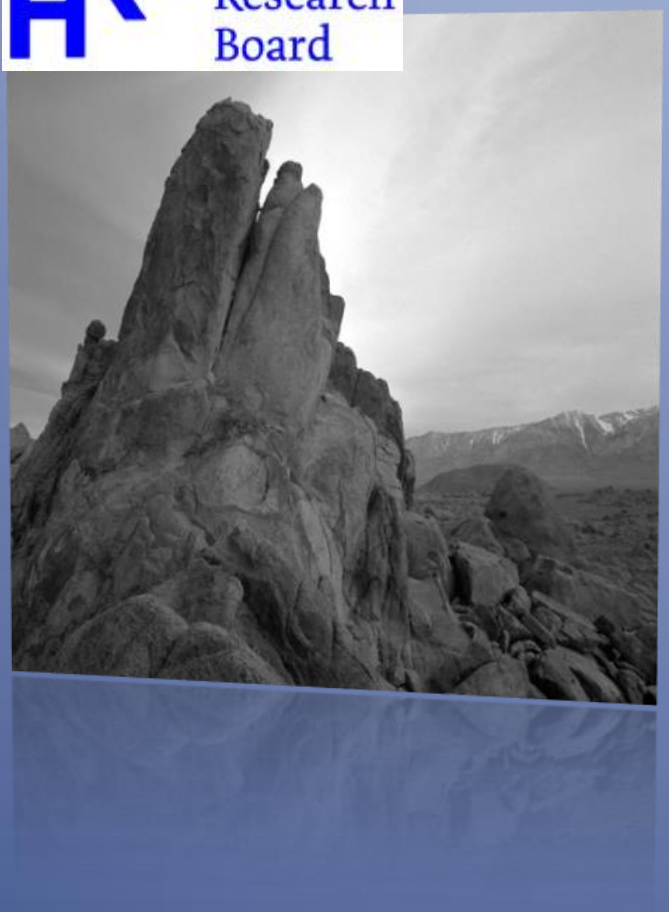

Outputs and outcomes of HRB awards completed in 2014 and 2015

Maura Hiney and Kate O'Keeffe

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Executive Summary

Introduction

This report presents an analysis of the outputs, outcomes and some emerging impacts across a range of metrics and indicators, arising from 198 HRB grants (combined value of €55 million) that completed in 2014 and 2015. The primary audience for the report is HRB Management and Board, to provide them with strategically useful information on the potential impacts of HRB-funded research and to provide the staff of the Research Strategy and Funding Directorate with information that can inform improvements in scheme design, peer review processes, reporting, and finalisation of metrics and so on.

In order to understand how well HRB researchers are doing in comparison to their peers internationally, the *2014/2015 Outputs, Outcome and Impacts Report* of the Medical Research Council UK[1], who collect a similar evaluation dataset, was used as a benchmark where possible. However, their outputs and outcomes are not always reported in a manner that allows direct comparison with HRB metrics. In addition, this comparison should be cautiously interpreted since the MRC operate in a different context, have different strategic objectives, structures, funding instruments and expected outcomes, and is of far greater scale than the HRB.

The data presented in this report relates to grants that were awarded predominantly in the 2010-2013 period, which coincides with the adoption of the HRB's *Strategic Business Plan 2010-2014*. Hence, the data presented can provide some indications of the impact of that strategy, with its ongoing shift in focus towards investment in applied health research, and in particular, population health sciences and health services research.

An important *proviso* in considering this report is that the analysis presented is not a complete picture of the outputs and outcomes of HRB-funded research, but rather a snapshot at the point of end-of-grant (EOG). Further outputs, outcomes and impacts would be expected to occur in the years following the completion of a grant.

Indicator framework

HRB evaluation data collection is guided by the Buxton-Hanney Payback Framework for Health Research (see Appendix 1 for the full framework). This framework groups evaluation metrics into five impact categories that span short to medium-term outputs, such as knowledge production, research capacity-building, informing policy and the public. The framework also spans longer-term outcomes, for example, policy changes, health sector innovations and economic and commercial activity. Evaluation data to populate the framework was collected via a bespoke online survey instrument (Outcomes Tracker).

[1] Medical Research Council UK (2016) Outputs, outcomes and Impacts of MRC research: 2014/2014 report. https://www.mrc.ac.uk/successes/outputs-report/

Summary of Outputs and Outcomes

The analysis reported here demonstrates a wide variety of outputs and outcomes produced by HRB-funded research in terms of scientific output, capacity-building outputs, health sector and economic benefits and outcomes. A more detailed summary of outputs, broken down by Grant type is provided in Appendix 2.

Key output statistics for grants ending in 2014/2015 compared to previous years

IMPACT CATEGORY	2014/15 (N=198)	2012/13 (N=134)	2010/11 (N=196)	2008/09 (N=204)
Value of investment	**€55 M**	**€44 M**	**€54.5 M**	**€45 M**
1. Knowledge production outputs				
No. peer-reviewed journal publications	693	584	470	526
Average no. of peer-reviewed papers/grant	3.5	4.5	2.4	2.5
Number of papers in high impact journals*	15.7%	15.7%	28%	31%
No. publications per €1 million spend	12.6	13.3	8.6	11.6
No. scientific presentations reported	1414	940	1427	1118
% PIs reporting scientific dissemination activity	72.2%	95.5%	87%	92%
No. of keynote presentations internationally	21	35	35	51
2. Research capacity-building outputs				
No. research related posts created	385	422	280	296
No PhD students trained	93	133	72	88
No. post-doctoral researchers supported	154	130	92	112
% of cohort from health professional background	43.6%	32.2%	29%	NA**
% of awards reporting indicator of recognition	42.9%	70%	75%	NA
3. Collaboration and partnerships				
Total no. new collaborations	413	278	415	384
% of new collaborations with health bodies	18.6%	14%	10%	NA
No. additional research awards	180	149	113	117
Total value of leveraged funding	€41.8 M	€39.5 M	€34.8 M	NA*
Amount leveraged per Euro of HRB investment	€0.76	€0.89	€0.64	NA
4. Influencing policy and practice				
No. policy and practice outputs	105	127	99	84
% grants reporting policy and practice outputs	26.8%	38%	24%	20%
No. policy/practice outputs per €1 million spend	1.9	2.9	1.8	0.9
5. Engagement with patients and the public				
No. broader dissemination activities	258	188	122	NA
% PIs reporting broader dissemination activity	47.5%	50%	35%	NA
No. dissemination events per €1 million spend	4.69	4.6	2.2	NA

IMPACT CATEGORY	2014/15 (N=198)	2012/13 (N=134)	2010/11 (N=196)	2008/09 (N=204)
6. Research tools, materials and methods				
No. new material/methods developed	96	112	85	NA
Avg. no. developments per €1 million spend	1.8	2.9	1.6	0.6
7. Health sector innovations				
No. health sector innovations	54	43	48	32
% grants reporting health sector innovations	20.7%	24.6%	21%	15%
No. health sector innovations per €1 million spend	1	1	0.9	0.7
8. Economic and commercial activity				
No. patents filed	24	16	11	12
No. licenced technologies developed	2	5	3	3
No. start-ups/spin-outs established or in train	4	2	2	2
No. industry collaborations established	58	88	25	10

**Bibliometric analysis of HRB publications 2013-2016 did not differentiate between years and the mean normalised citation score (MNCS) of more recent papers would be expected to be lower, given that publications take time to accumulate citations.*

*** Not all metrics were collected in every reporting period.*

Summary conclusions

The data described in this report demonstrates a wide variety of outputs produced by HRB-funded research in terms of scientific output, capacity-building, policy and practice outputs and health sector and economic benefits.

