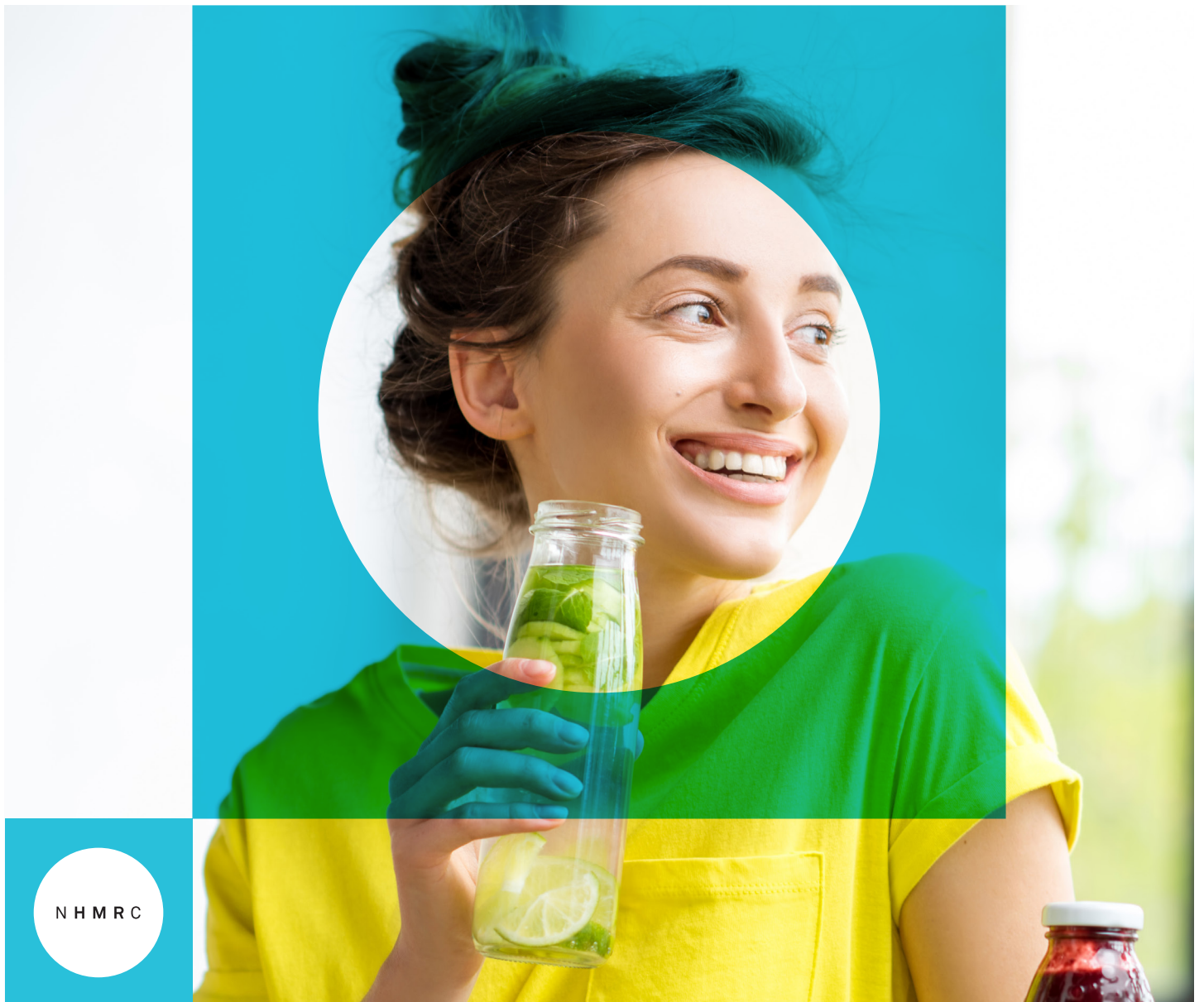




Measuring up 2018

NHMRC-supported research: the impact of journal publication output
2008-2012



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NHMRC SUPPORT FOR AUSTRALIAN HEALTH AND MEDICAL RESEARCH

31%

NHMRC publications contributed to **31%** of all Australian health and medical research output in 2008–2012

High impact research

The relative citation impact of NHMRC-supported publications was **68%** above the world average.

In comparison:

- The average citation rate for Australian health and medical research publications was **30%** above the world average.
- Australian health and medical research publications that were not supported by NHMRC funding were **12%** above the world average.

NHMRC funding supported nearly half (**45%**) of the Australian health and medical research publications that are in the top 1% of cited publications in the world.



NHMRC publications account for **three times** more publications than expected among the top 1% of cited publications in the world.

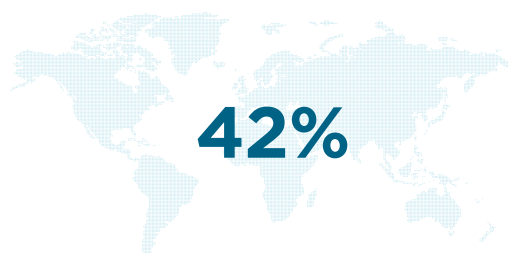
Some NHMRC grant schemes achieve almost twice the world average citation impact: Targeted Calls for Research (**100%** above the world benchmark), Practitioner Fellowships (**97%**), Program Grants (**97%**) and International Collaborations (**96%**).

Increasing citation impact

1.60  1.68

The relative citation impact of NHMRC publications increased from **1.60 to 1.68** since the previous *Measuring up* report.

International collaboration



42% of NHMRC publications involved international collaborations, up from 40% since the previous report. NHMRC-funded researchers collaborated with authors from over 135 countries—most often the United States, the United Kingdom, Canada, Germany or The Netherlands.

Executive summary



Background

Measuring up 2018 is a five-year bibliometric analysis of the scientific publication output of Australian health and medical research, focusing on research funded by the National Health and Medical Research Council (NHMRC).

Bibliometrics—analysis of publication output and citation impact—provides a measure by which NHMRC can assess the impact of its funded research in both a national and international context. This analysis also examines the extent of NHMRC support across the Australian health and medical research landscape and patterns of national and international research collaborations.

Measuring up 2018 analyses all Australian publications from 2008 to 2012 in biomedical journals indexed in the Web of Science (WoS) database.¹

Main findings

Australian health and medical research and NHMRC-supported research

Australia performs well in health and medical research (HMR). NHMRC's contribution to the national HMR effort is increasing.

- Australia's share of the world biomedical journal publication output was 3.6% in 2008–2012, up from 3.1% in 2005–2009.
- The number of publications attributed to NHMRC-supported research has increased since the last reporting period: from 20,960 in 2005–2009 to 29,523 in 2008–2012. This represents an increase in output of 41%. In the same period, world output grew by 18%—less than half NHMRC's rate—and Australia's overall publications output grew by 39%.
- The increase in NHMRC-supported publication output is seen across the board. However, the following sub-fields recorded a notable increase in their output since the 2005–2009 period:
 - Multidisciplinary Sciences (up 338%)
 - Biomedical Engineering (up 109%)
 - Public Health and Health Services (up 86%)
 - Medical Biochemistry and Metabolomics (up 65%)
 - Nutrition and Dietetics (up 62%)
 - Cardiovascular Medicine and Haematology (up 61%).
- The NHMRC-supported scientific journal publications rate within the Australian total has remained constant at 31%. This equates to just over 1% of the world's output in this area.
- One-third of publications from the Hospitals, Non-profit, and Universities sectors and two-thirds from the Research Institutes sector were linked to NHMRC support.

¹ The term 'biomedical' as used in this report encompasses all sub-fields of research in *Medical and Health Sciences*, covering clinical, public health and health services research, and also relevant sub-fields from *Biological Sciences*, *Physical Sciences* and *Biomedical Engineering*. See [Appendix C](#) for WoS journal subject categories used in this analysis.

Executive summary

- NHMRC support contributed to a large proportion of total Australian publications in the following sub-fields:
 - Immunology (55%)
 - Biochemistry and Cell Biology (45%)
 - Cardiovascular Medicine and Haematology (41%)
 - Neurosciences (41%)
 - Oncology and Carcinogenesis (40%)
 - Other Medical and Health Sciences (40%).

Citation impact

NHMRC-supported research is highly cited and accounts for a significant number of Australia's most highly cited publications.

- The relative citation impact of NHMRC-supported journal publications is 1.68, that is, 68% above the world average (up from 1.60 in the previous reporting period). Non-NHMRC-supported research in Australia is 1.12, that is, 12% above the world average.
- NHMRC-supported publications account for approximately three times more publications than expected among the top 1% of cited papers in the world.
- Approximately 45% of Australia's most highly cited publications (defined as the top 1% in the world) are attributed to NHMRC support. This is noteworthy given that NHMRC-supported publications represent only 31% of the total Australian publication output.
- The high citation impact was seen across all NHMRC grant schemes, with some achieving almost twice the world average citation impact, notably: Targeted Calls for Research (100% above the world average), Practitioner Fellowships and Program Grants (both 97% above the world average), and International Collaborations (96% above the world average).

Research collaboration

Collaboration in NHMRC-supported research is strong and growing. This reflects the world-wide trend of increased collaboration in research.

In the 2008-2012 period:

- 42% of NHMRC-supported publications had international co-authors, compared with just under 40% in the previous report. This is slightly lower than the Australian average (45%).
- NHMRC-supported publications with international authors achieved a high relative citation impact at 114% above the world average. Other Australian biomedical publications with international authors also performed well by world standards, with a relative citation impact 46% above the world benchmark.
- The percentage of domestic collaborations remains higher among NHMRC-supported publications than the Australian average (56% for NHMRC, compared to 50% for Australia).
- NHMRC-supported publications demonstrated a consistently higher proportion of cross-sector collaboration than other publications. For example, in the Hospitals sector, 97% of NHMRC-supported publications had at least one author from another sector, compared to 74% for non-NHMRC publications.
- NHMRC-funded researchers collaborated with authors from over 135 countries. The most frequent collaborating countries were the United States (42% of internationally collaborative papers had one or more co-author from the US—above the Australian average of 36%), followed by UK (22%), Canada (12%), Germany (11%) and the Netherlands (8%).

Methodology overview

Data used

The analyses in this report are based on WoS data for publications that appeared between 2008 and 2012 and the citations they attracted between 2008 and 2013.

Additional information on NHMRC-supported publications and NHMRC grant schemes is derived from NHMRC's Research Grants Management System (RGMS) and End of Grant Reports.

See [Section 1.1](#) for details.

Research sectors and NHMRC grant schemes analysed

For the purpose of this analysis, six '*research sectors*' have been identified: Government, Hospitals, Industry, Non-profit, Research Institutes, and Universities.

NHMRC research grant schemes have been analysed as '*NHMRC schemes*'. Thirteen schemes have been identified: Capacity Building Grants, Career Development Fellowships (CDFs), Centres of Research Excellence (CREs), Development Grants, Early Career Fellowships (ECFs), International Collaborations, Partnerships, Postgraduate Scholarships, Practitioner Fellowships, Program Grants, Project Grants, Research Fellowships and Targeted Calls for Research.

See [Section 1.2-1.3](#) for a description of each group and the identification of their publications.

Fields of research analysed

Measuring up 2018 focuses on biomedical fields and sub-fields of research. It uses WoS journal subject categories (detailed in [Appendix C](#)) to delineate the relevant fields of research.

See [Section 1.4](#) for details.

Bibliometric indicators used

The bibliometric indicators used in this report are:

- number of publications
- relative citation impact
- relative specialisation ratio
- distribution of highly cited publications
- level of collaboration.

These are detailed in [Section 1.6](#).

Limitations of bibliometric analyses

Bibliometric analysis is a valuable tool for gaining insights into the research landscape. However, as with any analytic tool, each bibliometric indicator has its own strengths and weaknesses and should not be used to draw conclusions selectively or in isolation. Only in combination with other quality measures of esteem, performance and visibility and with the testimony of expert peers can these measures provide a balanced evaluation of a body of work.

Comparison to previous report



Methodological changes

This report follows the methodology used in the previous bibliometric report, *Measuring up 2013*, which covered publications from 2005 to 2009. However, the following differences between the two reports should be taken into account when comparing data (see [Section 1.7](#) for further detail).

- Six additional grant schemes have been included in the current report, providing a more complete coverage of NHMRC-funded research. These new schemes have contributed to the overall increase in NHMRC-supported publication output.
- The research sectors have been expanded, with two new sectors: Industry and Non-profit. Cooperative Research Centres (CRCs), analysed as a separate sector in *Measuring up 2013*, are now covered within the Non-profit sector because of insufficient CRC publication numbers.
- The research sectors in this report are delineated differently from those in *Measuring up 2013*. Previously, any publication that was attributed to NHMRC support was removed from the research sectors category, enabling readers to make the distinction between publications that were supported through NHMRC funding and those that were not. Thus the sectors analysed in *Measuring up 2013* as 'research sectors' covered only publications that had no link to NHMRC funding. Research sector publications in the current report include the *complete* sector output as well as disaggregated totals based on the funding source (that is, those that received NHMRC support and those that did not).

Publication output and citation impact comparisons by research sector and NHMRC scheme

This report covers only those publications that have been reported to NHMRC and indexed in WoS journals. Therefore, the NHMRC-supported publication output included in both this bibliometric analysis and *Measuring up 2013* is a sub-set of the total output attributable to NHMRC support. Further factors that can contribute to the under-representation of NHMRC publications are discussed in [Section 1.3.1](#).

[Table 1](#) and [Table 2](#) present a comparison of publication output between this report and *Measuring up 2013* for individual NHMRC grant schemes and research sectors, respectively. As illustrated, the number of publications linked to NHMRC support has increased by 41%. However, this growth is not evenly spread. In the grant schemes that can be directly compared between the two reporting periods, three have shown a significant increase in publication outputs: Project Grants scheme (123% increase), Career Development Fellowships (46% increase) and Early Career Fellowships (43% increase). Publication output for Centres of Research Excellence has decreased by 18%.

The overall increase in NHMRC-supported output in this report is attributable to a number of factors, including:

- a general increase in research publication output across biomedical research fields
- increased funding by NHMRC
- expanded grant scheme coverage in this current report with six additional grant schemes, adding approximately 1,100 publications to the NHMRC total
- improvements in publication data collection mechanisms in RGMS since about 2011. These changes have enabled an increasing number of NHMRC-supported publications to be captured for analysis. This is reflected in the increased outputs recorded for the Project Grants scheme. Publications from Project Grants included in this analysis are primarily extracted from RGMS. Previously, data were obtained only from the End of Grant Reports which did not include all publications resulting from every grant, as publications continue to be produced long after these reports were submitted.

Comparison to previous report

Table 1: Publication output in *Measuring up 2013* and the current report, by NHMRC scheme

NHMRC scheme	<i>Measuring up 2013</i> (2005–2009)	Current report (2008–2012)	% change
Capacity Building Grants*	nd	945	na
Career Development Fellowships	3,851	5,611	46
Centres of Research Excellence	3,001	2,447	-18
Development Grants*	nd	203	na
Early Career Fellowships	3,276	4,676	43
International Collaborations*	nd	478	na
Partnerships*	nd	192	na
Postgraduate Scholarships*	nd	650	na
Practitioner Fellowships	1,600	2,078	30
Program Grants	7,678	8,107	6
Project Grants	6,278	13,992	123
Research Fellowships	7,625	10,149	33
Targeted Calls for Research*	nd	965	na
Australia total	68,657	95,693	39
Australia total linked to NHMRC funding[†]	20,960	29,523	41
Australia total without NHMRC funding	47,697	66,170	39
World	2,237,732	2,642,556	18

na = not applicable; nd = no data

* Not included in *Measuring up 2013*.

† There is some publication overlap between NHMRC schemes due to research collaborations. As a result, the sum of NHMRC schemes is greater than the NHMRC total.

Table 2: Publication output in *Measuring up 2013* and the current report, by research sector and NHMRC support

Research sector	NHMRC support	<i>Measuring up 2013</i> (2005–2009)	Current report (2008–2012)	% change
Government	Government total	6,578	6,845	4
	Linked to NHMRC funding	1,119	958	-14
	Without NHMRC funding	5,459	5,887	8
Hospitals	Hospitals total	18,764	36,193	93
	Linked to NHMRC funding	5,749	12,801	123
	Without NHMRC funding	13,015	23,392	80
Industry*	Industry total	nd	4,162	na
	Linked to NHMRC funding	nd	792	na
	Without NHMRC funding	nd	3,370	na
Non-profit*	Non-profit total	nd	5,860	na
	Linked to NHMRC funding	nd	1,987	na
	Without NHMRC funding	nd	3,873	na
Research Institutes	Research Institutes total	14,044	21,420	53
	Linked to NHMRC funding	9,525	14,189	49
	Without NHMRC funding	4,519	7,231	60
Universities	Universities total	52,822	81,209	54
	Linked to NHMRC funding	16,863	27,015	60
	Without NHMRC funding	35,959	54,194	51
Australia	Australia total[†]	68,657	95,693	39
	Linked to NHMRC funding	20,960	29,523	41
	Without NHMRC funding	47,697	66,170	39
World	World total	2,237,732	2,642,556	18

na = not applicable; nd = no data

* Not included in *Measuring up 2013*.

† There is some publication overlap between research sectors due to cross-sector collaborations. As a result, the sum of component sectors (Government, Hospitals, Industry, Non-profit, Research Institutes and Universities) is greater than the Australian total.

Comparison to previous report

Table 3 and Table 4 present a comparison of the relative citation impact of publication output between this report and *Measuring up 2013* for individual NHMRC grant schemes and research sectors, respectively. In aggregate terms, the relative citation impact (RCI) of NHMRC-linked publications has risen from 1.60, in the previous reporting period, to 1.68 in this Report. The citation rate of Australian publications without NHMRC funding, at 1.12, is lower than the NHMRC-linked RCI, but has increased more (+0.13). Given the overall citation performance of NHMRC-supported publications is well above the Australian and global average, additional gains above this level are not easy to achieve. All NHMRC schemes saw an increase in citation performance except for Research Fellowships in which the relative citation impact remained unchanged at 1.81. The most noticeable increase is in the Practitioner Fellowships scheme: 1.68 to 1.97 (+0.29).

Table 3: Relative citation impact of publication output in *Measuring up 2013* and the current report, by NHMRC scheme

NHMRC scheme	<i>Measuring up 2013</i> (2005–2009)	Current report (2008–2012)	Change
Capacity Building Grants*	nd	1.51	na
Career Development Fellowships	1.51	1.64	+0.13
Centres of Research Excellence	1.50	1.70	+0.19
Development Grants*	nd	1.73	na
Early Career Fellowships	1.51	1.70	+0.19
International Collaborations*	nd	1.96	na
Partnerships*	nd	1.73	na
Postgraduate Scholarships*	nd	1.69	na
Practitioner Fellowships	1.68	1.97	+0.29
Program Grants	1.92	1.97	+0.05
Project Grants	1.61	1.66	+0.05
Research Fellowships	1.81	1.81	0.00
Targeted Calls for Research*	nd	2.00	na
Australia total	1.17	1.30	+0.13
Australia total linked to NHMRC funding	1.60	1.68	+0.08
Australia total without NHMRC funding	0.98	1.12	+0.13
World	1.00	1.00	na

na = not applicable; nd = no data

* Not included in *Measuring up 2013*.

Table 4: Relative citation impact of publication output in *Measuring up 2013* and the current report, by research sector and NHMRC support

Research sector	NHMRC support	<i>Measuring up 2013</i> (2005–2009)	Current report (2008–2012)	Change
Government	Government total	1.09	1.21	+0.12
	Linked to NHMRC funding	1.41	1.87	+0.47
	Without NHMRC funding	1.03	1.09	+0.06
Hospitals	Hospitals total	1.01	1.30	+0.29
	Linked to NHMRC funding	1.40	1.68	+0.28
	Without NHMRC funding	0.85	1.08	+0.23
Industry*	Industry total	nd	1.12	na
	Linked to NHMRC funding	nd	1.58	na
	Without NHMRC funding	nd	0.99	na
Non-profit*	Non-profit total	nd	1.31	na
	Linked to NHMRC funding	nd	1.74	na
	Without NHMRC funding	nd	1.07	na
Research Institutes	Research Institutes total	1.63	1.72	+0.09
	Linked to NHMRC funding	1.83	1.85	+0.03
	Without NHMRC funding	1.26	1.43	+0.17
Universities	Universities total	1.13	1.29	+0.16
	Linked to NHMRC funding	1.51	1.62	+0.11
	Without NHMRC funding	0.96	1.11	+0.15
Australia	Australia total	1.17	1.30	+0.13
	Linked to NHMRC funding	1.60	1.68	+0.08
	Without NHMRC funding	0.98	1.12	+0.13
World	World total	1.00	1.00	na

na = not applicable; nd = no data

* Not included in *Measuring up 2013*.

