations.

5.2 Sensitivity analysis

Sensitivity analysis was also conducted on the results presented above for the forward looking investment model. The sensitivity analysis included:

- an allowance for growing NHMRC research funding over time – to highlight the potential results that may occur under the MRFF scheme;
- static funding in real terms – to highlight the potential continued low funding increases; and
- adjustment for the attribution of health and medical R&D to health outcomes.

5.2.1 Investment models

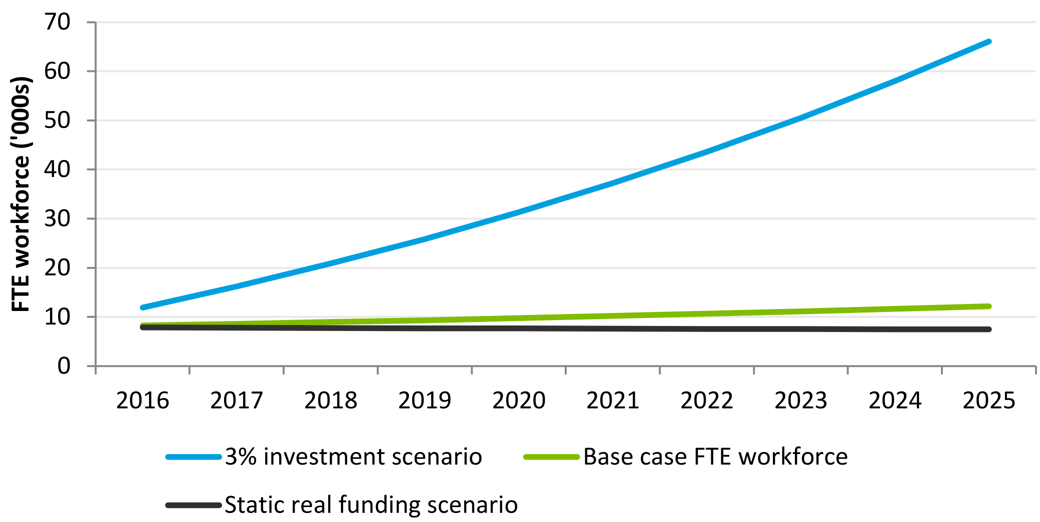
Two investment models were considered in the modelling for a forward looking investment model. These scenarios were:

- NHMRC expenditure was assumed to maintain a fixed share of total HSE from 2016 to 2025 – this fixed share was estimated to be approximately 0.55% in 2015 (or 0.81% of combined government HSE). This was the base case assumption;
- NHMRC expenditure was assumed to grow to 3% of total HSE (or 4.30% of combined government HSE) by 2025 from 0.55% in 2015 – the growth was assumed to be linear; and
- NHMRC expenditure was assumed to be constant in real terms from 2015 onwards (static real funding) – declining from 0.55% of total HSE in 2015 to 0.34% of total HSE by 2025.

Estimates of the total HSE were derived by applying a six-year rolling average growth to historical HSE estimates, while estimates of the Federal government HSE was taken from Deloitte Access Economics Intergenerational Model.

To estimate the changes in workforce and funding over this period, the relationships outlined in section 2.5 were used to model workforce given a certain level of funding, and output given the workforce estimated using the first step. The results of this analysis for the workforce are presented in Chart 5.4 for the workforce (in terms of number of FTEs).

Chart 5.4: Estimated workforce for each investment model, 2016-2025



Source: Deloitte Access Economics calculations.

For each investment model, the share of health returns attributable to the NHMRC funded health and medical research workforce were recalculated given the change in workforce, and subsequent change in output. To recalculate Australian output, the output from other Australian sources was assumed to be constant, while the total Australian output changed by the same amount as the estimated increase in NHMRC health and medical research output. The world output was also increased by the same amount.

