

NHMRC – supported
research: the impact of
journal publication output



INVESTING IN AUSTRALIA'S HEALTH



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NHMRC – supported research: the impact of journal publication output 1996–2000

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Paper-based publications

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CONTENTS

EXECUTIVE SUMMARY	V
ACKNOWLEDGMENTS	VII
INTRODUCTION	VIII
1 METHODOLOGY	1
1.1 Coverage of ISI database	1
1.2 Definition of sectors	1
1.3 Methodology overview	3
1.4 Performance Measures	5
1.4.1 Citations per publication	5
1.4.2 Actual and expected citation rates	5
1.4.3 Most highly cited publications	6
1.4.4 Level of collaboration	6
1.4.5 Research level	7
1.5 Underlying data	7
1.6 Comparison of 2001 and 2003 Assessments	7
2 SECTOR CHARACTERISTICS AND PERFORMANCE	9
2.1 Sector Research Profiles	9
2.2 Level of Research	10
2.3 Collaboration	11
2.4 Location of Australian research	12
2.5 Citation Performance	13
3 SELECTED CHARACTERISTICS AND PERFORMANCE OF NHMRC SCHEMES	16
3.1 Project Grants - Broad research area	16
3.2 Project Grants - Disciplines	17
3.3 Fellowships – Gender	18
3.4 Administering institution	19

Contents

4	RFCD FIELDS AND SUB-FIELDS OF RESEARCH	22
4.1	Sub-Field: Biochemistry and Cell Biology	22
4.2	Sub-Field: Genetics	24
4.3	Sub-Field: Microbiology	26
4.4	Sub-Field: Biotechnology	28
4.5	Field: Medical and Health Sciences	30
4.6	Sub-Field: Immunology	32
4.7	Sub-Field: Pharmacology and Pharmaceutical Science	34
4.8	Sub-Field: Medical physiology	36
4.9	Sub-Field: Neurosciences	38
4.10	Sub-Field: Clinical sciences	40
4.11	Sub-Field: Public health and health services	42
4.12	Sub-Field: Medicine general	44
4.13	Sub-Field: Multidisciplinary science	45
	BIBLIOGRAPHY	48
	TECHNICAL ANNEX: METHODOLOGY	49
T1	The Research Evaluation and Policy Project Database	49
T2	Assignment of multi-institutional addresses	49
T3	Field of research classification	50
T4	Small Numbers	51
T5	ISI Coverage	51
T6	Identification of publications from NHMRC sectors	52
T6.1	Project Grants (sector 1)	52
T6.2	Program Grants (sector 2)	56
T6.3	Block-funded research institute grants (sector 3)	57
T6.4	Research unit grants (sector 4)	57
T6.5	Research Fellowships Awards (sectors 5 and 6)	57

T7	Delineation of comparator sectors	58
T7.1	Other Research Institutes (sector 7)	58
T7.2	Cooperative Research Centres (sector 8)	59
T7.3	Other University publications (sector 9)	59
T7.4	Other Hospital publications (sector 10)	59
T7.5	Other Government publications (sector 11)	60
T8	Sector overlap	60
APPENDIX		62

LIST OF TABLES AND FIGURES

Table 1:	Distribution of publications in sectors by RFCD classification	9
Table 2:	International collaboration by sector and country (percent)	12
Table 3:	Distribution of Australian publications across sectors by RFCD classification	13
Table 4:	Citations per publication – all publications	14
Table 5:	Broad area of research of Project Grants linked to publications	16
Table 6:	Discipline classification of grants linked to publications	17
Table 7:	Citations per publication—Biochemistry and cell biology	22
Table 8:	Most highly cited Australian publications—Biochemistry and cell biology	22
Table 9:	Citations per publication—Genetics	24
Table 10:	Most highly cited Australian publications—Genetics	25
Table 11:	Citations per publication—Microbiology	26
Table 12:	Most highly cited Australian publications—Microbiology	26
Table 13:	Citations per publication—Biotechnology	28
Table 14:	Most highly cited Australian publications—Biotechnology	29
Table 15:	Citations per publication—Medical and Health Sciences	30
Table 16:	Most highly cited Australian publications—Medical and Health Sciences	31
Table 17:	Citations per publication—Immunology	32
Table 18:	Most highly cited Australian publications—Immunology	33
Table 19:	Citations per publication—Pharmacology & pharmaceutical science	34
Table 20:	Most highly cited Australian publications—Pharmacology & pharmaceutical science	35
Table 21:	Citations per publication—Medical physiology	36
Table 22:	Most highly cited Australian publications—Medical physiology	37
Table 23:	Citations per publication—Neurosciences	38
Table 24:	Most highly cited Australian publications—Neurosciences	39
Table 25:	Citations per publication—Clinical sciences	40
Table 26:	Most highly cited Australian publications—Clinical sciences	40
Table 27:	Citations per publication—Public health and health services	42
Table 28:	Most highly cited Australian publications—Public health and health services	43
Table 29:	Citations per publication—Medicine general	44
Table 30:	Most highly cited Australian publications—Medicine general	45
Table 31:	Citations per publication—Multidisciplinary science	45
Table 32:	Most highly cited Australian publications—Multidisciplinary science	47
Table T1:	Distribution of research by type of publication and field, 1995	51
Table T2:	Proportion of journal articles captured by ISI, all universities, 1991	52
Table T3:	Number of 1999-2002 Project Grant applications supplying data on linked publications	55
Table T4:	Coverage of successful Project Grants awarded between 1991 and 2000	56

Contents

Table T5: Overlap of sector publication sets (sectors 1-8).....	60
Table T6: Overlap of sector publication sets (sectors 1-5 and 8).....	61
Table T7: Overlap of sector publication sets (sectors 9-11).....	61
<u>Figure 1: Level of research by sector</u>	10
<u>Figure 2: Collaboration patterns by sector</u>	11
<u>Figure 3: Actual and expected citation rate—all publications</u>	14
<u>Figure 4: Actual and expected citation rates—broad areas of research</u>	16
<u>Figure 5: Actual and expected citation rates—disciplines</u>	18
<u>Figure 6: Actual and expected citation rates by type of Fellowship and gender</u>	19
<u>Figure 7A: Actual and expected citation rates by administering institution</u>	20
<u>Figure 7B: Actual and expected citation rates by administering institution</u>	20
<u>Figure 8: Actual and expected citation rates—Biochemistry and cell biology</u>	23
<u>Figure 9: Actual and expected citation rates—Genetics</u>	24
<u>Figure 10: Actual and expected citation rates—Microbiology</u>	26
<u>Figure 11: Actual and expected citation rates—Biotechnology</u>	28
<u>Figure 12: Actual and expected citation rates—Medical and Health Sciences</u>	30
<u>Figure 13: Actual and expected citation rates—Immunology</u>	32
<u>Figure 14: Actual and expected citation rates—Pharmacology & pharmaceutical science</u>	34
<u>Figure 15: Actual and expected citation rates—Medical physiology</u>	36
<u>Figure 16: Actual and expected citation rates—Neurosciences</u>	38
<u>Figure 17: Actual and expected citation rates—Clinical sciences</u>	41
<u>Figure 18: Actual and expected citation rates—Public health and health services</u>	42
<u>Figure 19: Actual and expected citation rates—Medicine general</u>	44
<u>Figure 20: Actual and expected citation rates—Multidisciplinary science</u>	46

Executive summary

Background

The Research Evaluation and Policy Project (REPP) was commissioned by the National Health and Medical Research Council (NHMRC) to update its 2001 analyses of the impact of publications resulting from the research it funded. The NHMRC has many diverse schemes for funding research, targeting different aggregations of effort – the institution, the unit, the research group, cross institutional programs, and the individual researcher. This current analysis, like the 2001 study, creates a series of publication sets that enable each of the NHMRC’s main research grants schemes to be evaluated on the basis of citation impact. The study was conducted in tandem with a similar analysis of the publication output attributable to Australian Research Council funding.

Database

The analysis is based primarily on the REPP database. It contains all Australian publications indexed in the Institute for Scientific Information’s three main indices: the Science Citation Index, the Social Sciences Citation Index, and the Arts and Humanities Citation Index. Additional information on grant and researcher characteristics provided by the NHMRC is incorporated into the analysis.

Sectors analysed

The report identifies eleven sectors. Six equate to NHMRC research grants schemes – Project Grants; Program Grants; block-funded research institutes; Research Unit grants; and Research Fellowship awards (institute and Project). The remaining five represent other sites of activity in Australian medical research – other research institutes; cooperative research centres; universities; hospitals; and government departments and agencies. The methodology used created sectors with quite distinct characteristics, and minimised the overlap between NHMRC sectors and their comparators.

Field of research

The study focuses on the biomedical fields and sub-fields of research. Most analyses are undertaken using journal sets to delineate fields. For Project Grants publications, a field analysis is also carried out using the NHMRC discipline codes.

Measures used

The analyses focus on publications that appeared between 1996 and 2000 and the citations they attracted in the same five-year period. The three standard bibliometric measures used are:

- citations per publication

Executive Summary

- most highly cited publications
- comparison of actual and expected citations

Using bibliometrics

Bibliometric data answer no single evaluative question in their own right. This information must be seen alongside other measures of esteem, performance, visibility and the testimony of expert peers in the activity that is being analysed. The efficacy of bibliometric measures for the evaluation of various NHMRC schemes varies, not between schemes, but in relation to the different fields of research covered by each scheme.

Main findings

- The general conclusion of the study is that NHMRC publications, both in aggregate and for each individual scheme, have very strong citation performances. In all fields of research the NHMRC citations per publication (cpp) rate is above the Australian average and, with two exceptions, is also above the world average. It accounts for a significant number of Australia's most highly cited biomedical publications.
- As a group, researchers on Fellowships through the block-funded institutes are foremost in all citation analyses. Their publications have an exceptionally high cpp rate, appear in very high impact journals, and attract well above the expected number of citations for these journals.
- The NHMRC block-funded institutes are also very prominent in all citation analyses. They also have a very high cpp rate, publish in very high impact journals, and attract more than the expected number of citations for these journals.
- The Project, Project Fellows, program, CRC and other research institute sectors all have similar research profiles and a comparable citation performance — below that of the two sectors previously highlighted, but well above that of other comparator sectors.
- Though analysis of the NHMRC's Research Units scheme is based on a small number of publications and focuses on a distinct mix of disciplines, its citation performance is very strong.
- In each of the individual biomedical fields and sub-fields, publications linked to NHMRC grants schemes have a higher cpp rate than the Australian average and, except in the case of medical physiology and neurosciences, are also above the world cpp rate.
- With the exception of biotechnology, NHMRC-funded output does not fall significantly below the line of convergence between actual and expected citations in any sub-field of research. In microbiology and in multi-disciplinary science, the NHMRC position is well above this line.
- The NHMRC's presence in the most highly cited bands of Australian publications is well above the expected level in most sub-fields — for medical and health sciences as a whole, it is associated with double the expected number of highly cited publications. In genetics,

immunology and general medical journals, two-thirds or more of Australia's most highly cited publications are linked to NHMRC funding schemes.

- In four biomedical sub-fields, NHMRC-linked publications account for over one-third of Australia's total publication output:

- Biochemistry and cell biology
- Immunology
- Medical physiology
- Neurosciences

- Using category B discipline codes to classify publications, the areas exhibiting the strongest citation impact from the Project and Program Grants are:

- Microbiology, parasitology and virology
- Genetics
- Vision and ophthalmology
- Renal diseases and science
- Psychiatry and psychology

Physiology and haematology were the areas, which dropped most below the expected citation levels.

- In analysing publications classified on the basis of the institution administering the grant, the major outliers were the Walter and Eliza Hall Institute and Garvan Institute of Medical Research at the high impact end, and Howard Florey Institute at the other end of the scale.
- Gender accounts for little difference in citation performance within the institute Fellows sector, but the difference is more marked in the Project Fellows sector, where the set of publications produced by male Fellows has a higher impact.

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Certain data included herein are derived from the **Australian National Citation Report** prepared by the Institute for Scientific Information®, Inc. (ISI®), Philadelphia, Pennsylvania, USA: © Copyright Institute for Scientific Information® 2000. All rights reserved.

Introduction

The Research Evaluation and Policy Project (REPP) was commissioned by the National Health and Medical Research Council (NHMRC) to update its 2001 analyses of the impact of publications resulting from the research it funded. The NHMRC has many diverse schemes for funding research, targeting different aggregations of effort — the institution, the unit, the research group, cross institutional programs, and the individual researcher. This current analysis, like the 2001 study, creates a series of publication sets that enable each of the NHMRC's main research grants schemes to be evaluated on the basis of citation impact. It links publications from 1996 to 2000, indexed by the Institute for Scientific Information (ISI), to each of the NHMRC's schemes. The study was conducted in tandem with a similar analysis of the publication output attributable to Australian Research Council funding.

The report presents a bibliometric analysis comparing the impact of publications linked to each of the schemes with other Australian medical and health sciences publications. The NHMRC funding mechanisms evaluated are block-funded research institute grants; Research Unit Grants; Program Grants; Project Grants; and Research Fellowship awards. A number of these schemes have recently been superseded by new funding arrangements, and the data in this analysis can be used as one benchmark against which to judge the success of these new arrangements. NHMRC publications are compared to other research institutes, other university research, other hospital research, cooperative research centres (CRCs) and government departments and agencies.

Bibliometric data answer no single evaluative question in their own right. This information must be seen along other measures of esteem, performance, visibility and the testimony of expert peers in the activity that is being analysed. The efficacy of bibliometric measures for the evaluation of various NHMRC schemes varies, not between schemes, but in relation to the different fields of research covered by each scheme.

This report is presented in four sections, and incorporates a technical annex containing a detailed discussion of the methodology employed. The contents of each section of the report are as follows:

- Section 1: *Methodology* — a brief outline of the project methodology.
- Section 2: *Sector characteristics and performance* — compares and contrasts the research focus of each of the nine sectors in the study, and analyses the citation performance of their total publication output.
- Section 3: *Selected characteristics and performance* of NHMRC schemes — looks at the characteristics of Project and Program Grants, and analyses the citation performance of publications on the basis of these characteristics.
- Section 4: *RFCD fields and sub-fields of research* — analyses the citation performance of each of the nine sectors in the study on the basis of journal sets using the Research Fields, Courses and Disciplines (RFCD) classification scheme.

1 Methodology

The publications that resulted from research supported by NHMRC funding were identified either directly from the REPP database using author and/or institutional address information; or from details obtained from Project Grant application forms. Full details of the methodology used to identify the publications for each of the NHMRC funding schemes, and the comparator sectors against which their performance was judged, is given in the Appendix.

1.1 Coverage of ISI database

The use of bibliometric analysis as a tool for evaluating research performance cannot be universally applied across all fields of research (Bourke, Butler and Biglia 1996, NBEET 1994). ISI does not comprehensively cover the output of Australian research in:

- most fields in the humanities and social sciences;
- engineering, information sciences, and other fields of research in the applied sciences; or,
- the applied end of the research spectrum, even for those fields generally well covered by ISI indices.

The implication for the medical and health sciences is that, while the ISI database provides a comprehensive coverage of the major journals in most sub-fields, it is not universal. Where the majority of research has a basic orientation, as in the case of immunology, ISI coverage of the field is extensive. But for those sub-fields or disciplines more focussed on applied research, such as nursing, public health and health services, and complementary/alternative medicine, the interpretation of bibliometric data should be undertaken with extreme caution. In these disciplines ISI coverage is patchy, and much of the output is found in other formats, such as monographs, reports, professional journals, and the like. It is the reason REPP has found very few ISI publications linked to grants classified to these disciplines. Section 1.4.5 below looks more closely at levels of research in biomedicine.

1.2 Definition of sectors

It is important to stress that the methodology used in this study was aimed at creating sectors with quite distinct characteristics and as little overlap as possible. In order to achieve this, some of the sectors created do not bear a strong resemblance to their commonly perceived definition. In particular, the other university, other government and other hospital sectors created as comparators are not comprehensive, covering only those publications not supported, at least in part, by NHMRC funding schemes.

The specifications for the study identified eleven sectors for analysis:

NHMRC sectors:

1 Project Grants

The Project Grants scheme supports research that is likely to be capable of solution within a relatively short time frame. Grants are normally of three years duration, and researchers usually retain teaching and/or clinical duties within their institutions. Publications resulting from this scheme were identified using information contained in Project Grant applications for the period 1999–2002.

2 Program Grants

Program Grants are awarded to research teams of scientific excellence, working collaboratively on a number of health and medical research Projects that are funded for a five-year period. This sector covers all the publications of researchers participating in a Program Grant.

3 Block-funded research institute grants

Six fully funded medical research institutes were supported through the NHMRC block-funded research institute grants scheme in the period 1996–2000. The sector covers all publications from the six institutions, which were directly identified in the REPP database using their institutional address.

4 Research Unit Grants

Research Unit grants are awarded in areas of health and medical research that the NHMRC has assessed as requiring special support to develop research and research training programs. The sector covers all the publications from the specified Units.

All Fellowship awards

Research Fellowship awards provide five years' salary for high-calibre researchers, allowing them to undertake full-time research. In the period covered by this analysis, Fellows could be funded either through the Project Grants scheme, or via the block-funded institutes grants scheme. With the demise of the latter scheme, it is thought useful to analyse the two groups of Fellows separately and in total. Their overall performance will provide a benchmark to judge the effectiveness of recent changes in this area.

5 Institute Fellowship awards

The sector incorporates all publications from each of the block-funded institute Fellows.

6 Project Fellowship awards

The sector incorporates all publications from each of the Fellows funded via the Project Grants scheme.

NHMRC total

In all analyses, data are presented in aggregate for all sectors funded by NHMRC (sectors 1 to 6). Duplications due to cross-sector collaboration have been removed.

Comparator sectors:

7 Other research institutes

Fully funded research institutions employing full-time researchers, viz. the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Institute of Advanced

Studies (IAS) at the Australian National University (ANU), and those members of the Australian Association of Medical Research Institutes (AAMRI) not included in 3 above. The sector covers all publications from the AAMRI institutions, and from those units within CSIRO and the IAS that were primarily engaged in medical research.

8 Cooperative research centres (CRCs)

Fully funded single focus research centres of six to nine years' duration, located within universities and employing full-time researchers. The sector covers all publications from biomedical CRC's.

9 Other University

Full-time and part-time researchers, most of who retain teaching and administrative responsibilities, funded principally through university general operating grants and through competitive grants obtained from other funding agencies. This sector specifically excludes any publications identified as having NHMRC support (ie are included in one or more of sectors 1 to 6) or that are collaborative works with either the CRCs or other research institutes (sectors 7 and 8).

10 Other Hospital

Full-time and part-time researchers funded principally through hospital general operating grants and through competitive grants obtained from other funding agencies. This sector specifically excludes any publications identified as having NHMRC support (ie are included in one or more of sectors 1 to 6) or that are collaborative works with either the CRCs or other research institutes (sectors 7 and 8).

11 Other Government departments and agencies

Full-time and part-time researchers located in federal and state government departments and agencies. This sector specifically excludes any publications identified as having NHMRC support (ie are included in one or more of sectors 1 to 6) or that are collaborative works with either the CRCs or other research institutes (sectors 7 and 8).

It is acknowledged that support for the research that leads to a particular publication can come from more than one source. Publications identified with the NHMRC sectors may well have additional funding sources that could see them included in one or more of sectors 9 to 11. It is impossible to identify sets of publications that have discrete funding sources. The aim in this study was to delineate sectors that would enable us to compare NHMRC-funded publications with those that received little support from the agency, and to delineate sectors that had identifiable, distinctive features. The methodology adopted enabled this to be successfully accomplished.

1.3 Methodology overview

A full description of the methodology used to identify each sector's publications is given in the Technical Annex. In this section of the report, a limited number of specific issues are discussed and the more significant aspects of that methodology are highlighted.

- **In-scope publications**

The analysis covered 1996 and 2000 publications, classified as articles, notes or reviews, that appeared in journals indexed in ISI's three main indices — the Science Citation Index (SCI), Social Sciences Citation Index (SSCI) and Arts and Humanities Citation Index (A&HCI).

- **Field of research classification**

Three methods of classifying publications to a field of research have been used in this report:

- i) publications are classified on the basis of the journal in which they appear using *ISI's subject category* journal classification scheme, which allows comparison across sectors at a low level of aggregation;
- ii) publications are classified on the basis of the journal in which they appear according to the *RFCD classification scheme*¹, which allows comparison across sectors at a more aggregated level; and
- iii) publications are classified on the basis of the code associated with the NHMRC grant to which they are linked. This method is only used for the Project Grants sector. It uses *category B codes*², and has the advantage that publications appearing in multi-disciplinary journals (eg *Nature*) can be ascribed to the field most appropriate to the content of the article.

- **Small numbers**

Because of the skewed nature of citation distributions, analyses based on any units with less than 100 publications are too unreliable and have been omitted. Experience suggests that extra caution should also be used for analyses based on units of less than 200 publications.

- **Identification of each sector's publications**

The methodologies used to identify the publications attributable to each of the sectors defined in section 1.2 above were:

- i) extracting all publications pertaining to specified "standardised addresses" in the REPP database (sectors 3–4, 7–11);
- ii) extracting all publications for specified authors (sectors 2, 5 and 6); and
- iii) extracting publication details from NHMRC grant applications (sector 1).

- **Overlap of sector publication sets**

Given the collaborative nature of most research, with multi-authored papers the norm, it is inevitable that there will be some *double counting*. Where authors from more than one sector collaborate on a publication, it is fully counted for each sector involved. The methods used to identify the relevant publications for each of the sectors resulted in some overlap within sectors 1 to 8, and sectors 9 to 11, but none between these two groups. Because recipients of the Research Fellowship awards were commonly associated with Project or Program Grants, or were located in one of the block-funded institutes, publications identified for the Fellows sectors do not

¹ The Research Fields, Courses and Disciplines classification scheme is prepared by the Australian Bureau of Statistics for use in the measurement and analysis of research and experimental development in Australia. The revised 1998 edition of the RFCD was used in this study

² The category B, or discipline, codes are the second level of NHMRC classification.

represent a distinct set (98% for institute Fellows and 79% for Project Fellows are also contained in one of the other NHMRC sectors). However, overlap for the Project, block and Unit sectors are restricted to approximately 25 percent.

- **Completeness of publication set for the Project Grants sectors**

To identify the publications relevant to this sector, the study relied on information contained in applications for new Project Grants made between 1999 and 2001. This will not have identified all publications that can be linked to this scheme for two reasons. Firstly, not all researchers or groups that received Project Grant funding in the period and were likely to have publications in our target period will have applied for a new grant in this period — some may have retired, gone overseas, moved to a non-research position, etc. Secondly, the electronic version of the form did not remind applicants to link their publication list to the outcomes of previously held NHMRC grants. The exact extent of under-reporting is impossible to calculate, but is likely to be in the range of 20 to 30 percent. This issue must be borne in mind when interpreting the results of the study, but given the large number of publications that were identified, it is unlikely to have a significant effect on the average citation rates that formed the basis of the analysis. It is of most concern when publication numbers drop to fairly low levels.