NHMRC-supported publication output and citation impact comparisons by field of research

Table 5 shows NHMRC-supported publication output broken down by sub-fields of research for both the current (2008–2012) and previous reporting period (2005–2009). It describes changes in publication output and citation impact at the discipline level. As shown, there has been an increase in publication output across all fields, with growth ranging from 13% in the sub-fields of Medical Physiology and Immunology to 338% in Multidisciplinary Sciences.

Citation performance increased in most disciplines. In the broad field of Medical and Health Sciences, the RCI increased from 1.66 to 1.79 (+0.12). Only eight sub-fields saw a reduction in citation performance, most notably Multidisciplinary Sciences, and Public Health and Health Services. However, the publication volume increase in both of these sub-fields since the last report was larger than in other disciplines.

Table 5: Number of NHMRC-supported publications and relative citation impact in *Measuring up 2013* and the current report, by field of research

Field of research	Sub-field of research	Publication output			Relative citation impact		
		<i>Measuring up 2013</i> (2005–2009)	Current report (2008–2012)	% change	<i>Measuring up 2013</i> (2005–2009)	Current report (2008–2012)	Change
Medical and Health Sciences	Total for Medical and Health Sciences field	17,191	23,733	38	1.66	1.79	+0.12
	Medical Biochemistry and Metabolomics	155	255	65	1.47	1.54	+0.06
	Cardiovascular Medicine and Haematology*	1,501	2,416	61	1.57	1.62	+0.05
	Clinical Sciences	6,519	8,594	32	1.66	1.75	+0.09
	Complementary and Alternative Medicine [†]	8	38	375	nd	nd	na
	Dentistry [†]	79	137	73	nd	2.02	na
	Human Movement and Sports Science	407	568	40	1.79	1.73	-0.05
	Immunology	1,823	2,051	13	1.51	1.54	+0.04
	Neurosciences	2,761	3,710	34	1.33	1.47	+0.14
	Nursing [†]	65	147	126	nd	1.60	na
	Nutrition and Dietetics	373	605	62	1.27	1.33	+0.06
	Oncology and Carcinogenesis	1,142	1,654	45	1.28	1.63	+0.36

Table 5: *continued*

Field of research	Sub-field of research	Publication output			Relative citation impact		
		<i>Measuring up 2013</i> (2005–2009)	Current report (2008–2012)	% change	<i>Measuring up 2013</i> (2005–2009)	Current report (2008–2012)	Change
Medical and Health Sciences (cont)	Optometry and Ophthalmology	507	669	32	1.45	1.70	+0.25
	Paediatrics and Reproductive Medicine	1,065	1,578	48	1.63	1.89	+0.25
	Pharmacology and Pharmaceutical Sciences	1,033	1,520	47	1.63	1.58	-0.05
	Medical Physiology	882	996	13	1.37	1.58	+0.21
	Public Health and Health Services*	1,546	2,876	86	1.49	1.45	-0.04
	Other Medical and Health Sciences	598	841	41	2.02	1.78	-0.23
	General Medical and Health Sciences	983	1,261	28	2.84	3.69	+0.85
Biological Sciences‡	General Biological Sciences	706	934	32	1.74	1.63	-0.11
	Biochemistry and Cell Biology	3,177	4,060	28	1.40	1.38	-0.02
	Genetics	929	1,190	28	1.48	2.05	+0.56
	Microbiology	974	1,257	29	1.27	1.54	+0.27
Physical Sciences‡	Biological Physics	311	441	42	1.26	1.17	-0.09
Engineering‡	Biomedical Engineering	137	286	109	1.37	1.57	+0.20
Multi-disciplinary Sciences	Total for Multi-disciplinary Sciences field	277	1,214	338	2.07	1.67	-0.40
All biomedical sciences	Total for all biomedical sciences	20,960	29,523	41	1.60	1.68	+0.08

na = not applicable; nd = no data

* Some changes have been made to journal categories analysed in these sub-fields since this report. See [Section 1.7.2](#) for details.

† Relative citation impact was not calculated for any units with fewer than 100 publications.

‡ These fields are not covered in their entirety. Only sub-fields relevant to biomedical research within these fields are analysed.

Introduction



Scientific research at the highest level is knowledge creation: it expands our understanding of the world. At the applied level, health and medical research contributes to improvements in health policy and practice, and to the development and commercialisation of diagnostic, preventative and therapeutic products. Knowledge creation is generally assessed by analysing scientific publication outputs.

Scientific publication outputs provide a useful measure because most publications are peer-reviewed, meaning their data and conclusions have undergone quality assurance. Publications are also important as they help disseminate new discoveries and eventually contribute to the development of new policies, practices and products and, in the case of health and medical research, ultimately lead to better health outcomes for all.

Measuring up 2018 is the latest in a series of scientific publication analyses that NHMRC has published since 1996.² It considers all Australian biomedical research publications published in peer-reviewed journals in the period 2008 to 2012 and indexed in the Web of Science database, and provides an analysis of knowledge production in terms of scientific publication output resulting from NHMRC-funded research. The analysis considers patterns of growth, citation impact, and the level and type of scientific collaboration, in both a national and international context. It also provides a comparative analysis of the relevant publication output by research sector.

This assessment contributes to the evidence base for NHMRC's strategic policy development and provides one means to measure the impact of NHMRC-funded research. It helps NHMRC to assess the effectiveness of its peer review processes for grant selection, while at the same time demonstrating the accomplishments of publicly funded research to the general community.

This report has four sections:

- Section 1: *Methodology* defines the sectors and outlines publication data selection and bibliometric indicators.
- Section 2: *Australian biomedical research* provides an overview of Australia's biomedical research landscape and NHMRC's contribution to the nation's health and medical research.
- Section 3: *Citation performance of Australian biomedical publications* provides an analysis of publication output in terms of relative citation impact and the percentile distribution of highly cited papers.
- Section 4: *Collaboration in scientific research* examines authorship patterns and the level of national and international collaboration in Australian health and medical research.

² NHMRC bibliometric reports are available at www.nhmrc.gov.au/funding/data-research/nhmrc-analysis-australian-health-and-medical-research-publications.

1. Methodology



The methodology of this report follows from the previous NHMRC bibliometric report *Measuring up 2013*.³ While there are some changes and refinements to the methodology used, care has been taken to retain key measures and indicators in order to make the findings of this report as closely comparable as possible to previous NHMRC bibliometric reports.

As in all previous NHMRC bibliometric reports, the term ‘biomedical’ is used to refer to publications appearing in journals classified to Web of Science (WoS) subject categories that encompass all sub-fields of research in *Medical and Health Sciences*, covering clinical, public health and health services research, and also relevant sub-fields from *Biological Sciences*, *Physical Sciences* and *Biomedical Engineering*. See [Appendix C](#) for WoS journal subject categories used in this analysis.

1.1 Data sources

Measuring up 2013 is based on publications and citation data available in two Clarivate Analytics databases: National Citation Report and Journal Performance Indicators. The version of the National Citation Report used for this report includes all Australian publications appearing in biomedical journals indexed in the WoS database, together with yearly counts of citations received by each publication. While WoS does not cover all the scientific journals published, it captures a significant proportion of peer-reviewed journals in biomedical sciences.

Information on NHMRC-supported publications and grant schemes has been obtained from NHMRC’s Research Grants Management System (RGMS) and End of Grant Reports, and incorporated into the publications dataset.

The publications dataset used for this report was developed using the following criteria:

- All publications must:
 - have at least one Australian address in the institution affiliation field
 - appear in biomedical journals (defined by WoS journal subject categories as shown in [Appendix C](#))
 - be indexed in the WoS (Science Citation Index Expanded, Social Science Citation Index)
- Research articles and reviews are included when published between 2008 and 2012
- Citation coverage of these publications is between 2008 and 2013.

Data were compiled on a publication-year basis, not a tape-year basis—that is, the year the item was published, not the year its details were entered into the WoS database.

This analysis is based on whole publication counts—that is, where more than one sector or NHMRC grant scheme contributed to a publication, each was given a count of one for that publication. While this can create an overlap between sectors/schemes, it provides an accurate picture of the relative contribution of each.

³ National Health and Medical Research Council (2013) *Measuring up 2013*. Canberra: National Health and Medical Research Council.

1.2 Definition of research sectors and NHMRC grant schemes

This report aims to provide a comparative analysis of publications arising from NHMRC-funded research and publications produced without NHMRC support. To achieve this, publications have been analysed on the basis of the site of research, defined as the *research sector*. Six research sectors have been identified, as described in [Section 1.2.1](#) below. Publications within each research sector have then been divided into two groups on the basis of NHMRC funding support: those that were linked to NHMRC funding and those that were not. NHMRC-supported publications have then been further divided on the basis of the NHMRC funding scheme that provided the funding support for the research projects, and analysed as *NHMRC schemes*. NHMRC schemes are described in [Section 1.2.2](#).

1.2.1 Research sectors

The six research sectors identified in this report are described below.

1. Government

The Government sector covers the output (publications in biomedical journals) of full-time and part-time researchers working in Federal and State government departments and agencies. This sector also includes the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

2. Hospitals

The Hospitals sector includes all relevant publications from hospitals, both public and private. It covers the output of full-time and part-time researchers, funded principally through hospital general operating grants and through competitive grants obtained from various funding sources.

3. Industry

The Industry sector includes relevant publications from for-profit businesses (e.g. biotechnology companies and medical practices).

4. Non-profit

The Non-profit sector comprises not-for-profit organisations, medical research institutes (that is, institutes that are not members of the Association of Australian Medical Research Institutes (AAMRI)), Cooperative Research Centres (CRCs) conducting research in health and medical sciences (e.g. CRC for Vaccine Technology), the Australian and New Zealand Intensive Care Society, industry bodies such as the Australian Medical Association and all other not-for-profit organisations not elsewhere included.

5. Research Institutes

The Research Institute sector covers medical research institutes employing researchers, funded principally through general operating grants and through competitive grants obtained from various funding sources. All the member institutions of AAMRI are included in this sector. See [Appendix B](#) for the full list of medical research institutions included in this sector.

6. Universities

The University sector covers the output of full-time and part-time researchers, most of whom retain teaching and administrative responsibilities, funded principally through university general operating grants and through competitive grants obtained from various funding sources. All relevant publications from universities appearing in biomedical journals are included.

1.2.2 NHMRC grant schemes

This analysis covers NHMRC funding schemes, both current and superseded, that supported any relevant publications in the period between 2008 and 2012. Thirteen schemes are identified.

1. Capacity Building Grants

Capacity Building Grants provide support to allow population health and health services researchers to pursue broadly based collaborative research activity. The teams are expected to contribute new knowledge at a leading national and international level in important areas of

health and medical research, tackle problems for which longer term stable funding is essential and provide training and career development opportunities within the team. The last funding application round for this scheme was 2008, but a sufficient number of publications have arisen from these grants for this scheme to be included in the report.

2. Career Development Fellowships (CDFs)

CDFs aim to further develop the career of early to mid-career Australian health and medical researchers. The four-year fellowship enables investigators to establish themselves as independent, self-directed researchers early in their research career; expand the capacity for biomedical, clinical, public health and health service delivery research, and for evidence-based policy development in Australian health systems; and encourage the translation of research outcomes into practice.

3. Centres of Research Excellence (CREs)

CREs provide support for teams of researchers to pursue collaborative research and develop capacity in clinical, population health and health services research. The duration of CREs is five years. For the purposes of this report, this scheme also includes publications from the Centres of Clinical Research Excellence (CCRE) scheme, which was superseded by the CREs in 2010.

4. Development Grants

Development Grants provide financial support to individual researchers and/or research teams to undertake health and medical research within Australia at the proof-of-principle or pre-seed stage. The research must specifically drive towards a commercial outcome within a five-year timeframe. Funding supports development work in a health-related field including diagnostics, medical devices, pharmaceutical product development, biotechnology, bioinformatics and biomaterials.

5. Early Career Fellowships (ECFs)

The aim of the four-year Early Career Fellowships is to enable developing health and medical researchers of outstanding ability to undertake advanced training in health and medical research either in Australia or overseas. A major objective of the scheme is to foster career development at the postdoctoral level by encouraging the grant recipient to experience a different research environment.

6. International Collaborations

A number of schemes are included under the category of International Collaborations. In general, these grants aim to provide assistance to Australian researchers to participate in multinational collaborative research projects with international researchers. The focus of these grants can be knowledge creation and/or research translation. Publications included under this category are from following grant schemes:

- International Collaborative Research Grants (ICRG) Scheme (which is a partnership between the Wellcome Trust, NHMRC and the Health Research Council (HRC) of New Zealand)
- NHMRC-European Union Collaborative Research Grants
- Diabetes Collaborative Research Grants
- International Indigenous Health Research Partnership
- Global Alliance for Chronic Diseases (GACD) Scheme.

7. Partnerships

A number of schemes are included under the title 'Partnerships' for the purpose of this report. Partnership programs are intended to improve health care through stronger evidence-based approaches, and to create effective collaboration between policy and research. The majority of publications in this group are from Partnership Projects and Partnership Centres, which fall under the NHMRC Partnerships for Better Health initiative. Also included under this group are the publications from:

- Health Research Partnership in Injury
- Health Research Partnership in Mental Health
- Health Research Partnership in Type 2 Diabetes.

1. Methodology

8. Postgraduate Scholarships

The Postgraduate Scholarships scheme funds outstanding health and medical graduates to attain a research-based postgraduate degree (Doctor of Philosophy (PhD) or a Master's Degree). The aim is to support early career graduates so they can develop a capacity for original independent research within Australia and be trained to conduct research that is internationally competitive.

9. Practitioner Fellowships

The Practitioner Fellowships scheme aims to support research that results in the translation of new evidence into improved clinical practice and health policy, and that delivers improvements in health and healthcare to Australians. Practitioner Fellowship holders are active clinicians and public health or health services professionals. These five-year fellowships are part-time with holders expected to devote 30–70% of their time to achieving the outcomes of the fellowship.

10. Program Grants

The aim of the Program Grants scheme is to provide support for teams of high calibre researchers to pursue broad-based, multi-disciplinary and collaborative research activities. Teams are expected to contribute to new knowledge at a leading international level in important areas of health and medical research. Funding is provided for a five year period.

11. Project Grants

The objective of the Project Grants scheme is to support the creation of new knowledge by funding the best investigator-initiated research project plan of five years or less, in any area relevant to human health. Researchers usually retain teaching and/or clinical duties within their institutions. Single investigators or teams of up to ten chief investigators are supported, as well as new investigators.

12. Research Fellowships

This five-year fellowship provides support for outstanding internationally recognised researchers with proven track records to undertake research that is both of major importance in its field and of significant benefit to Australian health and medical research. Research Fellowships support biomedical, clinical and public health research.

13. Targeted Calls for Research (TCR)

A Targeted Call for Research is a one-time solicitation for grant applications to address a specific health issue. This scheme complements NHMRC's suite of funding schemes by funding priority research in defined areas of need and when urgent research needs emerge.

Given the collaborative nature of most research, with multi-authored papers being very common, it is inevitable that there will be double-counting between sectors and grant schemes in this report. Where authors from more than one sector/scheme contribute to a publication, it is counted in full for each sector/scheme involved. That is, a publication might be counted once in the University sector and again in the Hospitals sector.

1.3 Identification of publications for each sector

1.3.1 NHMRC grant schemes

A number of methods have been employed to identify NHMRC-supported publications resulting from research funded through different grants schemes. The primary source of data is researcher CVs in RGMS. RGMS CVs require grant recipients to include publications data resulting from their NHMRC research projects as part of the end of grant reporting process. End of Grant Reports that NHMRC received up to May 2015 were also reviewed for relevant publications for the target period of this

report (2008–2012).⁴ Finally, publications from the WoS database and the Crossref funding data⁵ that acknowledged NHMRC support and gave the relevant grant identification number were included. After removing duplications, the final dataset for NHMRC grant schemes contained 29,523 unique publications that were indexed in the WoS database. These publications were linked to 7,348 NHMRC grants.

Completeness of NHMRC-supported publication set

The methodologies used to identify NHMRC-supported publications will not have identified all the publications that can be linked to NHMRC support for the following reasons:

- Not all researchers or groups that have publications in the current reference period have completed an End of Grant Report.
- Not all publications have been included in RGMS CVs.
- End of Grant Reports do not include all publications resulting from every grant, as publications continue to be produced long after these reports are submitted.
- Although the number of publications that have acknowledged NHMRC support for their research has increased over recent years, there are still a large number of publications without such information. Even when a publication carries a funding acknowledgment note, information enabling it to be linked to a specific grant may be missing.

The exact extent of under-representation in this report is not possible to calculate but, given the large number of publications identified in this report, it is unlikely to have a significant effect on any of the performance measures that formed the basis of the analysis.

1.3.2 Research sectors

The research sectors used in this report are Government, Hospitals, Industry, Non-profit, Research Institutes and Universities, as described in [Section 1.2.1](#). All the variations of author addresses for each publication in the Australian biomedical publication dataset of WoS have been identified and standardised. This is to ensure that each publication is assigned to the correct institution and sector. Then, all publications attributable to each of the sectors have been identified based on the standardised addresses and included in the publication dataset for the analysis.

Most authors in publications list only one institution in the address by-line. However, a relatively small number list two or more institutions. For example, an author might reference *Garvan Institute of Medical Research, University of New South Wales, St Vincent's Hospital, Sydney, Australia*. This is particularly common in health and medical sciences publications and may be explained by joint appointments and the obligation of researchers to acknowledge support received from multiple institutions. Multiple affiliations of single author addresses are allocated to all respective sectors (or institutions) as given in the address by-line.

1.4 Field of research classification

Publications are analysed on the basis of the Fields of Research classification scheme (part of the Australian and New Zealand Standard Research Classification—ANZSRC—system).⁶ The ANZSRC was prepared by the Australian Bureau of Statistics and Statistics New Zealand for use in the measurement and analysis of research and experimental development undertaken in Australia and New Zealand. It allows comparison across sectors at different levels of aggregation.

4 These End of Grant Reports were part of the reporting process from 2004 to 2015 when they were replaced by the RGMS-based online reporting system.

5 www.crossref.org/fundingdata (Accessed November 2015)

6 ABS and Statistics New Zealand (2008) *Australian and New Zealand Standard Research Classification (ANZSRC)*. Catalogue no. 1927.0, Canberra.

1. Methodology

The make-up of journal sets for Fields of Research analysis rests on WoS's classification schemes. WoS has its own descriptive classification system involving around 250 journal subject categories. NHMRC has translated these categories as closely as possible into the Fields of Research scheme from the ANZSRC. Most WoS subject categories slot neatly into one of the Fields of Research sub-fields. Where a single subject category had elements of two or more Fields of Research fields in its composition, it has been classified to a field where more than half of the journals appeared clearly to relate to that field. However, four categories could not be assigned to a single sub-field due to the diverse nature of journal composition within them. These journal sets cover a broad range of topics overlapping many sub-fields. These have been analysed as separate fields of research:

- WoS subject category Biochemical Research Methods was analysed as General Biological Sciences
- WoS subject category Biotechnology and Applied Microbiology was analysed as General Biological Sciences
- WoS subject category Medicine, General and Internal was analysed as General Medical and Health Sciences
- WoS subject category Multidisciplinary Sciences was analysed as Multidisciplinary Sciences.

WoS allocates some journals to more than one subject category. This can result in some double-counting between fields and/or sub-fields.

The subject categories ascribed to each biomedical field or sub-field are shown in [Appendix C](#).