When compared to the 2008/2009, 2010/2011 and 2012/2013 analysis, the data shows that HRB-funded research completing in 2014/2015 shows that HRB researchers continue to be highly productive across the full range of Payback Categories, with increases in many metrics, compared to previous reporting periods. The number of award reporting outputs was found to be very similar to the UK MRC, although the number of outputs per MRC award tended to be higher, which is understandable given the difference in scale of these awards.

From the trends observed in previous reporting periods, it was predicted that shift in investment away from basic and applied biomedical research since 2010 would result in a decrease in peer-reviewed publications and commercialisation outputs/opportunities. Instead, this report found that there was an increase in the number of 'scientific productivity' markers such as peer-review papers and presentation events at scientific conferences, indicating that HRB researchers in all broad research areas are increasingly internationally competitive.

In particular, the productivity of awards classified as HSR has increased from previous reporting periods across almost all Payback Categories. The results from this report and the Bibliometric Analysis 2013-2016 show that Irish HSR researchers are highly regarded internationally, as evidenced by their success in attracting more EU funding, international recognition and publication citations than other broad research areas of HRB research.

Overall, grants in HSR, PHS and Clinical Research produced the most health policy and practice outcomes, healthcare innovations and provided the most research training opportunities for health professionals. Grants in Applied Biomedical Research were the most likely to produce commercialisation outputs of all types. Therefore, in terms of delivering on a key HRB objective of improving people's health and health care provision, HRB funded research appears to be producing the type of outputs that have the potential to have real impact in this area.

The new HRB funding initiatives in Clinical Research, Health Services Research and Population Health Sciences, based on a multi-disciplinary collaborative funding model, along with the emphasis placed by international peer review panels on methodological rigour, ensures that only high-quality research is funded with the potential for both scientific, health and economic impact. Therefore, any future decreases in scientific productivity metrics will be more than offset by a concomitant increase in health sector outcomes such as development of healthcare innovations (e.g. interventions, therapies) and influences on policy and practice (e.g. clinical guidelines, policy briefs, advisory roles) which tend to be associated with these broad research areas.

Key Findings

Number, type and value of awards

- The 198 grants that reported on evaluation metrics in 2014/2015, with a combined value of €55 million, represented over 80% coverage of all grants that completed in this period.
- The vast majority of the analysed grants were awarded between 2010 and 2013, within the remit of the *HRB Strategic Business Plan 2010-2014*
- Project Grants accounted for almost half of total funding, Programme Grants accounted for 6.1% of awards but 27% of total funding, Fellowship Awards accounted for 21% of awards but 13% of total funding, and Infrastructure awards accounted for 2% of awards but 10% of total funding.
- Spend on awards categorised as Applied Biomedical Research has remained relatively constant since 2008/2009, while spend on Clinical Research and Health Service Research has increased over the same period. Spend on both Basic Biomedical and Population Health Sciences has decreased since 2008/2009.
- TCD, RCSI, UCD and NUI Maynooth, respectively, held the highest proportion of awards by value in 2014/2015 while in terms of number of awards NUI Galway and UCC hosted more awards than NUI Maynooth.

Achievement of objectives

- On average 60% of grant holders reporting achieving all of their objectives, although there were differences at the level of grant type, with Fellowship Awards (78%) and Programme Grants (64%) reporting higher level of achievement of all objectives.
- 'Insufficient time, or aspects of research took longer than originally anticipated' was the most commonly cited reason for non-fulfilment of all objectives.
- The percentage of awards achieving all objectives has been steadily increasing since 2006/2007 with the introduction of more robust application and monitoring procedures.

Scientific dissemination

Peer-reviewed journal papers

- 82% of grants completing in 2014/2015 reported at least one publication at the point of end of grant, which is comparable to the MRC metric of 85% over the same period.

- An average of 12.6 publications per €1 million spent was report, which is similar to previous reporting periods, although there was variation at the level of Grant Type and Broad Research Area.
- Infrastructure Awards performed particularly well, with the highest average number of papers per grant and per €1 million spent, an average citation impact of 1.75 times the world average, and almost one fifth of publications associated with this grant type in the top 10% of highly rated journals in their field.
- The broad research areas accounting for the most publications per award and per €1 million spend were Applied Biomedical Research, Clinical Research and Health Services Research.
- In terms of bibliometric indicators, Health Service Research had an average citation impact of 1.55 times the world average, over one fifth of publications in the top 10% of highly rated journals in their field, and a higher journal impact score than other HRB funded publications.
- Population Health Sciences publications also fared better than HRB aggregated results in terms of the number of publications in the top 10% of highly rated journals in their field (17.1%.)
- Over half of all publications were published in Open Access format, which reflects the findings of the 2013-16 Bibliometric Analysis that the top three journals used by HRB researchers in the 2013-2016 period were PLoS One (72 papers), BMJ Open (34 papers) and Cochrane Database of Systematic Reviews (26 papers).

Other scientific publications

- The most common types of other scientific publications were book chapters, health reports and articles in Professional Bulletins and many had a significant policy or clinical practice focus.
- HRB-funded researchers are very active in disseminating their work to peers at both national and international scientific events via conference presentation, keynote addresses, and had participated as invited speakers, conference organisers and session chairs in a large number of national and international events.
- Awards classified as Clinical Research and Health Services research accounted for a significant number of the total keynote invitations reported and 58% of all invitations to participate in national and international conferences.