1.4 Performance Measures

This section gives a general description of the standard bibliometric measures used in the study. Notes relevant to particular points of discussion are included throughout the report as required.

1.4.1 Citations per publication

Publications from 1996 to 2000 were counted and the citations these publications received during the same period were tabulated. A simple citation per publication (cpp) average was then calculated, and the sectors ranked according to the result.

1.4.2 Actual and expected citation rates

In this measure, the term Actual Citation Rate refers to the average number of citations actually achieved by the publications of the unit under study. The term Expected Citation Rate refers to the average number of citations achieved by all publications in the journals carrying the articles of the unit under study. ISI has supplied REPP with average citation rates for all publications in its journals for each year of publication and for each type of publication. The calculations are weighted by the year of publication and the frequency of publication in particular journals. The expected citation rate is a different calculation to ISI's journal impact factor³, though the measures are related.

³ The calculation for ISI's 1996 impact factor is a/b , where:
 a = 1996 citations to articles published in the journal in 1994 and 1995
 b = number of articles published in the journal in 1994 and 1995;

The graph essentially, therefore, allows a comparison of Actual and Expected citation rates. The diagonal on the graph indicates the point at which actual and expected citation rates converge so that, where the unit under study appears above this diagonal line, it is achieving a rate of citation higher than the ‘world’ average for the journals in which it publishes; and where it appears below the line, it is achieving a rate of citation lower than the ‘world’ average for its publications in those journals. Where a vertical line is drawn on a graph, it indicates the citation per publication figure for all publications in all journals in the field under study, that is, the world average.

In these graphs, the relationship to the diagonal and vertical lines is the salient point to observe. A point above the line and to the right of the ISI average indicates above world performance in high impact journals; a point below the line and to the left indicates below world performance in low impact journals. Between these extremes, there are many possibilities, such as appearing in high impact journals below the world expected rate or appearing in low impact journals but performing at a higher rate of citation than the expected world rate. Judgments about these relationships should be made carefully.

It is important to note here that the position of the diagonal line is driven largely by publications from the major research centres of America and Europe. For publications from Australia, or any other ‘peripheral’ country, to attract citations at or near this level is a strong performance. To achieve citations at a greater rate, is an exceptionally strong performance.

1.4.3 Most highly cited publications

For all RFCD biomedical fields and sub-fields, the number of citations required to rank a publication from 1996 to 2000 in the top 1% and 5% of publications in Australia was calculated. By extracting publications that fell within these bands, it was possible to identify the sectors in which these high impact articles belonged. For each of the sectors, tables show their total number of publications in the field or sub-field for 1996 to 2000, and the percentage of these publications falling within the two percentile clusters. The sectors are ranked by the percentage of their papers in the 5% band.

The majority of publications identified in this analysis are from 1996 and 1997, as few later publications will have had sufficient time to attract the required number of citations.

1.4.4 Level of collaboration

The REPP database enables publications with different types of authorship to be distinguished, viz.:

- Single author* one author only (ie no collaboration);
- Group* more than one author from the same AOU⁴ within an institution;

The calculation for the expected values used in this report is x/y , where:

x = number of citations received between 1996 and 2000 to all articles published in the journal in 1996

y = number of articles published in the journal in 1996

⁴ Academic Organisational Unit or CSIRO division.

Institutional more than one AOU from the same institution;
National: more than one Australian institution; and
International: more than one country.

The classification is not hierarchical and all collaborations present in a publication will be ascribed to it. For instance, if a publication involves collaboration between a number of Australian institutions as well as an overseas institution, it will be classified as both International and National.

For this report, data are not calculated on institutional collaboration as only addresses for universities and the CSIRO are ‘cleaned’ down to the level of department or equivalent⁵. Addresses for other institutions are generally not disaggregated.

1.4.5 Research level

CHI Research Inc (CHI) has developed a journal classification scheme ascribing most SCI journals to one of four research levels based on the research orientation of the journals. The four levels of research are⁶:

Level 1	Applied Technology (Clinical Observation);
Level 2	Engineering – Technological Science (Clinical Mix);
Level 3	Applied Research (Clinical Investigation);
Level 4	Basic Scientific Research.

An indicator of the research level of a field or set of journals is an important characteristic in bibliometric analysis. Studies indicate that the level of citation increases with the level of research, that is, basic scientific research is more highly cited than more applied research (Narin 1976).

1.5 Underlying data

The analyses presented in this report are principally in the form of figures, or tables showing percentage distributions. The data underlying the tables and figures in the main body of the report are given in the Appendix. In some instances, particularly in the discussion of highly cited publications, data in the Appendix are referred to during discussion of results.

1.6 Comparison of 2001 and 2003 Assessments

In 2001, REPP undertook an analysis of NHMRC-funded research, which focussed on publications that appeared in 1994 and 1995. The methodology was very similar to that used in the current study but the results are not directly comparable. Even though publication data

⁵ See sections T1 and T2 of the Technical Annex for an explanation of address ‘cleaning’ in the REPP database.

⁶ The terms given in parenthesis are those used to describe the four levels of research as they apply to biomedical fields.

Methodology

in the 2001 study was limited to the two years, citation data covered a full five-year window, from 1994 to 1998. This has the effect of inflating citation per publication averages in comparison to the current study, which covers five years from 1996 to 2000, and where the most recent publications had a significantly smaller citation window.

A second, relatively minor, difference between the two studies is to be found in the sectors analysed. In this current study, there are sufficient publications for the CRC sector to be included, this was not possible in 2001. In addition, the analysis of the Fellows sectors has been presented in a different format — in 2001 the institute Fellows were not analysed as a separate group.

Due to the increased coverage of years (from two up to five), we were also able to cover more sub-fields of research in this current analysis.

While the citations per publication levels are not directly comparable, it is possible to determine whether the relative performance of sectors or fields has changed. By comparing the figures showing actual and expected citation rates for a sector or field, and noting its position relative to the Australian average, the World average, and the diagonal line of convergence between actual and expected citations, it is possible to see whether any change in performance has occurred.

2 Sector characteristics and performance

2.1 Sector Research Profiles

The sectors delineated in this study do not have identical research profiles — their efforts are spread across a wide variety of research fields. Different fields of research have different citation practices so the profile of an institution is an essential piece of knowledge that needs to be taken into consideration when interpreting results.

Table 1 shows, for each sector, its journal output distributed across the RFCD biomedical fields and sub-fields. Sub-fields that account for more than 10% (blue) and 20% (red) of a sector's publication output have been highlighted. In addition, the second column shows the average citation per publication (cpp) rates for each field and sub-field, underscoring the differences that can occur, even within one field. For the other university and government sectors, the distribution given in the table is based on data limited to biomedical research, thus allowing for a more valid cross-sector comparison. In reality, of course, biomedical research only accounts for 31% and 28%, respectively, of the total output of these sectors as defined.

Table 1: Distribution of publications in sectors by RFCD classification—(percent)

RFCD fields/sub-fields	Cpp ⁷	NHMRC Sectors							NHMRC TOTAL	Comparator Sectors				
		Project		Unit	Project		All	Program		Research Institute	Other CRC	Other Univ	Other Hosp	Other Govt
		Block	Fellows		Institute	Fellows								
Biological Sciences														
Biochemistry & cell biology	8.25	23.0	26.4	9.7	23.0	27.0	24.0	20.6	22.7	25.1	26.8	16.4	4.3	8.7
Genetics	8.18	4.4	9.9	1.9	4.0	9.0	5.3	9.9	6.0	5.1	3.1	5.2	2.7	3.7
Microbiology	5.04	2.7	0.7	0.0	0.7	0.4	0.6	0.7	1.9	1.8	2.7	5.9	2.4	8.3
Biotechnology	4.56	3.7	4.6	1.9	2.4	4.1	2.9	4.6	3.7	3.9	7.1	6.6	1.3	7.0
Medical & Health Sciences	4.77	73.5	66.1	81.0	76.5	68.6	74.5	72.5	72.8	68.7	62.2	73.2	92.4	78.7
Immunology	6.82	11.7	12.4		10.5	12.6	11.2	11.1	11.2	13.7	17.6	4.2	5.1	3.0
Clinical chemistry	3.64	0.8	0.4	1.6	0.8	0.3	0.6	0.7	0.7	0.6	0.6	1.3	0.7	1.5
Pharmaceut & Pharmacol sciences	3.96	8.0	6.4	10.9	10.5	7.3	9.7	3.5	7.8	5.4	1.2	7.0	3.9	6.1
Medical physiology	3.87	7.8	8.1		8.7	10.8	9.4	6.0	7.9	4.7	3.1	6.3	1.8	3.3
Neurosciences	6.26	13.8	6.2	7.0	14.4	10.7	13.3	10.8	11.4	7.4	2.5	7.3	5.1	1.5
Dentistry	2.17	1.0	0.0		0.3	0.1	0.3		0.6	0.1	0.2	1.8		0.9
Clinical sciences	4.59	39.3	37.4	57.8	40.1	32.5	38.0	45.8	40.5	39.0	38.2	43.2	79.5	46.5
Nursing	1.27	0.1		0.4	0.0		0.0	0.1	0.1	0.7	0.2	1.7	0.9	1.4
Public health & health services	3.33	3.4	3.7	15.1	2.4	2.1	2.3	4.3	3.7	6.6	1.2	11.8	5.6	24.8
Human movt & sports sciences	2.97	0.7	0.1		0.7	0.2	0.6	0.8	0.6	0.7		2.0	0.9	3.2
Other medical & health sciences	4.08	0.4	0.3		0.3		0.3	0.7	0.4	0.3	0.2	0.5	0.9	0.5
General medical sciences	5.67	4.8	6.5	3.9	4.9	5.8	5.2	6.3	5.4	6.7	10.2	4.7	6.8	5.3
Multi-disciplinary Sciences	11.4	1.8	3.8	0.0	2.0	5.7	3.0	1.8	2.2	1.8	3.7	4.7	0.8	5.9
TOTAL	5.38	100	100	100	100	100	100	100	100	100	100	100	100	100

⁷ The citation per publication rate is calculated as the average achieved for all publications appearing between 1996 and 2000 in the journals classified to each (sub-) field of research during the same five year window. It is based on world data, and is not limited to Australian publications.

Using the distribution of aggregate NHMRC data as a reference point, it can be seen that three sectors (one NHMRC scheme and two comparators) have a different research focus to the others. The biomedical research output of the other hospital sector is, not surprisingly, very heavily concentrated in clinical sciences, with a relatively weak focus on high impact sub-fields such as biochemistry and cell biology, genetics and immunology. The profile of the other government sector also differs from that for other sectors in relation to the concentration of their activity in public health and health services research.

Within the NHMRC, the Units sector has significantly more output in clinical sciences and public health and health services research. Its unique profile is not surprising given the targeted nature of funding under this scheme.

2.2 Level of Research

The level of research undertaken in a sector is one of its most important characteristics to bear in mind when interpreting the data of bibliometric analyses. Figure 1 presents graphically the data on level of research for each sector. The levels were defined in section 1.4.5 above.

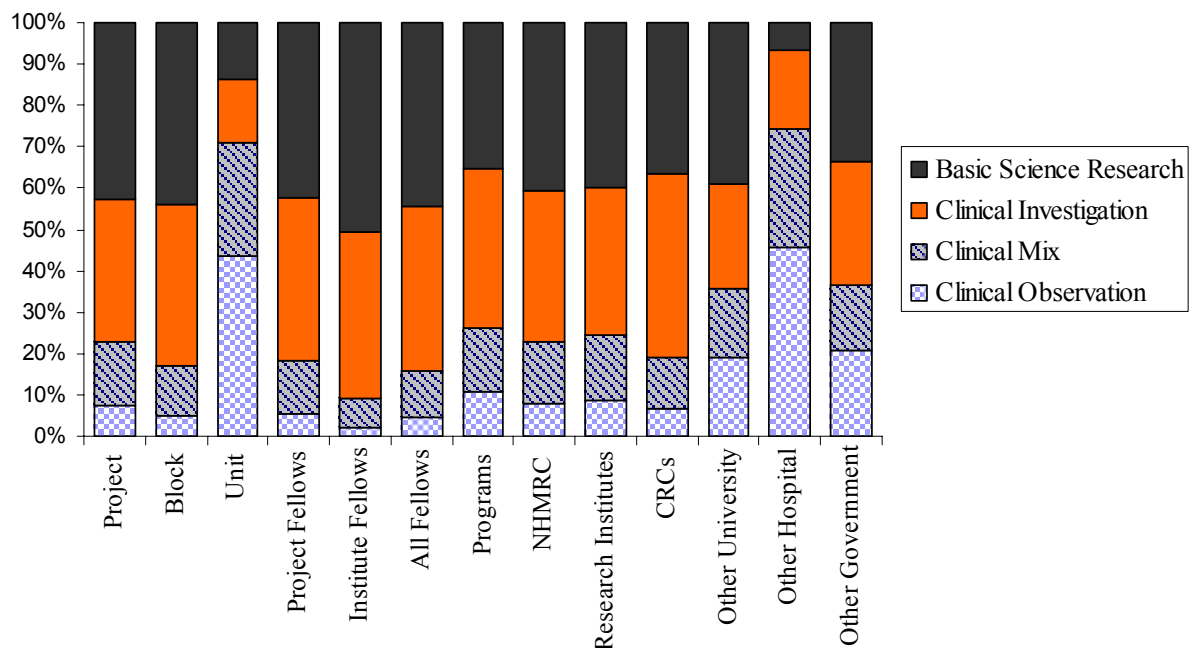


Figure 1: Level of research by sector

The distribution of research into four levels is based solely on the classification of ISI journals carrying their articles, and not on their total output. This perhaps accounts for one counter-intuitive result from this analysis. While the strong applied focus of both the Unit and other hospital sectors is as expected, we would also have anticipated seeing a similar spread across the levels for the CRCs. One explanation may be that only research of a more basic nature appears in the journal literature, while the results of more applied research is published in other outlets. As the profile for CSIRO, with a similar focus on more application-oriented research, is similar to that shown here for the CRCs, it seems the most likely explanation.

This analysis has important consequences for understanding the subsequent analyses that are contained in this report. Basic research is more highly cited than applied research so, all other things being equal, the hospital and government sectors would be expected to publish in journals of much lower impact than for the NHMRC or institutes sectors. The impact of journals carrying university publications should lie somewhere between the two. Figure 3 in Section 2.5 below shows that all but the last expectation, concerning university publications, holds true.

2.3 Collaboration

The structure of the REPP database enables the sectors to be described on the basis of their collaboration patterns. These are presented in Figure 2.

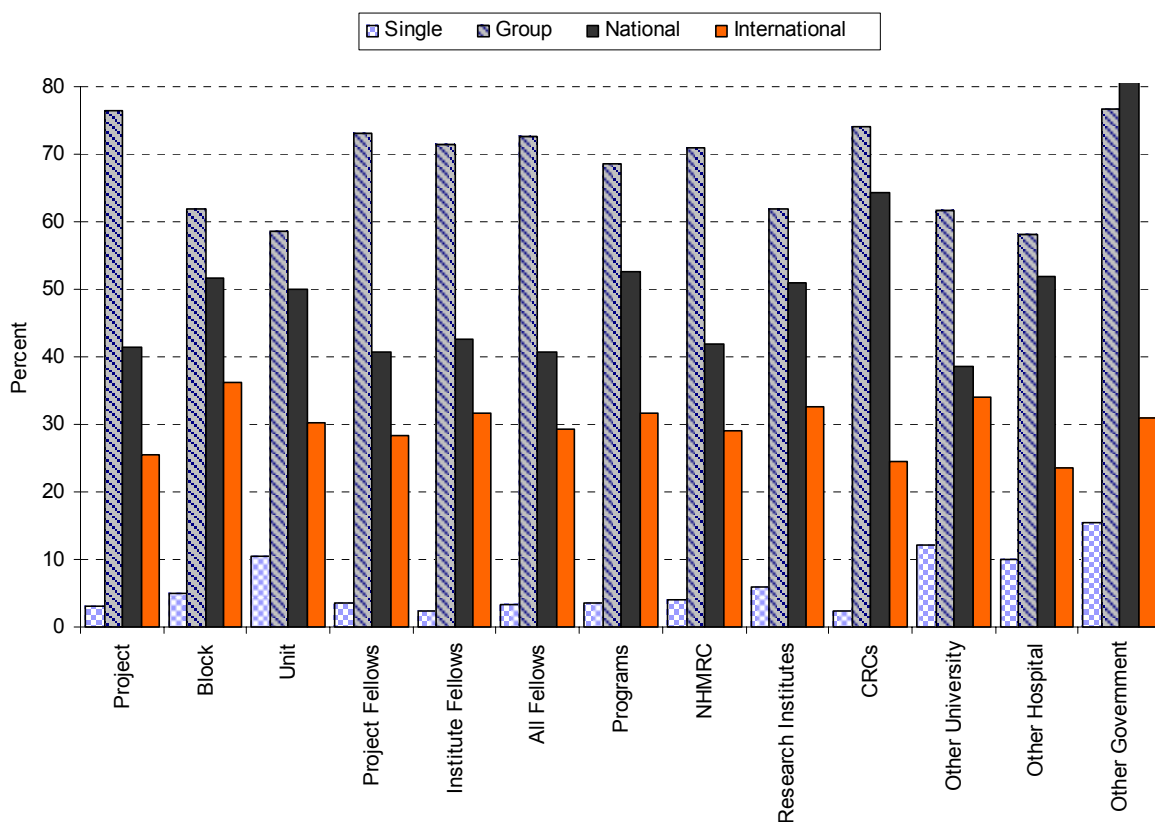


Figure 2: Collaboration patterns by sector

Multi-authored papers are the dominant forms of publication in the medical and health sciences. Within NHMRC sectors, the single author paper is relatively uncommon, accounting for less than 5% of the total output. The extent of national collaboration is much higher in the medical and health sciences than in other fields of science where the average level is 27% (Butler 2001). In contrast, international collaboration is not as strong in this field as for most others (an average of 34% for the period). International collaboration is most prevalent in the block-funded institutes and other university sectors, and least common in the project, CRC and other hospital sectors.

The direction of international collaboration for each sector is examined in detail in Table 2.

Table 2: International collaboration by sector and country (percent)

COUNTRY	NHMRC Sectors							NHMRC TOTAL	Comparator Sectors				
	Project Block	Units	Project Fellows	Institute Fellows	All Fellows	Program	Research Institutes		CRCs	Other Univ	Other Hosp	Other Govt	
United States	47	49	22	40	49	43	41	45	45	40	34	34	32
England	15	17	29	16	12	15	20	16	18	17	19	29	17
Germany	10	8	8	9	9	9	8	9	10	5	9	6	5
Japan	6	8	4	8	10	8	9	7	6	5	7	4	4
Canada	5	5	15	7	5	7	6	6	5	1	9	10	7
France	4	7	6	4	5	4	7	5	6	8	5	6	8
Sweden	5	3	6	4	5	4	4	5	4	4	4	5	3
Switzerland	4	6	8	4	5	4	2	4	3	2	3	4	2
New Zealand	4	3	18	7	4	6	4	4	4	7	6	7	11
Netherlands	3	2	5	2	3	2	5	3	3	4	3	5	3
Italy	3	2	3	2	2	2	3	3	4	0	3	5	3
China	3	3	1	1	1	1	1	2	2	1	2	1	2
Denmark	2	2	3	2	2	2	1	2	1	1	2	2	3
Finland	2	1	0	1	1	1	1	2	2	1	2	2	1
Belgium	1	1	5	2	0	1	2	1	2	1	1	3	1
South Africa	1	1	4	1	0	1	1	1	1	0	2	1	3
Spain	2	0	1	1	0	1	0	1	0	2	2	2	2
Thailand	1	1	6	0	1	0	2	1	1	1	1	1	2
Singapore	0	1	4	1	2	1	2	1	1	0	1	1	1
Austria	0	1	0	1	0	0	0	1	1	0	1	2	1
Norway	1	0	3	0	0	0	1	1	1	0	1	1	1
Hong Kong	0	0	3	0	0	0	0	0	1	0	1	2	2
India	0	0	0	0	0	0	0	0	0	4	1	1	1

Over recent years, the focus of Australia’s scientific collaborations has turned more to continental Europe, with a decreasing emphasis on the United States and England as partners in research. For the NHMRC, the extent of collaboration with the United States is stronger than for most other sectors, and well above the overall science average of 37% for the period. NHMRC collaboration with England is relatively weak compared to other sectors active in biomedical research (Butler 2001).

2.4 Location of Australian research

The importance of the NHMRC and other sectors as sites of basic research can be demonstrated by distributing all Australian publications in RFGD fields and sub-fields across the sectors. The data are presented in Table 3. Sub-fields for which a sector accounts for one-quarter or more of all Australian publications have been highlighted in red.