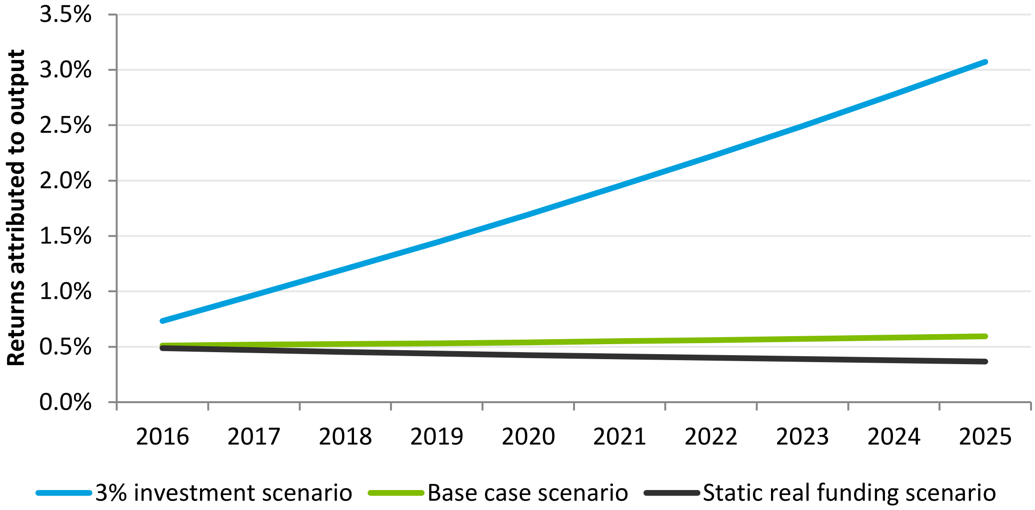
Chart 5.5 shows the health benefits attributed to NHMRC health and medical research output if:

- funding remains fixed as a share of total HSE (base case);
- funding grows to 3% of total HSE by 2025 (3% investment model); and

- funding is static in real terms.

As with the base case, the returns were assumed to occur 40 years after funding, on average.

Chart 5.5: Share of health benefits attributed to the NHMRC health and medical research workforce under each investment model, 2016-2025



Source: Deloitte Access Economics calculations.

The health benefits attributed to NHMRC health and medical research output were estimated for each investment scenario by multiplying the share of health returns that can be attributed to the health and medical workforce by the total DALYs averted (relative to 2000) – which were outlined in section 3.2. The benefits, costs and BCR of workforce returns for each scenario are shown in Table 5.2, for all NHMRC funded research (all causes) and selected conditions.

Table 5.2: Benefits, costs and BCR of workforce returns for each investment model, detailed causes, 2016-2025