Capacity-building and leadership

Posts created via HRB awards

- 385 research-related posts were supported by the 198 HRB grants that reported on this metric.
- Project Grants accounted for 74% of the posts created through HRB awards that completed in 2014/2015 and was the most productive in terms of posts created per €1 million of spend.
- Post-doctoral researchers were the largest grouping (40%), the majority being employed on Project and Programme Grants. Post-graduate students accounted for 20of the total posts.
- The most cost-effective grant type in terms of creating posts was the Project Grants, which created an average of 11 posts per €1 million spend at an average cost of €91k per post.
- The proportion of the total post-graduate students and post-doctoral researcher posts in Population Health Sciences and Health Services Research have shown a substantial increase in 2014/2015 in comparison to the figures reported from grants that completed in 2008/2009.
- It was also noted that there are higher numbers of post-doctoral researchers compared to post-graduate students in patient oriented and health services research in particular. This may be due to the inherent complexity of these research areas, and the requirement to align the research personnel requested with the scale, complexity and methodology of the projects.
- Almost half of positions were filled by people from a health professional background, which is an increase on the numbers recorded for the 2012/2013 and 2010/2011 reporting periods. Of these 45 were registered for a higher degree, either MSc (n=2), MD (n=4) or PhD (n=39).

Next destination

- By far the most common follow-on employment role reported was as a post-doctoral researcher (26.2%) or a research role (as a research assistant, research nurse or midwife, or research associate – 10.4%).
- 5.2% of personnel were back working in full time clinical practice (either as a doctor or a nurse/midwife), 27 people had secured lectureship posts, while ten more obtained dual lecturer/clinical appointments. 17 people had moved into science administration (71% of who had biomedical science backgrounds); while another 18 had secured industry R&D posts and only 13 of the 385 people supported on HRB grants were unemployed.
- A higher proportion (81%) of researchers were staying in Ireland or Northern Ireland in comparison to 2012/2013 (71%) and 2010/2011 (77.5%), which presumably reflects the improving economy in Ireland in recent years and the increasing availability of employment.

Awards, prizes and other recognition

- Research prize, medals or other acclaim was the most common type of recognition reported. HRB researchers were also invited to participate in international scientific bodies, and to contribute as keynote speakers, session chairs and on organising committees at international scientific conferences.
- Health Services Research accounted for only 23% of total spend, the productivity of this type of award with regards to awards/prizes/recognition outputs was the highest at 8.7 outputs per €1 million spend.
- The type of awards and recognition that HRB and UK MRC researchers attract is somewhat different. For HRB research prizes, medals or other acclaim are the most common, while for MRC invitations to present papers and keynotes at conferences are the most common. Relatively speaking HRB researchers received a significantly greater percentage of prestigious/honorary or advisory positions on external bodies that their MRC peers, while a higher proportion of MRC researchers were granted membership to a learned society.

Collaborations and partnerships

- 72% of HRB grant-holders reported the establishment of 413 new collaborations or partnerships during the lifetime of their HRB grant, which is considerably higher than the 48% of MRC award recipients who reported on this metric in the same reporting period. However, the number of collaborations established on average by award was 2.9 for HRB awards and 5.8 awards for MRC awards that established at least one collaboration.
- Almost three quarters of all collaborations reported were those involving an academic researcher, either in Ireland or based overseas.
- There were a significant number of collaborations established with health bodies who were either policy-focused or service delivery-focused, health charities or voluntary and community groups. The proportion of collaborations established with health bodies increased from 10% of total new collaborations in 2010/2011 to 19% of total new collaborations in 2014/2015.
- The most popular reason for collaborating with academic or industry partners was to gain access to infrastructure, materials, cohorts and datasets, followed by sharing of data, expertise and research findings and networking.
- There was an average productivity of 7.6 collaborations per €1 million spend. However, the number and cost of collaborations varied widely depending on the grant type and broad research area.
- Awards categorised as Applied Biomedical Research, Clinical Research and Health Services Research were most likely to establish both national and international academic collaborations and collaborations with national health service providers.

Additional funding leveraged

- 41% of PIs secured 180 additional awards in 2014/2015, with a combined total value of €41.8 million, which was an increase of over €2 million on the 2012/2013 reporting period. Per euro of HRB investment this accounts for €0.76 leveraged funding.
- The 2014/2015 figure compares well with the equivalent metric for UK MRC researchers, who reported instances of further funding in 47% of awards.
- Almost 45% of leveraged funding came from non-exchequer sources in Ireland and oversees such as the EU, charities and industry.
- Project Grants accounted for 69% of all leveraged awards, and 70% of the total amount leveraged, which represented a return on investment of €1.13 million for every €1 million spend on this grant type.
- Over half (54%) of all leveraged funding was associated with Applied Biomedical Research awards and a further 28% was associated with Clinical Research awards - these broad research areas also accounted for the highest return on investment in terms of leveraged funding.
- Nine grant-holders had secured follow-on technology development or commercialisation grants from Enterprise Ireland.
- Health Services Research awards also leveraged more funding from EU Framework programmes (FP6 and FP7) than either Clinical Research or Applied Biomedical Research.

Policy and practice influences

- PIs reported 105 policy and practice outputs from 53 grants or 27% of all analysed grants, which is similar to the 23% UK MRC grant holders who reported policy influences in 2014/2015.
- Although the percentage of grants reporting policy/practice outputs was slightly lower in 2014/2015 than in 2012/2013 (38%) the number of grants reporting policy and practice outputs continues to increase year on year.
- 54.3% of all outputs reported were presentation of finding to relevant stakeholders (policy makers, health managers etc.) through seminars, workshops and face-to-face meetings.
- Results were cited in influential policy and clinical practice documents such as Clinical Guidelines, clinical reviews, policy documents, and government reports or had an influence on the training or education of health professionals or policy makers.

Engagement with patients and the public

- 47.5% of grant holders reported 258 public and patient engagement outputs which is slightly lower that the equivalent metric reported by UK MRC researchers of 59% in the 2012/2015 period, but represents a year on year increase in public and patient engagement activities by HRB researchers.
- Presentation of research findings to public and patient groups was the most popular medium, followed by dissemination in the print media
- There was a significant increase in PIs reporting the issue of a press release describing their research , and a dramatic increase in the number of PIs using social media.
- MRCG Co-fund awards, while small in number, were very productive in terms of public engagement outputs per €1 million spend (15.4).
- Awards classified as Population Health Sciences and Health Services Research had the most engagement outputs per €1 million spend, at 8.9 and 7.3, respectively.

Research tools, materials and methods

- One third of awards reported the development of one or more (up to five) novel tools, materials or methods wholly or partly as a result of their HRB grant, which is slightly higher than the MRC figure of 28% for this metric in 2014/2015, but is a decrease on the 2012/2013 HRB figures.
- The most common type of research tool, material or method developed was the accumulation of biological samples or a biobank, the development of a novel experimental assay or method, new databases or datasets or the development of a new or expanded cohort. This distribution is similar to previous reporting periods.
- Project Grants produced by far the highest number of novel materials or methods (80% of reports), and were the most productive in terms of outputs per €1 million spend (average 3.0).
- Awards classified as Applied Biomedical Research accounted for over half (57%) of all reported development of novel materials or methods.
- Health Services Research awards predominantly reported the development of cohorts, datasets and virtual infrastructure, while for Population Health Sciences awards the most commonly reported tools, materials or methods were assays, for example for genetic markers, epidemiological biobanks and training materials.