Table 3: Distribution of Australian publications across sectors by RFCD classification

	NHMRC Sectors							NHMRC TOTAL	Comparator Sectors					AUS TOT
	Project		Unit	Institute		All			Research	Other		Other		
	Project	Block	Unit	Fellows	Fellows	Fellows	Program		Institute	CRCs	Univ	Hosp	Govt	
Biological Sciences														
Biochemistry & cell biology	20.6	10.1	0.4	9.9	4.4	14.1	4.6	36.1	18.5	2.0	44.5	6.1	3.0	100
Genetics	12.8	12.2	0.2	5.5	4.8	10.1	7.2	30.7	12.1	0.8	45.7	12.2	4.1	100
Microbiology	9.9	1.1	0.0	1.3	0.2	1.5	0.7	12.2	5.5	0.8	65.4	13.9	11.8	100
Biotechnology	10.5	5.6	0.2	3.2	2.1	5.3	3.3	18.8	9.1	1.7	56.7	5.8	7.7	100
Medical & Health Sciences														
Immunology	26.4	11.9		11.4	5.2	16.5	6.3	44.7	25.4	3.4	28.5	18.2	2.6	100
Clinical chemistry	11.4	2.5	1.0	5.4	0.7	6.2	2.5	18.1	7.9	0.7	58.7	15.8	8.9	100
Pharmaceut & Pharmacol Sciences	18.3	6.3	1.1	11.5	3.1	14.5	2.0	31.6	10.2	0.2	48.7	14.1	5.4	100
Medical physiology	21.0	9.3		11.3	5.4	16.6	4.1	37.8	10.4	0.7	51.7	7.6	3.4	100
Neurosciences	27.5	5.3	0.6	13.8	3.9	17.4	5.4	40.6	12.2	0.4	43.9	16.0	1.2	100
Dentistry	11.5	0.2		1.8	0.2	2.0		13.7	0.8	0.2	65.3		4.4	100
Clinical sciences	12.2	5.0	0.8	6.0	1.9	7.8	3.6	22.4	10.0	1.0	40.7	39.2	5.6	100
Nursing	1.3		0.3	0.3		0.3	0.3	1.8	8.5	0.3	78.0	20.5	8.5	100
Public health & health services	6.1	2.8	1.1	2.1	0.7	2.7	1.9	11.8	9.6	0.2	63.7	15.7	17.1	100
Human movt & sports sciences	7.9	0.6		3.9	0.4	4.2	2.3	11.6	7.1		70.3	16.0	14.5	100
Other medical & health sciences	11.3	3.4		4.9		4.9	5.4	21.1	7.8	0.5	42.2	43.6	5.9	100
General medical sciences	13.0	7.6	0.5	6.5	2.9	9.4	4.4	26.5	15.1	2.4	39.1	29.8	5.6	100
Multi-disciplinary Sciences														
	8.1	7.1		4.2	4.6	8.6	1.9	17.1	6.4	1.4	62.7	5.3	9.9	100

The centrality of NHMRC to the Australian biomedical research effort, particularly in those sub-fields at the basic end of the research spectrum, is highlighted in Table 3. Over one-third of Australia's output in biochemistry and cell biology, immunology, medical physiology, and neurosciences can be linked to NHMRC research grants schemes. The other university sector is a significant site of medical research in all sub-fields, but is particularly important for research in microbiology, dentistry, public health and health services research, nursing, human movement and sports science. The research institutes have their strongest presence in immunology, while for the other hospital sectors it is clinical sciences, other medical and health sciences and general medicine. The other government sector is most prominent in public health and health services research, and in human movement and sports science.

2.5 Citation Performance

The overall citation performance for each sector is shown in Table 4 and Figure 3. As noted above, other university and government publications are restricted to the biomedical sub-fields, which account for less than half their total output. The Australian data are calculated with a similar restriction. For all other sectors, and for each of the NHMRC schemes, all publications are included, irrespective of the sub-field. In these cases, biomedical sub-fields account for over 90% of their total output.

Table 4: Citations per publication – all publications

Sector	Pubs [†]	Cites [†]	cpp
NHMRC – institute Fellows	1117	14121	12.64
NHMRC – block-funded	2604	25671	9.86
NHMRC – all Fellows	3986	34442	8.64
Research Institutes	4990	39660	7.95
NHMRC	10805	82547	7.64
NHMRC – Project Fellows	2916	21145	7.25
NHMRC – Programs	1529	11058	7.23
CRCs	518	3716	7.17
NHMRC – Projects	6078	43301	7.12
NHMRC – Units	258	1525	5.91
Other University	18434	78043	4.23
Other Hospital	9638	39443	4.09
Other Government	2356	7399	3.14
Australia	39214	197727	5.04

[†] Where authors from more than one sector collaborate on a publication, it is full counted for each sector. This results in double counting, and totals (Australia and NHMRC) will be less than the sum of component sectors.

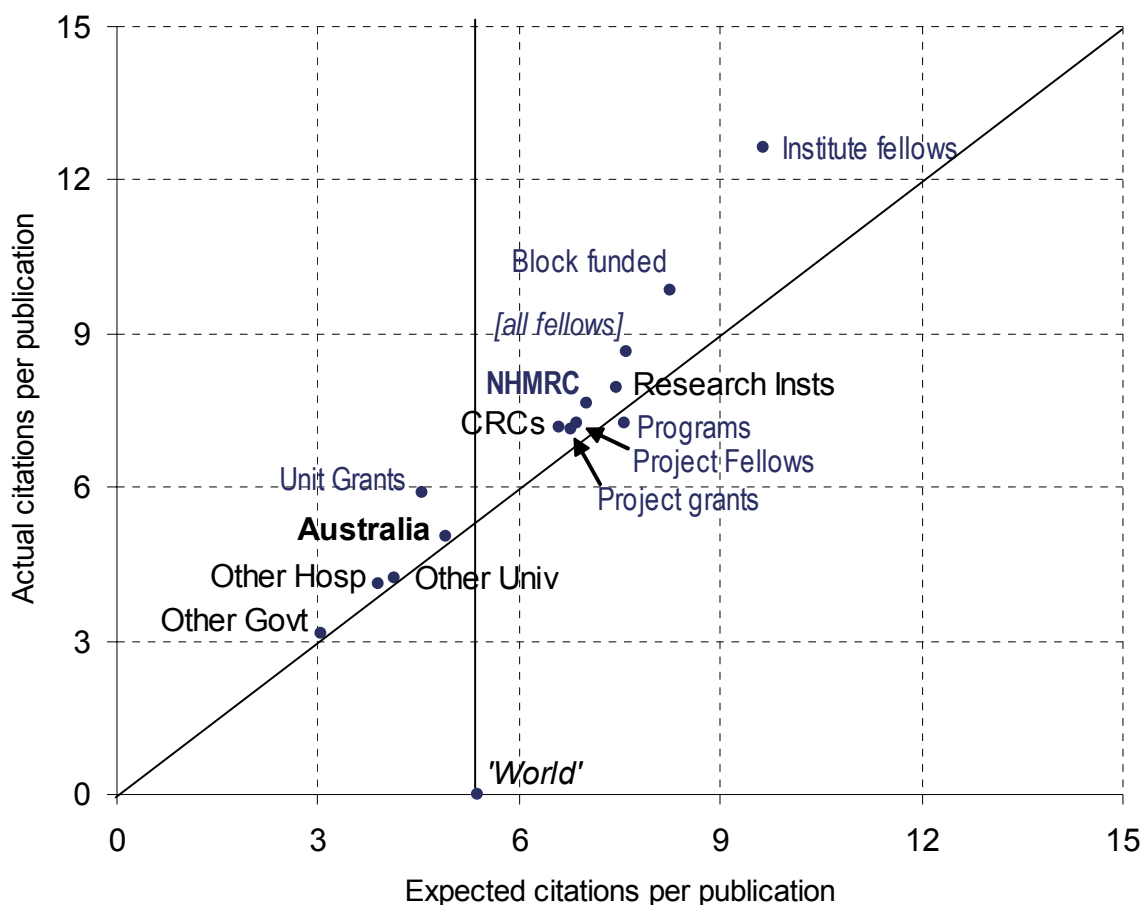


Figure 3: Actual and expected citation rate—all publications

Table 4 and Figure 3 highlight the high impact of the publications authored by the "Institute Fellows" – NHMRC Fellows located in the block-funded institutes. They account for over

40% of that block-funded sector's publications. The relative performance of the sectors and the individual NHMRC funding schemes is similar to that identified in a 2001 study conducted for the NHMRC. In general, research funded on a longer time trajectory (block – funded institutions, Units or Programs), whether through NHMRC or through other funding mechanisms, have a higher impact than those funded on a shorter time trajectory.

To a certain extent, the relative position of the various sectors and schemes in Figure 3 is governed by the orientation of their research – fundamental basic research, such as in immunology, is more highly cited than more applied clinical research. This will become apparent from the detailed analyses contained in Section 3 of this report. However, even allowing for the differences in research orientation between sectors, the performance of NHMRC funded research is notable.

3 Selected characteristics and performance of NHMRC schemes

An analysis of the performance of a number of NHMRC grants schemes based on selected characteristics is presented in this section. By linking publications back to the grants that funded the research effort, these publications can be analysed on the basis of characteristics attached to the originating grants. These include the field classification for Project Grants, the gender of Fellows, and the institution responsible for administering grants.

3.1 Project Grants - Broad research area

NHMRC Project Grants are classified to one of five broad areas of research. The distribution of grants to which publications are linked across these five areas is given in Table 5.

Table 5: Broad area of research of Project Grants linked to publications

Broad Area of Research	Linked grants		Number of Publications
	Number	%	
Basic science	994	64	3567
Clinical medicine and science	460	29	1737
Preventative medicine	39	2	123
Health services research	16	1	35
Public health	53	3	168

Proportionally more publications result from research funded in basic science, which is not unexpected as the dissemination of results from more applied research is far less likely to appear in ISI-indexed journals.

Nevertheless, there are sufficient publications resulting from four of the broad areas to undertake an analysis of actual and expected citation rates, as shown in Figure 4.

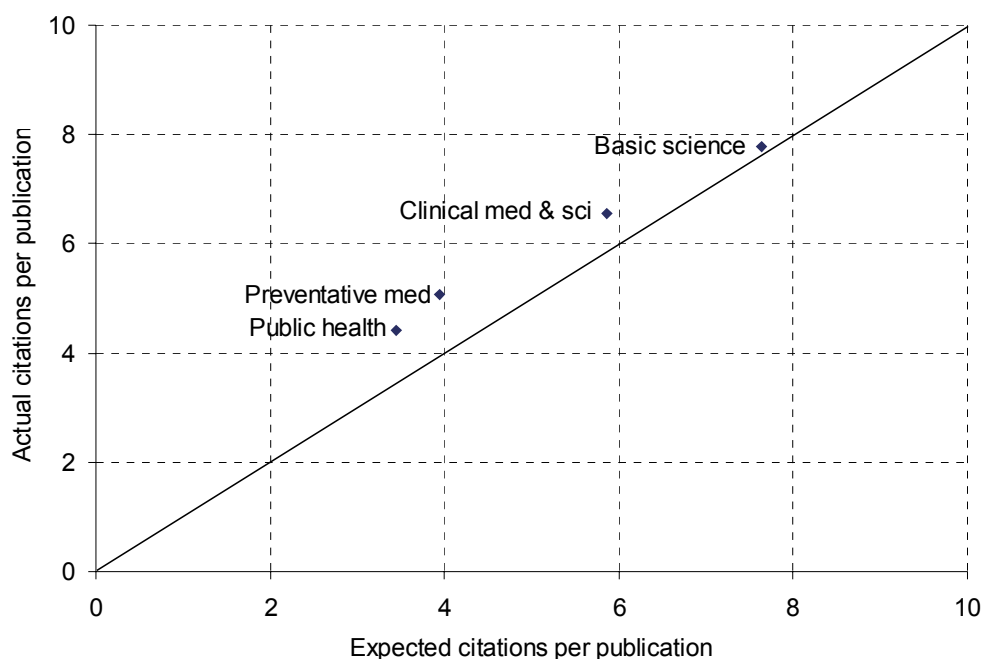


Figure 4: Actual and expected citation rates—broad areas of research

While the proportion of total output from all broad areas other than basic science is likely to be quite low, Figure 4 shows that, for the portion covered by the ISI indices, all areas exhibit a strong citation performance. All four areas achieve above expected citation levels for their set of journals. The distribution of areas along the x-axis is in line with the focus of their research – basic research generally appears in journals with a higher average impact than more applied research.

3.2 Project Grants - Disciplines

Most Project Grants are also classified to one of forty-one research disciplines. The distribution of grants across these disciplines is given in Table 6.

Table 6: Discipline classification of grants linked to publications

Discipline	Linked grants		Number of Publications
	Number	%	
Developmental biology and physiology	26	1.6	77
Nursing	1	0.1	4
Anaesthetics and intensive care	8	0.5	46
Biochemistry and clinical chemistry	137	8.3	528
Biomedical engineering and biophysics	0	0.0	0
Bio-statistics	2	0.1	3
Cardiovascular diseases and sciences	67	4.1	236
Community Health	4	0.2	6
Dentistry and oral surgery	23	1.4	85
Dermatology	4	0.2	12
Endocrinology	78	4.7	307
Epidemiology	29	1.8	81
Gastrointestinal diseases and sciences	59	3.6	267
Gerontology and geriatrics	8	0.5	36
Gynaecology and obstetrics	12	0.7	51
Haematology	35	2.1	108
Hepatology	15	0.9	42
Immunology	150	9.1	572
Microbiology, Parasitology, Virology	121	7.3	472
Morphology	8	0.5	26
Neurological diseases and neurosciences	182	11.1	731
Nutrition	14	0.9	43
Oncology and carcinogenesis	55	3.3	153
Orthopaedics	12	0.7	35
Otorhinolaryngology	6	0.4	23
Paediatrics	20	1.2	49
Pathology	11	0.7	27
Pharmacology	61	3.7	241
Physiology	88	5.3	312
Psychiatry and psychology	75	4.6	236
Radiology and organ imaging	1	0.1	1
Renal diseases and sciences	39	2.4	156
Reproduction	24	1.5	83
Respiratory diseases and sciences	46	2.8	177
Rheumatology	24	1.5	70
Surgery	12	0.7	41
Toxicology	9	0.5	32
Vision and ophthalmology	26	1.6	144
Nuclear Medicine	1	0.1	5
Genetics	44	2.7	151
Public health	22	1.3	72
Health economics	3	0.2	5
Total Project Grants	1647	100.0	5492

Figure 5 presents an analysis of actual and expected citations for the NHMRC disciplines. It is important to note that this analysis is not based on journal sets, but rather uses the researchers' own classification of their work for each grant. Consequently, publications are classified to the code relating to the grant with which they are associated, irrespective of the journal in which they appear. This is most important in relation to papers appearing in high impact journals such as Nature.

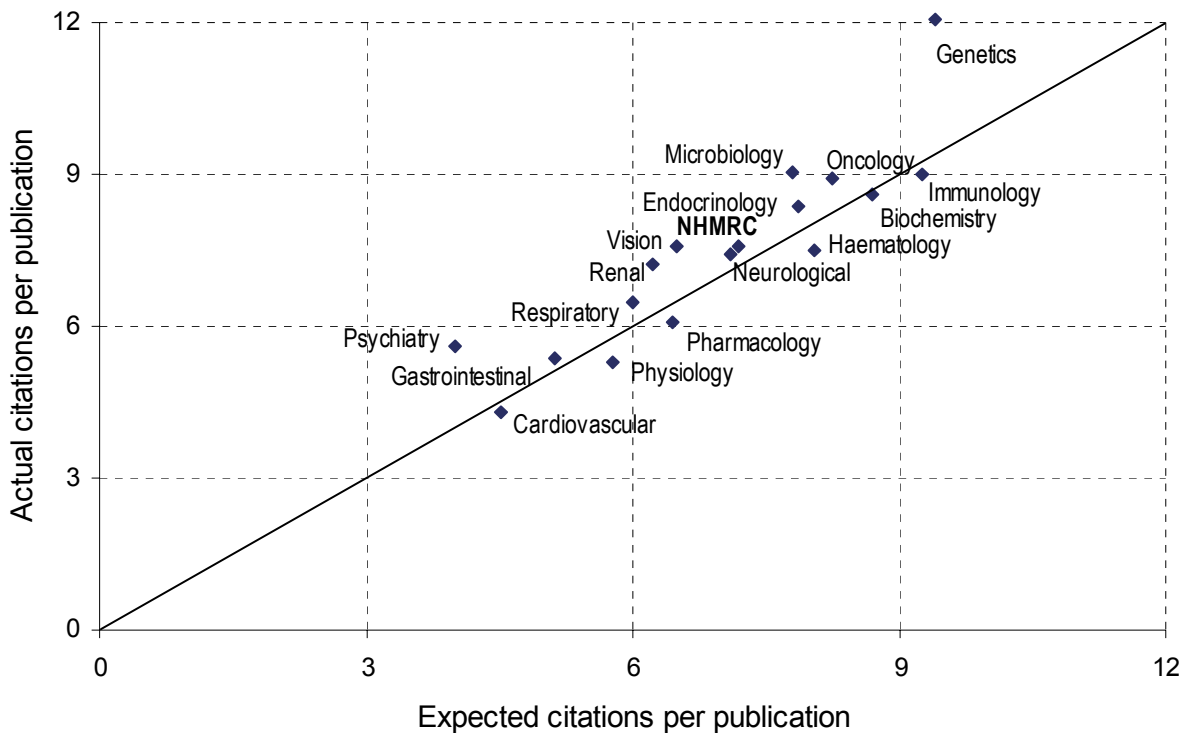


Figure 5: Actual and expected citation rates—disciplines

The grants exhibiting the strongest citation performance through 1996 to 2000, attracting at least 10 percent more citations than expected for their journal set, were those classified to: microbiology; psychiatry and psychology; renal diseases and sciences; vision and ophthalmology, and genetics. Physiology fell nearly 10 percent short of its expected level of citations.

This is only a partial view of the citation performance of the different publication sets as it is difficult to gauge whether they are appearing in relatively high or low impact journals for their discipline due to the inclusion of multi-disciplinary journals in the analysis. For this reason, the position of disciplines along the x-axis is not necessarily significant, though it does generally reflect the level of focus of research. More applied research appears in journals with a lower average impact than disciplines with a basic research focus.

3.3 Fellowships – Gender

A citation analysis was undertaken for Fellowship Grants, disaggregated to type of Fellowship (Project or institute) and gender. The result is shown in Figure 6.

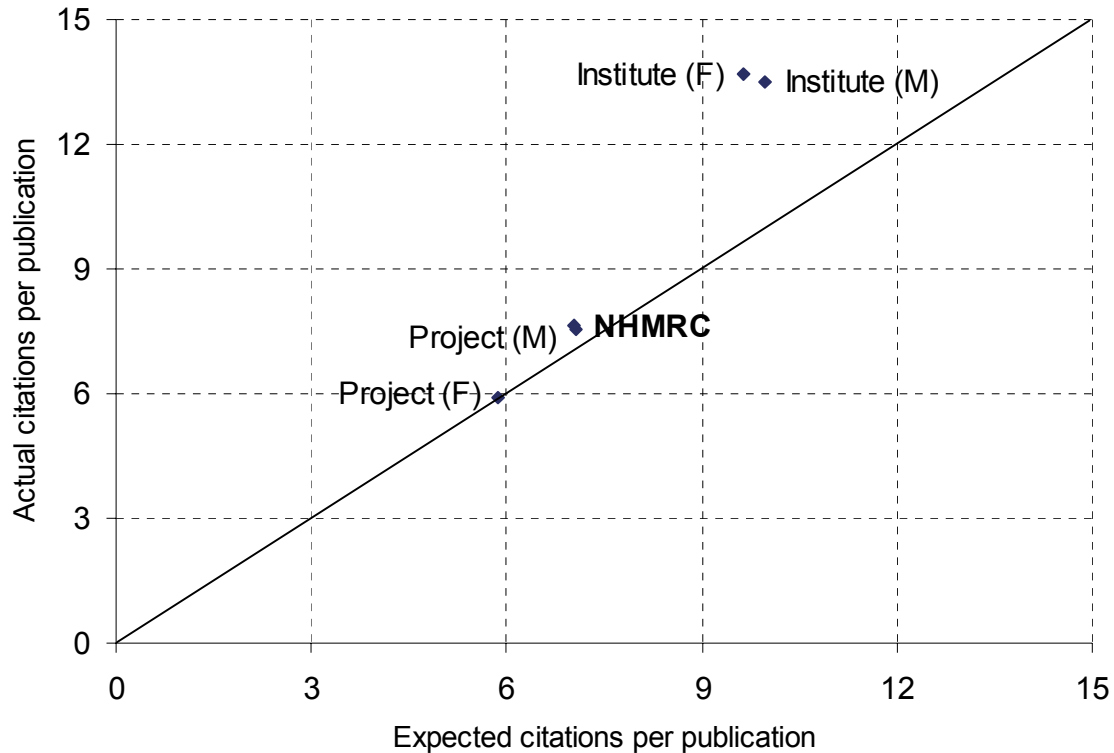


Figure 6: Actual and expected citation rates by type of Fellowship and gender

Gender accounts for little difference in citation performance within the Institute Fellows sector. Females (204 publications) have a slightly higher cpp rate and the publication set for males (970 publications) appears in slightly higher impact journals, but both differences are marginal and both achieve well above expected citation levels.

The difference is more marked within the Project Fellows sector, where both males and females achieve close to expected citation levels but the male set is appearing in higher impact journals. Only part of this difference can be explained by the difference in discipline focus for each group.

3.4 Administering institution

For the block, Fellows, Project and Unit sectors, it is possible to undertake an analysis based on the administering institution listed for each grant. Except in the case of the block-funded institutes, the analysis is restricted to those publications from an institution, which are linked to NHMRC support. This may account for only a very small proportion of their biomedical research. For example, for the University of Melbourne the following analysis covers only one-third of their total biomedical output, and for the Australian National University the proportion is even lower – only 13%. Other publications from the institutions listed below would appear in either the research institutes or other universities sector.

The analysis is restricted to those institutions with more than 200 publications, and is presented in figures (7A and (7B). Using two figures was necessary to enable the easy identification of the relative position of the all institution – it was impractical to include them

Selected characteristics and performance of NHMRC schemes

all on one chart given the positions of the Walter and Eliza Hall Institute and the Garvan Institute of Medical Research.