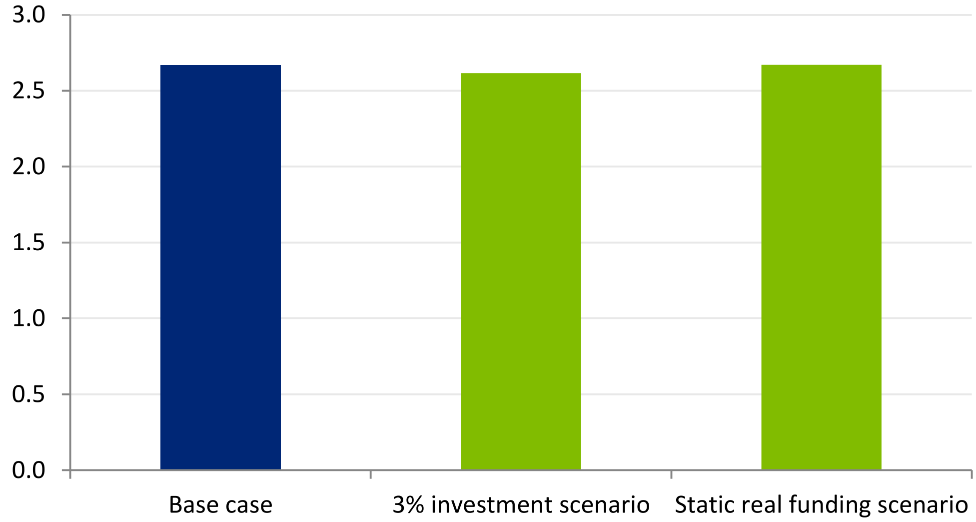
Scenario	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
Base case								
All causes	14.7	2.0	2.3	8.6	27.6	10.3	17.3	2.7
CVD (including stroke)	5.4	0.4	0.3	0.8	6.9	1.0	5.9	6.8
Cancer	3.5	0.2	0.2	1.3	5.1	1.5	3.6	3.3
Chronic respiratory	0.7	0.1	0.2	0.3	1.3	0.4	0.8	3.1
Injuries	0.8	0.1	0.3	0.3	1.5	0.4	1.1	3.8
Other	4.3	1.2	1.4	5.8	12.8	7.0	5.8	1.8
3% investment scenario								
All causes	49.4	6.7	7.8	31.1	94.9	36.3	58.7	2.6
CVD (including stroke)	17.9	1.4	1.0	3.1	23.3	3.6	19.7	6.5
Cancer	11.8	0.6	0.5	4.6	17.5	5.3	12.1	3.3
Chronic respiratory	2.3	0.2	0.5	1.2	4.3	1.4	2.9	3.0
Injuries	2.7	0.4	1.0	1.2	5.2	1.4	3.8	3.7
Other	14.7	4.1	4.8	21.0	44.6	24.5	20.1	1.8
Static real funding scenario								
All causes	11.3	1.5	1.8	6.5	21.2	7.9	13.2	2.7
CVD (including stroke)	4.2	0.3	0.2	0.6	5.3	0.8	4.6	6.8
Cancer	2.7	0.1	0.1	1.0	3.9	1.2	2.7	3.3
Chronic respiratory	0.5	0.1	0.1	0.3	1.0	0.3	0.6	3.1
Injuries	0.6	0.1	0.2	0.3	1.2	0.3	0.9	3.8
Other	3.4	0.9	1.1	4.4	9.8	5.4	4.4	1.8

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

In the base case, total benefits associated with the output of the health and medical research workforce's output were estimated to be $27.6 billion, while costs were estimated to be $10.3 billion. If NHMRC funding was increased to 3% of total HSE by 2025, the benefits and costs were estimated to $94.9 billion and $36.3 billion, respectively. For the static real funding scenario, the benefits and costs were estimated to be $21.2 billion and $7.9 billion, respectively.

Chart 5.6 shows the estimated BCR of workforce returns for both the base case and the 3% investment scenario. There was no substantial change in the BCR for any of the investment scenario.

Chart 5.6: BCR of workforce returns by scenario, all causes, 2016-2025



Source: Deloitte Access Economics calculations.

Overall, the modelling results showed small variances in the BCR under each investment scenario. The BCR was 2.7 in both the base case and static funding scenarios. The BCR was 2.6 in the 3% investment scenario, which represents a similar projection for both costs and benefits between 2016 and 2025.

In the base case, the net benefits are estimated to be $17.3 billion, or $172,000 per FTE worker. For the 3% investment scenario, the net benefits are estimated to be $58.7 billion, or slightly more than $162,000 per FTE worker. Under the static funding scenario, the net benefits are estimated to be $13.2 billion, or slightly less than $173,000 per FTE worker.

5.2.2 Workforce scenarios

Section 2.4 established the associations between NHMRC health and medical research funding, the FTE workforce and its output (in terms of the number of publications produced). Recall that:

1. for every additional $1 million of funding, the FTE workforce would increase by 12.7 people;[7] and
2. for every additional FTE worker, output would increase by 0.9 publications.

For these scenarios, the same workforce assumptions were used to derive the base values in 2015, which were then projected into the future using the logarithmic trends in chapter 2, as for the investment scenarios. Workforce scenarios are only presented for the base case investment scenario (fixed share of total HSE).

[7] Note that in the period between 2016 and 2025, this is implicitly lower due to the declining trend projected as shown in Chart 2.13.