Health sector innovations

- 20.7% of grants that completed in 2014/2015 reported that their HRB-funded research had either directly led to or contributed to the development of a total of 54 innovations.
- Almost twice as many HRB awards were linked to the development of one or more healthcare innovations than UK MRC awards. However, the average number of healthcare innovation outputs per MRC award was higher than per HRB awards (2.0 as opposed to 1.3 outputs.)
- The development of a new, or refinement of an existing, therapeutic intervention that was based on a new drug or a new indication for an existing drug was the most common output for both the HRB and UK MRC.
- Collectively, disease management strategies, decision support tools and care models and service outputs accounted for almost 28% of HRB outputs, which was more than double the equivalent statistic for UK MRC outputs.
- 44% of interventions were in early stage development, a further 39% were in the late stages of development or were being tested and refined as part of the award, and a further 17% of healthcare innovations had been adopted on a large scale.
- Projects Grants accounted for 65% of reported healthcare innovations and were distributed across almost all types of innovations.
- 74% of healthcare innovation outputs were developed by Applied Biomedical or Clinical Research awards, and of these, 16 had already attracted further funding to develop their innovations.
- Health Services Research awards focused on the development of care models, disease management strategies, clinical decision tools and preventative interventions, while Population Health Sciences awards focused on assessing new drug indications, care models, clinical decision tools and behavioural interventions.

Intellectual property and commercialisation activity

- HRB researchers whose awards completed in 2014/2015 were active in the enterprise arena, with a total of 104 outputs reported
- 24 patents were filed by grants that ended in 2014/2015, an increase of eight from 2012/2013 grants, and four PIs reported an output in terms of start-up companies.

- Of the four start-ups reported in 2014/2015 two companies hire a combined 13 employees and both have secured additional funding. Another start-up has secured EU Horizon 2020 funding while one new spin-out is yet to secure additional funding
- Project Grants accounted for the greatest number of commercialisation outputs of all types, representing 1.4 outputs in this category per €1 million spend.
- Applied Biomedical Research are the most likely to produce commercialisation outputs of all type, and accounted for over 60% of commercialisation outputs, with a productivity of 1.1 outputs per €1 million spend.
- PIs reported 58 instances of new or strengthened academic–industry collaborations from 25 awards (12%), which is slightly higher than the equivalent statistic reported by the UK MRC of 8% of all awards with this type of output in 2014/2015.
- Conducting joint-research projects, with both Irish and international industry partners, was the most commonly cited reason for collaboration with industry partners. Sharing data and expertise and obtaining access to either materials or infrastructure were also important reasons academic-industry collaboration.

1. Introduction and methods

1.1 Introduction

The HRB seeks to improve people's health by funding excellent research relevant to health and social gain. To that end, the HRB manages a variety of funding schemes that: support high-quality health research; build capacity for health research by supporting researchers' career development; and facilitate the conduct of world-class health research by providing vital research infrastructure and national networks of researchers. In order to understand how its research leads to impacts, it is imperative that the HRB is able to measure and track the extent to which this portfolio of funding is achieving its mission and delivering the intended benefits.

The value of the HRB's current funding commitment is in the region of €170 million. As this is public money, there is an onus on the HRB to account to government and other stakeholders, including the public, for the funds it allocates and the returns on this investment. In addition, the HRB is keen to use its limited funds as efficiently and effectively as possible and to ensure that the schemes it operates are meeting the objectives for which they were established in the most cost-effective way. There is also the need to inform HRB funding strategy and decisions relating to new or existing funding initiatives with relevant evaluation evidence.

All of these requirements can be fulfilled through systematic and formalised evaluation that allows the HRB to demonstrate value for research investment, and to ascertain the efficacy and effectiveness of funding policies and the variety of funding instruments used by the HRB; and the scientific, societal and economic impact of the HRB's investment in health research and ultimately its impact on people's health. The end-of-grant (EOG) report is used to systematically collate information on outputs and outcomes arising from HRB-funded research at the point of completion of the grant.

It should be noted that, depending on the research area, there can be a considerable time lag (> 5yrs) for research outputs to manifest in outcomes and ultimate impacts on society and the economy. Therefore, evaluation data collected at the point of end-of-grant can only provide a snapshot in time. Further outputs, outcomes and impacts would be expected to occur in the years following the completion of a grant.

1.2 The Payback Framework

HRB evaluation data collection is guided by the Buxton-Hanney Payback Framework for Health Research (Buxton and Hanney, 1994[2], 1996[3], 1997[4]), originally developed to examine the 'payback' of health services research. This framework groups metrics into five impact categories which span short to medium-term outcomes, that is knowledge production, research capacity-building, informing policy and the public, and longer-term impacts effected through policy and clinical practices changes, health sector innovations

[2] Buxton, Martin and Stephen Hanney (1994) *Assessing Payback from Department of Health Research and Development: Preliminary Report. Volume 1: The Main Report*. *HERG Research Report, No. 19*. Uxbridge: HERG, Brunel University.

[3] Buxton, Martin and Stephen Hanney (1996) How can payback from health services research be assessed? *Journal of Health Service Research and Policy*, **1**(1), 35–43.

[4] Buxton, Martin and Stephen Hanney (1997) *Assessing Payback from Department of Health Research and Development: Second Report. Volume 1: The Main Report*. HERG Research Report, No. 24. Uxbridge: HERG, Brunel University.

and economic and commercial activity. Table 1.1 provides examples of these metrics, adapted from Buxton and Hanney and Wooding *et al* (2004[5]*).*The full framework is presented in Appendix 1.

Table 1.1: Example of the multi-dimensional categorisation of paybacks of the Payback Framework

Impact Category	Key HRB metrics
Knowledge production	• Total no. peer-reviewed publications produced • Average no. of publications per grant • No. papers per €1 million spend by grant type and broad research area • No. and type of scientific presentations by grant type • % of keynote presentations internationally • No. and type of reports and 'grey literature produced • No. of publications that are open access
Human and research capacity-building	• No. and type of personnel funded • No. personnel with health professional background • No. PhDs and post-docs by grant type and broad research area • Next destination of funded personnel (employment type and geographical location) • No. and type of research awards and recognition • No. and type of new research collaborations • No., source and value of leveraged grants obtained • No. and type of new research tools, materials and methodologies
Informing policy, practice and public	• % grants reporting policy/practice influences and outputs • No. and types of outputs and influences reported (e.g. meetings with end users, reports, guidelines, submissions produced) • No. influences by grant type and broad research area • No. influences per € million spend by grant type and broad research area • No. and type of public/patient dissemination events
Health sector innovations	• % grants reporting development of health innovations • No. and types of health innovations developed (e.g. new drugs, interventions, diagnostics, ICT systems, care models) • Stage of development of innovations • No. innovations by grant type and broad research area • No. innovations per € million spend by grant type and broad research area
Economic and commercial activity	• No. invention disclosures filed • No. patents filed • No. technologies licenced • No. spin-out companies incorporated • No. industrial collaborations established • No. commercialisation grants secured

For the purposes of this report data on a substantial subset of quantitative metrics set out in the framework were collected using a bespoke online survey instrument (Outcome Tracker). Other metrics in the framework are more qualitative in nature and are not amenable to collection via a survey. However, the metrics that were collected allow the HRB to get a comprehensive overview of how its funding instruments are performing against their original objectives.