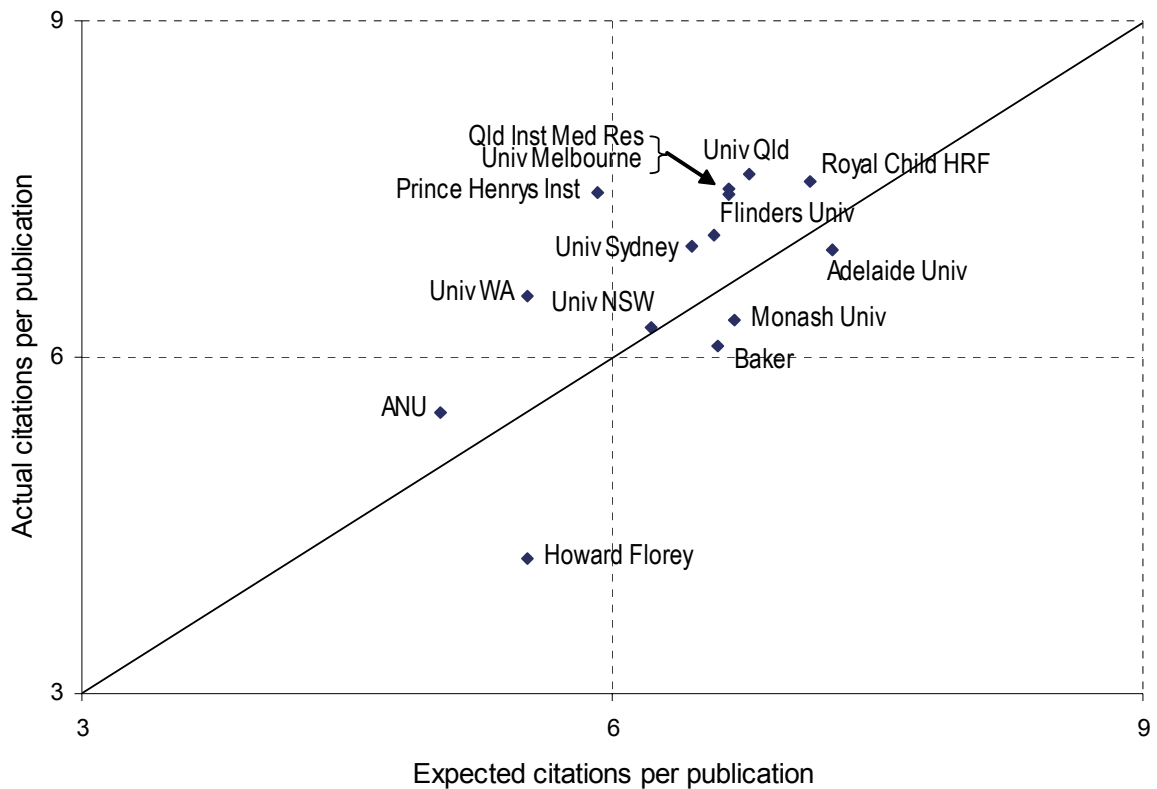


Figure 7A: Actual and expected citation rates by administering institution

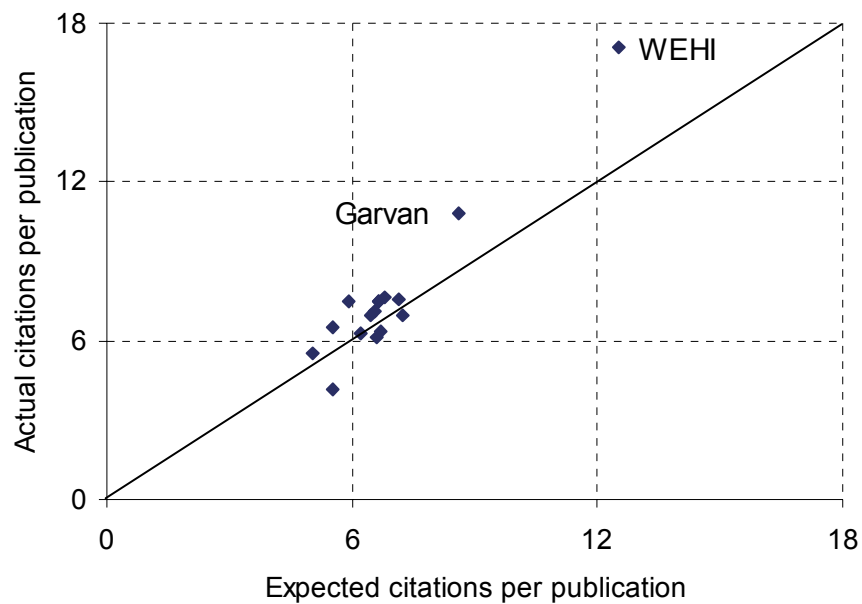


Figure 7B: Actual and expected citation rates by administering institution

The major outliers in the above analysis are the Walter and Eliza Hall Institute and the Garvan Institute of Medical Research at the high impact end, and Howard Florey Institute at the other end of the scale. All three differ significantly from expected citation levels. A more detailed analysis, which was not achievable within this Project, would need to be undertaken to determine the extent to which the position of institutions along the x-axis (showing average journal impact) is governed by the impact of disciplines in which their research is focussed.

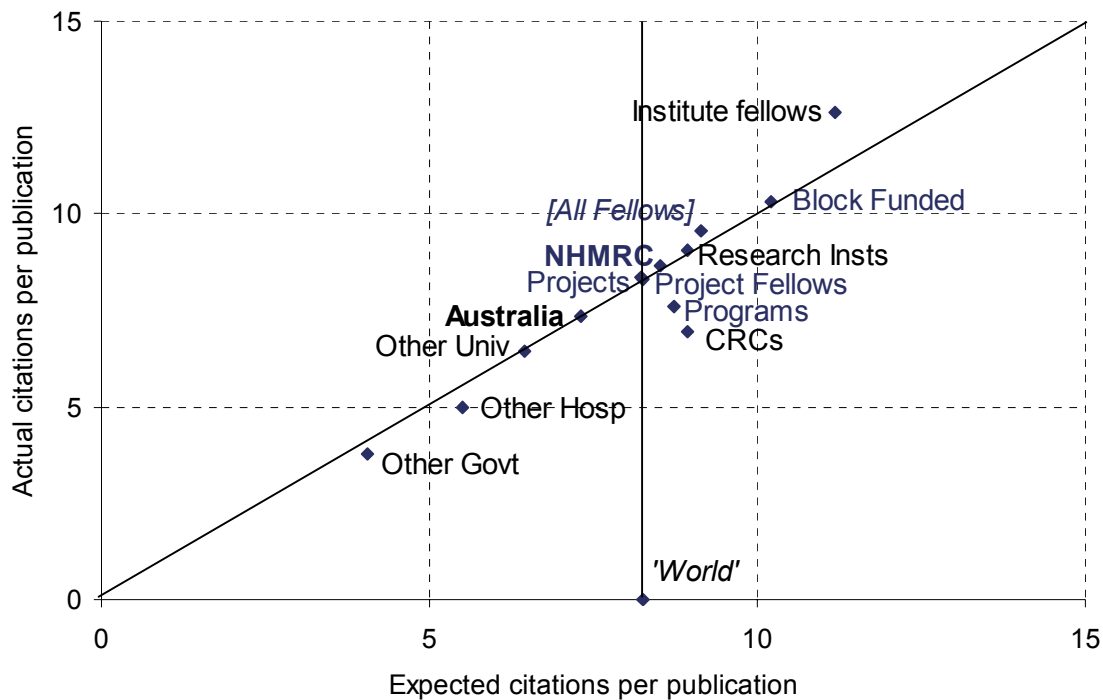


Figure 8: Actual and expected citation rates—Biochemistry and cell biology

Comments:

Over one-third of Australian publications classified to biochemistry and cell biology resulted from research funded, at least in part, by the NHMRC.

Australia's relatively weak citation performance in this sub-field has been well documented, and that analysis remains unchanged in the data for the most recent five-year period. While achieving the expected level of citations for the journals in which they appear, Australian research is appearing in a relatively low impact set of journals. In contrast, NHMRC research is appearing in journals with a marginally higher impact than the full journal set for the sub-field, and achieves the expected level of citations for these journals. Within that, the performance of the Institute Fellows is particularly noteworthy, with the sector publishing in very high impact journals and achieving above the expected citation rate. Given their size, their position in Table 8, where they are responsible for three times the number of highly cited publications, you would expect is a consequence of this strong citation performance.

The research institutes, responsible for nearly 20 percent of ISI publications in this sub-field, is the other strongly performing sector, with a citation rate above the world average. Publications from the CRC sector also appear in relatively high impact journals, but fall well below the expected citation rate for these journals. Their performance, however, is based on a low number of publications — just 139 for the five year period.

4.2 Sub-Field: Genetics
Field: Biological Sciences

ISI journal set analysed: Genetics and heredity.

Table 9: Citations per publication—Genetics

Sector	Cites	Pubs	cpp
NHMRC – institute Fellows	1438	100	14.38
NHMRC - all Fellows	2494	212	11.76
Research Institutes	2551	254	10.04
NHMRC – Project Fellows	1095	116	9.44
NHMRC	5819	644	9.04
NHMRC – block-funded	2248	257	8.75
NHMRC – Projects	2236	268	8.34
NHMRC – Programs	1181	151	7.82
Other Hospital	1673	256	6.54
Other University	5852	959	6.10
Australia	15255	2100	7.26

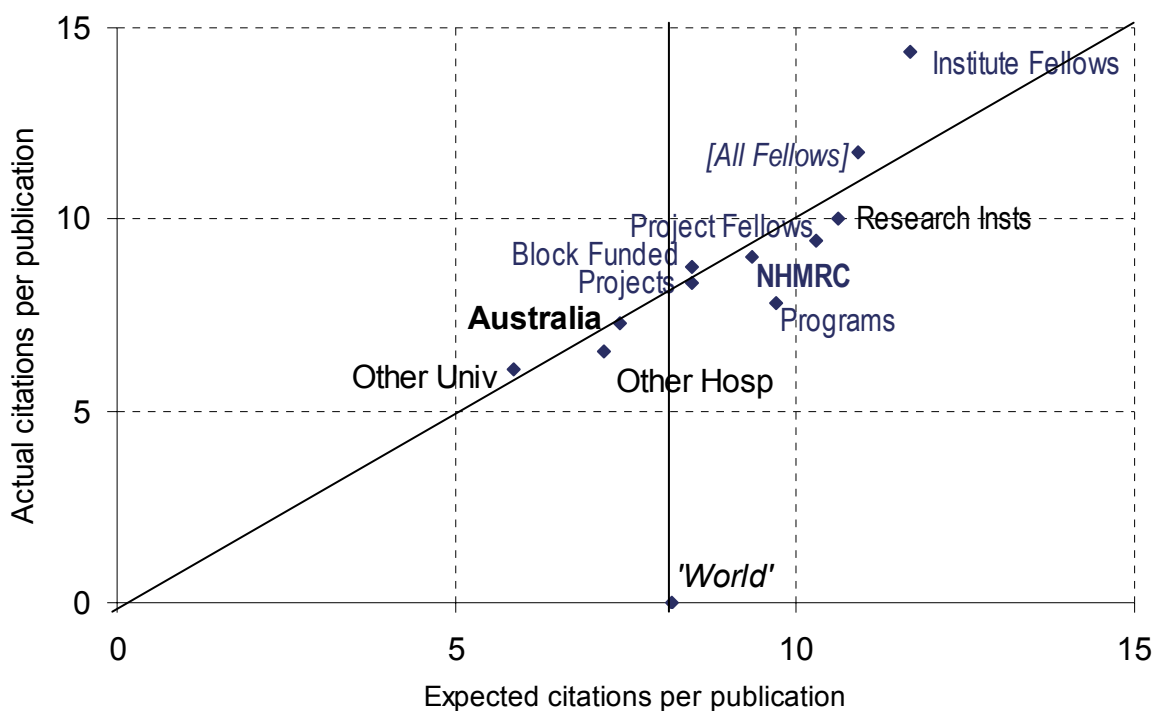


Figure 9: Actual and expected citation rates—Genetics

Table 10: Most highly cited Australian publications—Genetics

- Top 1% = 74 cites (21 pubs)
- Top 5% = 30 cites (104 pubs)

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
NHMRC – institute Fellows	100	5	14
NHMRC - all Fellows	212	3	10
Research Institutes	254	2	8
NHMRC – block-funded	257	2	6
NHMRC	644	2	6
NHMRC – Project Fellows	116	2	6
NHMRC – Projects	268	1	6
Other Hospital	256	0	5
NHMRC – Programs	151	1	4
Other University	959	1	4

Comments:

Genetics is another sub-field of biological sciences in which Australia's citation rate falls well below the world average. As with biochemistry and cell biology, the citation performance of NHMRC-funded publications is in stark contrast to the Australian position.

The centrality of NHMRC to research in this sub-field is demonstrated by the fact that two-thirds of the most highly cited Australian publications (14 of the 21 top 1%) are linked to its support. The research institutes sector also has a strong impact in genetics, with its publications appearing in high impact journals and achieving close to the expected level of citations for these journals. In addition, the sector had a strong presence in the most highly cited list of publications.

The performance of three sectors was based on less than 200 publications – Programs (151), Project Fellows (116) and institute Fellows (100). This should be taken into account when interpreting the performance of these sectors. The performance of the institute Fellows sector in genetics is in line with its overall citation performance, but this is not the case for Programs. As with their aggregate position, they are publishing in high impact journals, but in this case their actual citation count falls well short of the expected level.

4.3 Sub-Field: Microbiology
Field: Biological Sciences

ISI journal set analysed: Microbiology.

Table 11: Citations per publication—Microbiology

Sector	Cites	Pubs	cpp
NHMRC – Projects	1498	165	9.1
NHMRC	1634	204	8.0
Other University	5356	1091	4.9
Other Hospital	967	232	4.2
Other Government	782	196	4.0
Australia	8542	1668	5.1

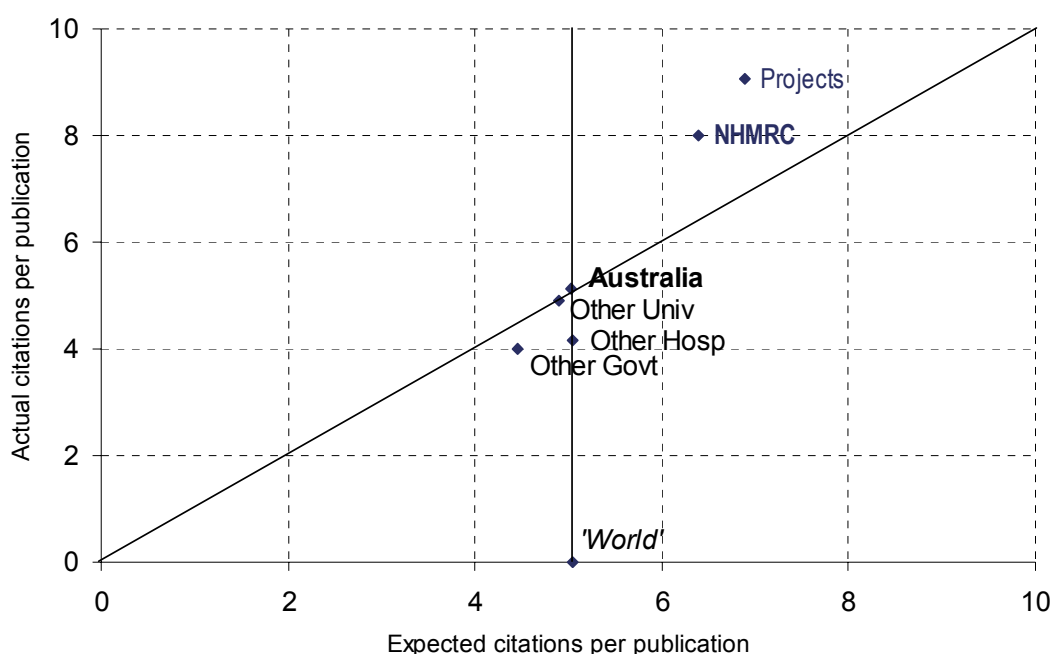


Figure 10: Actual and expected citation rates—Microbiology

Table 12: Most highly cited Australian publications—Microbiology

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
NHMRC – Projects	165	4	10
NHMRC	204	3	9
Other University	1091	1	3
Other Hospital	232	1	3
Other Government	196		2

Comments:

Few sectors are above the 100 publications threshold for this sub-field. It can be clearly seen that in this set of journals, the NHMRC performance, particularly for the set of publications resulting from Project Grants funding, is well in excess of both the Australian and world averages, which are at an almost identical level. However, as they account for only 12% of Australian publications in this sub-field they have only a small influence on the overall Australian performance, which is driven largely by the other university sector which accounts for nearly two-thirds of Australia's microbiology publications. Most of the NHMRC publications in microbiology are funded through the Project Grants scheme (80%).

Although only accounting for a modest proportion of the total, one-third of the most highly cited publications are linked to NHMRC funding.

4.4 Sub-Field: Biotechnology
Field: Biological Sciences

ISI journal sets analysed: Biotechnology and applied microbiology; Biochemical research methods.

Table 13: Citations per publication—Biotechnology

Sector	Cites	Pubs	cpp
NHMRC - all Fellows	722	114	6.3
NHMRC – block-funded	673	120	5.6
Research Institutes	1043	195	5.3
NHMRC	2047	404	5.1
Other Hospital	606	125	4.8
Other University	5742	1218	4.7
NHMRC – Projects	889	225	4.0
Other Government	528	166	3.2
Australia	10058	2147	4.7

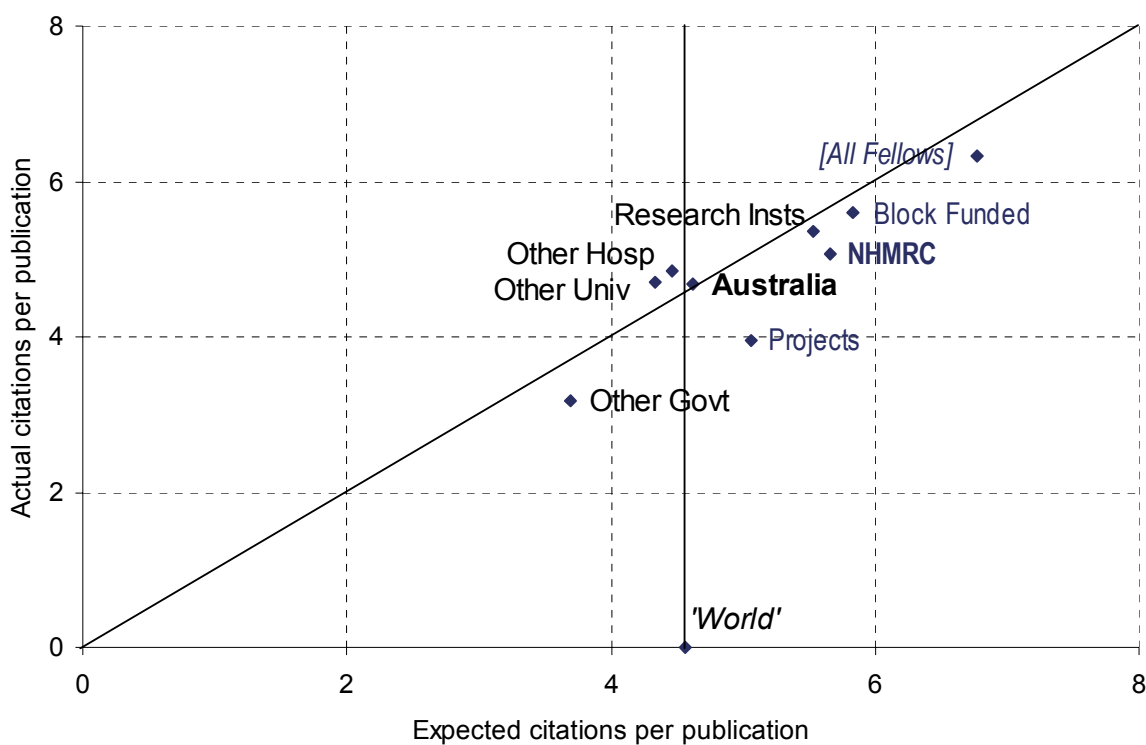


Figure 11: Actual and expected citation rates—Biotechnology

Table 14: Most highly cited Australian publications—Biotechnology

- Top 1% = 35 cites (19 pubs)
- Top 5% = 18 cites (107 pubs)

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
Research Institutes	195	1	8
NHMRC	404	1	5
Other University	1218	1	5
NHMRC - all Fellows	114	3	4
Other Hospital	125	2	4
NHMRC – block-funded	120	3	3
NHMRC – Projects	225	1	3
Other Government	166		2

Comments:

Biotechnology is one of the few biomedical sub-fields where NHMRC-funded publications do not have an average citation per publication rate well in excess of the world average. However, the aggregate data masks quite different performances among the various sectors. The combined Fellows sector publishes in very high impact biotechnology journals, achieving just below the expected citation level for these journals. In contrast, publications that result from Project Grant funding, while appearing in journals of higher impact than the world norm, significantly under-achieve in actual citation counts. As this sector accounts for just over half the total number of publications linked to NHMRC funding, it has a significant influence on NHMRC's overall citation performance.

The distribution of highly cited publications, particularly the 5% band, is more evenly distributed between the sectors than in many other disciplines.

4.5 Field: **Medical and Health Sciences**

ISI journal sets analysed: Journals from all subject categories listed in the sections 4.6 to 4.12 plus those in the following additional categories not analysed separately – Chemistry, medicinal; Dentistry, oral surgery and medicine; Nursing; Sports sciences; Medical laboratory technology.

Table 15: Citations per publication—Medical and Health Sciences

Sector	Cites	Pubs	cpp
NHMRC – institute Fellows	7265	766	9.48
NHMRC – block-funded	14093	1722	8.18
NHMRC - all Fellows	22262	2970	7.50
NHMRC – Programs	8051	1108	7.27
Research Institutes	24907	3429	7.26
NHMRC – Project Fellows	15266	2231	6.84
NHMRC	52842	7863	6.72
NHMRC – Units	1340	209	6.41
NHMRC – Projects	27713	4470	6.20
CRCs	1590	322	4.94
Other Hospital	35492	8907	3.98
Other University	53098	13495	3.93
Other Government	5509	1853	2.97
Australia	143234	30663	4.67

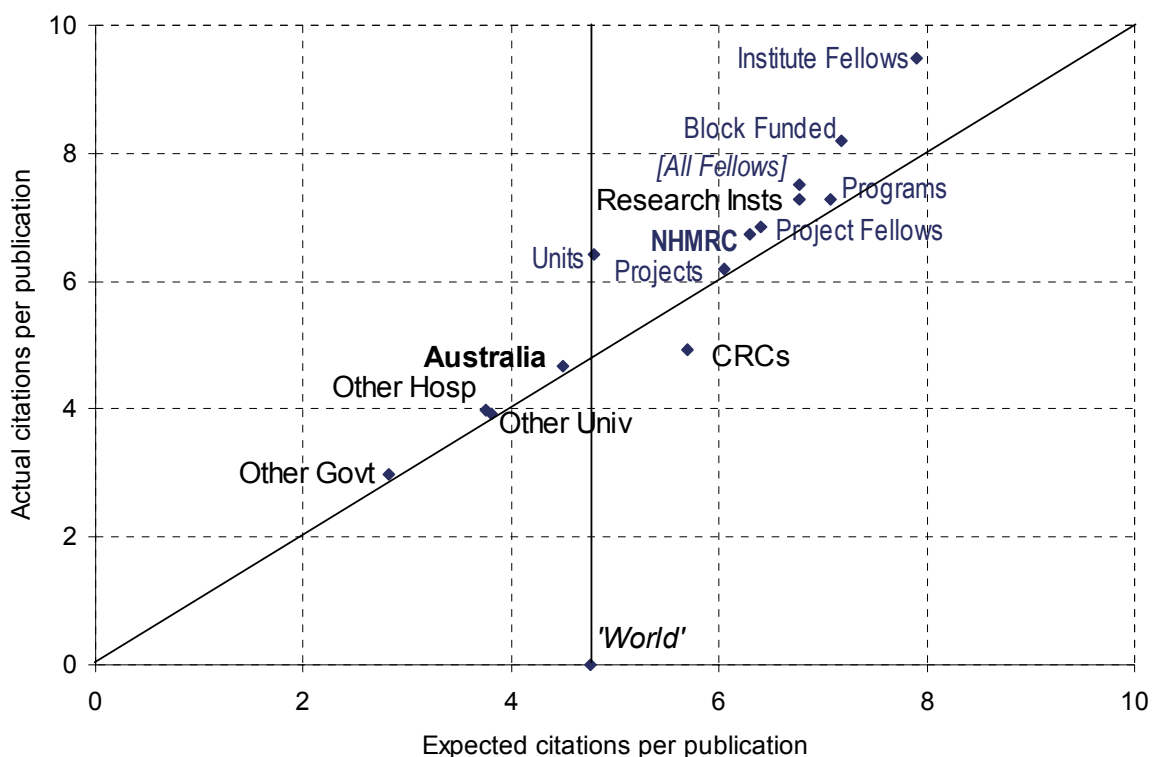


Figure 12: Actual and expected citation rates—Medical and Health Sciences

Table 16: Most highly cited Australian publications—Medical and Health Sciences

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
• Top 1% = 48 cites (298 pubs)			
• Top 5% = 20 cites (1425 pubs)			
NHMRC – institute Fellows	766	4	12
NHMRC – block-funded	1722	3	11
NHMRC – Programs	1108	2	10
NHMRC - all Fellows	2970	2	9
Research Institutes	3429	2	9
NHMRC	7863	2	8
NHMRC – Project Fellows	2231	2	8
NHMRC – Units	209	2	8
NHMRC – Projects	4470	1	7
CRCs	322	0	6
Other Hospital	8907	1	4
Other University	13495	1	3
Other Government	1853	0	2

Comments:

As medical and health sciences accounts for between 62% and 92% of the total output of each sector, it is not surprising that there is little difference between their citation performance in this field and in aggregate. Again we see the publications of all NHMRC sectors except Units appearing in high impact journals. All NHMRC sectors achieve above the expected citation level for their journal set – the institute Fellows, block-funded institutes and Units by a sizeable margin. The position of the Units sector along the x-axis (expected citations per publication) is to a large extent explained by its stronger focus on clinical medicine (71% of its output in the field) compared to other NHMRC sectors (55%). Also it has no publications in the high impact field of immunology, which accounts for 15% of total NHMRC output in the field.