The benefits, costs and BCR of workforce returns for each scenario are shown in Table 5.3 for all NHMRC funded research (all causes). In the base case, total benefits associated with the output of the health and medical research workforce's output are estimated to be $27.6 billion, while costs are estimated to be $10.3 billion. The sensitivity analysis on workforce changes suggests a range of benefits between $16.5 billion and $38.6 billion, while the range for costs were estimated to be $6.1 billion and $14.5 billion for the low and high workforce scenarios, respectively. Overall, the BCR estimated for the base case represents a mid-range of the low and high workforce scenarios, although there is minimal difference between the scenarios.

Table 5.3: Benefits, costs and BCR of workforce returns for each scenario, all causes, 2015-2026

Scenario	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
-40% workforce	8.9	1.2	1.4	5.1	16.5	6.1	10.4	2.70
-20% workforce	11.8	1.6	1.9	6.8	22.1	8.2	13.8	2.68
-10% workforce	13.2	1.8	2.1	7.7	24.8	9.3	15.6	2.67
-5% workforce	14.0	1.9	2.2	8.2	26.2	9.8	16.4	2.67
Base case	14.7	2.0	2.3	8.6	27.6	10.3	17.3	2.67
+5% workforce	15.4	2.1	2.4	9.0	29.0	10.9	18.1	2.67
+10% workforce	16.1	2.2	2.6	9.5	30.4	11.4	19.0	2.66
+20% workforce	17.6	2.4	2.8	10.3	33.1	12.5	20.7	2.66
+40% workforce	20.5	2.8	3.3	12.1	38.6	14.6	24.0	2.65

Source: Deloitte Access Economics calculations. Comm. = commercialisation

The benefits and costs of workforce returns in each workforce scenario are presented relative to the base case in Table 5.4. Costs were estimated to decrease or increase by up to $4.2 billion, while for benefits this was estimated to be $11.0 billion.

Table 5.4: Benefits, costs and BCR of workforce returns relative to the base case, 2015-2026, all causes

Scenario	Benefits ($b)					Costs ($b)	Net benefits ($b)
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*		
-40% workforce	-5.8	-0.8	-0.9	-3.5	-11.1	-4.2	-6.8
-20% workforce	-2.9	-0.4	-0.5	-1.8	-5.5	-2.1	-3.4
-10% workforce	-1.5	-0.2	-0.2	-0.9	-2.8	-1.1	-1.7
-5% workforce	-0.7	-0.1	-0.1	-0.4	-1.4	-0.5	-0.9
Base case	-	-	-	-	-	-	-
+5% workforce	0.7	0.1	0.1	0.4	1.4	0.5	0.9
+10% workforce	1.5	0.2	0.2	0.9	2.8	1.1	1.7
+20% workforce	2.9	0.4	0.5	1.8	5.5	2.1	3.4
+40% workforce	5.8	0.8	0.9	3.5	11.0	4.2	6.8

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

Overall, the modelling results showed small variances in the BCR under each workforce scenario. For the low workforce scenario, the net benefits per FTE worker are estimated to be around $172,500, while for the high workforce scenario, this is estimated to be around $170,500. In the base case, the net benefits per FTE worker are estimated to be around $171,500.

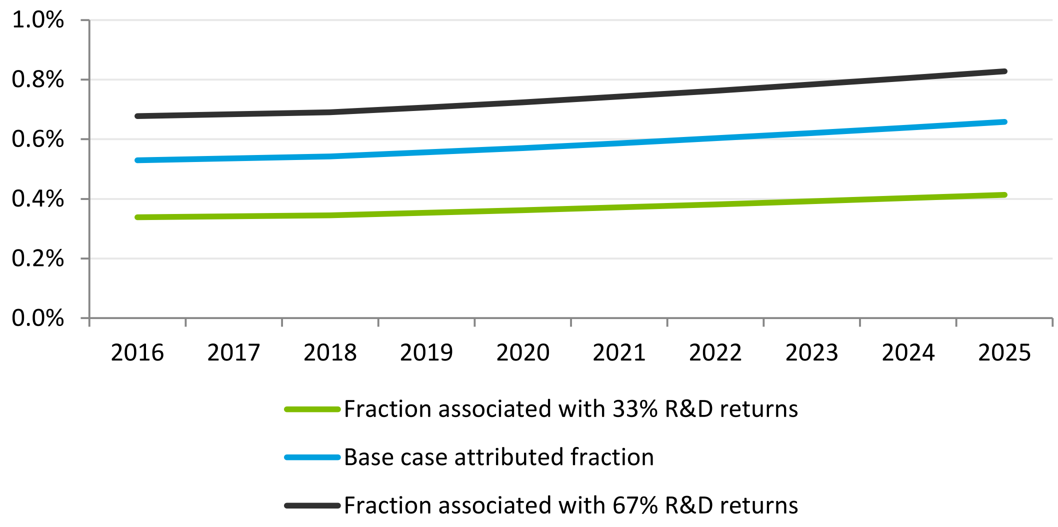
5.2.3 Attribution of health returns to R&D