[5] Wooding, Steve, Steve Hanney, Martin Buxton and Jonathan Grant (2004) *The Returns from Arthritis Research Volume 1: Approach, Analysis and Recommendations*. Cambridge: RAND Europe. http://www.rand.org/pubs/monographs/2004/ RAND_MG251.pdf

2. Number, type and value of awards

In order to achieve outputs and outcomes of benefit to health and wellbeing, the HRB makes investments in research projects and programmes, clinical infrastructure, fellowships and co-funded awards, across a broad spectrum of research areas of relevant to health. This chapter looks at these inputs, and how they were distributed across different funding mechanisms, broad research areas and host institutions.

Key Finding

- The 198 grants that reported on evaluation metrics in 2014/2015, with a combined value of €55 million, represented over 80% coverage of all grants that completed in this period.
- The vast majority of the analysed grants were awarded between 2010 and 2013, within the remit of the *HRB Strategic Business Plan 2010-2014*
- Project Grants accounted for almost half of total funding, Programme Grants accounted for 6.1% of awards but 27% of total funding, Fellowship Awards accounted for 21% of awards but 13% of total funding, and Infrastructure awards accounted for 2% of awards but 10% of total funding.
- Spend on awards categorised as Applied Biomedical Research has remained relatively constant since 2008/2009, while spend on Clinical Research and Health Service Research has increased over the same period. Spend on both Basic Biomedical and Population Health Sciences has decreased since 2008/2009.
- TCD, RCSI, UCD and NUI Maynooth, respectively, held the highest proportion of awards by value in 2014/2015 while in terms of number of awards NUI Galway and UCC hosted more awards than NUI Maynooth.

2.1 Number, value and year of award

In total, 198 grants that completed in 2014 and 2015 are analysed in this report. These grants had a combined value of €55 million. The equivalent statistics for grants that completed in 2012/2013, 2010/2011 and 2008/2009 were 134 grants (€44 million value), 196 grants (€54.5 million value) and 204 grants (€45 million value), respectively. The report does not contain complete information on all grants that finished in 2014/2015, and a small number of grant holders did not provide evaluation data. However, this report covers over 80% of grants across all schemes.

The year of award of these grants is plotted in Figure 2.1. This figure shows that the vast majority of the analysed grants were awarded between 2010 and 2013, within the remit of the *HRB Strategic Business Plan 2010-2014*.

Table 2.1 shows that most of the awards were standard project grants and fellowships of 2-4 year duration.

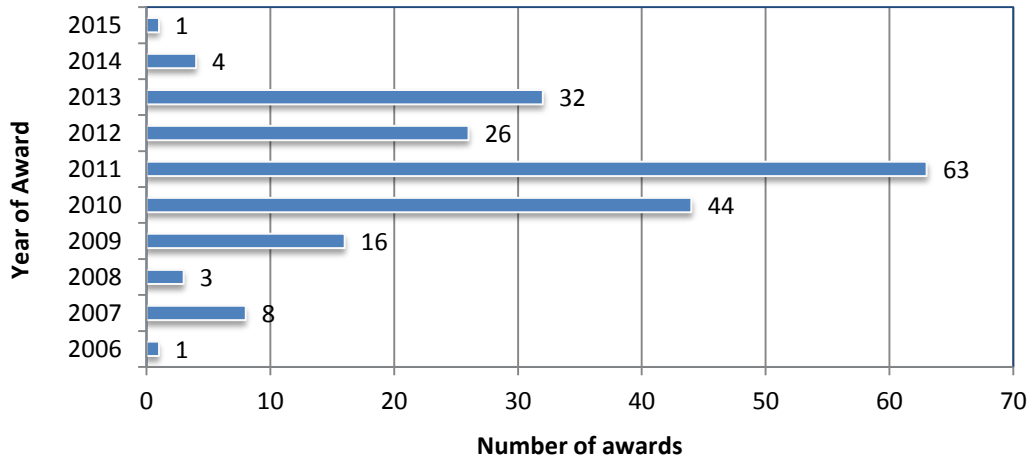

Figure 2.1: Breakdown of grants by year of award

Table 2.1: Breakdown of grants by grant type and year of award

Scheme	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	Total
Clinician Scientist Award							1				1
Cochrane Training Fellowship							7	4	1		12
COEN Award						1					1
Health Economics Fellowship				1	1	1					3
Health Professionals Fellowship				2	2	9	2		2		17
Health Research Award				9	37	36	14	1	1		98
Health Research Centre		1									1
ICE Award						3					3
ICRIN								1			1
IPPOSI										1	1
JPND Coordination								1			1
KEDS Supplement								11			11
Marie Curie / HRB Post-doctoral Fellowship				1	1						2
MRCG Co-Fund Award		1	2			6	2	1			12
National SPR Academic Fellowship				1		1					2
Nursing & Midwifery Research Priorities Study	1										1
PhD Scholars Programme		1									1
Post-doctoral Fellowship				2				1			3
Post-doctoral Fellowship in Translational Medicine						5					5
REA Supplement								12			12
Research Project Grant		1	1			1					3
Translational Research Award		4			3						7
Grand Total	**1**	**8**	**3**	**16**	**44**	**63**	**26**	**32**	**4**	**1**	**198**

2.1.1 Distribution of spend by grant type

Figure 2.2 shows the breakdown of the 198 grants by grant type and overall funding received. Project Grants[6] accounted for the largest number of awards and received the largest proportion of the total funding (46.7%), at an average cost of €204K per award. Programme Grants accounted for only 6.1% of the awards that completed in 2014/2015 but they received 26.7% of the total funding, at an average cost of €1.23 million per grant. These Grants included a PhD Scholars Programme and four Translational Research Awards of almost €1.5 million each.

As would be anticipated, the Infrastructure Awards was the most expensive grant type (Health Research Centre, ICRIN, IPPOSI and JPND Coordination). The four Infrastructure Awards accounted for only 2% of the total awards that completed in 2014/2015 but they received 9.8% of the total funding available. One Health Research Centre Award of almost €5 million accounted for the bulk of this expenditure, while the other three grants are all under €100K.