While accounting for 26% of Australia’s output in the field, NHMRC funding schemes are linked to 45% of the most highly cited publications. The research institutes also have a strong citation performance and presence in the most highly cited set of publications.

4.6 Sub-Field: Immunology
Field: Medical and Health Sciences

ISI journal sets analysed: Immunology; Allergy.

Table 17: Citations per publication—Immunology

Sector	Cites	Pubs	cpp
NHMRC – institute Fellows	2220	141	15.74
NHMRC – block-funded	4305	322	13.37
NHMRC - all Fellows	5144	446	11.53
Research Institutes	7122	686	10.38
NHMRC – Programs	1751	170	10.30
NHMRC	11894	1206	9.86
NHMRC – Project Fellows	2930	307	9.54
NHMRC – Projects	6002	712	8.43
Other Hospital	2679	492	5.45
Other University	3801	769	4.94
Australia	20806	2696	7.72

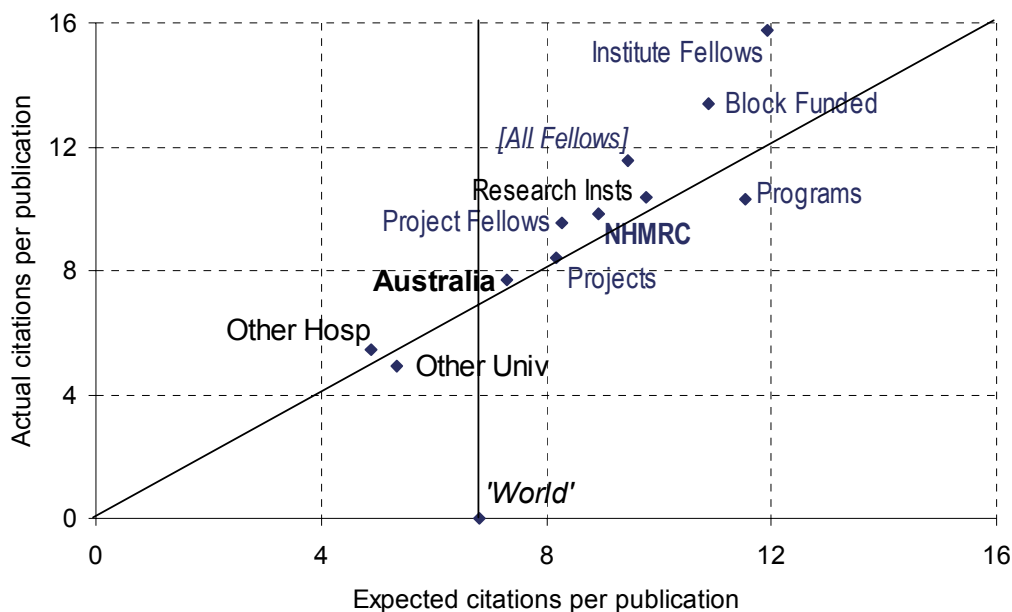


Figure 13: Actual and expected citation rates—Immunology

Table 18: Most highly cited Australian publications—Immunology

- Top 1% = 81 cites (27 pubs)
- Top 5% = 31 cites (129 pubs)

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
NHMRC - institute Fellows	141	6	13
NHMRC - block-funded	322	4	11
NHMRC - all Fellows	446	2	9
NHMRC – Programs	170	1	9
Research Institutes	686	2	8
NHMRC	1206	2	7
NHMRC - Project Fellows	307	1	7
NHMRC – Projects	712	1	6
Other University	769	0	2
Other Hospital	492	1	2

Comments:

Nearly half the Australian immunology publications are linked to NHMRC funding schemes, and two-thirds of all its highly cited publications.

Sectoral performance in immunology is broadly similar to their performance in medical and health sciences as a whole. The outstanding feature in this sub-field is the performance of the institute Fellows who are responsible for only 141 publications (or 5% of all Australian publications) yet account for nearly one-third of all the most highly cited publications.

The data highlights the centrality of NHMRC support to immunology research in general and particularly to high impact research in the discipline.

4.7 Sub-Field: Pharmacology and Pharmaceutical Science
Field: Medical and Health Sciences

ISI journal sets analysed: Pharmacology and pharmacy; Toxicology.

Table 19: Citations per publication—Pharmacology & pharmaceutical science

Sector	Cites	Pubs	cpp
NHMRC - all Fellows	1976	386	5.12
NHMRC - block-funded	853	167	5.11
NHMRC - Project Fellows	1539	305	5.05
NHMRC	4111	838	4.91
NHMRC - Projects	2249	485	4.64
Research Institutes	1004	270	3.72
Other Hospital	1384	374	3.70
Other University	4123	1292	3.19
Other Government	329	143	2.30
Australia	10028	2654	3.78

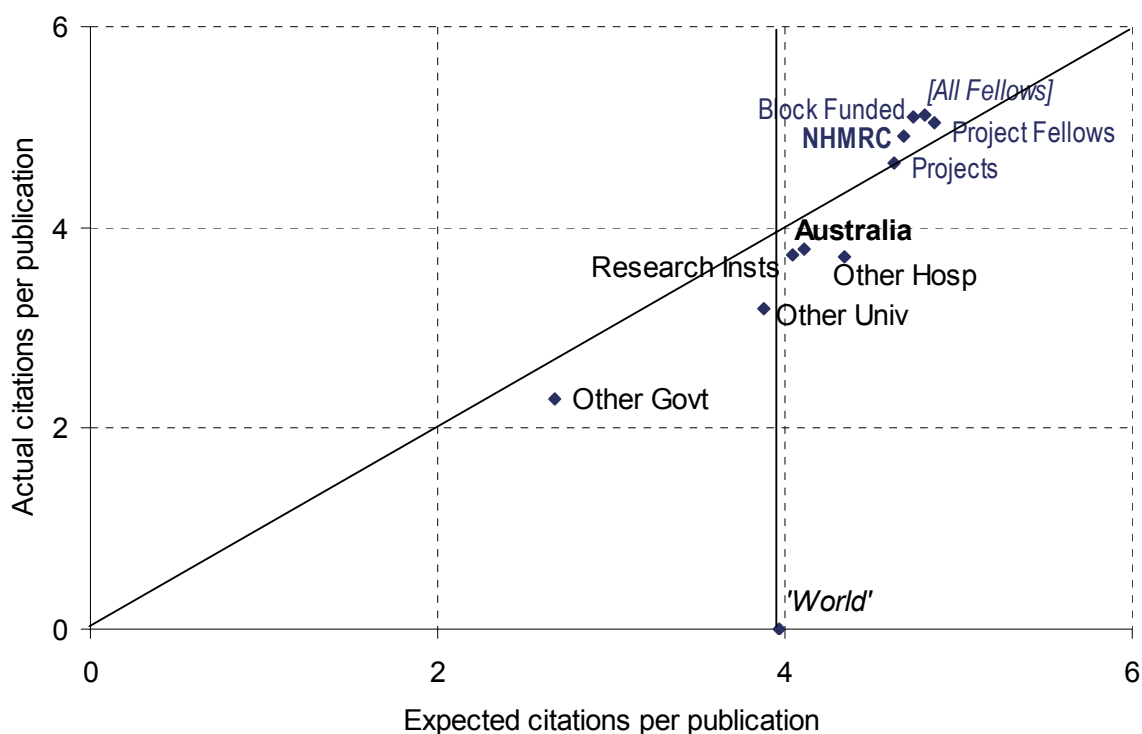


Figure 14: Actual and expected citation rates—Pharmacology & pharmaceutical science

Table 20: Most highly cited Australian publications—Pharmacology & pharmaceutical science

- Top 1% = 35 cites (22 pubs)
- Top 5% = 15 cites (127 pubs)

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
NHMRC - block-funded	167	2	8
NHMRC - all Fellows	386	2	8
NHMRC - Project Fellows	305	1	8
NHMRC	838	2	7
NHMRC - Projects	485	1	5
Research Institutes	270	0	4
Other University	1292	0	4
Other Hospital	374	1	4
Other Government	143	1	2

Comments:

Just under one-third of Australian publications in pharmacology and pharmaceutical science, and over half the highest impact articles, result from research funded by NHMRC. These publications are appearing in a high impact set of journals, and achieving above expected citation levels. In contrast to most other sub-fields, there is little to distinguish between the performance of the various NHMRC sectors, with all having similar citation levels and appearing in journal sets with a similar average impact.

4.8 Sub-Field: Medical physiology
Field: Medical and Health Sciences

ISI journal sets analysed: Anatomy and morphology; Physiology.

Table 21: Citations per publication—Medical physiology

Sector	Cites	Pubs	Cpp
Research Institutes	1423	234	6.08
NHMRC - Project Fellows	1181	255	4.63
NHMRC - all Fellows	1416	373	3.80
NHMRC - Projects	1780	474	3.76
NHMRC	3146	852	3.69
Other University	3484	1164	2.99
NHMRC - block-funded	601	210	2.86
Other Hospital	400	171	2.34
NHMRC - institute Fellows	238	121	1.97
Australia	7731	2253	3.43

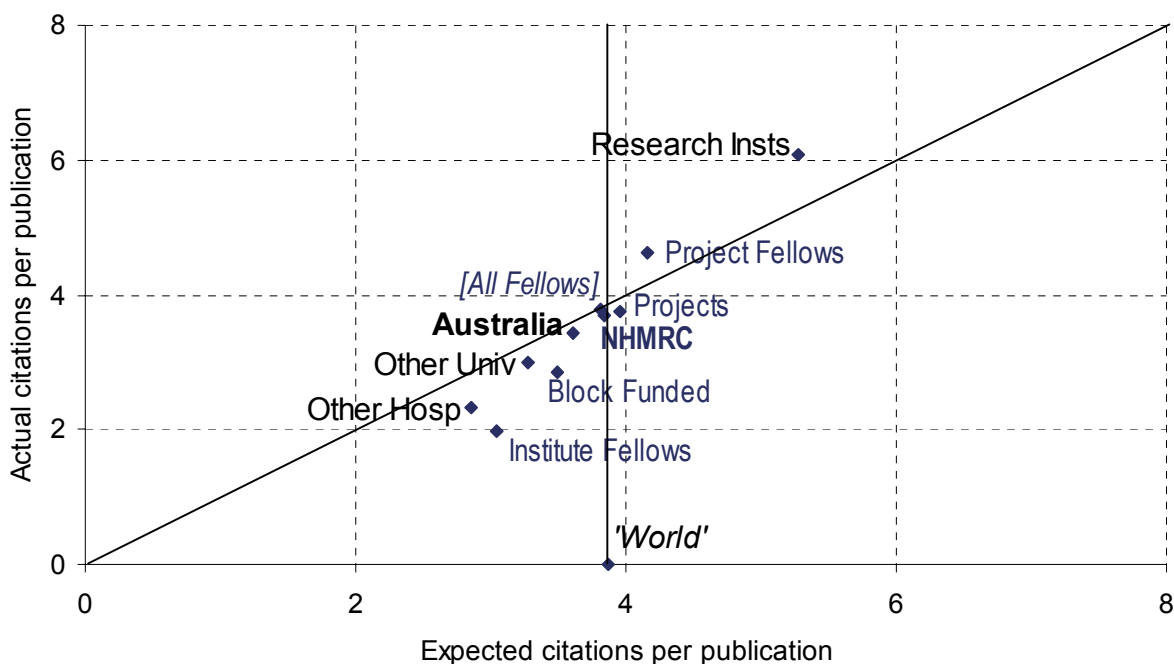


Figure 15: Actual and expected citation rates — Medical physiology

Table 22: Most highly cited Australian publications—Medical physiology

- Top 1% = 31 cites (19 pubs)
- Top 5% = 14 cites (113 pubs)

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
Research Institutes	234	3	12
NHMRC - Project Fellows	255	2	8
NHMRC - all Fellows	373	1	7
NHMRC - Projects	474	1	7
NHMRC	852	1	6
NHMRC - block-funded	210	1	4
NHMRC - institute Fellows	121		3
Other University	1164	0	3
Other Hospital	171	1	2

Comments:

Medical physiology is one of only three biomedical sub-fields in which NHMRC supported publications do not have a citation rate above the world average. The journal set in which the publications appear is also at average levels. The research institutes sector has the strongest performance in this discipline, with Project Fellows being the only other group to publish in high impact journals and achieve above the expected citation level.

The performance of the institute Fellows sector, while based on a low number of publications (121) is very modest, with most publications appearing in low impact journals and achieving below expected citation rates even for these journals.

4.9 Sub-Field: Neurosciences
Field: Medical and Health Sciences

ISI journal set analysed: Neurosciences.

Table 23: Citations per publication—Neurosciences

Sector	Cites	Pubs	cpp
NHMRC - block-funded	1269	162	7.83
NHMRC - institute Fellows	798	120	6.65
Research Institutes	2399	371	6.47
NHMRC - Projects	5347	838	6.38
NHMRC	7777	1236	6.29
NHMRC - all Fellows	3157	531	5.95
NHMRC - Project Fellows	2423	420	5.77
NHMRC - Programs	938	165	5.68
Other Hospital	2459	487	5.05
Other University	5852	1339	4.37
Australia	16553	3048	5.43

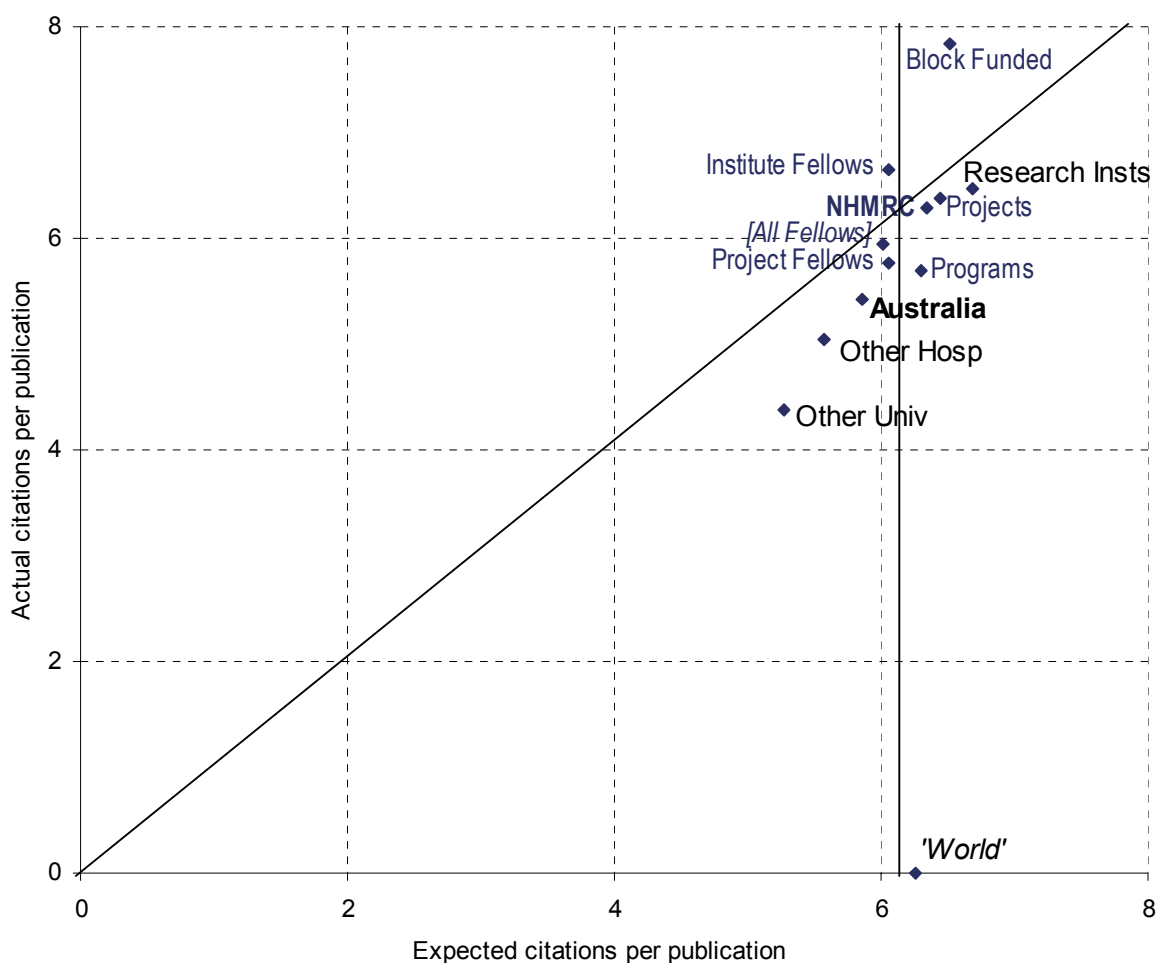


Figure 16: Actual and expected citation rates—Neurosciences

Table 24: Most highly cited Australian publications—Neurosciences

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
• Top 1% = 43 cites (29 pubs)			
• Top 5% = 21 cites (142 pubs)			
NHMRC - block-funded	162	3	9
NHMRC - institute Fellows	120	2	8
Research Institutes	371	1	8
NHMRC - all Fellows	531	1	6
NHMRC	1236	1	6
NHMRC - Projects	838	1	6
NHMRC - Project Fellows	420	0	5
NHMRC - Programs	165	2	5
Other Hospital	487	0	4
Other University	1339	1	3

Comments:

Publications resulting from NHMRC-funded research account for 40% of the Australian journal output in neurosciences. Only its share of immunology publications surpasses this level.

The performance of sector publication sets is more homogenous in neurosciences than in most other disciplines. There is a comparatively small variation in the average journal impact for each sector, though within this range the other hospital and other university sectors are at the lower end. The block-funded sector attracts more citations on average, and Programs the least. This is reflected in Table 24, which shows the block-funded institutes with a high proportion of their publications in the highly cited publication bands.

The neurosciences are a sub-field in which the aggregate citation performance of NHMRC-funded publications differs little from the world average.

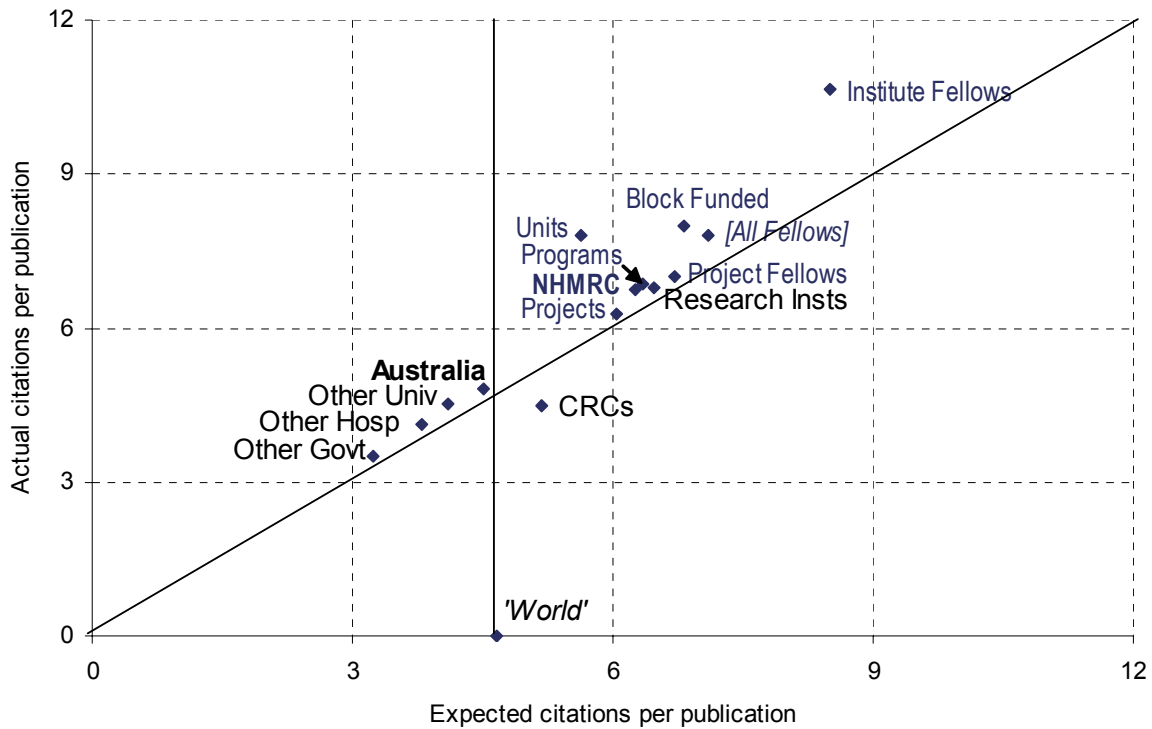


Figure 17: Actual and expected citation rates—Clinical sciences

Comments:

Clinical medicine is by far the largest sub-field in the RFCD classification of Medical and Health Sciences – it accounts for 55% of all publications. It is therefore not surprising that the citation performance of sectors in clinical sciences is very similar to their performance in medical and health sciences as a whole. The one exception is the Units sector. Its publications appearing outside the clinical sciences journal set have a lower cpp rate than those in the set; hence its performance when the analysis is limited to this sub-field appears stronger. It publishes in relatively high impact journals, and achieves nearly 40% above the expected citation level for this set of journals. However, it must be remembered that this analysis is based on only 149 publications — a relatively small number in bibliometric terms.