As with the historical workforce analysis, sensitivity analysis was also conducted on the attribution of health benefits to health and medical R&D. In the base case, it was assumed that 50% of all health benefits are attributed to health and medical R&D. The parameters considered for this analysis were (Cutler and Kadiyala, 2003):

- health and medical R&D was assumed to cause 33% of the change in health outcomes; and
- health and medical R&D was assumed to cause 67% of the change in health outcomes.

For each of these scenarios, the parameter affects the total benefits that are attributed to health and medical R&D as a linear transformation of the base case. Chart 5.7 presents the total health benefits that are attributed to NHMRC funded health and medical workforce research output for each year in the period 2016 to 2025.

Chart 5.7: Share of health benefits attributed to the NHMRC health and medical research workforce by R&D returns, 2016-2025



Source: Deloitte Access Economics calculations.

Table 4.4 shows the estimated health returns that may be attributed to the NHMRC funded health and medical research workforce for each of the scenarios listed. Costs only change with a change in the investment model, as presented in section 5.2.1.

Table 5.5: Benefits, costs and BCR of workforce returns for each scenario, all causes, 2016-2025

Scenario	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
Base case								
33% return to R&D	9.8	1.3	1.6	8.6	21.3	10.3	10.9	2.1
50% return to R&D	14.7	2.0	2.3	8.6	27.6	10.3	17.3	2.7
67% return to R&D	19.6	2.6	3.1	8.6	33.9	10.3	23.6	3.3
3% investment scenario								
33% return to R&D	32.9	4.4	5.2	31.1	73.6	36.3	37.4	2.0
50% return to R&D	49.4	6.7	7.8	31.1	94.9	36.3	58.7	2.6
67% return to R&D	65.8	8.9	10.4	31.1	116.2	36.3	79.9	3.2
Static real funding scenario								
33% return to R&D	7.6	1.0	1.2	6.5	16.3	7.9	8.4	2.1
50% return to R&D	11.3	1.5	1.8	6.5	21.2	7.9	13.2	2.7
67% return to R&D	15.1	2.0	2.4	6.5	26.1	7.9	18.1	3.3

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

It was estimated that benefits will range between $21.3 billion and $33.9 billion during the period 2016 to 2025 if NHMRC funded R&D maintains a fixed share of total HSE. Costs in this scenario would be $10.3 billion, giving a BCR between 2.1 and 3.3. The net benefits per FTE worker are expected to range from $108,500 to $234,500.

Under an investment model where NHMRC funded R&D increases to 3% of total HSE by 2025 (from 0.55% in 2015), it is estimated that benefits will range between $73.6 billion and $116.2 billion during the period 2016 to 2025. Costs in this scenario would be $36.3 billion, giving a BCR between 2.0 and 3.2. The net benefits per FTE worker are expected to range from $103,500 to $221,000.

For the static real funding scenario, where NHMRC funded R&D declines to 0.34% of total HSE by 2025, it is estimated that benefits will range between $16.3 billion and $26.1 billion during the period 2016 to 2025. Costs in this scenario would be $7.9 billion, giving a BCR between 2.1 and 3.3. The net benefits per FTE worker are expected to range from $109,500 to $237,500.