Fellowship Awards[7] accounted for 22% of all awards that completed in 2014/2015, and at an average cost of €158K per award, were the cheapest of the grant types that completed in 2014/2015.

The MRCG Co-fund awards accounted for 6% of total awards, and 4% of total funding, and had an average cost of €185k per award

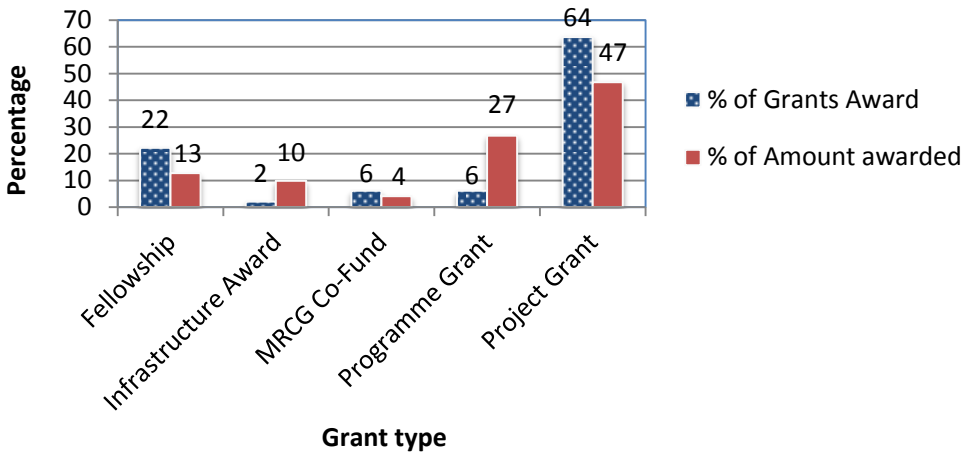

Figure 2.2: Number and value of awards by grant type

2.1.2 Distribution of spend by broad research area

Distribution of the €55 million investment across the five broad research areas is shown in Figure 2.3. For ease of analysis, each grant was allocated a single classification to represent the predominant focus of the award. A proportion of grants span more than one area of health research (e.g. clinical/HSR) and in in these cases the amount awarded was split equally between the two broad research areas.

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[6] The Project Grants category includes: Research Project Grants (N=3), Health Research Awards (N=98). KEDs Supplements (N=11), REA Supplements (N=12), one COEN Award and one Nursing and Midwifery Research Priorities Study.

[7] The Fellowship Awards category includes: Cochrane Training Fellowship (N=12), Health Economics Fellowship (N=3), Health Professional Fellowship (17), Marie Curie Postdoctoral Fellowship (N=2), National SPR Academic Fellowship (N-2), Post-doctoral Fellowship in Translational Medicine (N=5) and Post-doctoral Fellowship (N=3).

Basic biomedical research accounted for 1% of total spend on awards completing in 2014/2015, down from 7% that completed in 2012/2013 and 12% for grants that completed in 2010/2011. All three awards categorised as Basic Biomedical Research were made before 2010. This is in line with the HRB's shift in funding focus from basic biomedicine to funding more patient-oriented research (Applied Biomedical Research and Clinical Research), Population Health Sciences and Health Services Research.

Figure 2.3: Distribution of spend across broad research areas

Applied biomedical research accounted for the largest proportion of funding (43%). Clinical research accounted for 32% of the total spend. Population health sciences accounted for 5% of the total amount spent; while Health Services Research accounted for 19% of the total spend. This is an increase from the figures reported in 2012/2013 (18% of total spend combined across the two areas). This illustrates positive effect on research in these areas as a result of the HRB's shift in emphasis to building these broad research pillars to be a significant proportion of the HRB funding portfolio.

It is also interesting to compare the broad research areas that are the focus of grants that completed over the eight years from 2008 to 2015 (Figure 2.4).

The distribution of spend on these grants remains relatively constant for Applied Biomedical Research. In particular, in 2014 four large Programme Grants and one PhD Scholars Programme categorised as Applied Biomedical Research came to an end, which would account for the large proportion of funding in this category on awards that completed in this year.

Funding of grants categorised as Basic Biomedical Research has been in steady decline from 2008 to 2015. Basic biomedical research accounted for only 1% of the total funding for completed grants in 2014/2015, a decrease from 7% in 2012/2013, 12% in 2010/2011 and 21% in 2008/2009.

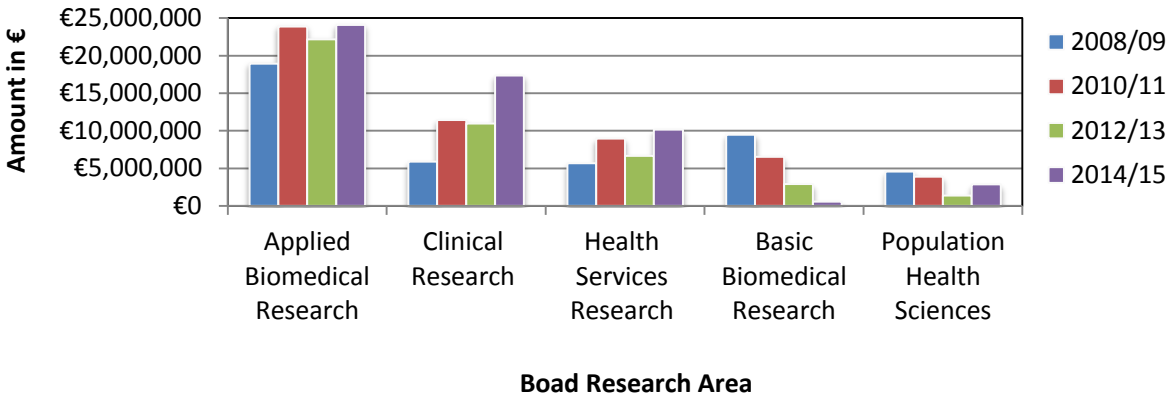


Figure 2.4: Comparison of spend across broad research areas for grants ending in 2008/2009, 2010/2011, 2012/2013 and 2014/2015

The amount spent on grants categorised as Clinical Research more than tripled from 2008 to 2015. Three large programme grants and one Infrastructure Award that completed in 2014/2015 accounted for the increase in the amount spent on clinical Research. While the HRB spend in this area would be expected to remain at its current levels in the next few years, with a number of Clinician Scientist Awards due to complete in 2017, as well as completion of the current phase of CRF funding in 2017 (they all stretched their funding beyond their original completion dates, based on generated income), there will be an anticipated spike for Clinical Research funding in the outputs report for that year.

Spending on grants categorised as Health services research that completed between 2008 and 2015 peaked in 2014/2015 with the completion of a Health Research Centre Award made in 2007. This trend is expected to continue as the HRB supports new initiatives in this area.