While NHMRC sectors account for only 22% of total Australian output in clinical sciences, research funded under these schemes account for over one-third of highly cited publications in both the top 1% and 5% bands. In relation to these publications, the performance of the institute Fellows is particularly outstanding.

NHMRC publications are, in aggregate, appearing in high impact journals, and achieve above the expected citation rate for these journals — and 50% higher than the world citation per publication rate.

4.11 Sub-Field: Public health and health services

Field: Medical and Health Sciences

ISI journal sets analysed: Ergonomics; Health care sciences and services; Health policy and services (SSCI); Medical informatics; Nutrition and dietetics; Public, environmental and occupational health; Substance abuse

Table 27: Citations per publication—Public health and health services

Sector	Cites	Pubs	cpp
NHMRC	2077	402	5.17
NHMRC – Projects	941	209	4.50
Other Hospital	1922	535	3.59
Research Institutes	1170	328	3.57
Other University	5764	2172	2.65
Other Government	1377	585	2.35
Australia	10235	3412	3.00

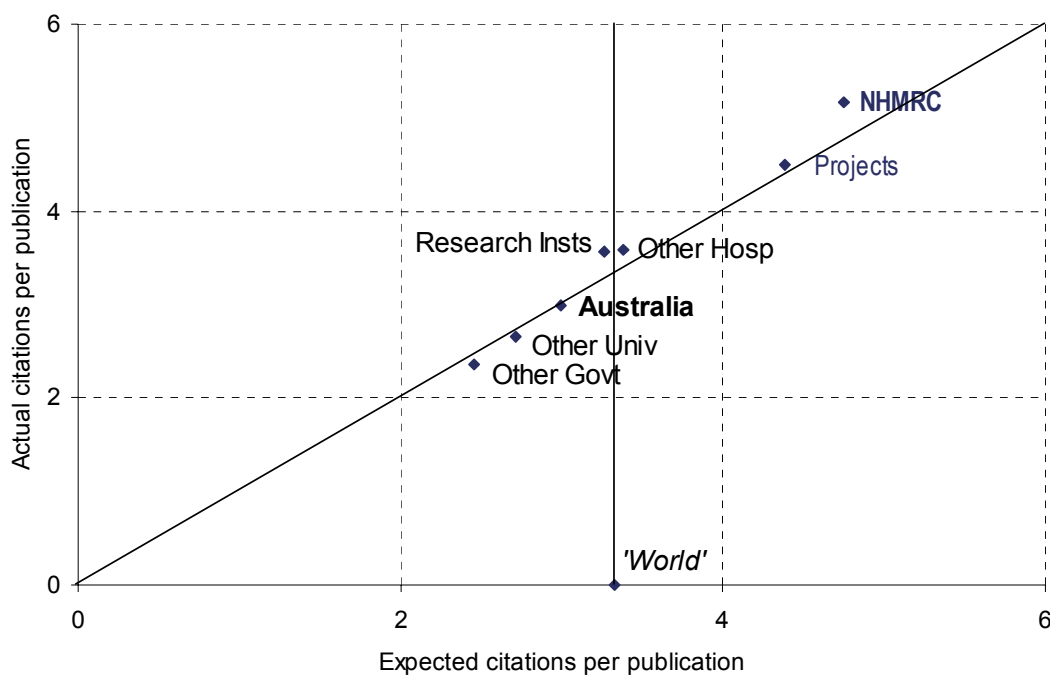


Figure 18: Actual and expected citation rates—Public health and health services

Table 28: Most highly cited Australian publications—Public health and health services

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
NHMRC	402	3	12
NHMRC - Projects	209	2	10
Research Institutes	328	2	7
Other Hospital	535	1	6
Other University	2172	1	4
Other Government	585	0	2

- Top 1% = 29 cites (33 pubs)
- Top 5% = 13 cites (165 pubs)

Comments:

Much of the output from public health and health services research appears in media other than the ISI-indexed journals, such as professional or locally-based journals, government reports, newspapers, and the like. Nevertheless, there are over 3,400 publications indexed by ISI that can be classified to the sub-field, and an analysis of their citation impact is useful additional data to use in conjunction with other measures of the impact and esteem of research funded by NHMRC in this area.

The NHMRC's share of publications classified to public health and health services research is modest (12%), yet they account for one-third of the most highly cited publications in the top 1% band, and just under 30 percent in the top 5% band. NHMRC publications are appearing in very high impact journals and achieving above expected citation levels for them.

4.12 Sub-Field: Medicine general
Field: Medical and Health Sciences

A number of journals, classified by ISI as ‘Medicine, General and Internal’, cannot be allocated to a specific sub-field as they have a wide discipline coverage. Examples are the *Medical Journal of Australia*, *Lancet*, *New England Journal of Medicine*, and the like. This section separately analyses this set of journals.

Table 29: Citations per publication—Medicine general

Sector	Cites	Pubs	cpp
NHMRC - block-funded	2279	168	13.57
NHMRC - all Fellows	2760	209	13.21
Research Institutes	4228	335	12.62
NHMRC - Project Fellows	1533	144	10.65
NHMRC	5812	587	9.90
NHMRC - Projects	2340	289	8.10
Other University	3266	867	3.77
Other Hospital	2127	659	3.23
Other Government	327	124	2.64
Australia	12754	2215	5.76

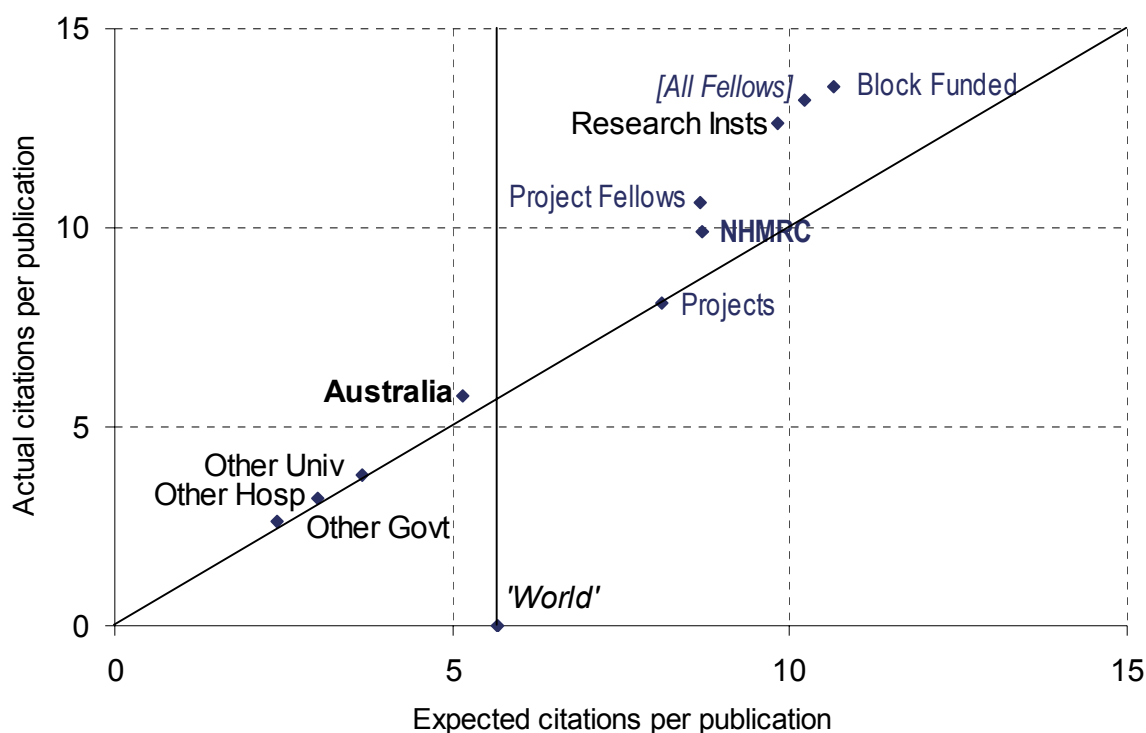


Figure 19: Actual and expected citation rates—Medicine general

Table 30: Most highly cited Australian publications—Medicine general

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
• Top 1% = 74 cites (22 pubs)			
• Top 5% = 24 cites (108 pubs)			
NHMRC - block-funded	168	5	15
NHMRC - all Fellows	209	4	13
Research Institutes	335	4	13
NHMRC	587	3	10
NHMRC - Project Fellows	144	3	10
NHMRC - Projects	289	2	9
Other University	867	0	3
Other Hospital	659		2
Other Government	124		1

Comments:

As in all fields, general journals usually have a higher citation rate than specialty journals. The general medical journals reflect this with an average citation per publication rate of 5.7 compared to 4.8 for the field as a whole (world averages).

NHMRC publications appear in a subset of these journals with a high average impact and achieve greater than expected levels of citation. The block-funded institutes sector has a particularly strong performance in this sector, their publications appearing in very high impact journals and attracting many more citations than expected even for this set of journals.

The average citation per publication rates for NHMRC-funded articles is well in excess of both the Australian and World averages, which are at a similar level.

4.13 Sub-Field: Multi-disciplinary science

Field: Science - general

Some journals indexed by ISI cover a wide variety of disciplines and cannot be classified to a particular field, or even sub-field. ISI groups them together in a ‘Multi-disciplinary Sciences’ subject category, and it covers journals such as *Nature*, *Science*, *Proceedings of the National Academy of Science*, etc.

Table 31: Citations per publication—Multi-disciplinary science

Sector	Cites	Pubs	cpp
NHMRC - all Fellows	3720	119	31.26
NHMRC	6562	237	27.69
NHMRC - Projects	2535	112	22.63
Other University	6486	871	7.45
Other Government	789	138	5.72
Australia	16748	1389	12.06

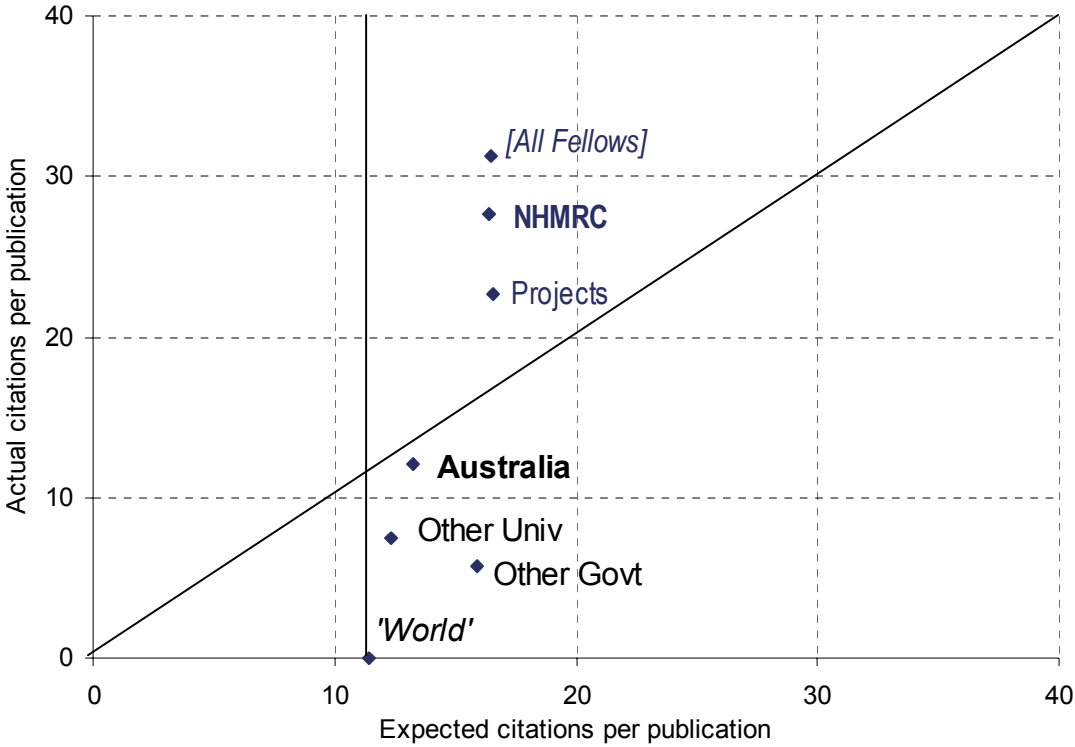


Figure 20: Actual and expected citation rates— Multi disciplinary science

Table 32: Most highly cited Australian publications—Multi-disciplinary science

Sector	Total No. Pubs	% Pubs in Top 1%	% Pubs in Top 5%
• Top 1% = 153 cites (14 pubs)			
• Top 5% = 53 cites (68 pubs)			
NHMRC - Projects	112	2	13
NHMRC - all Fellows	119	4	12
NHMRC	237	4	12
Other University	871	0	3
Other Government	138		1

Comments:

Multi-disciplinary journals are more highly cited than any other set of journals. However, not all fields achieve the same elevated citation levels that occur for these journals in aggregate. Studies have shown that biomedical articles in these journals are, on average, more heavily cited than, for example, articles on botany. These latter articles may well attract many more citations than is the norm for even the most highly cited journal in their specialty, but it is still likely to fall well short of the average levels for these journals. This, to a large extent, explains the position of the other government and university sectors. For example, in the other university sector 179 of their publications come from engineering departments, 99 from earth sciences departments, 87 from mathematics departments, etc.

The average citation rate for NHMRC publications in this journal set is more than double the world average, and is particularly strong for the two Fellows sectors who together account for half the NHMRC's output in this sub-field. Nine of the fourteen most highly cited publications in the journal set result from NHMRC-funded research, as do nearly half the publications found in the top 5% band.

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Technical Annex: Methodology

T1 The Research Evaluation and Policy Project Database

The REPP database was created from data files purchased from the Institute for Scientific Information (ISI) and, at the time this study was commissioned covered the period 1981–2000. It captures all publications with an Australian address in the three major ISI Indices: Science Citation Index (SCI), Social Sciences Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI). The database also contains the yearly counts of citations to each of the Australian publications.

The focus of the database is the departmental and the institutional address (es) given for each publication rather than the names of authors. REPP ‘cleans’ the addresses in the database to enable analysis to be done at different levels of aggregation. ‘Cleaning’ means ensuring that all variations of the same address are identified and that all publications with variants of that address are allocated the one ‘standardised address’. The standardised addresses for all Australian universities and other major research institutions are set up in a hierarchical format, from the institution down through faculties or schools to the department, enabling tabulations at these different levels of aggregation to be produced. Addresses in most other sectors are ‘cleaned’ only to the institution level. The REPP database as it now stands contains just over 450,000 Australian publications.

Since there is no consensus in the research policy community about the ‘best’ way to count publications and citations, we list a series of options available in the REPP database and used for the tables compiled for this analysis:

- the types of publications counted were limited to articles, notes and review articles;
- data was compiled on a publication-year basis, not a tape-year basis (ie the year the item was published, not the year its details were entered in ISI’s database);
- the analysis focuses on the period 1996-2000;
- the analysis was based on whole publication counts (ie where more than one sector collaborated in a publication, each was given a count of 1 for that publication⁸).

T2 Assignment of multi-institutional addresses

Most publications in the REPP database list only one institution in the organisation field of the address. A small proportion, however, refer to two institutions, a phenomenon almost exclusively found in the medical and health sciences. Two examples of this type of address are:

WOOLLONGABBA/UNIV QUEENSLAND, PRINCESS ALEXANDRA HOSP, DEPT MED
SYDNEY/GARVAN INST MED RES, UNIV NEW S WALES

Three interpretations can be applied to this form of address:

- i) it represents a collaboration between authors from the two institutions; or
- ii) it represents a joint appointment for a single author; or
- iii) the second segment of the address merely represents the physical location of the first listed institution.

⁸ The exception to this rule was in the delineation of comparator sectors — see the discussion in section T7.

REPP undertook extensive consultation with universities and funding agencies before deciding how to treat these two types of addresses. These discussions led to the consistent view that in the case of a multi-address referring to a university and a hospital, the publication should be attributed to the university. It was considered that the hospital part of the address was, in the majority of cases, merely a reflection of the university department's physical location. This was supported by the distribution of such addresses, which were principally in clinically oriented faculty of medicine departments.

In the case of multi-addresses referring to a university and a medical research institute, there were more divergent views. However the clear preference of the funding agencies, in particular the ARC and the NHMRC, was to allocate these publications to the medical research institutes, and REPP has adopted this strategy. Relatively few publications are affected by this decision – for example, in relation to the University of Sydney, there were less than 10 such publications a year. It must be noted, also, that these publications may still have been allocated to the university as in some instances additional addresses (from a multi-authored paper) will refer to the university specifically.

T3 Field of research classification

The ideal scenario for field of research analysis is to classify each publication separately. This is usually impossible for large-scale studies, and standard practice is to classify the journal, which carries the publication (Narin 1976). The major advantage of the methodology used in this study is that, for publications linked to Project and Program Grants, it has been possible to use the investigators' own classification of their research for analytical purposes. This means that publications appearing in multi-disciplinary journals (eg *Nature*) can be ascribed to the field of research most appropriate to the content of the article. The NHMRC category B discipline codes were used. However, for other sectors it is necessary to revert to the standard practice of journal set analysis. The results of both types of field analyses are presented in this study.

The make-up of journal sets for field of research analysis rests on ISI's classification schemes. ISI has its own descriptive classification system involving around 200 subject categories and REPP has, for a number of previous exercises, translated these as closely as possible into the fields and sub-fields of the Research Fields, Courses and Disciplines (RFCD) Classification scheme (ABS 1998). The RFCD was prepared by the Australian Bureau of Statistics for use in the measurement and analysis of research and experimental development undertaken in Australia. Most ISI subject categories slot neatly into one of the RFCD sub-fields, but some problems were encountered. For example, in contrast to the RFCD, ISI does not distinguish between research that focuses on animals and that which focuses on humans. Subject categories such as Physiology, Virology and Parasitology can have elements of two or more RFCD fields in their composition. To avoid allocating too many categories to interdisciplinary codes, REPP classified a journal set to a particular field where more than half the journals appeared clearly related to that field. The subject categories ascribed to each biomedical ASRC sub-field are shown at the start of each analysis in Section 4.

It should be noted that ISI allocates some journals to more than one subject category with the effect of some double counting between fields and/or sub-fields.

T4 Small Numbers

A special note of caution is required concerning the small numbers of publications tabulated in some research fields. In the ISI system as a whole, many publications receive no citations at all, and the majority receive less than 5 citations (Garfield 1989). The number achieving a high citation count is extremely small. The very nature of citation practice means that averages can be disproportionately affected by a single highly cited publication. The smaller the number of publications being analysed, the greater the effect such an item will have on the average.

For the bibliometric measures used in this analysis, citation information based on any units with less than 100 publications have been omitted.

Our experience also suggests that extra caution should be used for citation figures based on units with between 100 and 200 publications.

T5 ISI Coverage

Before any discussion of publications and citations occurs, it is important to be clear about the proportion of research output from the units under study that is covered by bibliometric measures.

Fields of research vary in the extent to which journal publication can be regarded as the normal mode of research dissemination. The most extensive database relevant to this subject is the Research Quantum Publications Collection from the Department of Employment, Education Training and Youth Affairs which has been collected yearly since 1993. For the 1995 collection, each publication reported in the collection was allocated to a field of research. Table T1 shows the distribution by type of publication for each of the major fields of science and for the social sciences and the humanities. The distribution is limited to the four publication types that continue to be reported rather than the twenty-two publication types originally collected.

Table T1: Distribution of research by type of publication and field, 1995

	Book	Book Chapter	Journal Article	Conf. Publ.	Total
Mathematical Sciences	2.1	4.6	76.7	16.7	100.0
Physical Sciences	0.8	2.8	77.6	18.7	100.0
Chemical Sciences	0.0	3.0	83.9	13.1	100.0
Earth Sciences	1.8	14.4	61.3	22.5	100.0
Inform, Comput & Commun	0.4	5.7	21.4	72.5	100.0
Applied Sciences & Tech	0.8	4.4	40.2	54.6	100.0
General Engineering	0.6	2.4	33.4	63.5	100.0
Biological Sciences	0.9	12.7	77.0	9.3	100.0
Agricultural Sciences	1.0	12.6	62.2	24.2	100.0
Medical & Health Sciences	1.2	14.7	73.7	10.4	100.0
Social Sciences	5.7	27.9	49.2	17.1	100.0
Humanities	8.9	33.1	48.1	9.9	100.0
Total	3.1	16.8	56.5	23.6	100.0

Source: DEETYA Financial and Research Publications Data Collection (1995, unpublished Table)

Table T1 shows that in the biomedical fields (Biological Sciences and Medical and Health Sciences), output in journals represent approximately three-quarters of total output from the university sector, and experience has shown that for the medical research institutes the level is even higher. However, this level is not universal for all biomedical disciplines, with the proportion for public health and health services research, for example, being considerably less.

The other aspect of coverage to be borne in mind is the extent to which journals in a particular field of research are indexed by ISI and therefore captured in this analysis. The following table illustrates the varying pick-up rates across selected disciplines:

Table T2: Proportion of journal articles captured by ISI, all universities, 1991

Field / sub-field of research	All journal articles	ISI journal articles	
		No.	%
Public Health Research	633	145	24
Genetics, Molecular Biology & Biochemistry	267	218	82
Microbiology	185	152	82
Pharmacology	431	347	81
Clinical sciences	3161	2568	81
Neurosciences	443	375	85
Immunology	363	316	87
Biochemistry	475	440	93

Source: NBEET (1994)

The data in Tables T1 and T2 clearly show why bibliometric analysis is problematic in research disciplines such as public health research. Much of their research is not published in journal articles, and even when it is, the capture rate in ISI indices is very small. However, bibliometric analysis is appropriate for most other biomedical disciplines, though any data should be carefully interpreted by experts in the disciplines under scrutiny.

T6 Identification of publications from NHMRC sectors

A number of methods were needed to identify NHMRC publications resulting from research funded through different grant Programs.