1.5 Publication volume threshold

The citation distribution among publications is very uneven. While very few publications achieve high citation counts, the great majority receive very few or no citations at all. The smaller the number of publications being analysed, the greater the effect this unevenness will have on the average. Therefore, to ensure that one or a few highly cited publications do not skew the results, no citation analyses were presented for any units with fewer than 100 publications. Where datasets contain fewer than 200 publications, results should also be interpreted with caution.

Similarly, the relative specialisation ratio was not calculated for any units with fewer than 100 publications as the interpretation of specialisation patterns of these smaller units may not be statistically valid.

1.6 Bibliometric indicators

This section gives a general description of the bibliometric indicators used in the report.

1.6.1 Number of publications

The number of scientific publications produced is an indication of research outcomes and the scale of research activity. In this report, the total number of scientific journal publications attributable to each sector has been calculated for the five-year period 2008–2012.

The publication volume, given as the scientific output of the sector being analysed, is provided to illustrate relative size—that is, the context for the analysis—but should not be taken to be the absolute scientific output of the unit for the given period. The NHMRC-supported publication volume included in this report is a subset of the total research output—that is, only publications that have been reported to NHMRC and indexed in WoS. Therefore, in addition to the absolute numbers, this report provides publication volumes in relative proportions, which allows more meaningful comparisons between sectors.

1.6.2 Relative specialisation ratio

The relative specialisation ratio is an indication of research intensity of a given research unit, institution, sector or country, relative to the intensity of the reference entity (e.g. world), in a given field of research. It is calculated by dividing an entity's share of publications in a particular field by the global share of publications in the same field.⁷ A specialisation ratio above 1.0 indicates that a given entity has a higher share of publications in a scientific field than the global average (that is, it is 'specialised' in the research field), while a ratio of less than 1.0 indicates the opposite. Specialisation in a particular field also reflects how the entity is placing more focus on that area at the expense of other areas.

1.6.3 Relative citation impact (RCI)

Research profiles—the publication mix within different fields—vary from one research sector to another. Publishing and citation patterns also vary greatly between different fields of research. This means that raw citation counts and simple citations per publication (CPP) data are not comparable between research sectors or between research fields. The *relative citation impact* allows more meaningful data comparison. It compares the citation rate of the unit being analysed with the relevant world average. It is calculated by dividing the average number of citations of a publication by a research unit in a given sub-field by the average number of citations for all publications in that sub-field (that is, the world citation rate for that sub-field). Thus a relative citation impact of more than 1.0 indicates a higher position than the world average for similar research, while a relative citation impact of less than 1.0 indicates a lower performance than the world average. As this ratio is calculated by taking into account the age and type of publication and the research field in which the publication appeared, it provides a level of normalisation to adjust for these differences, providing a basis for meaningful comparison between different sectors and research fields.

1.6.4 Percentile distribution of highly cited publications

WoS citation data are used to calculate the performance of each Australian article relative to all other articles in the world in the same category and same year, based on the citations received by each publication.

For each field and sub-field in this report, the publications linked to NHMRC and all the other sectors, showing the number and proportion of total output in each category, have been classified into six bands: those amongst the 1% most highly cited in the world, those in the 2% to 5% range, those in the 6% to 10% range, those in the 11% to 20% range, those in the 21% to 50% range, and those in the bottom half of cited publications. The relative share of publications in these citation impact bands indicates how NHMRC schemes and other sectors have performed relative to each other in different fields of research. The distribution of publications across different bands can also reveal whether a high relative citation impact score is due to a large number of well-cited publications or a very few highly cited publications.

[Table 6](#) below uses sample data to illustrate how the centile profiles for each sector are presented. *Expected level* shows the average publication share expected for each centile band to be on par with the average distribution of the world share. For example, 1% share at the Top 1% band indicates average performance, while 6.0% share at the Top 1% band indicates six times the world average. A higher proportion of publication share in the top two or three bands is an indicator of strong citation performance.

7 UNESCO Institute for Statistics (2005). What do bibliometric indicators tell us about world scientific output? *Bulletin on Science and Technology Statistics*, issue no 2, Montreal. unesdoc.unesco.org/images/0021/002171/217111e.pdf

1. Methodology

Table 6: Citation centile distribution (sample data)

Sector	Top 1%, no. (%)	Top 2–5%, no. (%)	Top 6–10%, no. (%)	Top 11–20%, no. (%)	Top 21–50%, no. (%)	Bottom 50%, no. (%)	Total publications, no.
Sector 1	7 (6.0)	5 (4.2)	10 (8.4)	17 (14.3)	30 (25.2)	50 (42.0)	119
Sector 2	4 (3.2)	4 (3.2)	5 (4.0)	12 (9.7)	44 (35.5)	55 (44.4)	124
Sector 3	8 (5.4)	6 (4.1)	8 (5.4)	19 (12.9)	39 (26.5)	67 (45.6)	147
Expected level	1%	4%	5%	10%	30%	50%	na

na= not applicable

1.6.5 Level of collaboration

The level of scientific collaboration is assessed by looking at publication authorship. The published author affiliation addresses allow categorisation into one of three categories:

- *Single author*—one author only (that is, no collaboration)
- *Domestic*—more than one author from Australia (this can include authors from the same research group, academic unit, a single institution or across multiple institutions)
- *International*—at least one author working in a country other than Australia.

1.7 Comparison to methodologies in previous bibliometric report

There are a number of methodological differences between the current report and the previous bibliometric report, *Measuring up 2013*, which covered publications from 2005 to 2009. These differences should be taken into account when comparing the performance outcomes presented in the two reports.

1.7.1 Changes to schemes and sectors

The current report includes six additional grant schemes that were not part of *Measuring up 2013*. They are:

- Capacity Building Grants
- Development Grants
- International Collaborations
- Partnerships
- Postgraduate Scholarships
- Targeted Calls for Research.

With inclusion of these grant schemes, the report provides a more complete coverage of NHMRC research outputs, encompassing nearly all the funding schemes, both current and superseded, that produced relevant publications in the period between 2008 and 2012. The new schemes have contributed to the overall increase in NHMRC's publication output by approximately 1,100 publications but are unlikely to have had a noticeable impact on the overall citation performance of NHMRC.

The composition of the research sector has changed since the last report, with the addition of two new sectors: Industry and Non-profit. In addition, publications from CRCs conducting research in health and medical sciences are now covered within the Non-profit sector, rather than in a category of their own, due to insufficient numbers.

1.7.2 Changes to Fields of Research

The WoS journal category *Primary Health Care* has been included in the Public Health and Health Services sub-field. This resulted in an increase of 100 publications in this sub-field. However, this change had no effect on the total output attributed to NHMRC, Australia and the World total, as *Primary Health Care* journals are also included in other WoS journal categories.

The WoS journal category *Respiratory System* has now been included under the Cardiovascular Medicine and Haematology sub-field. This change better aligns the journal composition in this category with the 'Respiratory Diseases' discipline, which is a sub-set of Cardiovascular Medicine and Haematology under the ANZSRC classification. While this has added extra publications to Cardiovascular Medicine and Haematology sub-field, it has no impact on publication volume at higher aggregated levels (grant scheme, research sector, NHMRC and Australia). In *Measuring up 2013*, *Respiratory System* was analysed under Clinical Sciences.

1.7.3 Research sector composition

In *Measuring up 2013*, the overlap between NHMRC schemes and research sectors was removed by excluding from the *research sectors* group any publication attributed to NHMRC support. Therefore the research sectors presented in the previous report covered *only* publications that had no funding from NHMRC. This was to identify NHMRC-funded research publications and their impact, and to distinguish them from research publications produced without NHMRC support.

The current report provides publication output and citation impact data by research sector at different levels of aggregation:

- research sector publications that were linked to NHMRC support (a)
- research sector publications that were not linked to NHMRC support (b)
- sector total (a) + (b).

The current methodology provides a complete picture of each sector's contribution to Australia's publication output and allows a better comparison between sectors.

1.7.4 Improved publication data collections

Continuing improvements to publication data collection mechanisms within RGMS have enabled an increase in the number of NHMRC-supported publications captured for this report. Up-to-date research publication records for each grant holder are stored within the grants management system and grant holders can link each publication to a specific grant or set of grants that supported the research project. These improvements enable records to be easily mapped against bibliometric databases such as WoS and PubMed.

2. Australian biomedical research



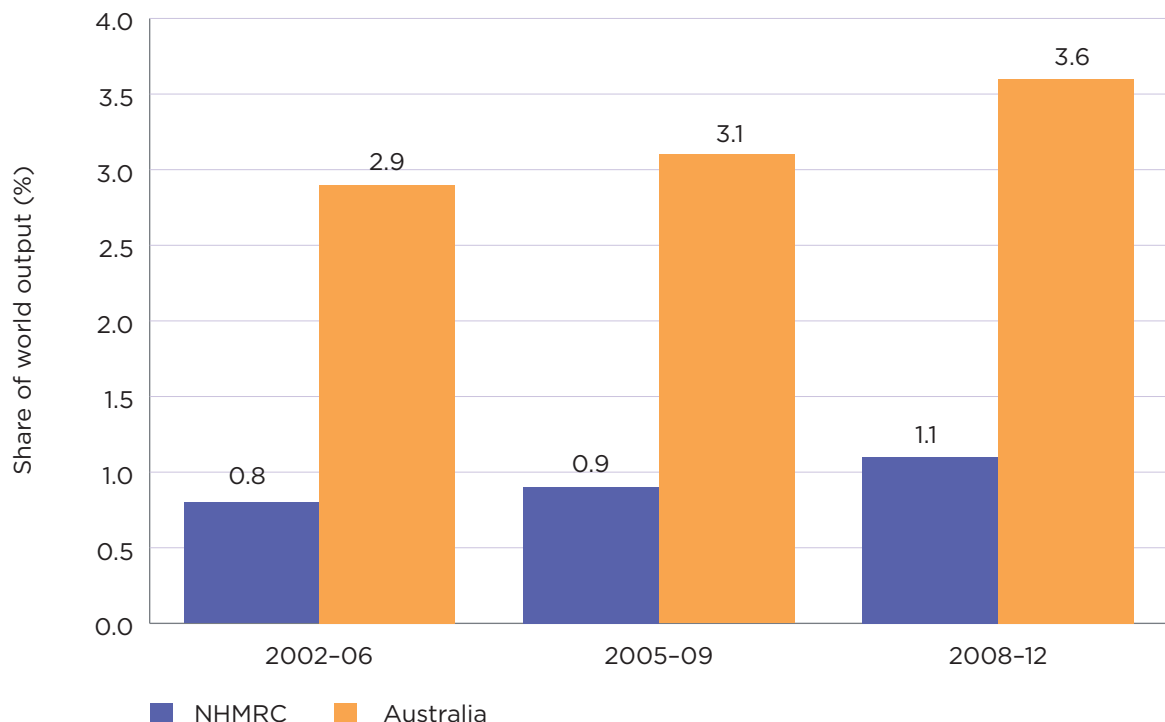
This section provides an overview of Australia’s biomedical research landscape and an analysis of the NHMRC contribution to the nation’s research in the field of health and medical research.

Australia’s share of the world biomedical journal publication output, indexed in the WoS database, is 3.6% in the current reporting period (2008–2012), up from 3.1% (2005–2009). This represents an increase in output of 39%, twice the world publication output growth, which stands at 18%. This increase in output at a rate higher than the global average reflects Australia’s strength in biomedical research, investments and research capacity. The number of publications attributed to NHMRC-supported research has also substantially increased since the last reporting period, from 20,960 in 2005–2009 to 29,523 in 2008–2012. However, as illustrated in [Figure 1](#) below, the total Australian publication output has also increased in this period and the proportion of the NHMRC-supported publication output within the Australian total has remained constant, at 31%. This equates to just over 1% of the world’s publication output in this area.

Australia’s total biomedical research publication output is analysed in this Report on the basis of the research sector of contributing authors, broken down into six sectors, as described in [Section 1.2.1](#). Given the highly collaborative nature of health and medical research, there is a significant overlap between sectors. Where authors from more than one sector collaborate on a publication, publication data are included for *each* sector, thereby providing an accurate picture of each sector’s relative contribution.

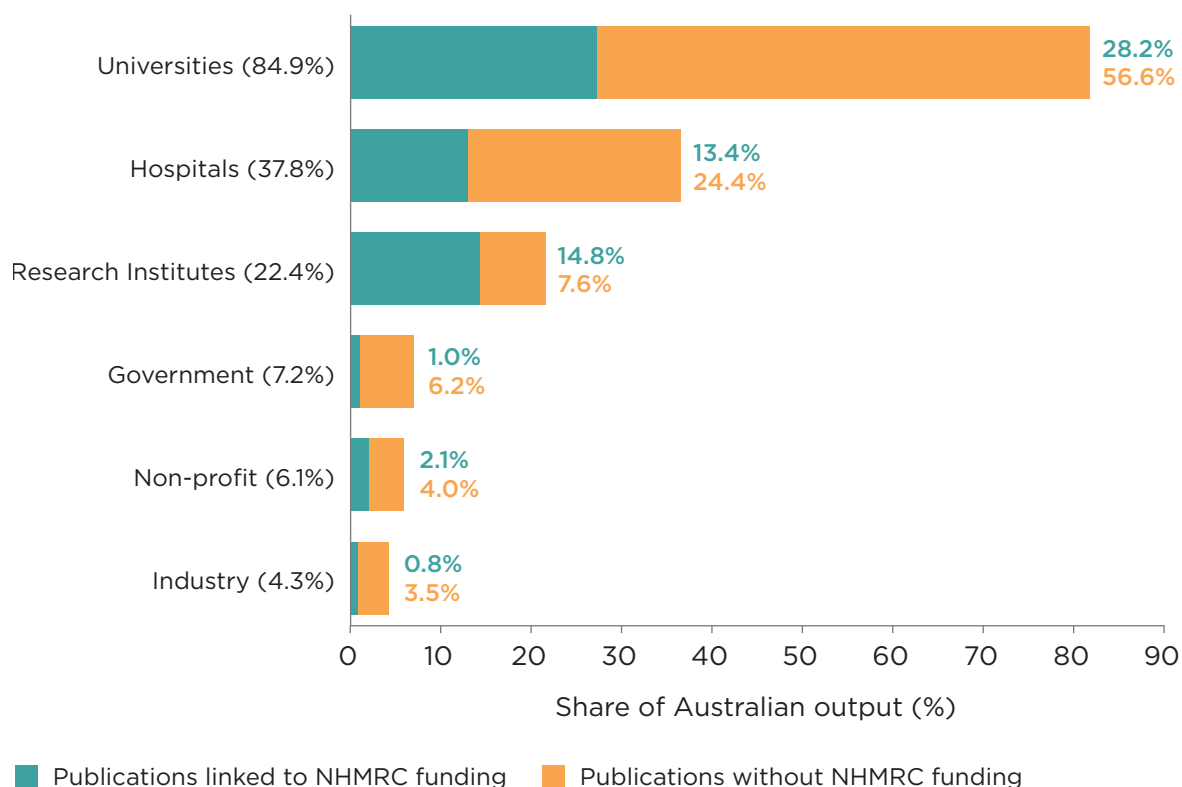
As illustrated in [Figure 2](#), below, the level of contribution to the overall Australian publication output varies considerably between sectors, as does the proportion of NHMRC support. A substantial proportion of Australian biomedical publications (currently 85%, up from 77% in the previous report) are linked to the Universities sector, followed by Hospitals (38%) and Research Institutes (22%). The contribution of the remaining sectors to overall publication output is much smaller. The proportion of publications linked to NHMRC support is particularly high within the Research Institutes sector, at 66%—two-thirds—of the sector output. Approximately one-third of publications in the Universities, Hospitals, and Non-profit sectors are linked to NHMRC funding. A detailed analysis of the distribution of NHMRC-supported publications within research sectors is available in [Table 9](#).

Figure 1: Australian and NHMRC share of world biomedical publications, 2002–2012



2. Australian biomedical research

Figure 2: Proportion of Australian biomedical publications by research sector of contributing author(s), split by NHMRC funding support, 2008–2012



Notes: Where authors from more than one sector collaborate on a publication, it is fully counted for each sector involved. Due to these cross-sector collaborations, the sum of all sectors is greater than 100%. The total sector contribution to Australian biomedical research is given in parentheses.

The sector contribution to the Australian biomedical research effort at discipline level is highlighted in [Table 7](#). This table shows the distribution of all biomedical publications across the sectors as a proportion of the total Australian output in each field and sub-field of research. As the figures in the table clearly illustrate, the University sector is critical to Australia’s biomedical research effort: 85% of all the Australian biomedical publications have one or more authors linked to a university. The Universities sector is a significant site of medical research in all sub-fields, but is particularly important for research in Medical Physiology, Complementary and Alternative Medicine, Nursing, Biological Physics, Human Movement and Sports Science, Biomedical Engineering, Dentistry, Medical Biochemistry and Metabolomics, Public Health and Health Services, Neurosciences, and Optometry and Ophthalmology. For these disciplines, the University sector accounts for more than 90% of the output.

The Hospitals sector has strongest presence in Paediatrics and Reproductive Medicine, Cardiovascular Medicine and Haematology, Oncology and Carcinogenesis, Clinical Sciences, and General Medical and Health Sciences. More than half of the Australian publications in these sub-fields have at least one author from this sector. Within Research Institutes, Oncology and Carcinogenesis, and Immunology contributed 41% and 40%, respectively, to the Australian total.

Table 7: Distribution of biomedical publications in research sectors, by biomedical fields and sub-fields of research (as a percentage of total Australian output), 2008–2012

Field of research	Sub-field	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities
Medical and Health Sciences	Total for Medical and Health Sciences field	4.9	43.2	4.6	6.4	22.8	84.4
	Medical Biochemistry and Metabolomics	10.1	6.9	7.3	1.9	10.9	90.9
	Cardiovascular Medicine and Haematology	1.4	61.7	3.5	5.3	35.7	73.3
	Clinical Sciences	4.2	52.8	5.2	6.0	21.6	81.9
	Complementary and Alternative Medicine	1.3	14.2	7.0	4.9	4.9	94.1
	Dentistry	2.6	22.5	2.8	6.0	3.8	91.2
	Human Movement and Sports Science	11.5	15.4	4.5	7.8	7.1	91.8
	Immunology	5.4	41.5	4.7	6.9	40.4	83.2
	Neurosciences	1.6	41.0	3.2	4.3	29.6	90.2
	Nursing	3.3	36.3	2.3	5.8	3.5	93.6
	Nutrition and Dietetics	14.0	25.5	2.8	5.3	15.6	89.1
	Oncology and Carcinogenesis	2.9	54.2	5.3	9.8	40.9	75.2
	Optometry and Ophthalmology	0.8	32.6	6.0	12.0	39.3	90.2
	Paediatrics and Reproductive Medicine	2.5	65.4	5.4	4.8	28.6	80.5
	Pharmacology and Pharmaceutical Sciences	8.9	28.5	5.6	3.2	17.4	86.8
	Medical Physiology	6.7	16.3	1.8	3.5	19.2	94.7
Public Health and Health Services	7.6	25.4	4.0	9.9	13.7	90.6	
Other Medical and Health Sciences	4.2	42.2	7.2	5.8	32.0	81.0	
General Medical and Health Sciences	5.8	53.3	5.8	9.3	18.1	78.5	

2. Australian biomedical research

Table 7: *continued*

Field of research	Sub-field	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities
Biological Sciences*	General Biological Sciences	18.2	11.0	6.0	7.4	13.7	86.0
	Biochemistry and Cell Biology	9.2	18.9	2.6	3.6	30.5	88.7
	Genetics	19.9	25.5	4.1	6.6	28.1	80.9
	Microbiology	18.5	29.9	4.2	4.8	20.2	82.9
Physical Sciences*	Biological Physics	8.9	11.7	2.3	3.4	17.4	92.3
Engineering*	Biomedical Engineering	9.5	25.1	4.2	5.5	10.3	91.7
Multi-disciplinary Sciences	Total for Multidisciplinary Sciences field	16.0	15.9	2.6	4.0	23.2	87.5
All biomedical sciences	Total for all biomedical sciences	7.2	37.8	4.3	6.1	22.4	84.9

Note: There is some publication overlap between research sectors due to cross-sector collaborations. As a result, the sum of component sectors (Government, Hospitals, Industry, Non-profit, Research Institutes and Universities) is greater than 100%.