Overall, the modelling showed that net benefits per FTE worker are relative stable between each investment scenario, while altering the share of health benefits attributed to health and medical R&D altered the net benefits between approximately $103,500 and $237,500.

6 Recommendations

In conclusion, the data in this report highlight the major changes currently occurring in the NHMRC-funded workforce and provide evidence of the exceptional health and economic returns of investing in Australia's productive and highly talented research workforce. The data suggest that Australia still has capacity to provide greater output and benefits as a result of investing further in the NHMRC and the workforce it supports.

There are two pertinent recommendations given the findings in this report:

1. There should be an immediate investment into the NHMRC's Medical Research Endowment Account to mitigate the decline in the health and medical research workforce and put the sector back on a sound footing.
2. The success of the Medical Research Future Fund needs to be ensured by creating a long term investment strategy for the NHMRC Medical Research Endowment Account with the purpose of generating a predictable and sustainable health and medical research ecosystem. This will ensure continued health and economic gains which will assist to mitigate the rising and unsustainable cost of health care and the burden of disease Australia is facing.

These two recommended measures will support Australia's expert people to provide exceptional returns to the Australian community now and into the future. People make research happen.

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Appendix A: Detailed results

Table A.1: Benefits, costs and BCR of workforce returns for each scenario, detailed causes, 2000-2015

Scenario/ Condition	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
-40% workforce								
All causes	10.67	1.44	1.69	4.49	18.30	6.23	12.07	2.9
CVD (including stroke)	4.29	0.34	0.24	0.44	5.31	0.61	4.70	8.7
Cancer	2.35	0.11	0.10	0.70	3.26	0.97	2.29	3.4
Chronic respiratory	0.47	0.05	0.11	0.17	0.80	0.23	0.57	3.5
Injuries	0.55	0.07	0.20	0.15	0.97	0.21	0.76	4.7
Other	3.00	0.88	1.04	3.04	7.96	4.21	3.75	1.9
-20% workforce								
All causes	15.51	2.10	2.46	6.02	26.09	8.34	17.74	3.1
CVD (including stroke)	6.25	0.49	0.35	0.59	7.67	0.82	6.85	9.4
Cancer	3.42	0.16	0.15	0.93	4.66	1.29	3.36	3.6
Chronic respiratory	0.69	0.07	0.16	0.22	1.14	0.31	0.83	3.7
Injuries	0.80	0.11	0.28	0.20	1.39	0.28	1.11	5.0
Other	4.36	1.27	1.52	4.07	11.22	5.64	5.58	2.0
-10% workforce								
All causes	17.92	2.42	2.84	6.78	29.97	9.40	20.57	3.2
CVD (including stroke)	7.22	0.57	0.40	0.66	8.85	0.92	7.93	9.6
Cancer	3.95	0.18	0.17	1.05	5.35	1.46	3.90	3.7
Chronic respiratory	0.80	0.08	0.19	0.25	1.32	0.35	0.97	3.8
Injuries	0.92	0.12	0.33	0.23	1.60	0.31	1.29	5.1
Other	5.04	1.47	1.75	4.59	12.85	6.36	6.49	2.0
-5% workforce								
All causes	19.13	2.59	3.04	7.16	31.91	9.93	21.98	3.2
CVD (including stroke)	7.70	0.60	0.43	0.70	9.44	0.97	8.46	9.7
Cancer	4.21	0.20	0.18	1.11	5.70	1.54	4.16	3.7
Chronic respiratory	0.85	0.08	0.20	0.27	1.40	0.37	1.03	3.8
Injuries	0.98	0.13	0.35	0.24	1.70	0.33	1.37	5.2
Other	5.38	1.57	1.87	4.84	13.67	6.72	6.95	2.0
Base case								
All causes	20.33	2.75	3.23	7.54	33.85	10.46	23.39	3.2
CVD (including stroke)	8.19	0.64	0.46	0.74	10.03	1.02	9.00	9.8
Cancer	4.48	0.21	0.19	1.17	6.05	1.62	4.43	3.7
Chronic respiratory	0.90	0.09	0.21	0.28	1.49	0.39	1.10	3.8
Injuries	1.04	0.14	0.37	0.25	1.81	0.35	1.46	5.2
Other	5.72	1.67	1.99	5.10	14.48	7.08	7.40	2.0