T6.1 Project Grants (sector 1)

T6.1.1 Background to methodology

Project Grants are awarded to individual researchers, or groups of researchers, and the publications linked to this scheme cannot be identified directly from the REPP database. There are three possible methods for identifying the relevant publications: surveying the researchers directly; obtaining publication details from the final reports of the grant; or, obtaining publication details from the application forms researchers submit when applying for new grants.

It is unlikely that a survey of researchers would result in a response rate high enough to identify an accurate set of publications.

The final report from a successful Project Grant is not useful in providing details of the research publications that result from that grant, as many are still in press, in draft form, or still in “gestation” at the time the report is submitted. It is not until a number of years have elapsed after the completion of the grant that a more accurate account of the research output can be made.

The best methodology lies in the third scenario. Applications for new Project Grants within the NHMRC rubric require chief investigators to list all their previous NHMRC support and the publications that resulted from this support. By focussing on new applications for the 1999-2002 period, REPP expected to obtain a comprehensive coverage of 1996 to 2000 publications for these applicants, and be able to extract a full list of publications linked to previous NHMRC Project Grants.

The efficacy of the methodology relies on the following assumptions:

- virtually all active medical researchers will apply for a new grant at least once in the selected period; and
- application forms will be meticulously and accurately completed.

A previous study conducted by REPP for the NHMRC (Butler and Biglia 2001) showed that this methodology "resulted in an accurate, though not perfect, set of publications for analysing output from the NHMRC's Project Grants scheme" (p.72). Since that study was undertaken, there has been one significant change to NHMRC procedures – the instruction to link the researchers publication list to previous NHMRC support was not spelt out in the on-line application form, though it was contained in the accompanying file of instructions. There is no doubt that some applications did not follow the instructions relating to this section, and thus our list of publications will be incomplete, however it is estimated that under-reporting accounts for less than 5% of the expected output. We remain confident that the publications identified accurately reflect the output of NHMRC research supported by the Project Grants scheme.

T6.1.2 Outline of methodology

An outline of the methodology used to identify publications resulting from research funded by the NHMRC Project Grants scheme is set out in the box below, followed by a detailed discussion of some aspects of the methodology.

Step 1: Bibliographic details for all publications in the REPP database for 1996 to 2000, limited to articles, notes and reviews, were extracted.

Step 2: NHMRC provided an electronic list of all successful large grants for the period 1990-2000.

Step 3: An electronic list of all applications received by NHMRC for Project Grants in the period 1999-2002 was obtained.

Step 4: Details of the publications linked to past NHMRC Project Grants were extracted from applications in Excel spreadsheet format.

Step 5: Publication lists from all 2002 applications that reported links to past grants were printed out from the electronic application files.

Step 6: Publications from our target years, 1996 to 2000, were identified in the publication lists and matched against the publications in the REPP database.

Step 7: Where a match was made, the relevant grant number was appended to the publication record.

Step 8: 2001 applications were checked to identify any that linked publications to grants not already reported in 2002 applications, and steps 4 to 6 were repeated.

Step 9: Steps 4 to 7 were repeated for 2000 applications, then 1999 applications.

Step 10: Analysis was undertaken of the resulting publication set.

T6.1.3 Discussion of the methodology

Step 1:

The bibliographic details extracted for 1996 to 2000 publications were: publication ID, title, journal, volume, start page, and authors. This provided sufficient information to make a confident match with details provided in the publication lists of the grant applications.

Step 2:

Experience gained in a previous analysis of the output from NHMRC Project Grants (Butler and Biglia 2001), led us to expect that nearly all 1996 to 2000 publications linked to this scheme would have come from grants commenced between 1990 and 2000.

Steps 3-4:

The analysis was limited to details contained in applications for large grants made between 1999 and 2002 because the identification of links between publication lists and past NHMRC grants was available electronically. Prior to this period, individual paper application files would have had to be searched to discover this information. Applications from 2002 were targeted in the first instance, as these had the most complete bibliographic information for 1996 to 2000 publications, and because the researchers' publication lists were available electronically. If no 2002 applications relating to a particular prior NHMRC Project Grant could be found, a 2001 application was selected, followed by 2000 applications and then 1999 applications. The distribution of files examined is shown in Table T3.

Table T3: Number of 1999-2002 Project Grant applications supplying data on linked publications

Application Year	Examined		Total applications
	No.	%	
2002	767	44	1754
2001	245	13	1851
2000	181	10	1769
1999	64	4	1505

Even for the 2002 round, details were not extracted from every application reporting publications linked to prior grants as in many instances researchers or groups had made multiple applications and the information they contained was duplicated. For 2001 and earlier rounds, the number of applications from which data was extracted declined as only those with publications linked to grants for which we did not already have details were accessed.

Steps 5 to 7:

The publication lists obtained from application files were examined, and journal publications in the target period, 1996 to 2000, were identified. In most cases, full bibliographic details were available and matching publications to the REPP database was a straightforward, though very time consuming, task. In 13% of cases, researchers linked a publication to more than one Project Grant.

T6.1.4 Final database

The comprehensive and detailed methodology outlined above resulted in the identification of 6,078 publications that could be linked directly to NHMRC Project Grants; could also be found in the REPP database and were classified as articles, notes and reviews.

T6.1.5 Coverage achieved

The methodology used to identify publications that result from research funded under the Project Grants scheme is not perfect. Not all researchers or groups who were awarded Project Grants in earlier years will have applied for a new grant during the four years we targeted in this study. Researchers may have retired, moved out of research, or gone overseas, and information about this group will be missing. It is difficult to know what proportion this group would be of the total, but I would expect it to be in excess of 10%.

Table T4: Coverage of successful Project Grants awarded between 1991 and 2000

Grant year	Total grants awarded	Grants with linked pubs	Grants with no in-scope pubs	No. grants covered	
				No.	%
1991	406	22	35	57	14
1992	395	55	42	97	25
1993	311	103	52	155	50
1994	371	213	28	241	65
1995	387	251	15	266	69
1996	307	211	14	225	73
1997	404	273	25	298	74
1998	356	197	36	233	65
1999	336	152	66	218	65
2000	396	80	94	174	44

From the data contained in the above table, it is clear that this current study does not identify all publications that result from NHMRC Project Grants. The exact extent of under-reporting is impossible to calculate. It is likely to be in the range of 20 to 30 percent. The most important cohort of grants are those that commenced between 1994 and 1999, as these provide most of the targeted publications (1996 to 2000). Between two-thirds and three-quarters of the grants from these years have been covered. The lower coverage of grants commenced before 1994 and after 1999 will not have a huge impact on total coverage and is not of major concern.

It is the belief of the project team that some of the under-reporting is due to the omission of clear instructions to link researchers publications to past NHMRC grants in the electronic version of the application form, even though this direction was given in the accompanying instructions. This is based on a significantly better coverage of approximately 90 percent in our 2001 study.

This issue must be borne in mind when interpreting the results of the study, but given the large number of publications that were identified, it is unlikely to have a significant effect on the average citation rates on which most of the analysis is based. It is of most concern when publication numbers drop to fairly low levels.

T6.2 Program Grants (sector 2)

A list of Program Grants active during 1996 to 2000 was provided by NHMRC, together with the years for which they were in receipt of funding, and the details of the researchers associated with the grants. All the researchers' publications for 1996 to 2000 were extracted from the REPP database. The author's institutional location was also used as an additional field for identification, particularly where common surnames were involved.

Where a program was not in receipt of funding for the whole period, the publications extracted were limited to the funding period, with a one-year time lag built in. For example, publications were limited to 1996 and 1997 for those researchers whose grant finished in 1996; and publications were limited to 1999 and 2000 for those researchers whose grant commenced in 1998.

The Program Grants were linked to 1,529 in-scope publications in the REPP database.

T6.3 Block-funded research institute grants (sector 3)

The block-funded institutes receiving NHMRC support during 1996 to 2000 were:

- Garvan Institute of Medical Research
- Baker Medical Research Institute
- Howard Florey Institute
- Walter and Eliza Hall Institute
- Murdoch Institute for Research into Birth Defects
- Queensland Institute of Medical Research (commenced 1998)

The REPP database is structured to enable publications to be attributed to the institutions on the basis of addresses. It is therefore a straightforward task to identify all publications for the listed block-funded institutes. QIMR publications included in this sector were limited to 1998 to 2000.

From the REPP database, 2604 in-scope publications for the block-funded institutes were identified in the relevant time period.

T6.4 Research Unit Grants (sector 4)

The Research Units receiving grants at the relevant period were:

- NHMRC Psychiatric Epidemiology Research Centre at the Australian National University
- Clinical Trials Unit at the University of Sydney
- NHMRC Network for Brain Research into Mental Disorders at the University of Melbourne
- National Research Centre for Environmental Toxicology at the University of Queensland
- NHMRC Road Accident Research Unit at the University of Adelaide (until 1998)
- Health Economics Research Unit at Monash University (1998-99)

The REPP database is structured to enable publications to be attributed to the institutions of their authors. This attribution is also possible down to the level of faculty and department (or their equivalent) in universities, CSIRO and some government departments. In Australian universities it is possible to assign over 90% of all publications to departments (Bourke and Butler 1998). In the case of five of the six Units, it was a straightforward task to identify their publications. However, the Network for Brain Research, involving cross-institutional collaboration, could not readily be created on an address basis from the REPP database and this may have resulted in some under-reporting of publications.

From the database, 258 in-scope publications were identified with the Research Units.

T6.5 Research Fellowships Awards (sectors 5 and 6)

A list of recipients of Research Fellowships funded during the period 1995 to 2000 was provided by NHMRC. Both researchers funded under the scheme linking Research Fellowships to Project Grants, and those taking up their Fellowship in the block-funded institutes, were included, though separately identified.

Details of all the researchers' publications for the period they were on scholarship were extracted from the REPP database, with a one-year time lag built in. For example, publications were limited to 1996 and 1997 for those researchers whose award finished in 1996; and publications were limited to 1999 and 2000 for those researchers whose award commenced in 1998.

The research Fellows were linked to 3986 in-scope publications in the REPP database: 1117 related to institute Fellows, and 2916 to Project Fellows (with some overlap). The definition of this sector leads to considerable overlap with other NHMRC sectors. Many of the Fellowship holders are linked to Project Grants, and most of the remainder are associated with NHMRC's six block-funded institutes, with the result that most publications for this sector are also associated with sectors 1 and 3. However, the sector is retained as a separate entity as it draws together the work of researchers from a number of different types of institutions who have been identified as the leading researchers in their fields.

T7 Delineation of comparator sectors

The methodology used in this analysis aimed at creating sectors with quite distinct characteristics and as little overlap as possible. *It will become clear from the methodology employed that some of the sectors created do not bear a strong resemblance to their commonly perceived definition.*

T7.1 Other Research Institutes (sector 7)

The sector covers all in-scope publications (ie 1994 and 1995 articles, notes and reviews) from block-funded institutions (or part thereof) active in medical research. This sector covers:

Institute of Advanced Studies, The Australian National University

John Curtin School of Medical Research

CSIRO

Division of Health Science

Medical Research Institutes

Austin Research Institute

Brain Research Institute

Centenary Institute of Cancer Medicine and Cell Biology

Child Health Research Institute

Children's Cancer Institute Australia

Children's Medical Research Institute

Genomic Disorders Research Centre

Hanson Centre for Cancer Research

Heart Research Institute

Ludwig Institute for Cancer Research

Lyons Eye Institute

Macfarlane Burnet Institute

Mater Medical Research Institute

Mental Health Research Institute

Menzies School of Health Research

Murdoch Children's Research Institute

National Ageing Research Institute
 Peter MacCallum Cancer Institute
 Prince Henry's Institute of Medical Research
 Prince of Wales Medical Research Institute
 Queensland Institute of Medical Research (1996 and 1997 publications only)
 St Vincent's Research Institute
 TVW Telethon Institute for Child Health Research
 Victor Chang Cardiac Research Institute
 Wesley Research Institute Ltd
 Westmead Millennium Institute
 Woolcock Institute of Medical Research

2,604 in-scope publications were identified for this sector.

T7.2 Cooperative Research Centres (sector 8)

All in-scope publications from the CRC's classified as Medical Science and Technology and which were in existence during 1996 to 2000 were identified. The relevant CRC's were:

CRC for Bio-pharmaceutical Research
 CRC for Cardiac Technology
 CRC for Cellular Growth Factors
 CRC for Cochlear Implant, Speech and Hearing Research
 CRC for Diagnostics
 CRC for Discovery of Genes for Common Human Diseases
 CRC for Eye Research and Technology
 CRC for Tissue Growth and Repair
 CRC for Vaccine Technology

All components of a CRC, whichever participating institution appeared on the publication address were identified and resulted in 518 publications being classified to the sector.

T7.3 Other University publications (sector 9)

The sector covers all in-scope publications (ie1996 to 2000 articles, notes and reviews) from universities appearing in journals classified to the biomedical sciences.

Publications that were found in a number of other sectors were specifically excluded from this sector; viz. those publications identified with sectors 1 to 8. In this respect, *the sector is not a true reflection of total university output, but is more accurately a reflection of output funded principally through general operating grants and funding agencies other than NHMRC. Some publications resulting from ARC funding, however, will be included in this sector.*

T7.4 Other Hospital publications (sector 10)

The sector covers all in-scope publications (ie1996 to 2000 articles, notes and reviews) from hospitals, both public and private institutions.

Publications that were found in a number of other sectors were specifically excluded from this sector; viz. those publications identified with sectors 1 to 8. In this respect, *the sector is not a true reflection of total hospital output, but is more accurately a reflection of output funded principally through general operating grants and funding agencies other than NHMRC. Some publications resulting from ARC funding, however, will be included in this sector.*

T7.5 Other Government publications (sector 11)

The sector covers all in-scope publications (ie1996 to 2000 articles, notes and reviews) from state and commonwealth departments and agencies appearing in biomedical journals.

Publications that were found in a number of other sectors were specifically excluded from this sector; viz. those publications identified with sectors 1 to 8. *In this respect, the sector is not a true reflection of the total government sector output, but is more accurately a reflection of output funded principally through departmental and agency recurrent funds. Some publications resulting from ARC funding, however, will be included in this sector.*

T8 Sector overlap

Given the nature of research in the medical and health sciences, it would be impossible to create completely discrete sectors without severely distorting the analysis. Less than 15% of publications are attributed to a single author and over 50% result from collaboration between two or more institutions (Butler, Biglia, Bourke 1998). The success of the methodology used in this study lie in creating sectors with quite distinct sets of publications and where the degree of overlap has been restricted.

Three grids showing the overlap between pairs of sectors were developed. Table T5 shows the overlap between sectors 1 to 8. As publications from the Fellows sector are, by definition, also be expected to appear in either the block or Project sectors, the data are recalculated excluding these sectors (Table T6). Table T7 shows the overlap between sectors 9 to 11. The methodology ensured there was no overlap between the two groups of sectors. The tables also show the total number of in-scope publications in each sector and the total number and percentage of a sector’s publications that appear in one or more of the other sectors.

Table T5: Overlap of sector publication sets (sectors 1-8)

	<i>Project Grants</i>		<i>Block-funded grants</i>		<i>Unit Grants</i>		<i>Research institutes</i>	
Block-funded grants	375							
Unit Grants	18	4						
Research institutes	1098	237	35					
CRCs	64	138	0	62				
Institute Fellows	155	1032	3	109	81			
Project Fellows	1343	283	117	1089	44	47		
Program Grants	147	108	4	702	22	22	416	
Total publications	6078	2604	258	4990	518	1117	2916	1529
Total duplications	2295	1617	138	2311	269	1096	2316	947
Percentage overlap	38%	62%	53%	46%	52%	98%	79%	62%

Table T6: Overlap of sector publication sets (sectors 1-5 and 8)

	<i>Project Grants</i>					
Block-funded grants	375	<i>Block-funded grants</i>				
Unit Grants	18	4	<i>Unit Grants</i>			
Research institutes	1098	237	35	<i>Research institutes</i>		
CRCs	64	138	0	62	<i>CRCs</i>	
Program Grants	147	108	4	702	22	<i>Programs</i>
Total publications	6078	2604	258	4990	518	1529
Total duplications	1501	689	58	1969	266	844
Percentage overlap	25%	26%	22%	39%	51%	55%

Table T7: Overlap of sector publication sets (sectors 9-11)

	<i>Other university</i>		
Other hospital	3430	<i>Other hospital</i>	
Other government	1160	532	<i>Other government</i>
Total publications	18434	9638	2356
Total duplications	4325	3697	1427
Percentage overlap	23%	38%	61%

None of the sectors are composed of discrete sets of publications. This was to be expected, given the collaborative nature of medical research. Once the publications of Fellows have been excluded from the calculation, the highest overlaps occurred with the CRC and Programs sector, and also with the other government sector.

Table A2: Level of research by sector (Figure 1)

Sector	Level 1		Level 2		Level 3		Level 4		Total
	No.	%	No.	%	No.	%	No.	%	
NHMRC – Project	440	8	878	15	2011	35	2498	43	5827
NHMRC – block	124	5	302	12	985	39	1100	44	2511
NHMRC – Unit	93	44	58	27	33	15	29	14	213
NHMRC - Project Fellows	156	6	353	13	1110	40	1187	42	2806
NHMRC - institute Fellows	23	2	77	7	443	40	553	50	1096
NHMRC - all Fellows	179	5	428	11	1537	40	1711	44	3855
NHMRC – Programs	160	11	223	15	568	39	515	35	1466
NHMRC	828	8	1524	15	3771	36	4232	41	10355
Research institutes	403	9	737	16	1647	36	1852	40	4639
CRCs	34	7	63	12	226	44	187	37	510
University	3500	19	3039	17	4634	25	7110	39	18283
Hospital	4115	46	2594	29	1734	19	583	6	9026
Government	593	21	453	16	857	30	970	34	2873

Table A3: Collaboration patterns by sector (Figure 2)

Sector	Single		Group		National		International		Total
	No.	%	No.	%	No.	%	No.	%	
NHMRC – Project	194	3	4643	76	2511	41	1551	26	6078
NHMRC – block	132	5	1610	62	1347	52	944	36	2604
NHMRC – Unit	27	10	151	59	129	50	78	30	258
NHMRC - Project Fellows	107	4	2134	73	1187	41	824	28	2916
NHMRC - institute Fellows	27	2	799	72	477	43	354	32	1117
NHMRC - all Fellows	134	3	2894	73	1621	41	1163	29	3986
NHMRC – Programs	54	4	1049	69	804	53	483	32	1529
NHMRC	459	4	7625	71	4573	42	3180	29	10805
Research institutes	300	6	3084	62	2542	51	1631	33	4990
CRCs	12	2	383	74	333	64	127	25	518
University	2243	12	11389	62	7106	39	6286	34	18434
Hospital	956	10	5597	58	5012	52	2267	24	9638
Government	365	15	1807	77	1985	84	731	31	2356

Table A4: International collaboration by sector and country (Table 2)

Country	NHMRC Sectors												NHMRC TOTAL			Comparator Sectors													
	Project			Block			Unit			Institute			All Fellows Programs			Pubs	%	Pubs	%	Research Institutes		CRCs		Other Univ		Other Hosp		Other Govt	
	Pubs	%	Pubs	%	Pubs	%	Pubs	%	Pubs	%	Pubs	%	Pubs	%	Pubs					%	Pubs	%	Pubs	%	Pubs	%	Pubs	%	Pubs
US	728	47	461	49	17	22	331	40	172	49	495	43	198	41	1441	45	727	45	51	40	2131	34	777	34	234	32	234	32	
England	237	15	156	17	23	29	128	16	44	12	170	15	99	20	521	16	286	18	21	17	1190	19	665	29	125	17	125	17	
Germany	158	10	80	8	6	8	76	9	32	9	107	9	41	8	286	9	169	10	6	5	537	9	147	6	38	5	38	5	
Japan	92	6	75	8	3	4	63	8	36	10	96	8	43	9	228	7	106	6	6	5	415	7	93	4	30	4	30	4	
Canada	84	5	45	5	12	15	61	7	18	5	79	7	30	6	187	6	82	5	1	1	554	9	223	10	50	7	50	7	
France	69	4	64	7	5	6	30	4	18	5	48	4	35	7	166	5	102	6	10	8	326	5	131	6	61	8	61	8	
Sweden	83	5	24	3	5	6	32	4	16	5	48	4	20	4	145	5	64	4	5	4	270	4	118	5	20	3	20	3	
Switzerland	58	4	59	6	6	8	31	4	17	5	48	4	9	2	139	4	51	3	3	2	198	3	82	4	18	2	18	2	
New Zealand	61	4	27	3	14	18	59	7	13	4	70	6	21	4	132	4	64	4	9	7	400	6	167	7	82	11	82	11	
Netherlands	52	3	22	2	4	5	19	2	9	3	28	2	23	5	105	3	44	3	5	4	215	3	117	5	19	3	19	3	
Italy	46	3	17	2	2	3	18	2	8	2	26	2	16	3	89	3	59	4	1	1	208	3	122	5	23	3	23	3	
China	44	3	25	3	1	1	11	1	2	1	13	1	4	1	77	2	29	2	1	1	114	2	32	1	15	2	15	2	
Denmark	30	2	19	2	2	3	13	2	6	2	19	2	7	1	63	2	17	1	1	1	156	2	48	2	23	3	23	3	
Finland	30	2	13	1	1	1	11	1	4	1	15	1	7	1	51	2	27	2	1	1	97	2	48	2	4	1	4	1	
Belgium	16	1	8	1	4	5	13	2	1	0	14	1	11	2	41	1	26	2	1	1	77	1	69	3	9	1	9	1	
South Africa	15	1	5	1	3	4	11	1	1	0	12	1	3	1	32	1	9	1	1	1	103	2	32	1	23	3	23	3	
Spain	24	2	4	0	1	1	8	1	1	0	9	1	1	0	32	1	8	0	2	2	105	2	37	2	13	2	13	2	
Thailand	9	1	12	1	5	6	1	0	4	1	5	0	8	2	31	1	20	1	1	1	73	1	13	1	13	2	13	2	
Singapore	5	0	9	1	3	4	6	1	6	2	12	1	8	2	23	1	10	1	1	1	58	1	27	1	5	1	5	1	
Austria	7	0	6	1	1	1	5	1	1	0	5	0	4	1	17	1	9	1	1	1	93	1	56	2	6	1	6	1	
Norway	12	1	1	0	2	3	1	0	1	0	2	0	4	1	17	1	9	1	1	1	56	1	33	1	6	1	6	1	
Hong Kong	7	0	2	0	2	3	1	0	1	0	2	0	2	0	12	0	11	1	1	1	89	1	52	2	11	2	11	2	
India	3	0	1	0	1	0	1	0	1	0	1	0	2	0	5	0	5	0	5	4	42	1	22	1	8	1	8	1	
TOTAL	1551		944		78		824		354		1163		483		3180		1631		127		6286		2267		731		731		