* These fields are not covered in their entirety. Only sub-fields relevant to biomedical research within these fields are analysed.

2.1 Sector research focus and specialisation

The research focus of individual institutions and research units is determined their priorities, strategies and research specialisations and is reflected in their research profile and publication output. The research focus of each sector is in turn characteristic of the publication profiles of the individual institutions and research units that make up the sector. Therefore the sectors presented in this report, including those supported by NHMRC, have different profiles. This section looks at the differences in research focus and the patterns of research specialisation in terms of the publication output within individual sectors.

The relative specialisation ratio is used to measure the relative research specialisation among sectors. This measure indicates whether a sector has a higher or lower share of publications in a given field relative to the world average in the same field: a value higher than 1.0 indicates the sector has a higher share of publications in that field compared with the world average.

[Table 8](#) shows the relative specialisation ratio for each research sector and the research focus within each sector, along with the relative proportion of research within the Australian and international context.

As [Table 8](#) illustrates, the Medical and Health Sciences field accounts for 80% of all NHMRC-supported publications. This is marginally down from its 2005–2009 level (82%). Publication output in Public Health and Health Services research has increased to almost 10% of all NHMRC-supported publications currently, compared with 7% between 2005 and 2009. The proportional share of Biochemistry and Cell Biology has decreased to 13.8%. Although this is only slightly down from its 2005–2009 level of 15%, it is a substantial change from 2002–2006, when it accounted for 21% of all NHMRC-supported publications.

The biomedical research output of the Hospitals sector is heavily concentrated in the Medical and Health Sciences field (92%), in particular the sub-fields of Clinical Science, and Paediatrics and Reproductive Medicine, with a relatively weak focus in Biological Sciences sub-fields (including Biochemistry and Cell Biology, Genetics, and Microbiology). The research profile of the Government sector differs from the other sectors, with a relatively high focus in Biological Sciences research and relatively less focus in Medical and Health Sciences.

When compared with the global output, Australia produces a relatively large number of papers in Nursing, Human Movement and Sports Science, Public Health and Health Services, and Optometry and Ophthalmology, as shown by the high specialisation ratio. Public Health and Health Services research is particularly important given its contribution to the total biomedical research effort (11.5% of Australia's research output and 6.4% of the world research output). The other three fields—Human Movement and Sports Science, Nursing, and Optometry and Ophthalmology—are much smaller, contributing between 1% and 1.5% of the world output. Nearly all the Human Movement and Sports Science publications are linked to the Australian Institute of Sports. As a result, the Government sector has a very high share of publications in this sub-field, shown by the relative specialisation ratio of 3.74. Sectors with particular focus on the sub-field of Nursing are Universities (relative specialisation ratio 2.68), Hospitals (2.33) and Non-profit (2.30).

The following sub-fields are notable because they represent a relatively high proportion of NHMRC publications *and* have high intensity of research relative to the world (as shown by the specialisation ratio):

- Immunology (specialisation ratio 1.75, the highest among all disciplines for NHMRC, accounting for 7% of all NHMRC-supported publications)
- Neurosciences (relative specialisation 1.33; 12.6% of NHMRC-supported publications)
- Cardiovascular Medicine and Haematology (relative specialisation 1.15; 8% of NHMRC-supported publications)
- Biochemistry and Cell Biology (relative specialisation 1.1; 13.8% of NHMRC-supported publications).

The sub-field of Pharmacology and Pharmaceutical Sciences accounts for 7.7% of the world publication output. However, all the Australian research sectors in this field have a much lower concentration of papers than the world average, as shown by a relative specialisation value of less than 1. This is true for both those linked to NHMRC-supported research and those not linked.

Table 8: Relative specialisation ratio in research sectors and research focus (individual sector output as a percentage of total biomedical sciences sector output), by biomedical fields and sub-fields of research, 2008-2012

Field of research	Sub-field	Relative specialisation ratio										Research focus (%)																
		Linked to NHMRC funding	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities	Australia	Linked to NHMRC funding	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities	Australia	World										
Medical and Health Sciences	Total for Medical and Health Sciences field	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	80.4	55.3	91.6	84.3	83.7	81.5	79.7	80.0	76.0	
	Medical Biochemistry and Metabolomics	0.36	0.67	nc	nc	nc	0.23	0.50	0.47	0.9	1.6	nc	nc	nc	nc	nc	nc	nc	0.6	0.6	1.2	1.1	1.1	1.2	1.2	1.1	2.4	
	Cardiovascular Medicine and Haematology	1.15	nc	1.40	0.69	0.74	1.37	0.74	0.86	8.2	10.0	4.9	5.3	9.8	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	7.1
	Clinical Sciences	0.96	0.61	1.43	1.22	1.00	0.99	0.99	1.02	29.1	18.5	43.5	37.0	30.4	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.4
	Complementary and Alternative Medicine	nc	nc	nc	nc	nc	nc	1.09	0.98	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.4	
	Dentistry	0.30	nc	0.42	nc	nc	nc	0.76	0.71	0.5	nc	0.6	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.5	
	Human Movement and Sports Science	1.36	3.74	0.95	2.40	2.99	0.74	2.52	2.33	1.9	5.3	1.3	3.4	4.2	1.0	3.6	3.3	1.4	1.0	1.0	3.6	3.3	3.3	3.6	3.6	3.3	1.4	
	Immunology	1.75	0.74	1.08	1.08	1.11	1.78	0.97	0.99	6.9	2.9	4.3	4.3	4.4	7.1	3.8	3.9	4.0	7.1	7.1	3.8	3.9	4.4	7.1	3.8	3.9	4.0	
	Neurosciences	1.33	0.23	1.08	0.73	0.70	1.32	1.06	1.00	12.6	2.2	10.2	6.9	6.6	12.4	10.0	9.4	9.4	12.4	12.4	10.0	9.4	6.6	12.4	10.0	9.4	9.4	
	Nursing	0.43	nc	2.33	nc	2.30	nc	2.68	2.43	0.5	nc	2.7	nc	2.6	nc	3.1	2.8	1.1	0.5	0.5	2.7	nc	2.6	nc	3.1	2.8	1.1	
	Nutrition and Dietetics	1.21	2.62	0.90	0.86	1.15	0.93	1.41	1.34	2.0	4.5	1.5	1.5	2.0	1.6	2.4	2.3	1.7	2.0	2.0	4.5	1.5	1.5	2.0	1.6	2.4	2.3	
	Oncology and Carcinogenesis	1.00	0.32	1.12	0.96	1.26	1.43	0.69	0.78	5.6	1.8	6.3	5.3	7.0	8.0	3.9	4.4	5.6	5.6	1.8	6.3	5.3	7.0	8.0	3.9	4.4	5.6	
	Optometry and Ophthalmology	1.47	nc	1.31	2.09	2.97	2.66	1.61	1.51	2.3	nc	2.0	3.2	4.6	4.1	2.5	2.3	1.5	2.3	nc	2.0	3.2	4.6	4.1	2.5	2.3	1.5	

Table 8: continued

Field of research	Relative specialisation ratio										Research focus (%)						
	Linked to NHMRC funding	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities	Australia	Linked to NHMRC funding	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities	Australia	World
Medical and Health Sciences (cont)																	
Paediatrics and Reproductive Medicine	1.15	0.39	1.92	1.38	0.88	1.42	1.05	1.11	5.3	1.8	8.9	6.4	4.1	6.6	4.9	5.2	4.6
Pharmacology and Pharmaceutical Sciences	0.67	0.79	0.48	0.82	0.33	0.49	0.65	0.64	5.1	6.1	3.7	6.3	2.5	3.8	5.0	4.9	7.7
Medical Physiology	1.48	1.16	0.53	0.53	nc	nc	1.38	1.24	3.4	2.7	1.2	nc	nc	2.4	3.2	2.8	2.3
Public Health and Health Services	1.51	1.90	1.21	1.65	2.89	1.09	1.91	1.79	9.7	12.2	7.8	10.6	18.6	7.0	12.3	11.5	6.4
Other Medical and Health Sciences	0.85	nc	0.72	1.08	0.62	0.93	0.62	0.65	2.8	nc	2.4	3.6	2.1	3.1	2.1	2.2	3.3
General Medical and Health Sciences	1.13	1.10	1.93	1.83	2.07	1.10	1.27	1.37	4.3	4.1	7.3	6.9	7.8	4.2	4.8	5.1	3.8
Biological Sciences*																	
General Biological Sciences	0.46	1.74	0.20	0.94	0.82	0.42	0.69	0.69	3.2	12.1	1.4	6.5	5.7	2.9	4.8	4.8	6.9
Biochemistry and Cell Biology	1.10	0.97	0.38	0.46	0.45	1.03	0.79	0.76	13.8	12.2	4.7	5.7	5.6	12.9	9.9	9.5	12.5
Genetics	1.19	3.47	0.84	1.17	1.35	1.56	1.19	1.25	4.0	11.8	2.9	4.0	4.6	5.3	4.0	4.2	3.4
Microbiology	0.93	2.22	0.68	0.82	0.67	0.78	0.84	0.86	4.3	10.2	3.1	3.8	3.1	3.5	3.8	3.9	4.6
Biological Physics	0.67	0.77	0.19	nc	nc	0.48	0.67	0.62	1.5	1.7	0.4	nc	nc	1.1	1.5	1.4	2.2
Physical Sciences*																	

Table 8: continued

Field of research	Sub-field	Relative specialisation ratio										Research focus (%)						
		Linked to NHMRC funding	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities	Australia	Linked to NHMRC funding	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities	Australia	World
Engineer-	Biomedical Engineering	0.48	1.13	0.56	nc	nc	0.39	0.91	0.84	1.0	2.3	1.1	nc	nc	0.8	1.8	1.7	2.0
Multi-	Total for Multidisciplinary Sciences	0.98	2.23	0.42	0.59	0.65	1.03	1.02	0.99	4.1	9.4	1.8	2.5	2.7	4.3	4.3	4.2	4.2
Sciences																		

nc = not calculated

Notes: Some journals are classified in more than one Web of Science journal category. As a result, some publications are included in more than one field/sub-field. Due to this overlap, the total of all the sub-fields is greater than 100%. Publication profile and relative specialisation measures were not calculated for any sectors with fewer than 100 papers.

* These fields are not covered in their entirety. Only sub-fields relevant to biomedical research within these fields are analysed.

2.2 Australian health and medical research and NHMRC support

As explored earlier, NHMRC-supported publications accounted for approximately 31% of all Australian health and medical research output during the current reporting period and, although publication output has increased, this proportion remains unchanged since *Measuring up 2013*. [Figure 3](#), below, illustrates NHMRC support for Australian health and medical research by biomedical fields and sub-fields of research. Support for the research that leads to a particular publication can come from more than one source. The publications identified as being supported by NHMRC funding may have also had other funding sources.

Over half (55%) of Australia's output in the field of Immunology can be linked to NHMRC support, followed by Biochemistry and Cell Biology (45%), Cardiovascular Medicine and Haematology (41%), Neurosciences (41%), Oncology and Carcinogenesis (40%), and Other Medical and Health Sciences⁸ (40%).

The number of NHMRC-supported publications in Public Health and Health Services has increased by 86% since the previous reporting period, but the NHMRC share within the national output changed only marginally, from 25% to 26%.

The number of NHMRC-supported publications in Cardiovascular Medicine and Haematology has increased by 61% since *Measuring up 2013*. However, the proportion of NHMRC-supported publications within the total Australian output in this discipline slightly decreased (from 44% to 41%). This reflects the substantial recent growth in the total Australian publication output in this discipline, with a 70% increase in publications since the 2005–2009 reporting period.

Since *Measuring up 2013*, the proportion of publications linked to NHMRC funding has increased in 19 out of the 25 sub-fields analysed in this report, notably:

- Biochemistry and Cell Biology (45%, up from 40%)
- Microbiology (33%, up from 31%)
- Biological Physics (33%, up from 30%)
- Paediatrics and Reproductive Medicine (32%, up from 28%)
- Pharmacology and Pharmaceutical Sciences (32%, up from 29%)
- Multidisciplinary Sciences (30%, up from 23%)
- Medical Biochemistry and Metabolomics (23%, up from 20%)
- Biomedical Engineering (17%, up from 14%).

The relative proportion of NHMRC-supported publications among disciplines varies between sectors. [Table 9](#) details the number of publications attributed to NHMRC funding as a proportion of the sector output within each discipline. Among the biomedical sub-fields, about one-third of publications from the Universities, Non-profit and Hospitals sectors and two-thirds from the Research Institutes sector were linked to NHMRC funding. A substantial proportion of publications from all biomedical sub-fields within the Research Institutes sector have received NHMRC support. In comparison to the previous bibliometric report, the proportion of NHMRC-supported publications has increased in the Hospitals sector (from 31% to 35%) and the Universities sector (from 32% to 33%), while it has decreased in the Government sector (from 17% to 14%) and the Research Institutes sector (from 68% to 66%).

⁸ WoS journal subject categories analysed under this subfield are *Medical Laboratory Technology*, and *Medicine, Research and Experimental*.

2. Australian biomedical research

Figure 3: Proportion of Australian biomedical publications linked to NHMRC support, by field and sub-field of research, 2008–2012

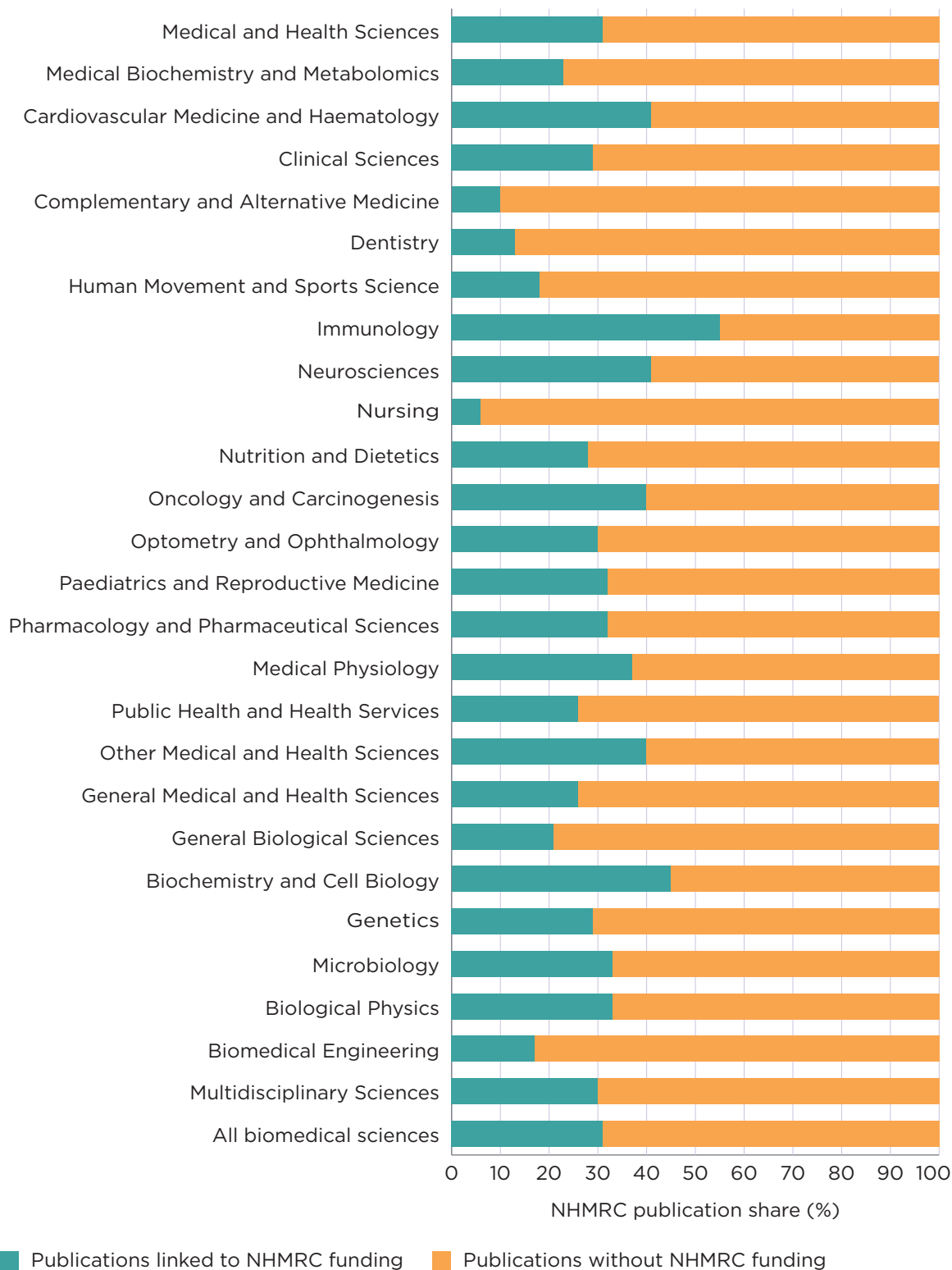


Table 9: Percentage of all biomedical publications attributable to NHMRC support within the total field/sub-field output, for each sector and Australia, 2008-2012

Field of research	Sub-field	Government				Research			
		Hospitals	Industry	Non-profit	Institutes	Universities	Australia		
Medical and Health Sciences	Total for Medical and Health Sciences field	19.7	33.3	19.5	64.2	33.7	31.0		
	Medical Biochemistry and Metabolomics	7.2	40.8	18.8	62.2	24.4	23.3		
	Cardiovascular Medicine and Haematology	41.0	34.8	29.8	68.7	47.6	41.2		
	Clinical Sciences	22.1	29.7	18.9	60.6	32.6	28.8		
	Complementary and Alternative Medicine	20.0	20.0	14.8	42.1	10.4	9.8		
	Dentistry	18.5	9.4	6.9	55.0	14.0	13.2		
	Human Movement and Sports Science	9.1	32.0	16.3	65.2	19.0	18.0		
	Immunology	23.4	55.1	34.8	78.5	57.2	54.7		
	Neurosciences	30.4	43.6	24.1	69.0	44.0	41.3		
	Nursing	3.4	4.9	8.2	38.3	5.7	5.5		
	Nutrition and Dietetics	16.1	42.1	11.5	64.7	29.1	27.7		
	Oncology and Carcinogenesis	25.2	39.2	29.7	59.6	44.5	39.6		
	Optometry and Ophthalmology	29.4	41.6	11.2	49.5	31.7	29.9		
	Paediatrics and Reproductive Medicine	43.2	30.5	24.1	62.7	36.4	32.0		
	Pharmacology and Pharmaceutical Sciences	11.5	41.8	13.3	64.8	34.9	32.5		
	Medical Physiology	6.6	56.8	12.0	74.8	36.7	36.8		
Public Health and Health Services	21.7	31.0	17.7	63.0	27.3	26.0			
Other Medical and Health Sciences	29.5	43.8	30.0	68.5	44.8	40.5			
General Medical and Health Sciences	25.7	24.9	11.5	59.3	29.4	25.6			

Table 9: *continued*

Field of research	Sub-field	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities	Australia
Biological Sciences*	General Biological Sciences	4.8	53.3	9.6	18.2	70.6	21.8	20.5
	Biochemistry and Cell Biology	10.4	65.2	26.2	38.5	76.1	45.7	44.9
	Genetics	5.4	56.1	10.8	34.0	72.8	30.5	29.4
	Microbiology	10.5	47.5	23.6	22.9	73.6	36.8	33.4
Physical Sciences*	Biological Physics	9.3	46.8	16.1	20.0	68.7	34.5	33.4
	Biomedical Engineering	6.4	24.6	11.6	27.8	50.0	18.3	17.5
Multidisciplinary Sciences	Total for Multidisciplinary Sciences field	7.5	66.4	30.1	30.0	75.4	31.7	30.3
All biomedical sciences	Total for all biomedical sciences	14.0	35.4	19.0	33.9	66.2	33.3	30.9

Notes: Each cell represents the number of NHMRC-supported publications within the field or sub-field output of the sector divided by the total number of publications produced by the sector in that field or sub-field, expressed as a percentage. If a sector produced 100 immunology publications, of which 40 have been attributed to NHMRC support, then this is shown in the table as 40.0 under Immunology for this sector.