Scenario/ Condition	Benefits ($b)					Costs ($b)	Net benefits ($b)	BCR
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*			
5% workforce								
All causes	21.53	2.91	3.42	7.92	35.78	10.99	24.79	3.3
CVD (including stroke)	8.67	0.68	0.48	0.78	10.61	1.08	9.53	9.9
Cancer	4.74	0.22	0.20	1.23	6.40	1.71	4.69	3.8
Chronic respiratory	0.96	0.09	0.23	0.29	1.57	0.41	1.16	3.8
Injuries	1.11	0.15	0.40	0.26	1.91	0.37	1.55	5.2
Other	6.05	1.77	2.11	5.36	15.29	7.43	7.86	2.1
10% workforce								
All causes	22.73	3.07	3.61	8.31	37.72	11.52	26.20	3.3
CVD (including stroke)	9.16	0.72	0.51	0.81	11.20	1.13	10.07	9.9
Cancer	5.01	0.23	0.22	1.29	6.74	1.79	4.96	3.8
Chronic respiratory	1.01	0.10	0.24	0.31	1.66	0.43	1.23	3.9
Injuries	1.17	0.16	0.42	0.28	2.02	0.38	1.63	5.3
Other	6.39	1.87	2.23	5.62	16.10	7.79	8.31	2.1
20% workforce								
All causes	25.13	3.40	3.99	9.07	41.58	12.58	29.00	3.3
CVD (including stroke)	10.12	0.79	0.56	0.89	12.37	1.23	11.14	10.0
Cancer	5.53	0.26	0.24	1.41	7.44	1.95	5.48	3.8
Chronic respiratory	1.12	0.11	0.26	0.34	1.83	0.47	1.36	3.9
Injuries	1.29	0.17	0.46	0.30	2.23	0.42	1.81	5.3
Other	7.06	2.06	2.46	6.13	17.72	8.51	9.21	2.1
40% workforce								
All causes	29.90	4.04	4.75	10.60	49.28	14.70	34.59	3.4
CVD (including stroke)	12.05	0.94	0.67	1.04	14.70	1.44	13.26	10.2
Cancer	6.58	0.31	0.28	1.64	8.82	2.28	6.54	3.9
Chronic respiratory	1.33	0.13	0.31	0.39	2.17	0.55	1.62	4.0
Injuries	1.54	0.21	0.55	0.35	2.64	0.49	2.15	5.4
Other	8.41	2.45	2.93	7.17	20.95	9.94	11.01	2.1

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

Table A.2: Benefits, costs and BCR of workforce returns for each scenario relative to the base case, detailed causes, 2000-2015