Table A5: Actual and expected citation rate – all publications (Figure 3)

Sector	Actual Cites	Expected Cites	No. Pubs	Av. Exp.	Av. Act.
NHMRC - institute Fellows	14121	10767	1117	9.64	12.64
NHMRC – block	25671	21457	2604	8.24	9.86
NHMRC - all Fellows	34442	30321	3986	7.61	8.64
Research institutes	39660	37240	4990	7.46	7.95
NHMRC	82547	75876	10805	7.02	7.64
NHMRC - Project Fellows	21145	20029	2916	6.87	7.25
NHMRC – Programs	11058	11596	1529	7.58	7.23
CRCs	3716	3415	518	6.59	7.17
NHMRC – Project	43301	41208	6078	6.78	7.12
NHMRC – Unit	1525	1176	258	4.56	5.91
University	78043	76238	18434	4.14	4.23
Hospital	39443	37616	9638	3.90	4.09
Government	7399	7205	2356	3.06	3.14
Australia	197727	192532	39214	4.91	5.04
World	7663721	7663721	1424694	5.38	5.38

Table A6: Actual and expected citation rates – broad areas of research (Figure 4)

Broad Area of Research	Actual Cites	Expected Cites	No. Pubs	Act./ Exp.	Av. Exp.	Av. Act.
Basic science	27764	27227	3567	1.0	7.6	7.8
Clinical medicine & science	11393	10178	1737	1.1	5.9	6.6
Preventative medicine	623	484	123	1.3	3.9	5.1
Public health	742	578	168	1.3	3.4	4.4

Table A7: Actual and expected citation rates – disciplines (Figure 5)

Category B	Actual Cites	Expected Cites	No. Pubs	Act./ Exp.	Av. Exp.	Av. Act.
Genetics	1818	1420	151	1.28	9.4	12.0
Microbiology, Parasitology, Virology	4273	3685	472	1.16	7.8	9.1
Immunology	5149	5290	572	0.97	9.2	9.0
Oncology & carcinogenesis	1362	1262	153	1.08	8.2	8.9
Biochemistry & clinical chemistry	4552	4590	528	0.99	8.7	8.6
Endocrinology	2572	2413	307	1.07	7.9	8.4
Vision & ophthalmology	1092	934	144	1.17	6.5	7.6
Haematology	809	869	108	0.93	8.0	7.5
Neurological diseases & neurosciences	5431	5184	731	1.05	7.1	7.4
Renal diseases & sciences	1124	972	156	1.16	6.2	7.2
Respiratory diseases & sciences	1144	1062	177	1.08	6.0	6.5
Pharmacology	1467	1556	241	0.94	6.5	6.1
Psychiatry & psychology	1326	945	236	1.40	4.0	5.6
Gastrointestinal diseases & sciences	1438	1370	267	1.05	5.1	5.4
Physiology	1646	1804	312	0.91	5.8	5.3
Cardiovascular diseases & sciences	1014	1065	236	0.95	4.5	4.3
Total	38733	36840	5259	1.05	7.0	7.4

Table A8: Actual and expected citation rates by type of Fellowship and gender (Figure 6)

Gender	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
Institute (F)	2788	1966	204	1.42	9.6	13.7
Institute (M)	13077	9668	970	1.35	10.0	13.5
NHMRC total	82547	75876	10805	1.09	7.0	7.6
Project (M)	17473	16404	2320	1.07	7.1	7.5
Project (F)	4043	4016	683	1.01	5.9	5.9

Table A9: Actual and expected citation rates by administering institution (Figure 7A & 7B)

Administering Institution	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
WEHI	14432	10578	846	1.36	12.5	17.1
Garvan Inst of Med Research	3603	2856	332	1.26	8.6	10.9
Royal Children's Hosp Res Foun.	1951	1836	258	1.06	7.1	7.6
University of Queensland	5920	5260	776	1.13	6.8	7.6
Prince Henry Inst of Med Res	2104	1670	282	1.26	5.9	7.5
Queensland Inst Med Research	5054	4513	678	1.12	6.7	7.5
University of Melbourne	9454	8387	1260	1.13	6.7	7.5
Flinders University	2331	2164	329	1.08	6.6	7.1
University of Adelaide	2820	2934	405	0.96	7.2	7.0
University of Sydney	7268	6704	1040	1.08	6.4	7.0
University of Western Australia	4942	4175	756	1.18	5.5	6.5
Monash University	5848	6182	924	0.95	6.7	6.3
University of NSW	6009	5970	960	1.01	6.2	6.3
Baker Medical Research Institute	3054	3303	501	0.92	6.6	6.1
Australian National University	1295	1182	235	1.10	5.0	5.5
Howard Florey Institute	1234	1623	294	0.76	5.5	4.2

Table A10: Actual and expected citation rates—Biochemistry and cell biology (Figure 8)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - institute Fellows	3817	3374	302	1.1	11.2	12.6
NHMRC - block-funded	7083	7015	687	1.0	10.2	10.3
NHMRC - all Fellows	9185	8751	958	1.0	9.1	9.6
Research Institutes	11368	11192	1254	1.0	8.9	9.1
NHMRC	21155	20842	2449	1.0	8.5	8.6
NHMRC - Project Fellows	5582	5544	671	1.0	8.3	8.3
NHMRC – Projects	11670	11517	1400	1.0	8.2	8.3
NHMRC – Programs	2391	2753	315	0.9	8.7	7.6
CRCs	963	1241	139	0.8	8.9	6.9
Other University	19559	19543	3024	1.0	6.5	6.5
Other Hospital	2078	2285	415	0.9	5.5	5.0
Other Government	781	837	206	0.9	4.1	3.8
Australia	50037	49538	6790	1.0	7.3	7.4
World	2305014	2305014	279290	1.0	8.3	8.3

Table A11: Most highly cited Australian publications—Biochemistry and cell biology (Table 8)

Sector	Total Pubs	Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%
NHMRC - institute Fellows	302	10	3	41	14
NHMRC - block-funded	687	16	2	62	9
NHMRC - all Fellows	958	13	1	76	8
Research Institutes	1254	15	1	83	7
NHMRC	2449	29	1	156	6
NHMRC - Project Fellows	671	4	1	38	6
CRCs	139			8	6
NHMRC – Projects	1400	14	1	84	6
NHMRC – Programs	315	1	0	13	4
Other University	3024	24	1	119	4
Other Hospital	415	1	0	10	2
Other Government	206			1	0

Table A12: Actual and expected citation rates—Genetics (Figure 9)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - institute Fellows	1438	1169	100	1.2	11.7	14.4
NHMRC - all Fellows	2494	2318	212	1.1	10.9	11.8
Research Institutes	2551	2703	254	0.9	10.6	10.0
NHMRC - Project Fellows	1095	1197	116	0.9	10.3	9.4
NHMRC	5819	6031	644	1.0	9.4	9.0
NHMRC - block-funded	2248	2179	257	1.0	8.5	8.7
NHMRC – Projects	2236	2268	268	1.0	8.5	8.3
NHMRC – Programs	1181	1468	151	0.8	9.7	7.8
Other Hospital	1673	1833	256	0.9	7.2	6.5
Other University	5852	5600	959	1.0	5.8	6.1
Australia	15255	15544	2100	1.0	7.4	7.3
World	492787	492787	60255	1.0	8.2	8.2

Table A13: Most highly cited Australian publications—Genetics (Table 10)

Sector	Total Pubs	Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%
NHMRC - institute Fellows	100	5	5	14	14
NHMRC - all Fellows	212	7	3	21	10
Research Institutes	254	4	2	20	8
NHMRC - block-funded	257	6	2	16	6
NHMRC	644	14	2	41	6
NHMRC - Project Fellows	116	2	2	7	6
NHMRC – Projects	268	4	1	16	6
Other Hospital	256	1	0	14	5
NHMRC – Programs	151	2	1	6	4
Other University	959	5	1	37	4

Table A14: Actual and expected citation rates—Microbiology (Figure 10)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC – Projects	1498	1137	165	1.3	6.9	9.1
NHMRC	1634	1305	204	1.3	6.4	8.0
Other University	5356	5338	1091	1.0	4.9	4.9
Other Hospital	967	1172	232	0.8	5.0	4.2
Other Government	782	874	196	0.9	4.5	4.0
Australia	8542	8386	1668	1.0	5.0	5.1
World	297775	297775	59049	1.0	5.0	5.0

Table A15: Most highly cited Australian publications—Microbiology (Table 12)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	No.	%	No.	%
NHMRC – Projects	165	6	4	4	17	10
NHMRC	204	6	3	3	18	9
Other University	1091	9	1	1	38	3
Other Hospital	232	3	1	1	7	3
Other Government	196				3	2

Table A16: Actual and expected citation rates—Biotechnology (Figure 11)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - all Fellows	722	772	114	0.9	6.8	6.3
NHMRC - block-funded	673	699	120	1.0	5.8	5.6
Research Institutes	1043	1078	195	1.0	5.5	5.3
NHMRC	2047	2288	404	0.9	5.7	5.1
Other Hospital	606	558	125	1.1	4.5	4.8
Other University	5742	5285	1218	1.1	4.3	4.7
NHMRC – Projects	889	1139	225	0.8	5.1	4.0
Other Government	528	613	166	0.9	3.7	3.2
Australia	10058	9909	2147	1.0	4.6	4.7
World	375946	375946	82375	1.0	4.6	4.6

Table A17: Most highly cited Australian publications—Biotechnology (Table 14)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	No.	%	No.	%
Research Institutes	195	1	1	1	15	8
NHMRC	404	6	1	1	20	5
Other University	1218	12	1	1	59	5
NHMRC - all Fellows	114	3	3	3	5	4
Other Hospital	125	2	2	2	5	4
NHMRC - block-funded	120	3	3	3	3	3
NHMRC – Projects	225	2	1	1	6	3
Other Government	166				4	2

Table A18: Actual and expected citation rates—Medical and Health Sciences (Figure 12)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - institute Fellows	7265	6056	766	1.2	7.9	9.5
NHMRC - block-funded	14093	12359	1722	1.1	7.2	8.2
NHMRC - all Fellows	22262	20139	2970	1.1	6.8	7.5
Research Institutes	24907	23242	3429	1.1	6.8	7.3
NHMRC – Programs	8051	7845	1108	1.0	7.1	7.3
NHMRC - Project Fellows	15266	14292	2231	1.1	6.4	6.8
NHMRC	52842	49542	7863	1.1	6.3	6.7
NHMRC – Units	1340	1004	209	1.3	4.8	6.4
NHMRC – Projects	27713	27060	4470	1.0	6.1	6.2
CRCs	1590	1837	322	0.9	5.7	4.9
Other Hospital	35492	33424	8907	1.1	3.8	4.0
Other University	53098	51423	13495	1.0	3.8	3.9
Other Government	5509	5245	1853	1.1	2.8	3.0
Australia	143234	138121	30663	1.0	4.5	4.7
World	5259394	5259394	1103163	1.0	4.8	4.8

Table A19: Most highly cited Australian publications—Medical and Health Sciences (Table 16)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	No.	%	No.	%
NHMRC - institute Fellows	766	28	4	4	94	12
NHMRC - block-funded	1722	52	3	3	181	11
NHMRC – Programs	1108	25	2	2	108	10
NHMRC - all Fellows	2970	62	2	2	266	9
Research Institutes	3429	70	2	2	310	9
NHMRC	7863	133	2	2	613	8
NHMRC - Project Fellows	2231	35	2	2	177	8
NHMRC – Units	209	4	2	2	16	8
NHMRC – Projects	4470	52	1	1	304	7
CRCs	322	1	0	0	20	6
Other Hospital	8907	72	1	1	323	4
Other University	13495	93	1	1	468	3
Other Government	1853	4	0	0	28	2

Table A20: Actual and expected citation rates—Immunology (Figure 13)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - institute Fellows	2220	1684	141	1.3	11.9	15.7
NHMRC - block-funded	4305	3503	322	1.2	10.9	13.4
NHMRC - all Fellows	5144	4215	446	1.2	9.5	11.5
Research Institutes	7122	6702	686	1.1	9.8	10.4
NHMRC – Programs	1751	1960	170	0.9	11.5	10.3
NHMRC	11894	10776	1206	1.1	8.9	9.9
NHMRC - Project Fellows	2930	2543	307	1.2	8.3	9.5
NHMRC – Projects	6002	5822	712	1.0	8.2	8.4
Other Hospital	2679	2403	492	1.1	4.9	5.4
Other University	3801	4100	769	0.9	5.3	4.9
Australia	20806	19687	2696	1.1	7.3	7.7
World	626768	626768	91929	1.0	6.8	6.8

Table A21: Most highly cited Australian publications—Immunology (Table 18)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	No.	%	No.	%
NHMRC - institute Fellows	141	8	6	6	19	13
NHMRC - block-funded	322	12	4	4	36	11
NHMRC - all Fellows	446	11	2	2	41	9
NHMRC – Programs	170	1	1	1	15	9
Research Institutes	686	11	2	2	53	8
NHMRC	1206	19	2	2	86	7
NHMRC - Project Fellows	307	3	1	1	22	7
NHMRC – Projects	712	6	1	1	44	6
Other University	769	2	0	0	17	2
Other Hospital	492	3	1	1	11	2

Table A22: Actual and expected citation rates—Pharmacology & pharmaceutical science (Figure 14)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - block-funded	853	792	167	1.1	4.7	5.1
NHMRC - all Fellows	1976	1856	386	1.1	4.8	5.1
NHMRC - Project Fellows	1539	1483	305	1.0	4.9	5.0
NHMRC	4111	3927	838	1.0	4.7	4.9
NHMRC – Projects	2249	2244	485	1.0	4.6	4.6
Research Institutes	1004	1091	270	0.9	4.0	3.7
Other Hospital	1384	1625	374	0.9	4.3	3.7
Other University	4123	5009	1292	0.8	3.9	3.2
Other Government	329	382	143	0.9	2.7	2.3
Australia	10028	10921	2654	0.9	4.1	3.8
World	500108	500108	126180	1.0	4.0	4.0

Table A23: Most highly cited Australian publications—Pharmacology & pharmaceutical science (Table 20)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%	
NHMRC - block-funded	167	3	2	13	8	
NHMRC - all Fellows	386	6	2	31	8	
NHMRC - Project Fellows	305	4	1	23	8	
NHMRC	838	13	2	55	7	
NHMRC – Projects	485	7	1	26	5	
Research Institutes	270	1	0	12	4	
Other University	1292	4	0	50	4	
Other Hospital	374	4	1	15	4	
Other Government	143			3	2	

Table A24: Actual and expected citation rates—Medical physiology (Figure 15)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
Research Institutes	1423	1234.94	234	1.2	5.3	6.1
NHMRC - Project Fellows	1181	1062.09	255	1.1	4.2	4.6
NHMRC - all Fellows	1416	1423.23	373	1.0	3.8	3.8
NHMRC – Projects	1780	1878.01	474	0.9	4.0	3.8
NHMRC	3146	3274.62	852	1.0	3.8	3.7
Other University	3484	3815.22	1164	0.9	3.3	3.0
NHMRC - block-funded	601	733.81	210	0.8	3.5	2.9
Other Hospital	400	488.5	171	0.8	2.9	2.3
NHMRC - institute Fellows	238	367.46	121	0.6	3.0	2.0
Australia	7731	8116.89	2253	1.0	3.6	3.4
World	213186	213186	55120	1.0	3.9	3.9

Table A25: Most highly cited Australian publications—Medical physiology (Table 22)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%	
Research Institutes	234	7	3	28	12	
NHMRC - Project Fellows	255	4	2	21	8	
NHMRC - all Fellows	373	4	1	25	7	
NHMRC – Projects	474	7	1	32	7	
NHMRC	852	11	1	55	6	
NHMRC - block-funded	210	2	1	9	4	
NHMRC - institute Fellows	121			4	3	
Other University	1164	4	0	38	3	
Other Hospital	171	1	1	3	2	

Table A26: Actual and expected citation rates—Neurosciences (Figure 16)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - block-funded	1269	1055.3	162	1.2	6.5	7.8
NHMRC - institute Fellows	798	727.19	120	1.1	6.1	6.7
Research Institutes	2399	2480.61	371	1.0	6.7	6.5
NHMRC – Projects	5347	5397.07	838	1.0	6.4	6.4
NHMRC	7777	7832.77	1236	1.0	6.3	6.3
NHMRC - all Fellows	3157	3195.7	531	1.0	6.0	5.9
NHMRC - Project Fellows	2423	2541.88	420	1.0	6.1	5.8
NHMRC – Programs	938	1040.41	165	0.9	6.3	5.7
Other Hospital	2459	2712.14	487	0.9	5.6	5.0
Other University	5852	7064.34	1339	0.8	5.3	4.4
Australia	16553	17854.22	3048	0.9	5.9	5.4
World	791676	791676	126459	1.0	6.3	6.3

Table A27: Most highly cited Australian publications—Neurosciences (Table 24)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	No.	%	No.	%
NHMRC - block-funded	162	5	3	3	15	9
NHMRC - institute Fellows	120	2	2	2	9	8
Research Institutes	371	4	1	1	28	8
NHMRC - all Fellows	531	4	1	1	30	6
NHMRC	1236	16	1	1	71	6
NHMRC – Projects	838	9	1	1	48	6
NHMRC - Project Fellows	420	2	0	0	22	5
NHMRC – Programs	165	3	2	2	9	5
Other Hospital	487	2	0	0	19	4
Other University	1339	7	1	1	43	3

Table A28: Actual and expected citation rates—Clinical sciences (Figure 17)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - institute Fellows	3861	3083	363	1.3	8.5	10.6
NHMRC - block-funded	7777	6643	974	1.2	6.8	8.0
NHMRC - all Fellows	11801	10760	1515	1.1	7.1	7.8
NHMRC – Units	1161	840	149	1.4	5.6	7.8
NHMRC - Project Fellows	8180	7832	1168	1.0	6.7	7.0
NHMRC – Programs	4815	4452	701	1.1	6.4	6.9
Research Institutes	13171	12618	1946	1.0	6.5	6.8
NHMRC	29528	27371	4373	1.1	6.3	6.8
NHMRC – Projects	14956	14468	2390	1.0	6.1	6.3
CRCs	887	1024	198	0.9	5.2	4.5
Other University	36139	32718	7960	1.1	4.1	4.5
Other Hospital	31606	29159	7663	1.1	3.8	4.1
Other Government	3836	3553	1095	1.1	3.2	3.5
Australia	93902	88181	19547	1.1	4.5	4.8
World	3347630	3347630	719302	1.0	4.7	4.7

Table A29: Most highly cited Australian publications—Clinical sciences (Table 26)

Sector	Total Pubs	Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%
NHMRC - institute Fellows	363	17	5	54	15
NHMRC - all Fellows	1515	34	2	151	10
NHMRC - block-funded	974	28	3	100	10
NHMRC – Units	149	3	2	15	10
NHMRC - Project Fellows	1168	18	2	102	9
NHMRC	4373	67	2	348	8
Research Institutes	1946	30	2	160	8
NHMRC – Programs	701	16	2	58	8
NHMRC – Projects	2390	22	1	168	7
CRCs	198			11	6
Other University	7960	76	1	351	4
Other Hospital	7663	66	1	293	4
Other Government	1095	4	0	25	2

Table A30: Actual and expected citation rates—Public health and health services (Figure 18)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC	2077	1910.83	402	1.1	4.8	5.2
NHMRC – Projects	941	916.4	209	1.0	4.4	4.5
Research Institutes	1170	1072.3	328	1.1	3.3	3.6
Other Hospital	1922	1807.72	535	1.1	3.4	3.6
Other University	5764	5898.57	2172	1.0	2.7	2.7
Other Government	1377	1435.36	585	1.0	2.5	2.4
Australia	10235	10224.29	3412	1.0	3.0	3.0
World	307372	307372	92335	1.0	3.3	3.3

Table A31: Most highly cited Australian publications—Public health and health services (Table 28)

Sector	Total Pubs	Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%
NHMRC	402	11	3	48	12
NHMRC – Projects	209	4	2	21	10
Research Institutes	328	5	2	24	7
Other Hospital	535	8	1	30	6
Other University	2172	12	1	80	4
Other Government	585	2	0	12	2

Table A32: Actual and expected citation rates—Medicine general (Figure 19)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - block-funded	2279	1787.73	168	1.3	10.6	13.6
NHMRC - all Fellows	2760	2138.84	209	1.3	10.2	13.2
Research Institutes	4228	3290.27	335	1.3	9.8	12.6
NHMRC - Project Fellows	1533	1248.4	144	1.2	8.7	10.6
NHMRC	5812	5113.4	587	1.1	8.7	9.9
NHMRC – Projects	2340	2344.08	289	1.0	8.1	8.1
Other University	3266	3171.34	867	1.0	3.7	3.8
Other Hospital	2127	1971.46	659	1.1	3.0	3.2
Other Government	327	297.44	124	1.1	2.4	2.6
Australia	12754	11412.78	2215	1.1	5.2	5.8
World	403030	403030	71036	1.0	5.7	5.7

Table A33: Most highly cited Australian publications—Medicine general (Table 30)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%	
NHMRC - block-funded	168	8	5	25	15	
NHMRC - all Fellows	209	9	4	28	13	
Research Institutes	335	13	4	45	13	
NHMRC	587	15	3	61	10	
NHMRC - Project Fellows	144	4	3	14	10	
NHMRC – Projects	289	5	2	25	9	
Other University	867	3	0	22	3	
Other Hospital	659			11	2	
Other Government	124			1	1	

Table A34: Actual and expected citation rates—Multi-disciplinary science (Figure 20)

Sector	Actual Cites	Expected Cites	No. Pubs	Act./Exp.	Av. Exp.	Av. Act.
NHMRC - all Fellows	3720	1966	119	1.9	16.5	31.3
NHMRC	6562	3890	237	1.7	16.4	27.7
NHMRC – Projects	2535	1851	112	1.4	16.5	22.6
Other University	6486	10742	871	0.6	12.3	7.4
Other Government	789	2192	138	0.4	15.9	5.7
Australia	16748	18460	1389	0.9	13.3	12.1
World	871182	871182	76421	1.0	11.4	11.4

Table A35: Most highly cited Australian publications—Multi-disciplinary science (Table 32)

Sector	Total Pubs		Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%	
NHMRC – Projects	112	2	2	14	13	
NHMRC - all Fellows	119	5	4	14	12	
NHMRC	237	9	4	29	12	
Other University	871	3	0	23	3	
Other Government	138			1	1	