* These fields are not covered in their entirety. Only sub-fields relevant to biomedical research within these fields are analysed.

3. Citation performance of Australian biomedical publications



This section examines Australian biomedical research publications using citation impact analysis. It assesses publication output by funding source (with or without NHMRC funding), research sector and by field of research. It also compares publication output within the NHMRC funding schemes, comparing performance based on the type of NHMRC grant awarded.

Two bibliometric indicators are used to measure the citation impact: the RCI and the percentile distribution of highly cited publications. Bibliographic citations are an indication of the scientific influence of a piece of research. The RCI provides meaningful international context. It is calculated by taking the average citation rate of the unit being evaluated and dividing it by the global citation rate for similar research worldwide (the world average). Field-specific differences, publication type (e.g. articles or conference proceedings) and age are taken into account, allowing the RCI to be used to make meaningful comparisons across different entities such as grant schemes and sectors. The percentile distribution indicates the extent to which publications of an entity (e.g. sector or grant scheme) are present in different impact bands (e.g. Top 1%, Top 5%). When used in conjunction with RCI it indicates whether the entity's high citation score is a result of a few highly cited publications or a larger number of well-cited publications in the top 2-3 impact bands.

3.1 RCI performance over time

The RCI of NHMRC-supported publications is consistently high by world standards and is steadily increasing. Australian performance in general, while lower, is also above the world average and improving. Analysis of the most recent figures available indicates an RCI for NHMRC-linked publications of 1.68, that is, 68% higher than the world average. The Australian RCI for the same period is 1.30. [Figure 4](#), below, illustrates Australia's and NHMRC's RCI over time.

3.2 RCI by research sector

[Figure 5](#) analyses RCI by sector. It shows that NHMRC-supported publications outperform those that were not linked to NHMRC funding across all sectors, and are all well above the world and Australian average. The RCIs for non-NHMRC publications, with the exception of Research Institutes, are below the Australian average. This is illustrated in [Figure 5](#) below.

3.3 RCI by NHMRC funding scheme

[Figure 6](#), below, illustrates the relative performance of publications based on the NHMRC grant scheme which funded the research. As the diagram illustrates, all NHMRC schemes have performed well above the national and international benchmarks while Targeted Calls for Research, Practitioner Fellowships, Program Grants and International Collaborations had a relative citation impact of almost twice the world average.

The Project Grants scheme, the largest scheme in this analysis in publications output, has an RCI close to the NHMRC average. The number of publications linked to Projects Grants has increased 123% (from 6,278 to 13,992) since *Measuring up 2013*. This increase can be partly attributed to improvements in the end of grant reporting process within RGMS in recent years. RGMS is now the

3. Citation performance of Australian biomedical publications

Figure 4: Relative citation impact for NHMRC-supported and Australian biomedical publications over time, 1999-2012

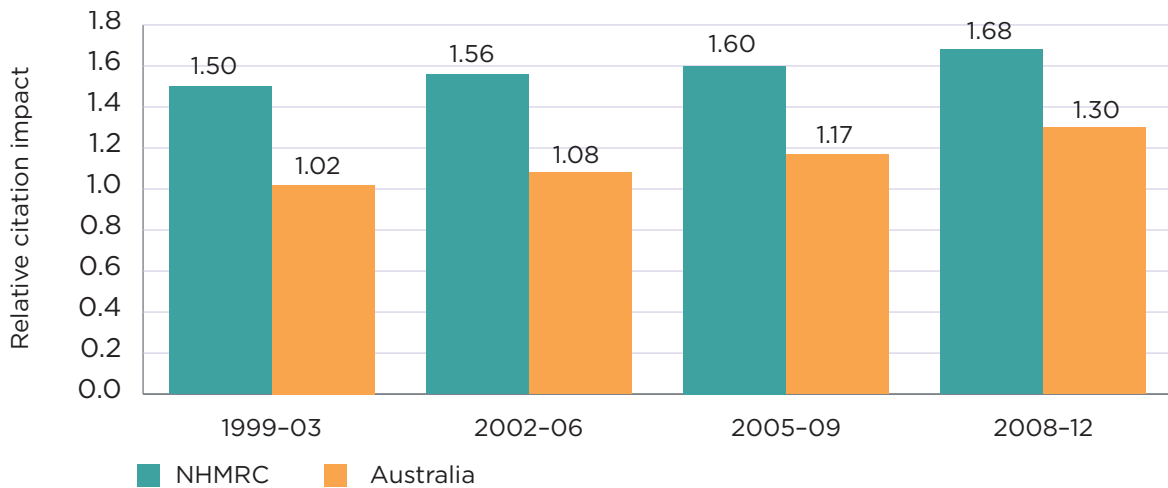
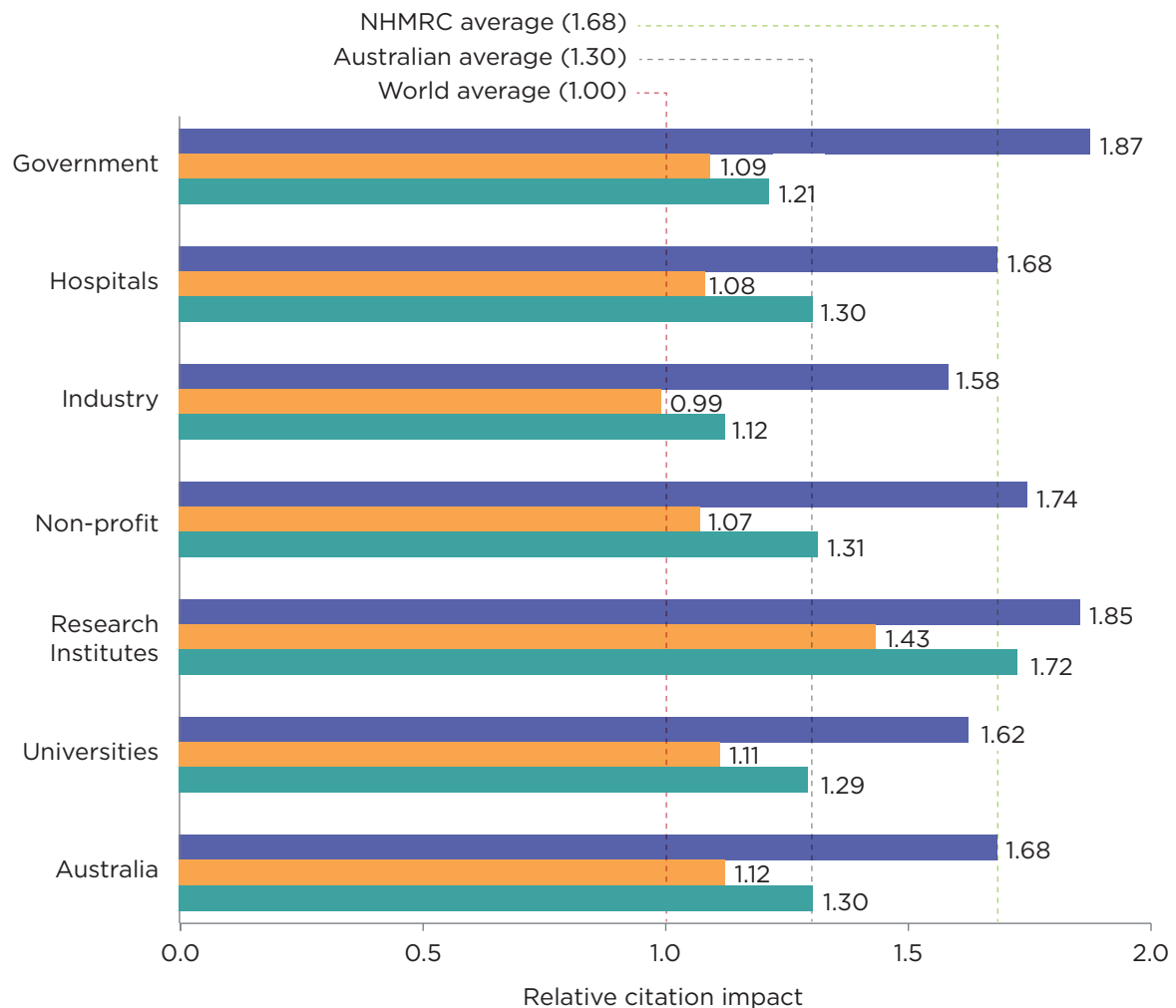


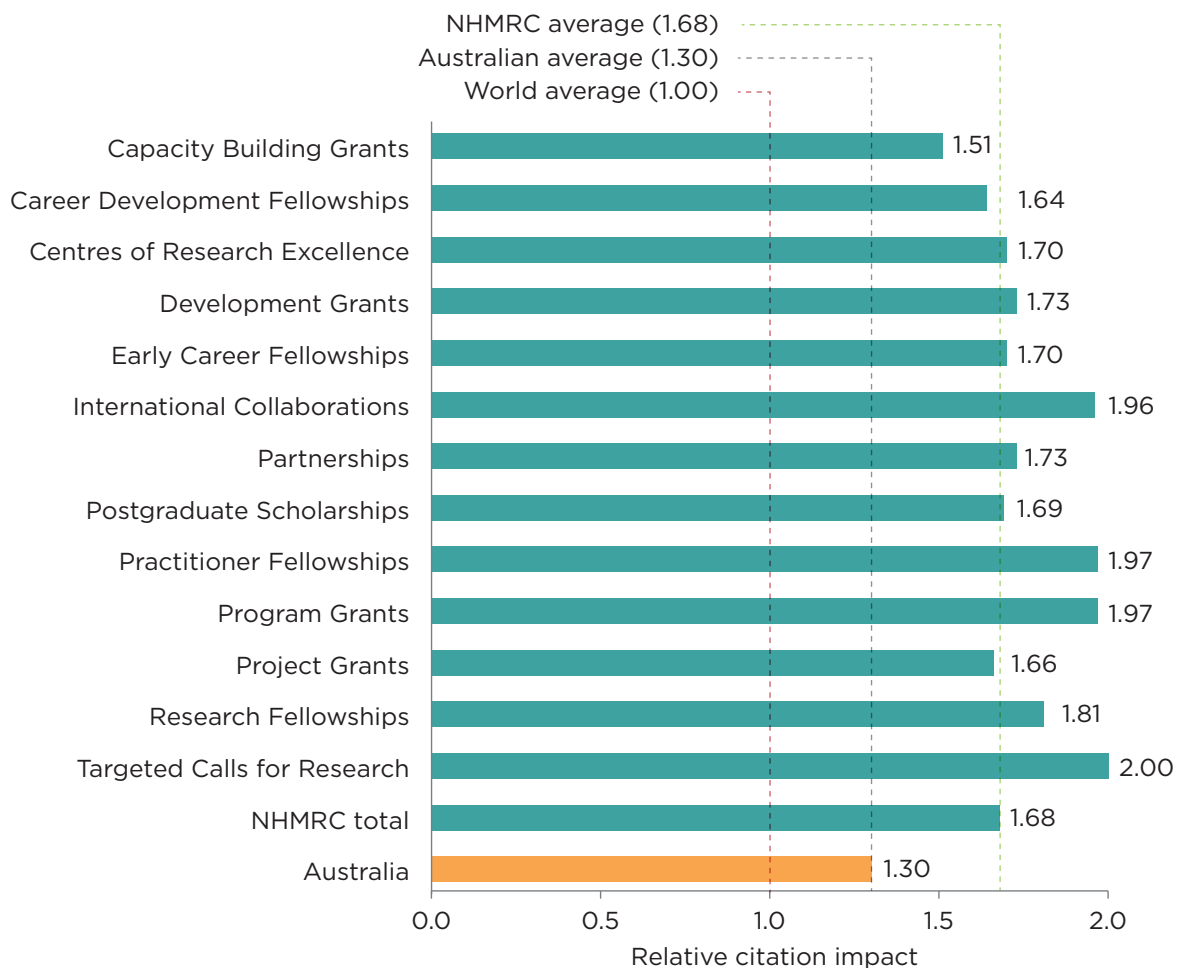
Figure 5: Relative citation impact of biomedical publications within research sectors and Australian total, by funding source, 2008-2012



■ Publications linked to NHMRC funding ■ All publications
■ Publications without NHMRC funding

Note: Where authors from more than one sector collaborate on a publication, it is counted in full for each sector. The relative citation impact figure for the Australian total is not an average of the component sectors but is based on the dataset as a whole.

Figure 6: Relative citation impact of biomedical publications within NHMRC schemes and Australian total, 2008–2012



Note: Where authors from more than one grant scheme collaborate on a publication, it is counted in full for each scheme. Relative citation impact figures for totals (NHMRC total and Australia) are not averages of the component sectors but are based on the dataset as a whole.

primary source of publications data for this scheme.⁹ A relatively large proportion of publications in this analysis have been attributed to more recent grants, leading to an uneven distribution of publications over the five-year period of the analysis. This may have had a negative impact on the relative citation impact of the Project Grants scheme, as recent publications have had less time to attract citations.

The RCI for all NHMRC schemes has increased since the previous report (as shown in [Table 3](#)). The exception is the Research Fellowships scheme, where the citation impact remains unchanged at 1.81, that is, 81% above the world average. The number of publications linked to the Research Fellowships Scheme rose by 33%, to 10,149 publications. The RCI of the Practitioner Fellowships scheme improved significantly since the last report (+0.29), followed by Centres of Research Excellence (+0.19), Early Career Fellowships (+0.19) and Career Development Fellowships (+0.13). The Postgraduate Scholarships scheme recorded a relative citation impact of 1.69, a strong performance given the early stage in the research career of the award holders. The number of publications linked to this scheme is 650. Further, there may be under-reporting for this scheme as Scholarship awardees are exempt from submitting end of grant reports.¹⁰

9 For *Measuring up 2013* report, publications metadata were sourced from End of Grant Reports which did not contain all the publications attributable to relevant grants, as publications continue to be produced long after these reports are submitted.

10 Data for Scholarship awardees is sourced from Web of Science and researcher CVs in RGMS.

3.4 RCI by field and sub-field of research

As noted in [Section 3.2](#), publications linked to NHMRC funding outperform other Australian publications across all sectors. The RCI of NHMRC-supported publications is consistently above that of other Australian publications at the field and sub-field level, as presented in [Figure 7](#) below.

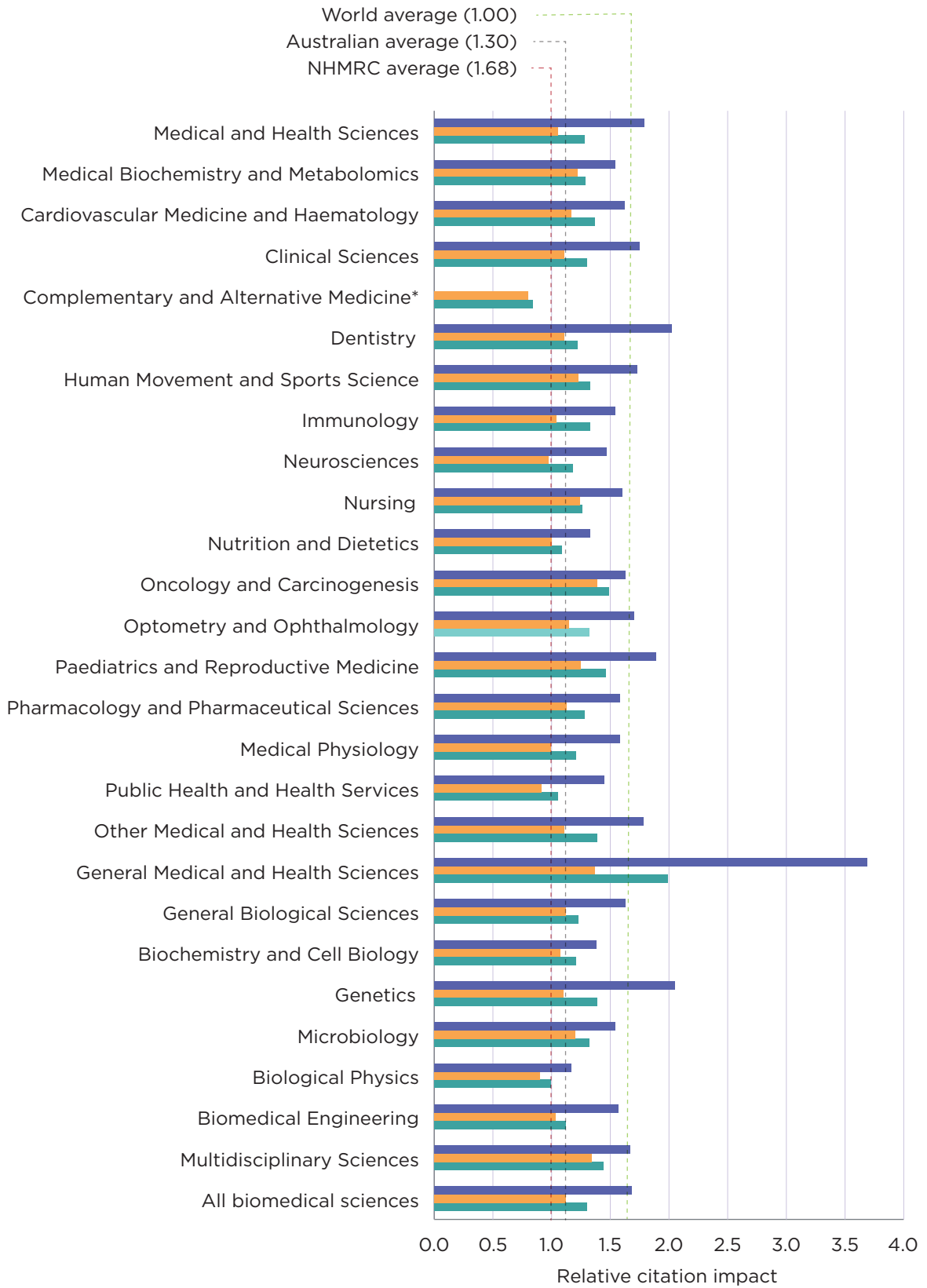
As shown in [Figure 7](#), the General Medicine and Health Sciences sub-field has a particularly high RCI (3.69). This is largely due to the fact that it includes the WoS journal category *Medicine, General and Internal* which contains a diverse range of journals, some of which are interdisciplinary in nature (e.g. *Medical Journal of Australia*, *The Lancet* and *New England Journal of Medicine*). Publications in multidisciplinary journals generally have a higher citation rate than specialty journals.

3.5 Citation percentile distribution

[Table 10](#) shows the number and percentage of publications with citation numbers in each of six performance bands: from those amongst the 1% most highly cited in the world to those in the bottom half of citation counts. The number and percentage within each band are relative to the total sector publication output. The *expected level* shows the average publication share expected for each centile band to be on par with the average distribution of the world share. A higher than expected percentage of publications appearing in the top two to three bands indicates stronger citation performance than the world average.

The overall performance of NHMRC-supported publications is well above the expected level in the top three bands. NHMRC-supported publications account for approximately three times more publications than expected among the top 1% of cited papers in the world and more than double the expected proportion in the top 2-5% band. While all NHMRC schemes were associated with high performance in each band, Targeted Calls for Research, International Collaborations, Program Grants, Practitioner Fellowships and Research Fellowships stand out. Nearly half (862) of the most highly cited Australian publications (defined as the top 1% in the world) are linked to NHMRC support. This is noteworthy given NHMRC's overall contribution to the Australian biomedical publication output stands at 31%. Among research sectors, Research Institutes led others with a higher overall percentage of highly cited publications within top centile bands (see [Table 11](#)).

Figure 7: Relative citation impact of Australian biomedical publications, by field and sub-field of research and funding source, 2008–2012



■ Publications linked to NHMRC funding ■ All publications
 ■ Publications without NHMRC funding

* The publication set of Complementary and Alternative Medicine that was linked to NHMRC funding was not analysed due to the low volume threshold.