In 2014/2015 the declining trend in population health science spending reversed and increased significantly. This reflects the HRB's emphasis on increasing the funding to this broad research grant area as part of the Strategic Business Plan 2010-2014. This upwards trend in amount spent on population health sciences is expected to continue as more grants that benefited from the HRB's push on this area of research are completed.

2.1.3 Distribution of spend by host institutions

In relation to the location and hosting of HRB grants, Figure 2.5 shows the host institutions administering grants that completed in the period 2014/2015.

Note the variations within institutions between the proportions of awards administered (blue key in Figure 2.5) versus the proportion of the total amount of funding being administered by that institution (red key in Figure 2.5). One large Infrastructure Award completed in RCSI in 2015, and a PhD Scholars Programme completed in NUI Maynooth in 2014, which explains the disproportionate percentage of funding versus number of awards in these host institution. In most other institutions, the value of individual awards was generally in the range €150-350K for project grants, with fellowships tending to be worth slightly less monetarily.

It should also be noted that the research work on a number of grants administered by universities was, in reality, carried out in clinical settings, so that the total funding assigned to large teaching hospitals and smaller clinical units in Figure 2.5 is most likely an underestimation of the total funding or number of grants awarded to health professionals working in these settings.

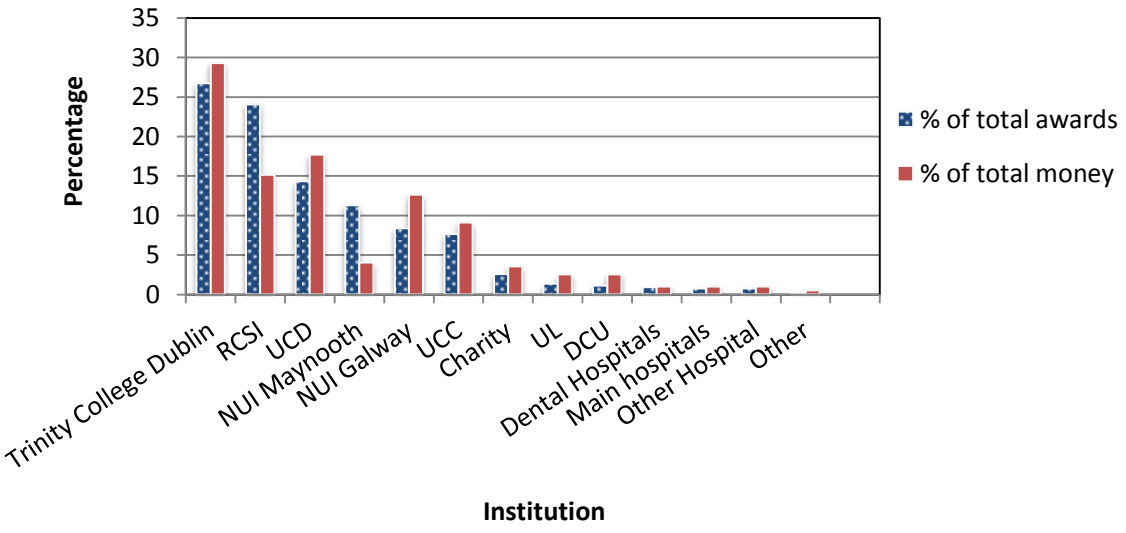


Figure 2.5: Distribution of grants across host institutions

3. Achievement of objectives

In their original grant application, principal investigators (PIs) outlined specific research objectives that they sought to achieve with their HRB funding. At the completion of their grants, PIs were asked to indicate the extent to which these objectives were fulfilled during the period of the grant.[8] The purpose of this question was not punitive, but rather to learn about the impediments HRB researchers experience in carrying out their research. This chapter looks at the response to that question.

Key Finding

- On average 60% of grant holders reporting achieving all of their objectives, although there were differences at the level of grant type, with Fellowship Awards (78%) and Programme Grants (64%) reporting higher level of achievement of all objectives.
- 'Insufficient time, or aspects of research took longer than originally anticipated' was the most commonly cited reason for non-fulfilment of all objectives.
- The percentage of awards achieving all objectives has been steadily increasing since 2006/2007 with the introduction of more robust application and monitoring procedures.

3.1 Number of awards achieving all objectives

As shown in Figure 3.1, 60% of grant holders indicated that they had achieved all of the original grant objectives by the time of completing their grant. This demonstrates a steady increase in this statistic since 2008 when only 43% of grant holders indicated that they had achieved all of their objectives [60% (2014/2015), 58% (2012/2013), 51% (2010/2011) and 43% (2008/2009)]. The reasons for this upward trend are difficult to quantify with any certainty. It is most likely due to careful review and improved feedback from international peer review panels on the feasibility of achieving the stated objectives over the period of the grant and with the available resources. It may also be due to growing researcher experience of what can be realistically achieved over the lifetime of an award.

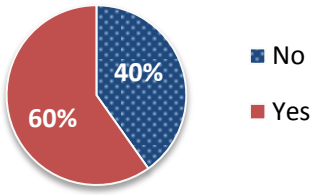


Figure 3.1: Proportion of grants with all objectives achieved

[8] It should be noted that grant holders are asked if they achieved all of the original grant objectives – this does not take into account the fact that PIs may have received formal approval from the HRB to change an objective(s) during the course of the grant, based on sound scientific rationale.

Figure 3.2 provides a breakdown of the statistic by grant type. As can be seen, for all grant types 50% or more of awards reported that they had achieved all of their original objectives. This rate was particularly high for Fellowships (78%) and Programme Grants (64%).

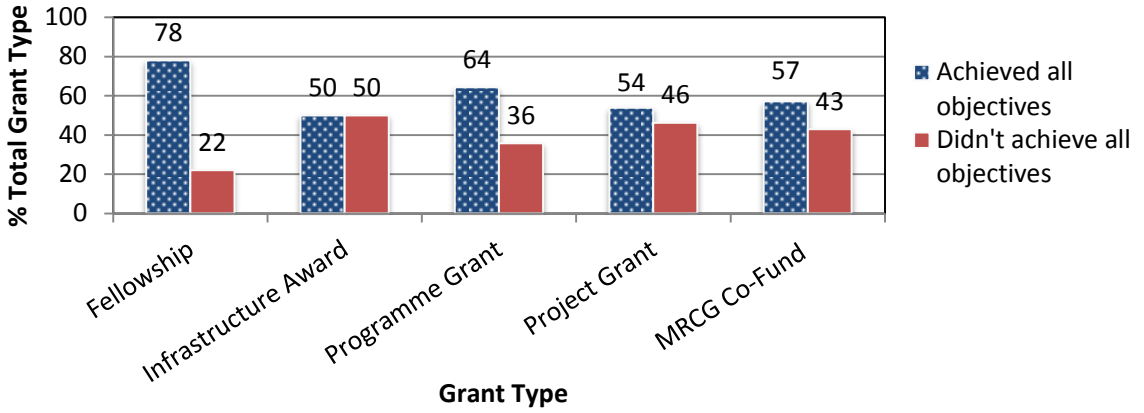


Figure 3.2: Achievement of grant objectives by grant type

3.2 Reasons for non-fulfilment of all original objectives

Grant holders were asked to indicate the reasons behind their inability to fulfil all of the original grant objectives. 96% of the PIs that did not achieve all of their original objectives provided a reason for not doing so and PIs could also choose more than one reason. Figure 3.3 shows the number of times each of the given reasons was cited.