Scenario/ Condition	Benefits ($b)					Costs ($b)	Net benefits ($b)
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*		
-40% workforce							
All causes	-9.66	-1.31	-1.53	-3.05	-15.55	-4.24	-11.32
CVD (including stroke)	-3.89	-0.30	-0.22	-0.30	-4.72	-0.41	-4.30
Cancer	-2.13	-0.10	-0.09	-0.47	-2.79	-0.66	-2.13
Chronic respiratory	-0.43	-0.04	-0.10	-0.11	-0.69	-0.16	-0.53
Injuries	-0.50	-0.07	-0.18	-0.10	-0.84	-0.14	-0.70
Other	-2.71	-0.79	-0.95	-2.06	-6.52	-2.86	-3.65
-20% workforce							
All causes	-4.82	-0.65	-0.76	-1.53	-7.76	-2.12	-5.64
CVD (including stroke)	-1.94	-0.15	-0.11	-0.15	-2.35	-0.21	-2.15
Cancer	-1.06	-0.05	-0.05	-0.24	-1.39	-0.33	-1.06
Chronic respiratory	-0.21	-0.02	-0.05	-0.06	-0.34	-0.08	-0.26
Injuries	-0.25	-0.03	-0.09	-0.05	-0.42	-0.07	-0.35
Other	-1.35	-0.40	-0.47	-1.03	-3.25	-1.43	-1.82
-10% workforce							
All causes	-2.41	-0.33	-0.38	-0.76	-3.88	-1.06	-2.82
CVD (including stroke)	-0.97	-0.08	-0.05	-0.07	-1.18	-0.10	-1.07
Cancer	-0.53	-0.02	-0.02	-0.12	-0.70	-0.16	-0.53
Chronic respiratory	-0.11	-0.01	-0.03	-0.03	-0.17	-0.04	-0.13
Injuries	-0.12	-0.02	-0.04	-0.03	-0.21	-0.04	-0.17
Other	-0.68	-0.20	-0.24	-0.52	-1.63	-0.72	-0.91
-5% workforce							
All causes	-1.20	-0.16	-0.19	-0.38	-1.94	-0.53	-1.41
CVD (including stroke)	-0.48	-0.04	-0.03	-0.04	-0.59	-0.05	-0.54
Cancer	-0.26	-0.01	-0.01	-0.06	-0.35	-0.08	-0.27
Chronic respiratory	-0.05	-0.01	-0.01	-0.01	-0.09	-0.02	-0.07
Injuries	-0.06	-0.01	-0.02	-0.01	-0.10	-0.02	-0.09
Other	-0.34	-0.10	-0.12	-0.26	-0.81	-0.36	-0.45
Base case							
All causes	-	-	-	-	-	-	-
CVD (including stroke)	-	-	-	-	-	-	-
Cancer	-	-	-	-	-	-	-
Chronic respiratory	-	-	-	-	-	-	-
Injuries	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-

Scenario/ Condition	Benefits ($b)					Costs ($b)	Net benefits ($b)
	Wellbeing	*Direct*	*Indirect*	*Comm.*	*Total*		
5% workforce							
All causes	1.20	0.16	0.19	0.38	1.94	0.53	1.41
CVD (including stroke)	0.48	0.04	0.03	0.04	0.59	0.05	0.53
Cancer	0.26	0.01	0.01	0.06	0.35	0.08	0.27
Chronic respiratory	0.05	0.01	0.01	0.01	0.09	0.02	0.07
Injuries	0.06	0.01	0.02	0.01	0.10	0.02	0.09
Other	0.34	0.10	0.12	0.26	0.81	0.36	0.45
10% workforce							
All causes	2.40	0.32	0.38	0.76	3.87	1.06	2.81
CVD (including stroke)	0.97	0.08	0.05	0.07	1.17	0.10	1.07
Cancer	0.53	0.02	0.02	0.12	0.69	0.16	0.53
Chronic respiratory	0.11	0.01	0.03	0.03	0.17	0.04	0.13
Injuries	0.12	0.02	0.04	0.03	0.21	0.04	0.17
Other	0.67	0.20	0.24	0.52	1.62	0.72	0.91
20% workforce							
All causes	4.80	0.65	0.76	1.53	7.73	2.12	5.61
CVD (including stroke)	1.93	0.15	0.11	0.15	2.34	0.21	2.14
Cancer	1.06	0.05	0.05	0.24	1.39	0.33	1.06
Chronic respiratory	0.21	0.02	0.05	0.06	0.34	0.08	0.26
Injuries	0.25	0.03	0.09	0.05	0.42	0.07	0.35
Other	1.35	0.39	0.47	1.03	3.24	1.43	1.81
40% workforce							
All causes	9.57	1.29	1.52	3.05	15.44	4.24	11.20
CVD (including stroke)	3.86	0.30	0.22	0.30	4.68	0.41	4.26
Cancer	2.11	0.10	0.09	0.47	2.77	0.66	2.11
Chronic respiratory	0.43	0.04	0.10	0.11	0.68	0.16	0.52
Injuries	0.49	0.07	0.18	0.10	0.84	0.14	0.69
Other	2.69	0.79	0.94	2.06	6.48	2.86	3.61

Source: Deloitte Access Economics calculations. Comm. = commercialisation.

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