3. Citation performance of Australian biomedical publications

Table 10: Citation percentile distribution of biomedical publications, by NHMRC scheme, 2008–2012

NHMRC scheme	Top 1%, no. (%)	Top 2–5%, no. (%)	Top 6–10%, no. (%)	Top 11–20%, no. (%)	Top 21–50%, no. (%)	Bottom 50%, no. (%)	Total publications, no.
Capacity Building Grants	16 (1.7)	70 (7.4)	78 (8.3)	123 (13.0)	322 (34.1)	334 (35.4)	943
Career Development Fellowships	133 (2.4)	482 (8.6)	516 (9.2)	845 (15.1)	1,889 (33.7)	1,734 (31.0)	5,599
Centres of Research Excellence	72 (2.9)	178 (7.3)	219 (9.0)	362 (14.8)	834 (34.1)	780 (31.9)	2,445
Development Grants	4 (2.0)	20 (9.9)	25 (12.3)	30 (14.8)	60 (29.6)	64 (31.5)	203
Early Career Fellowships	134 (2.9)	404 (8.7)	440 (9.4)	747 (16.0)	1,535 (32.9)	1,401 (30.1)	4,661
International Collaborations	23 (4.8)	49 (10.3)	50 (10.5)	70 (14.7)	139 (29.2)	145 (30.5)	476
Partnerships	3 (1.6)	13 (6.8)	24 (12.5)	27 (14.1)	59 (30.7)	66 (34.4)	192
Postgraduate Scholarships	16 (2.5)	59 (9.1)	56 (8.6)	114 (17.5)	198 (30.5)	207 (31.8)	650
Practitioner Fellowships	76 (3.7)	201 (9.7)	172 (8.3)	311 (15.0)	686 (33.0)	630 (30.3)	2,076
Program Grants	352 (4.4)	791 (9.8)	774 (9.6)	1,274 (15.8)	2,624 (32.5)	2,270 (28.1)	8,085
Project Grants	372 (2.7)	1,197 (8.6)	1,264 (9.1)	2,088 (15.0)	4,813 (34.5)	4,228 (30.3)	13,962
Research Fellowships	352 (3.5)	905 (8.9)	960 (9.5)	1,530 (15.1)	3,406 (33.6)	2,969 (29.3)	10,122
Targeted Calls for Research	48 (5.0)	83 (8.6)	100 (10.4)	121 (12.6)	294 (30.5)	318 (33.0)	964
NHMRC total	862 (2.9)	2,441 (8.3)	2,513 (8.5)	4,302 (14.6)	9,917 (33.7)	9,422 (32.0)	29,457
Expected level (world average distribution)	1.0%	4.0%	5.0%	10.0%	30.0%	50.0%	na

na = not applicable

Notes: The count and percentage within each band are relative to the total publication output for each NHMRC scheme. The expected level indicates the world average distribution for each centile band. A higher than expected percentage of publications appearing in the top two to three bands indicates stronger citation performance than the world average.

Table 11: Citation percentile distribution of biomedical publications, by research sector, 2008-2012

Research sector	NHMRC support	Top 1%, no. (%)	Top 2-5%, no. (%)	Top 6-10%, no. (%)	Top 11-20%, no. (%)	Top 21-50%, no. (%)	Bottom 50%, no. (%)	Total publications, no.
Government	Government total	114 (1.8)	298 (4.6)	390 (6.0)	705 (10.9)	2,015 (31.2)	2,928 (45.4)	6,450
	Linked to NHMRC funding	45 (4.7)	82 (8.6)	71 (7.5)	118 (12.4)	316 (33.2)	321 (33.7)	953
	Without NHMRC funding	69 (1.3)	216 (3.9)	319 (5.8)	587 (10.7)	1,699 (30.9)	2,607 (47.4)	5,497
Hospitals	Hospitals total	786 (2.2)	2,174 (6.0)	2,275 (6.3)	4,151 (11.5)	10,786 (29.8)	15,986 (44.2)	36,158
	Linked to NHMRC funding	393 (3.1)	1,077 (8.4)	1,081 (8.5)	1,823 (14.3)	4,260 (33.3)	4,156 (32.5)	12,790
	Without NHMRC funding	393 (1.7)	1,097 (4.7)	1,194 (5.1)	2,328 (10.0)	6,526 (27.9)	11,830 (50.6)	23,368
Industry	Industry total	61 (1.5)	213 (5.2)	234 (5.7)	432 (10.5)	1,198 (29.1)	1,985 (48.1)	4,123
	Linked to NHMRC funding	21 (2.7)	75 (9.5)	75 (9.5)	100 (12.7)	266 (33.7)	252 (31.9)	789
	Without NHMRC funding	40 (1.2)	138 (4.1)	159 (4.8)	332 (10.0)	932 (28.0)	1,733 (52.0)	3,334
Non-profit	Non-profit total	118 (2.0)	320 (5.5)	347 (6.0)	657 (11.3)	1,877 (32.4)	2,472 (42.7)	5,791
	Linked to NHMRC funding	70 (3.5)	150 (7.6)	144 (7.3)	280 (14.1)	698 (35.2)	641 (32.3)	1,983
	Without NHMRC funding	48 (1.3)	170 (4.5)	203 (5.3)	377 (9.9)	1,179 (31.0)	1,831 (48.1)	3,808
Research Institutes	Research Institutes total	703 (3.3)	1,729 (8.1)	1,780 (8.3)	2,979 (13.9)	6,916 (32.4)	7,252 (34.0)	21,359
	Linked to NHMRC funding	514 (3.6)	1,271 (9.0)	1,308 (9.2)	2,143 (15.1)	4,686 (33.1)	4,232 (29.9)	14,154
	Without NHMRC funding	189 (2.6)	458 (6.4)	472 (6.6)	836 (11.6)	2,230 (31.0)	3,020 (41.9)	7,205
Universities	Universities total	1,507 (1.9)	4,683 (5.9)	5,093 (6.4)	9,464 (11.9)	24,858 (31.1)	34,256 (42.9)	79,861
	Linked to NHMRC funding	726 (2.7)	2,185 (8.1)	2,295 (8.5)	3,933 (14.6)	9,109 (33.8)	8,709 (32.3)	26,957
	Without NHMRC funding	781 (1.5)	2,498 (4.7)	2,798 (5.3)	5,531 (10.5)	15,749 (29.8)	25,547 (48.3)	52,904
Australia	Australia total	1,899 (2.0)	5,562 (5.9)	5,936 (6.3)	10,959 (11.6)	28,725 (30.5)	41,067 (43.6)	94,148
	Linked to NHMRC funding	862 (2.9)	2,441 (8.3)	2,513 (8.5)	4,302 (14.6)	9,917 (33.7)	9,422 (32.0)	29,457
	Without NHMRC funding	1,037 (1.6)	3,121 (4.8)	3,423 (5.3)	6,657 (10.3)	18,808 (29.1)	31,645 (48.9)	64,691
Expected level	World average distribution	1.0%	4.0%	5.0%	10.0%	30.0%	50.0%	na

na = not applicable

Notes: The count and percentage within each band are relative to the total sector publication output. The expected level indicates the world average distribution for each centile band. A higher than expected percentage of publications appearing in the top two to three bands indicates stronger citation performance than the world average.

4. Collaboration in scientific research



The scientific world is increasingly interconnected, with international collaboration on the rise. The growth in collaboration is facilitated by improved communications and cheaper travel, but is driven by necessity: collaboration enables researchers to share not only knowledge and skills, but also funding, resources and risks. Domestic collaboration offers many of the same efficiencies and benefits. This section considers research collaboration patterns in Australia as indicated by co-authorship of publications.

Three categories are considered: single author (no collaboration), multi-author domestic (more than one Australian author from within one research team or institution), and international (at least one co-author from a country other than Australia). Publications are also considered by research sector and by NHMRC funding scheme. This section also looks at collaboration trends over time.

4.1 Author collaboration patterns in Australian biomedical research

[Figure 8](#) below shows the authorship patterns associated with NHMRC schemes and research sectors. As illustrated, single-author papers are uncommon in the biomedical sciences, with multi-authored papers being the norm across all grant types and all sectors. Almost all (98%) NHMRC-supported biomedical publications during the 2008–2012 period involved two or more authors, compared with 95% for all Australian publications.

The majority (56%) of NHMRC's publications fall in the category of domestic collaborations, that is, they have more than one Australian author from within one research team or institution. This compares to a domestic collaboration rate of 50% for Australia as a whole. There is a notably high level of cross-sector collaboration evident in NHMRC publications. This is further examined in [Section 4.2](#).

Forty-two percent of all NHMRC publications fall in the category of international collaborations for the 2008–2012 period, that is, 42% of papers have at least one author from a country other than Australia. The rate of international collaboration for Australia as a whole is 45%. Although the NHMRC average is slightly lower than the Australian average, the proportion of NHMRC-supported publications with at least one international author has been rising steadily in recent years, from an average of 29% for the period 1996–2000, to 43% for the period 2008–2012.¹¹ Significantly, despite the lower rate of international collaboration, NHMRC-linked publications perform exceptionally well in citation impact. This is further explored in [Section 4.3](#), with international collaborations further considered in [Section 4.4](#).

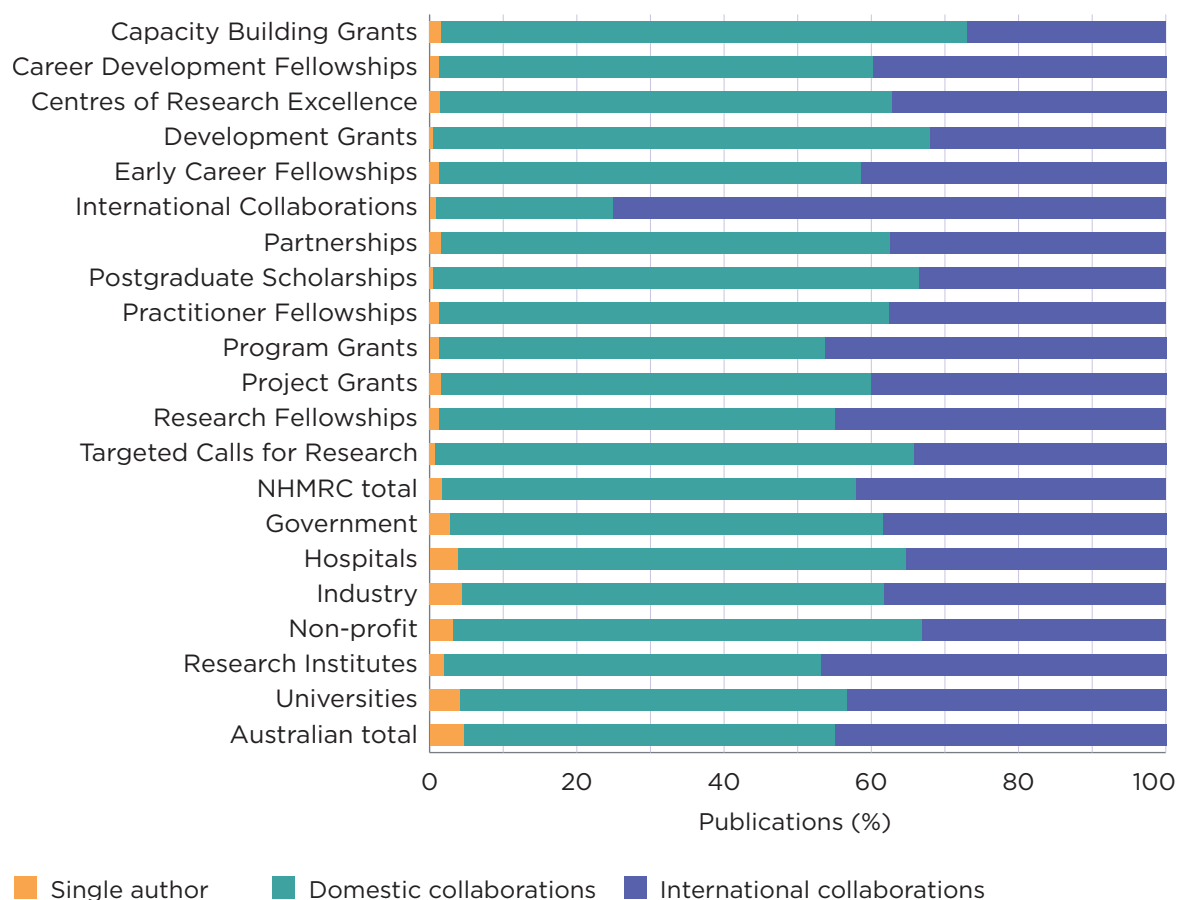
Within the NHMRC funding schemes, the proportion of domestic versus international collaboration varies widely, depending on scheme type. For example, in the schemes referred to as International Collaborations, 75% of all publications had international authors—the highest for any grant scheme or research sector. This reflects the strategic intent of the schemes in this category.¹² The Program Grants and Research Fellowships schemes also have a slightly higher proportion of international

11 Data for 1999–2003 are from L Butler, B Biglia and K Henadeera (2005). *NHMRC-supported research: the impact of journal publication output*, National Health and Medical Research Council, Canberra

12 For the purposes of this report, International Collaborations incorporates more than one grant type. See [Section 1.2.2](#) for details.

4. Collaboration in scientific research

Figure 8: Author collaboration in publications (as a proportion of total output), by NHMRC scheme and research sector, 2008–2012



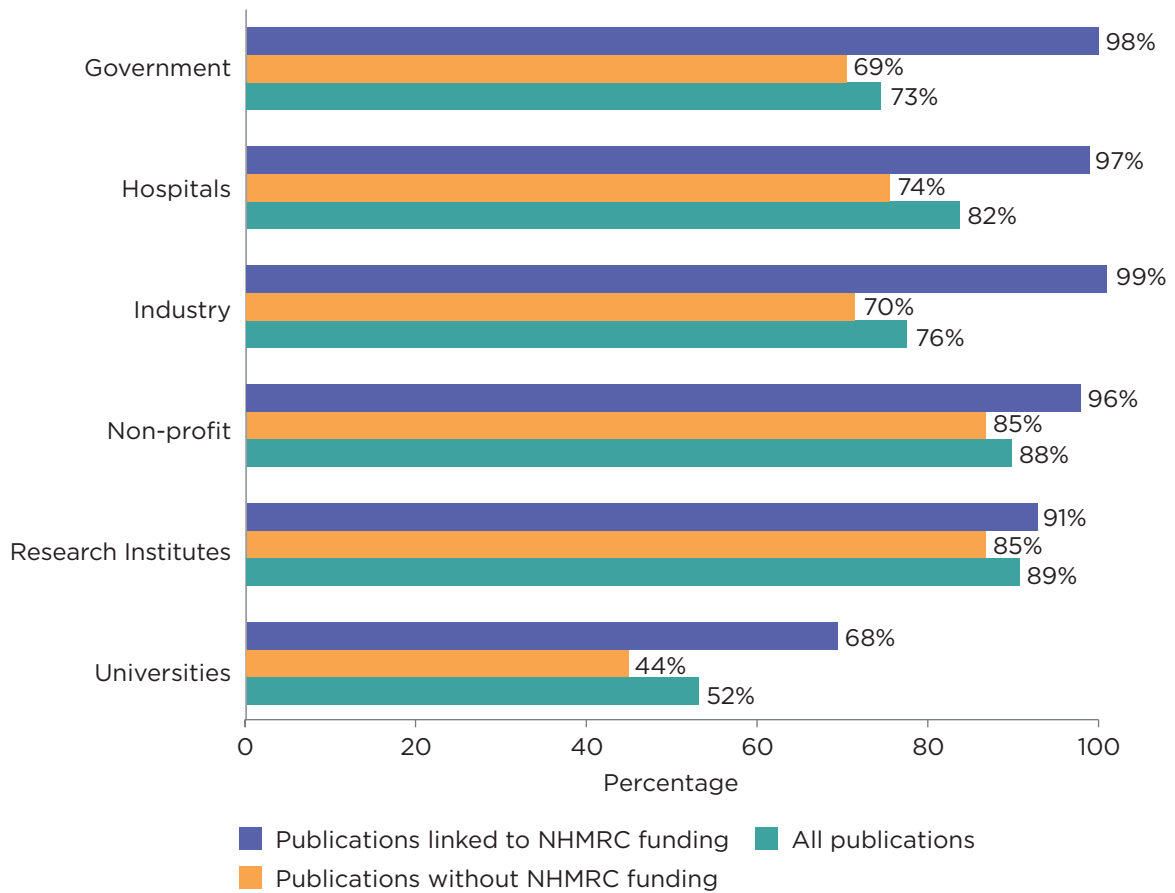
publications than the NHMRC average. Conversely, there is more domestic collaboration and relatively less international collaboration evident for Capacity Building Grants, Development Grants, Targeted Calls for Research, Centres of Research Excellence, and Partnerships. Again, these collaboration patterns are consistent with the research team composition and strategic national focus of these schemes.

Comparing the sectors, the data show that Research Institutes collaborate more often with international authors than other research sectors, at 47%. In contrast, only about one-third of Non-profit sector publications had an international author.

4.2 Cross-sector collaboration

Authorship patterns in NHMRC-supported publications show strong research collaboration linkages between the six research sectors analysed in this report, with consistently higher cross-sector collaboration evident across all sectors compared to publications without NHMRC funding. This is illustrated in [Figure 9](#). The great majority of NHMRC-supported publications from the Industry (99%), Government (98%), Hospitals (97%) and Non-profit (96%) sectors had at least one author from another sector. The rate of cross-sector collaborations in non-NHMRC publications is noticeably lower in the Government, Hospitals, Industry and Universities sectors than in NHMRC-supported research.

Figure 9: Proportion of publications with cross-sector collaborations, by research sector and funding source, 2008–2012



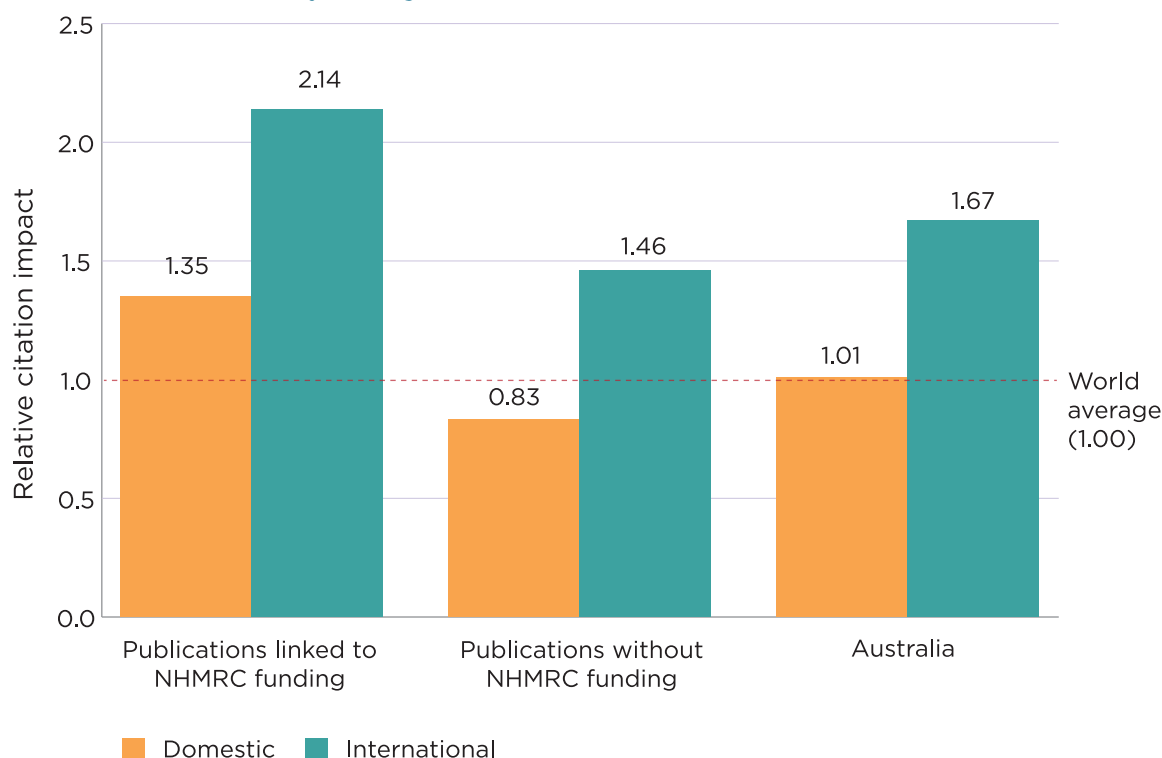
4.3 Citation impact of collaborative research

The relationship between collaboration patterns and relative citation impact is shown in [Figure 10](#). As illustrated in this diagram, the overall citation impact of NHMRC publications is notably higher than that of non-NHMRC publications for all collaboration types. That is, the NHMRC-linked RCI is above the Australian and world average for both domestic and international collaborations.

NHMRC-supported publications with at least one international author had an RCI of 2.14, that is, a relative citation impact 114% above world average. This compares with an RCI of 1.46 (46% above the world average) for publications with international authors but no NHMRC support. NHMRC-supported publications with only Australian (domestic) authors had an RCI of 1.35 (35% above world average). In contrast, solely domestic publications without NHMRC funding support had an RCI of 0.83 (17% below world average).

4. Collaboration in scientific research

Figure 10: Relative citation impact of biomedical publications involving domestic and international collaborations, by funding source, 2008–2012



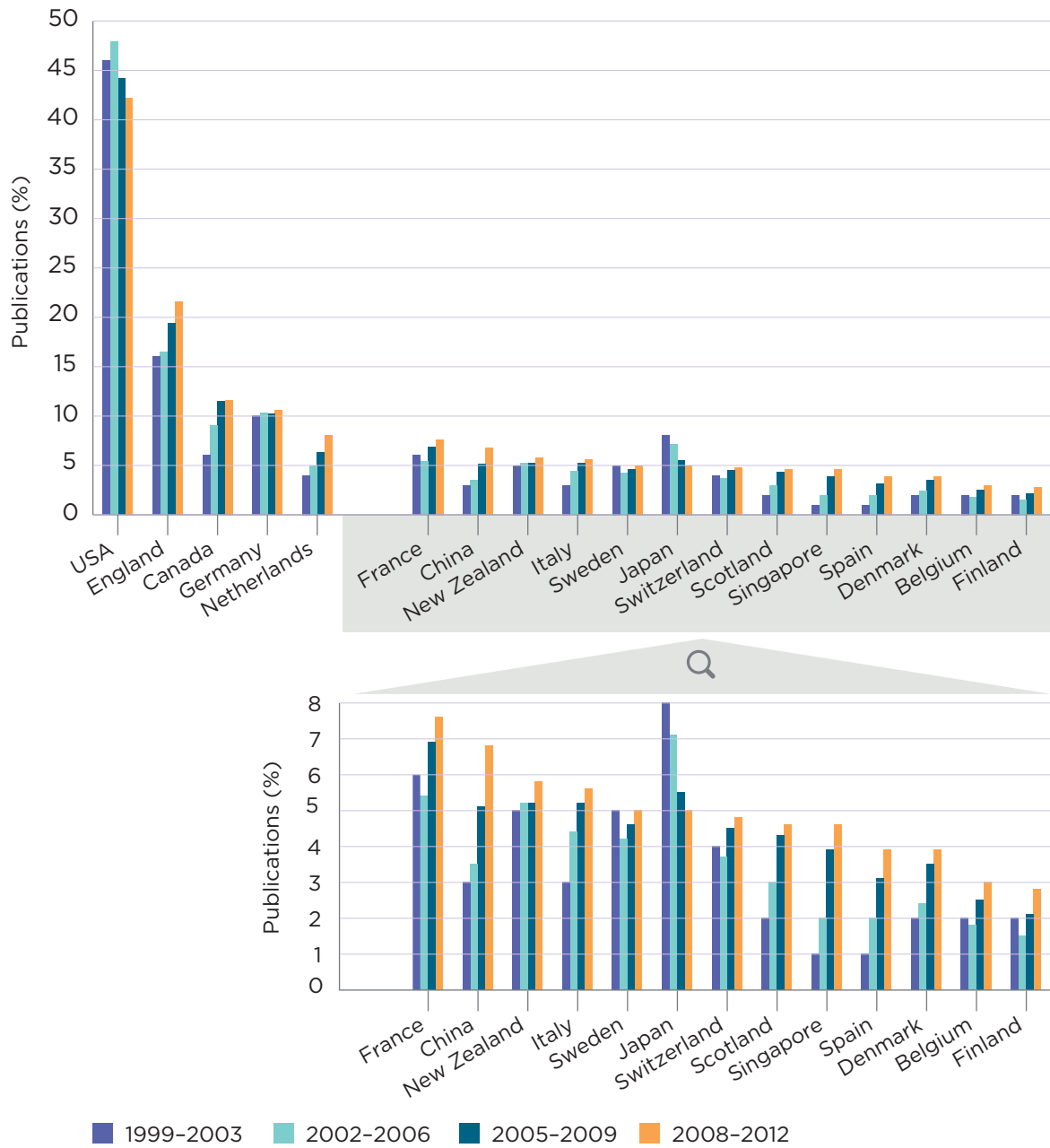
4.4 Collaborating countries

NHMRC-supported research analysed in this report produced joint publications with researchers from 139 countries. [Figure 11](#) shows patterns of co-authorship with the top 18 collaborating countries over the period 1999 to 2012.

The highest growth in publication collaboration since the 1999–2003 period was with Singapore, followed by Spain, Scotland, China and the Netherlands. In the same period, only two countries showed a decrease in the relative share of collaborative papers: the United States (46% to 42%) and Japan (8% to 5%). Notwithstanding its decrease in relative share, the actual number of collaborative papers with the United States increased 43% between the 2005–2009 period and the 2008–2012 period, from 3,663 to 5,254. Further, the United States remains the main collaborative partner, accounting for 42% of all partnerships in the period covered by this report, above the Australian average of 36% (see [Table 12](#) and [Table 13](#)).

The proportion of publications with international collaboration for each grant scheme and research sector is examined in detail in [Table 12](#) and [Table 13](#), respectively. All the countries with which NHMRC supported 100 or more collaborative publications are included in this table. For the full list of countries with which NHMRC supported 10 or more collaborative publications, see Appendix [Table A1](#).

Figure 11: NHMRC-supported publications with one or more international collaborating authors, as a proportion of international collaborative papers, by country, 1999–2012



Source: Data for 1999–2003 and 2002–2006 are from L Butler, B Biglia and K Henadeera (2005). *NHMRC-supported research: the impact of journal publication output*, National Health and Medical Research Council, Canberra; and L Butler and K Henadeera (2009). *Measuring up 2009: NHMRC-supported research—the impact of journal publication output 2002–2006*, National Health and Medical Research Council, Canberra.

4. Collaboration in scientific research

Table 12: Percentage of international collaborative publications, by NHMRC scheme and country, 2008–2012

Country	Capacity Building Grants	Career Development Fellowships	Centres of Research Excellence	Development Grants	Early Career Fellowships	International Collaborations	Partnerships	Postgraduate Scholarships	Practitioner Fellowships	Program Grants	Project Grants	Research Fellowships	Targeted Calls for Research	NHMRC total
USA	37.6	40.3	36.9	33.8	42.1	41.8	31.9	42.2	38.7	46.1	43.1	44.9	47.7	42.2
England	35.7	22.7	22.1	16.9	23.3	42.9	27.8	23.9	26.5	24.1	20.3	21.6	35.3	21.6
Canada	13.7	9.6	13.6	7.7	9.1	15.9	29.2	7.8	23.3	13.2	10.4	11.4	12.1	11.6
Germany	7.8	8.8	8.4	27.7	7.7	21.2	15.3	3.7	13.6	13.2	11.0	11.9	10.6	10.6
Netherlands	11.0	7.5	8.1	4.6	8.8	24.0	9.7	3.2	7.7	10.0	6.7	9.2	17.2	8.0
France	8.2	6.1	6.0	7.7	5.5	15.3	15.3	8.3	7.7	10.6	7.0	8.6	10.6	7.6
China	2.4	4.7	7.9	4.6	6.7	2.5	30.6	2.3	6.1	7.8	6.2	7.0	2.1	6.8
New Zealand	7.5	6.5	7.4	3.1	3.4	4.7	18.1	6.9	9.0	5.8	5.3	4.8	7.3	5.8
Italy	4.3	4.6	6.0	1.5	4.4	15.6	5.6	2.3	9.0	7.7	4.9	6.0	9.1	5.6
Sweden	9.8	4.8	6.1	3.1	4.9	16.2	8.3	2.3	6.1	5.8	5.0	5.9	10.0	5.0
Japan	2.0	4.1	4.0	1.5	4.6	1.9	5.6	2.3	5.1	7.1	4.8	6.0	4.5	5.0
Switzerland	1.6	4.6	5.7	3.1	3.9	7.5	1.4	4.1	8.2	6.1	3.9	5.1	5.4	4.8
Scotland	2.7	3.4	4.6	3.1	6.1	13.1	9.7	4.1	6.0	5.5	4.2	5.3	10.9	4.6
Singapore	7.1	5.3	8.6	13.8	4.3	4.7	0.0	6.0	4.5	3.3	4.2	4.9	3.9	4.6
Spain	6.3	3.4	4.9	1.5	3.8	12.0	1.4	4.6	4.2	4.6	3.5	4.4	5.1	3.9
Denmark	6.7	3.3	5.0	0.0	2.9	15.0	5.6	1.8	3.8	4.6	3.8	5.0	4.2	3.9
Belgium	4.3	2.3	4.0	3.1	2.2	7.5	8.3	0.5	2.9	4.1	2.6	3.6	2.7	3.0
Finland	10.2	2.3	2.2	1.5	2.2	15.3	2.8	2.3	3.1	3.9	2.7	4.1	8.8	2.8
Norway	4.7	1.6	4.0	0.0	1.6	5.0	6.9	0.5	2.4	2.2	2.2	2.4	4.2	2.1

Table 12: continued

Country	Capacity Building Grants	Career Development Fellowships	Centres of Research Excellence	Development Grants	Early Career Fellowships	International Collaborations	Partnerships	Postgraduate Scholarships	Practitioner Fellowships	Program Grants	Project Grants	Research Fellowships	Targeted Calls for Research	NHMRC total
Thailand	4.3	1.8	1.8	1.5	1.6	15.0	4.2	2.3	4.2	2.1	2.2	1.6	0.9	2.0
Austria	1.6	1.2	3.4	1.5	1.3	5.6	1.4	0.5	2.6	2.8	1.5	2.3	2.1	2.0
Ireland	2.0	1.9	1.6	0.0	1.8	3.9	4.2	0.9	2.4	2.3	1.9	1.8	3.6	1.8
Brazil	1.2	1.4	1.4	0.0	1.4	0.3	0.0	1.4	3.3	1.5	1.3	1.6	0.3	1.6
Poland	3.9	1.2	1.0	0.0	0.6	8.6	2.8	0.5	1.4	2.3	1.6	2.0	0.9	1.3
Israel	0.4	0.9	1.6	0.0	1.0	4.2	0.0	0.5	1.5	2.4	1.0	1.9	2.1	1.3
India	3.5	2.4	3.7	0.0	1.6	1.1	1.4	1.4	2.3	1.3	0.8	1.1	0.9	1.3
South Korea	1.6	1.1	1.2	1.5	0.8	2.5	1.4	0.5	2.9	1.8	0.9	1.0	0.3	1.3
Wales	0.8	1.4	1.3	3.1	1.3	1.1	1.4	1.8	1.0	1.3	1.2	1.4	2.1	1.2
South Africa	2.0	0.7	2.7	0.0	1.1	1.1	2.8	0.0	1.4	1.5	0.7	1.4	0.3	1.1
Greece	0.8	0.9	1.1	0.0	0.5	2.8	1.4	0.5	1.3	1.0	0.8	1.1	0.9	0.9
Malaysia	0.4	0.9	0.3	6.2	0.4	1.7	1.4	0.0	1.3	0.9	0.9	0.7	2.1	0.9
Taiwan	3.1	0.8	1.4	0.0	0.8	3.1	1.4	0.0	1.8	1.2	0.8	0.8	1.5	0.8

4. Collaboration in scientific research

Table 13: Percentage of international collaborative publications, by research sector and country, 2008–2012

Country	Government	Hospitals	Industry	Non-profit	Research Institutes	Universities	Australia
USA	36.9	37.2	43.5	40.0	42.1	34.6	36.2
England	17.9	25.7	20.2	25.4	23.6	21.1	22.0
Canada	10.6	14.3	11.6	16.7	10.0	10.7	11.4
Germany	10.0	12.4	9.4	11.7	11.5	9.6	10.5
Netherlands	5.3	8.4	5.1	9.0	8.6	6.1	6.7
France	8.9	9.2	6.8	9.2	8.1	6.5	7.4
China	11.7	7.3	6.6	8.4	6.9	9.4	9.0
New Zealand	9.6	8.3	10.1	11.3	5.5	6.7	6.8
Italy	4.1	8.8	5.8	7.0	6.3	5.2	6.0
Sweden	4.6	5.4	3.9	8.6	5.4	4.5	4.7
Japan	6.1	4.5	3.8	4.8	4.6	4.6	4.7
Switzerland	4.1	6.6	4.6	4.2	5.9	4.7	5.1
Scotland	3.7	4.2	2.4	4.8	4.8	3.5	3.8
Singapore	2.9	4.5	2.5	5.4	6.4	4.1	3.8
Spain	4.1	5.3	3.6	6.8	4.4	3.4	3.9
Denmark	3.5	3.6	1.9	5.0	4.1	3.1	3.2
Belgium	3.3	5.2	3.3	4.3	3.4	3.0	3.4
Finland	1.9	2.7	0.9	5.2	3.5	1.9	2.1
Norway	2.8	2.5	1.4	3.3	2.2	1.9	2.0
Thailand	2.3	1.9	1.1	2.4	1.9	2.1	2.0
Austria	2.0	3.0	3.9	1.6	2.4	1.8	2.1
Ireland	1.1	1.9	1.6	2.1	1.7	1.7	1.7
Brazil	2.8	2.9	2.4	2.3	2.2	2.1	2.3
Poland	0.7	2.3	1.4	2.9	1.7	1.1	1.4
Israel	1.4	2.3	1.9	1.9	1.6	1.5	1.6
India	2.9	2.7	2.3	4.2	3.0	2.2	2.3
South Korea	1.6	1.7	2.3	2.3	1.5	1.3	1.5
Wales	1.4	1.3	1.4	1.9	1.4	1.3	1.3
South Africa	3.5	1.6	2.0	2.7	1.5	1.7	1.8
Greece	0.4	1.2	1.2	1.2	0.9	0.7	0.8
Malaysia	2.5	1.6	1.5	1.9	1.0	1.5	1.5
Taiwan	1.4	1.4	2.1	1.9	1.0	1.4	1.5

Abbreviations

AAMRI	Association of Australian Medical Research Institutes
ANZSRC	Australian and New Zealand Standard Research Classification
CPP	Citations per publication rate
CRCs	Cooperative Research Centres
CREs	Centres of Research Excellence
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ECFs	Early Career Fellowships
HMR	Health and medical research
NHMRC	National Health and Medical Research Council
RGMS	Research Grants Management System (NHMRC)
RCI	Relative citation impact
SSCI	Social Sciences Citation Index
WoS	Web of Science

Appendices



Appendix A: Data tables

Table A1: International collaborative publications in each research sector, by country, 2008-2012

Country	NHMRC, no. (%)	Government, no. (%)	Hospitals, no. (%)	Industry, no. (%)	Non-profit, no. (%)	Research Institutes, no. (%)	Universities, no. (%)	Australia, no. (%)
USA	5,254 (42.2)	975 (36.9)	4,768 (37.2)	696 (43.5)	776 (40.0)	4,242 (42.1)	1,2252 (34.6)	15,579 (36.2)
England	2,681 (21.6)	474 (17.9)	3,295 (25.7)	323 (20.2)	493 (25.4)	2,374 (23.6)	7,476 (21.1)	9,481 (22.0)
Canada	1,441 (11.6)	280 (10.6)	1,825 (14.3)	185 (11.6)	325 (16.7)	1,008 (10.0)	3,802 (10.7)	4,901 (11.4)
Germany	1,315 (10.6)	264 (10.0)	1,586 (12.4)	151 (9.4)	228 (11.7)	1,156 (11.5)	3,410 (9.6)	4,507 (10.5)
Netherlands	996 (8.0)	141 (5.3)	1,081 (8.4)	81 (5.1)	175 (9.0)	870 (8.6)	2,178 (6.1)	2,894 (6.7)
France	943 (7.6)	234 (8.9)	1,174 (9.2)	108 (6.8)	179 (9.2)	816 (8.1)	2,300 (6.5)	3,168 (7.4)
China	850 (6.8)	308 (11.7)	938 (7.3)	105 (6.6)	163 (8.4)	695 (6.9)	3,327 (9.4)	3,885 (9.0)
New Zealand	718 (5.8)	255 (9.6)	1,066 (8.3)	161 (10.1)	219 (11.3)	558 (5.5)	2,385 (6.7)	2,913 (6.8)
Italy	701 (5.6)	109 (4.1)	1,125 (8.8)	92 (5.8)	136 (7.0)	636 (6.3)	1,830 (5.2)	2,594 (6.0)
Sweden	623 (5.0)	121 (4.6)	693 (5.4)	63 (3.9)	167 (8.6)	541 (5.4)	1,580 (4.5)	2,014 (4.7)
Japan	618 (5.0)	162 (6.1)	575 (4.5)	61 (3.8)	93 (4.8)	464 (4.6)	1,625 (4.6)	2,040 (4.7)
Switzerland	602 (4.8)	109 (4.1)	839 (6.6)	74 (4.6)	81 (4.2)	596 (5.9)	1,670 (4.7)	2,212 (5.1)
Scotland	570 (4.6)	99 (3.7)	536 (4.2)	39 (2.4)	93 (4.8)	484 (4.8)	1,255 (3.5)	1,623 (3.8)
Singapore	567 (4.6)	76 (2.9)	575 (4.5)	40 (2.5)	105 (5.4)	643 (6.4)	1,449 (4.1)	1,632 (3.8)
Spain	481 (3.9)	108 (4.1)	678 (5.3)	57 (3.6)	132 (6.8)	439 (4.4)	1,220 (3.4)	1,676 (3.9)
Denmark	480 (3.9)	93 (3.5)	466 (3.6)	30 (1.9)	98 (5.0)	415 (4.1)	1,082 (3.1)	1,396 (3.2)
Belgium	372 (3.0)	86 (3.3)	660 (5.2)	53 (3.3)	84 (4.3)	338 (3.4)	1,049 (3.0)	1,447 (3.4)
Finland	352 (2.8)	51 (1.9)	347 (2.7)	15 (0.9)	101 (5.2)	353 (3.5)	681 (1.9)	919 (2.1)

Table A1: *continued*

Country	NHMRC, no. (%)	Government, no. (%)	Hospitals, no. (%)	Industry, no. (%)	Non-profit, no. (%)	Research Institutes, no. (%)	Universities, no. (%)	Australia, no. (%)
Norway	259 (2.1)	75 (2.8)	320 (2.5)	22 (1.4)	64 (3.3)	223 (2.2)	690 (1.9)	850 (2.0)
Thailand	251 (2.0)	62 (2.3)	237 (1.9)	18 (1.1)	47 (2.4)	196 (1.9)	735 (2.1)	881 (2.0)
Austria	246 (2.0)	52 (2.0)	382 (3.0)	62 (3.9)	32 (1.6)	245 (2.4)	639 (1.8)	920 (2.1)
Ireland	226 (1.8)	29 (1.1)	248 (1.9)	25 (1.6)	40 (2.1)	172 (1.7)	591 (1.7)	731 (1.7)
Brazil	202 (1.6)	75 (2.8)	368 (2.9)	39 (2.4)	45 (2.3)	221 (2.2)	750 (2.1)	1,000 (2.3)
Poland	167 (1.3)	18 (0.7)	297 (2.3)	23 (1.4)	57 (2.9)	176 (1.7)	393 (1.1)	603 (1.4)
Israel	165 (1.3)	36 (1.4)	292 (2.3)	31 (1.9)	36 (1.9)	161 (1.6)	528 (1.5)	694 (1.6)
India	164 (1.3)	77 (2.9)	342 (2.7)	36 (2.3)	82 (4.2)	299 (3.0)	765 (2.2)	1,006 (2.3)
South Korea	164 (1.3)	42 (1.6)	216 (1.7)	37 (2.3)	44 (2.3)	155 (1.5)	471 (1.3)	661 (1.5)
Wales	153 (1.2)	37 (1.4)	167 (1.3)	22 (1.4)	36 (1.9)	138 (1.4)	463 (1.3)	569 (1.3)
South Africa	139 (1.1)	93 (3.5)	201 (1.6)	32 (2.0)	53 (2.7)	156 (1.5)	614 (1.7)	794 (1.8)
Greece	118 (0.9)	11 (0.4)	156 (1.2)	19 (1.2)	23 (1.2)	93 (0.9)	256 (0.7)	354 (0.8)
Malaysia	111 (0.9)	66 (2.5)	207 (1.6)	24 (1.5)	36 (1.9)	101 (1.0)	528 (1.5)	637 (1.5)
Taiwan	103 (0.8)	37 (1.4)	177 (1.4)	34 (2.1)	36 (1.9)	102 (1.0)	498 (1.4)	627 (1.5)
Iran	92 (0.7)	31 (1.2)	110 (0.9)	8 (0.5)	14 (0.7)	68 (0.7)	408 (1.2)	454 (1.1)
Czech Republic	90 (0.7)	21 (0.8)	147 (1.1)	26 (1.6)	13 (0.7)	58 (0.6)	232 (0.7)	351 (0.8)
Papua New Guinea	89 (0.7)	11 (0.4)	72 (0.6)	8 (0.5)	5 (0.3)	81 (0.8)	164 (0.5)	186 (0.4)
Iceland	83 (0.7)	14 (0.5)	61 (0.5)	0 (0.0)	14 (0.7)	75 (0.7)	105 (0.3)	135 (0.3)
Indonesia	79 (0.6)	32 (1.2)	83 (0.6)	5 (0.3)	16 (0.8)	91 (0.9)	254 (0.7)	276 (0.6)

Table A1: *continued*

Country	NHMRC, no. (%)	Government, no. (%)	Hospitals, no. (%)	Industry, no. (%)	Non-profit, no. (%)	Research Institutes, no. (%)	Universities, no. (%)	Australia, no. (%)
Portugal	72 (0.6)	23 (0.9)	109 (0.9)	7 (0.4)	9 (0.5)	58 (0.6)	255 (0.7)	327 (0.8)
Russia	71 (0.6)	16 (0.6)	90 (0.7)	13 (0.8)	25 (1.3)	62 (0.6)	188 (0.5)	245 (0.6)
Sri Lanka	67 (0.5)	8 (0.3)	69 (0.5)	6 (0.4)	6 (0.3)	21 (0.2)	184 (0.5)	202 (0.5)
Northern Ireland	65 (0.5)	12 (0.5)	118 (0.9)	6 (0.4)	13 (0.7)	79 (0.8)	220 (0.6)	264 (0.6)
Mexico	62 (0.5)	45 (1.7)	94 (0.7)	41 (2.6)	25 (1.3)	49 (0.5)	241 (0.7)	337 (0.8)
Vietnam	58 (0.5)	24 (0.9)	58 (0.5)	5 (0.3)	12 (0.6)	57 (0.6)	195 (0.6)	221 (0.5)
Argentina	55 (0.4)	36 (1.4)	156 (1.2)	18 (1.1)	15 (0.8)	49 (0.5)	198 (0.6)	329 (0.8)
Hungary	51 (0.4)	15 (0.6)	78 (0.6)	27 (1.7)	16 (0.8)	65 (0.6)	165 (0.5)	261 (0.6)
Turkey	50 (0.4)	14 (0.5)	114 (0.9)	22 (1.4)	1 (0.1)	35 (0.3)	186 (0.5)	258 (0.6)
Estonia	48 (0.4)	9 (0.3)	37 (0.3)	2 (0.1)	5 (0.3)	46 (0.5)	81 (0.2)	104 (0.2)
Fiji	43 (0.3)	5 (0.2)	29 (0.2)	2 (0.1)	16 (0.8)	37 (0.4)	78 (0.2)	92 (0.2)
Chile	42 (0.3)	20 (0.8)	58 (0.5)	4 (0.3)	15 (0.8)	32 (0.3)	131 (0.4)	175 (0.4)
Saudi Arabia	36 (0.3)	13 (0.5)	76 (0.6)	11 (0.7)	8 (0.4)	28 (0.3)	146 (0.4)	183 (0.4)
Philippines	35 (0.3)	24 (0.9)	53 (0.4)	11 (0.7)	12 (0.6)	36 (0.4)	148 (0.4)	193 (0.4)
Bulgaria	33 (0.3)	5 (0.2)	36 (0.3)	1 (0.1)	7 (0.4)	32 (0.3)	54 (0.2)	78 (0.2)
Slovenia	31 (0.2)	11 (0.4)	40 (0.3)	8 (0.5)	8 (0.4)	29 (0.3)	76 (0.2)	108 (0.3)
Colombia	27 (0.2)	21 (0.8)	40 (0.3)	7 (0.4)	7 (0.4)	23 (0.2)	105 (0.3)	132 (0.3)
Croatia	26 (0.2)	15 (0.6)	45 (0.4)	6 (0.4)	7 (0.4)	27 (0.3)	70 (0.2)	110 (0.3)
Egypt	21 (0.2)	5 (0.2)	40 (0.3)	14 (0.9)	2 (0.1)	17 (0.2)	83 (0.2)	114 (0.3)
Pakistan	21 (0.2)	13 (0.5)	48 (0.4)	9 (0.6)	5 (0.3)	25 (0.2)	106 (0.3)	131 (0.3)

Table A1: continued

Country	NHMRC, no. (%)	Government, no. (%)	Hospitals, no. (%)	Industry, no. (%)	Non-profit, no. (%)	Research Institutes, no. (%)	Universities, no. (%)	Australia, no. (%)
Kenya	20 (0.2)	18 (0.7)	18 (0.1)	7 (0.4)	14 (0.7)	43 (0.4)	92 (0.3)	131 (0.3)
Cambodia	19 (0.2)	4 (0.2)	12 (0.1)	0 (0.0)	2 (0.1)	15 (0.1)	67 (0.2)	69 (0.2)
Lithuania	18 (0.1)	4 (0.2)	23 (0.2)	3 (0.2)	2 (0.1)	16 (0.2)	30 (0.1)	47 (0.1)
Latvia	17 (0.1)	4 (0.2)	15 (0.1)	5 (0.3)	1 (0.1)	18 (0.2)	32 (0.1)	46 (0.1)
Belarus	16 (0.1)	0 (0.0)	16 (0.1)	2 (0.1)	10 (0.5)	16 (0.2)	22 (0.1)	31 (0.1)
Mozambique	16 (0.1)	3 (0.1)	13 (0.1)	4 (0.3)	2 (0.1)	16 (0.2)	30 (0.1)	42 (0.1)
Romania	16 (0.1)	2 (0.1)	43 (0.3)	11 (0.7)	4 (0.2)	15 (0.1)	66 (0.2)	94 (0.2)
Peru	15 (0.1)	14 (0.5)	14 (0.1)	4 (0.3)	5 (0.3)	12 (0.1)	49 (0.1)	65 (0.2)
Bangladesh	13 (0.1)	7 (0.3)	26 (0.2)	1 (0.1)	4 (0.2)	17 (0.2)	103 (0.3)	115 (0.3)
Nigeria	13 (0.1)	8 (0.3)	17 (0.1)	1 (0.1)	2 (0.1)	14 (0.1)	52 (0.1)	72 (0.2)
Ghana	12 (0.1)	6 (0.2)	12 (0.1)	1 (0.1)	4 (0.2)	14 (0.1)	35 (0.1)	45 (0.1)
Tanzania	12 (0.1)	8 (0.3)	9 (0.1)	0 (0.0)	6 (0.3)	30 (0.3)	46 (0.1)	73 (0.2)
Lebanon	11 (0.1)	1 (<0.1)	29 (0.2)	1 (0.1)	1 (0.1)	12 (0.1)	52 (0.1)	64 (0.1)
Malawi	11 (0.1)	1 (<0.1)	30 (0.2)	0 (0.0)	1 (0.1)	27 (0.3)	61 (0.2)	67 (0.2)
Serbia	11 (0.1)	2 (0.1)	29 (0.2)	3 (0.2)	2 (0.1)	10 (0.1)	37 (0.1)	57 (0.1)
Total	12,436	2,643	12,802	1,600	1,941	10,067	35,420	43,064

Appendix B: Research Institutes

This sector covers the following 47 member institutes of the Association of Australian Medical Research Institutes, as listed at www.aamri.org as of 15 July 2015, when the analysis commenced:

- ANZAC Research Institute
- Australian Institute of Tropical Health and Medicine
- Australian Regenerative Medicine Institute
- Baker IDI Heart & Diabetes Institute
- Bionics Institute
- Brien Holden Vision Institute
- Burnet Institute
- Centenary Institute of Cancer Medicine and Cell Biology
- Centre for Cancer Biology
- Centre for Eye Research Australia
- Children's Cancer Institute
- Children's Medical Research Institute
- Florey Institute of Neuroscience and Mental Health
- Garvan Institute of Medical Research
- Hanson Institute
- Harry Perkins Institute of Medical Research
- Heart Research Institute
- Hudson Institute of Medical Research
- Hunter Medical Research Institute
- Institute for Breathing and Sleep
- Kolling Institute of Medical Research
- Lions Eye Institute
- Mater Research
- Melanoma Institute Australia
- Menzies Institute for Medical Research
- Menzies School of Health Research
- Murdoch Children's Research Institute
- National Ageing Research Institute
- Neuroscience Research Australia
- Olivia Newton-John Cancer Research Institute
- Orygen, The National Centre of Excellence in Youth Mental Health
- Peter MacCallum Cancer Centre
- QIMR Berghofer Medical Research Institute
- Queensland Children's Medical Research Institute
- Queensland Eye Institute
- Schizophrenia Research Institute
- South Australian Health and Medical Research Institute

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- St Vincent's Institute of Medical Research
- Telethon Kids Institute
- The George Institute for Global Health
- Translational Research Institute
- Victor Chang Cardiac Research Institute
- Walter and Eliza Hall Institute of Medical Research
- Wesley Medical Research (formerly Wesley-St Andrew's Research Institute)
- Westmead Millennium Institute
- Women's & Children's Health Research Institute
- Woolcock Institute of Medical Research

Appendix C: Correspondence between fields of research (ANZSRC) and Web of Science journal subject categories

The following Web of Science subject categories were mapped to the Australian and New Zealand Standard Research Classification (ANZSRC) fields and sub-fields of research for the analyses. Information on these subject categories can be found at the [Clarivate Analytics Master Journal List](#).¹³

The term 'biomedical publications' as used in this report refers to publications appearing in journals classified in any of the following journal subject categories from the Web of Science database.

Table C1: Mapping of fields and sub-fields of research to Web of Science subject categories

Fields/sub-fields of research	Web of Science subject categories
Biological Physics	Biophysics
General Biological Sciences*	Biochemical Research Methods; Biotechnology and Applied Microbiology
Biochemistry and Cell Biology	Biochemistry and Molecular Biology; Cell Biology
Genetics	Genetics and Heredity
Microbiology	Microbiology; Virology
Biomedical Engineering	Engineering, Biomedical; Materials Science, Biomaterials
General Medical and Health Sciences*	Medicine, General and Internal
Medical Biochemistry and Metabolomics	Chemistry, Medicinal
Cardiovascular Medicine and Haematology	Cardiac and Cardiovascular Systems; Hematology; Peripheral Vascular Disease; Respiratory System
Clinical Sciences	Anesthesiology; Critical Care Medicine; Dermatology; Emergency Medicine; Endocrinology and Metabolism; Gastroenterology and Hepatology; Geriatrics and Gerontology; Gerontology (SSCI); Infectious Diseases; Orthopedics; Otorhinolaryngology; Pathology; Psychiatry; Psychiatry (SSCI); Psychology; Radiology, Nuclear Medicine and Medical Imaging; Rehabilitation; Rehabilitation (SSCI); Rheumatology; Surgery; Urology and Nephrology; Transplantation; Tropical Medicine
Complementary and Alternative Medicine	Integrative and Complementary Medicine
Dentistry	Dentistry, Oral Surgery and Medicine
Human Movement and Sports Science	Sport Sciences
Immunology	Allergy; Immunology
Neurosciences	Neurosciences; Clinical Neurology; Neuroimaging
Nursing	Nursing; Nursing (SSCI)
Nutrition and Dietetics	Nutrition and Dietetics

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Table C1: *continued*

Fields/sub-fields of research	Web of Science subject categories
Oncology and Carcinogenesis	Oncology
Optometry and Ophthalmology	Ophthalmology
Paediatrics and Reproductive Medicine	Andrology; Obstetrics and Gynecology; Pediatrics
Pharmacology and Pharmaceutical Sciences	Pharmacology and Pharmacy; Toxicology
Medical Physiology	Anatomy and Morphology; Physiology
Public Health and Health Services	Ergonomics (SSCI); Health Care Sciences and Services; Primary Health Care; Public, Environmental and Occupational Health; Public, Environmental and Occupational Health (SSCI); Health Policy and Services (SSCI); Medical Informatics; Substance Abuse; Substance Abuse (SSCI)
Other Medical and Health Sciences	Medical Laboratory Technology; Medicine, Research and Experimental
Multidisciplinary Sciences*	Multidisciplinary Sciences

* Non-standard ANZSRC Fields of Research category. See [Section 1.4](#) for details.

Appendix D: Data tables for selected figures

Table D1: Percentage of Australian biomedical publications linked to NHMRC support, by fields and sub-fields of research, 2008–2012 (data table for Figure 3)

Fields and sub-fields of research	Publications linked to NHMRC funding	Publications without NHMRC funding
Medical and Health Sciences	31	69
Medical Biochemistry and Metabolomics	23	77
Cardiovascular Medicine and Haematology	41	59
Clinical Sciences	29	71
Complementary and Alternative Medicine	10	90
Dentistry	13	87
Human Movement and Sports Science	18	82
Immunology	55	45
Neurosciences	41	59
Nursing	6	94
Nutrition and Dietetics	28	72
Oncology and Carcinogenesis	40	60
Optometry and Ophthalmology	30	70
Paediatrics and Reproductive Medicine	32	68
Pharmacology and Pharmaceutical Sciences	32	68
Medical Physiology	37	63
Public Health and Health Services	26	74
Other Medical and Health Sciences	40	60
General Medical and Health Sciences	26	74
General Biological Sciences	21	79
Biochemistry and Cell Biology	45	55
Genetics	29	71
Microbiology	33	67
Biological Physics	33	67
Biomedical Engineering	17	83
Multidisciplinary Sciences	30	70
All biomedical sciences	31	69

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Table D2: Relative citation impact of biomedical publications within research sectors and Australian total, by funding source, 2008–2012 (data table for Figure 5)

Sector	Publications linked to NHMRC funding	Publications without NHMRC funding	All publications
Government	1.87	1.09	1.21
Hospitals	1.68	1.08	1.30
Industry	1.58	0.99	1.12
Non-profit	1.74	1.07	1.31
Research Institutes	1.85	1.43	1.72
Universities	1.62	1.11	1.29
Australia	1.68	1.12	1.30

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Table D3: Relative citation impact of Australian biomedical publications, by field and sub-field of research and funding source, 2008–2012 (data table for Figure 7)

Field/sub-field of research	Publications linked to NHMRC funding	Publications without NHMRC funding	All publications
Medical and Health Sciences	1.79	1.05	1.28
Medical Biochemistry and Metabolomics	1.54	1.22	1.29
Cardiovascular Medicine and Haematology	1.62	1.17	1.37
Clinical Sciences	1.75	1.11	1.30
Complementary and Alternative Medicine*	nc	0.80	0.84
Dentistry	2.02	1.11	1.22
Human Movement and Sports Science	1.73	1.23	1.33
Immunology	1.54	1.04	1.33
Neurosciences	1.47	0.97	1.18
Nursing	1.60	1.24	1.26
Nutrition and Dietetics	1.33	1.00	1.09
Oncology and Carcinogenesis	1.63	1.39	1.49
Optometry and Ophthalmology	1.70	1.15	1.32
Paediatrics and Reproductive Medicine	1.89	1.25	1.46
Pharmacology and Pharmaceutical Sciences	1.58	1.13	1.28
Medical Physiology	1.58	0.99	1.21
Public Health and Health Services	1.45	0.91	1.05
Other Medical and Health Sciences	1.78	1.11	1.39
General Medical and Health Sciences	3.69	1.37	1.99
General Biological Sciences	1.63	1.12	1.23
Biochemistry and Cell Biology	1.38	1.07	1.21

Table D3: *continued*

Field/sub-field of research	Publications linked to NHMRC funding	Publications without NHMRC funding	All publications
Genetics	2.05	1.10	1.39
Microbiology	1.54	1.20	1.32
Biological Physics	1.17	0.90	0.99
Biomedical Engineering	1.57	1.03	1.12
Multidisciplinary Sciences	1.67	1.34	1.44
All biomedical sciences	1.68	1.12	1.30

nc = not calculated

* The publication set of Complementary and Alternative Medicine that was linked to NHMRC funding was not analysed due to the low volume threshold.

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Table D4: Author collaboration in publications, by NHMRC scheme and research sector, 2008–2012 (data table for Figure 8)

NHMRC scheme/Research sector	Single author (%)	Domestic collaborations (%)	International collaborations (%)
Capacity Building Grants	1.5	71.5	27.0
Career Development Fellowships	1.2	59.0	39.9
Centres of Research Excellence	1.4	61.3	37.4
Development Grants	0.5	67.5	32.0
Early Career Fellowships	1.3	57.2	41.6
International Collaborations	0.8	24.1	75.1
Partnerships	1.6	60.9	37.5
Postgraduate Scholarships	0.5	66.0	33.5
Practitioner Fellowships	1.3	61.1	37.6
Program Grants	1.2	52.5	46.4
Project Grants	1.6	58.3	40.2
Research Fellowships	1.3	53.7	45.0
Targeted Calls for Research	0.7	65.1	34.3
NHMRC total	1.7	56.2	42.1
Government	2.8	58.7	38.6
Hospitals	3.8	60.9	35.4
Industry	4.4	57.2	38.4
Non-profit	3.1	63.8	33.1
Research Institutes	2.0	51.1	47.0
Universities	4.1	52.5	43.6
Australia	4.6	50.5	45.0

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Appendices

Table D5: Percentage of publications with cross-sector collaborations, by research sector and funding source, 2008–2012 (data table for Figure 9)

Research sector	Publications linked to NHMRC funding	Publications without NHMRC funding	All publications
Government	98	69	73
Hospitals	97	74	82
Industry	99	70	76
Non-profit	96	85	88
Research Institutes	91	85	89
Universities	68	44	52

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Table D6: NHMRC-supported publications with one or more international collaborating authors, as a percentage of international collaborative papers, by country, 1999–2012 (data table for Figure 11)

Country	1999–2003	2002–2006	2005–2009	2008–2012
USA	46	47.9	44.2	42.2
England	16	16.5	19.4	21.6
Canada	6	9.0	11.5	11.6
Germany	10	10.3	10.2	10.6
Netherlands	4	5.0	6.3	8.0
France	6	5.4	6.9	7.6
China	3	3.5	5.1	6.8
New Zealand	5	5.2	5.2	5.8
Italy	3	4.4	5.2	5.6
Sweden	5	4.2	4.6	5.0
Japan	8	7.1	5.5	5.0
Switzerland	4	3.7	4.5	4.8
Scotland	2	3.0	4.3	4.6
Singapore	1	2.0	3.9	4.6
Spain	1	2.0	3.1	3.9
Denmark	2	2.4	3.5	3.9
Belgium	2	1.8	2.5	3.0
Finland	2	1.5	2.1	2.8

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