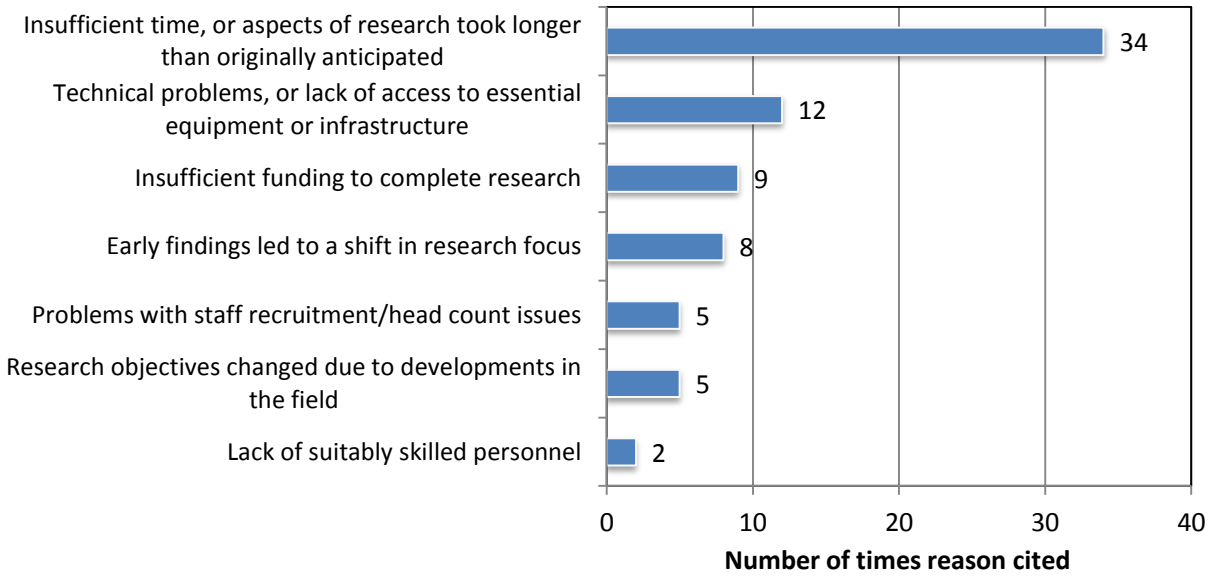


Figure 3.3: Cited reasons for non-fulfilment of original grant objectives

The most common reasons cited for non-fulfilment of all of the original grant objectives were 'Insufficient time, or aspects of the research took longer than originally anticipated' (45%); 'Technical problems, or lack of access to essential equipment or infrastructure' (16%); 'Insufficient funding to complete research'

(12%); or 'early findings led to a shift in research focus' (10.7%). Grant holders also cited 'Problems with staff recruitment /head count issues (6.7%) and 'Research objectives changed due to developments in the field' (6.7%). A small number of projects (N=2) cited 'Lack of suitably skilled personnel' as preventing them from achieving all of their original objectives.

As can be seen in Table 3.1 the specific reasons offered by PIs for being unable to achieve all of the original objectives vary, and there is often more than one reason as to why a grant might not obtain all of its objectives.

Table 3.1: Examples of explanations cited by researchers for not completing their objectives

Grant Type	Reasons for non-completion of all objectives	Description of issue by PI
Fellowship	Early findings led to a shift in research focus	As the project developed, it began to emerge that it was critical to assess the underlying molecular mechanisms before investigating the effect in disease. Although the effect in disease wasn't fully fleshed out, the PI did find correlative effects.
Project Grant	Insufficient funding to complete research	It became apparent that the finance available from this award would not be sufficient to deliver the commercial-related tasks and so appropriate funding from alternative sources was sought, some already successfully, and some the PI is confident will materialize in the near future. Therefore, overall the intended outputs will be achieved, although extra leveraged funding was required.
Project Grant	Insufficient time, or aspects of research took longer than originally anticipated	The final objectives were not met within the lifetime of the award due to insufficient time and funding availability. In particular, there were staffing difficulties early in the award which delayed the project. Nevertheless, the main experiments were completed and results have been published or are in submission/preparation.
Project Grant	Insufficient time, or aspects of research took longer than originally anticipated	In the original proposal it was proposed to measure the impact of sharing personalised clinical information on patient, clinical and psycho-social outcomes and a qualitative analysis of a sub-sample of consultations. This quantitative analysis took longer than anticipated and as a result it was not feasible to conduct a more detailed qualitative analysis of the content of patient conversation during the consultation during the time-frame of the project.
Project Grant	Problems with staff recruitment/head count issues	One member of the team went on maternity leave twice during the tenure of the grant, meaning another person had to be hired for the last five months of the grant.
Project Grant	Research objectives changed due to developments in the field	During the course of the project, a number of papers were published that answered the question posed in Objective 4. These findings agreed with results in Objective 1, and it was felt that it would be wasteful of resources to repeat these published experiments.
Project Grant	Technical problems, or lack of access to essential equipment or infrastructure	Many patients were discharged before day three of admission, so the numbers eligible for the questionnaire were less than planned. Also, it was not always possible to ascertain if the study subject had dementia at the time they were given the questionnaire, and so some completed questionnaires are from people who had cognitive impairment but perhaps not dementia.

3.3 Comment on findings

The finding that 40% of grant-holders did not achieve all of the original objectives should be placed in context.

- There is a significant increase in the percentage of PIs who reported achieving all of their objectives, compared to previous reporting periods.
- Almost half of the grants analysed in this report were categorised as basic or Applied Biomedical Research, fields which are exploratory in nature and therefore it could be expected that objectives would shift in line with early findings or developments in the field.
- For larger awards (Programme Grants, Infrastructure Awards, etc.) the HRB proactively seeks to confirm whether the original objectives are still appropriate and to revise them where necessary, through an interim review process. This re-focusing of the original objectives is a positive response to changing external developments that may influence the direction of the research.
- In 2009 the HRB completed the process of moving to purely international peer review panels and much greater scrutiny of the feasibility of grant proposals.
- In parallel, the HRB adopted more robust application procedures including requiring applicants to clearly identify their objectives, timelines, deliverables and milestones, justify the appropriateness of personnel and provide more detailed methodology information.

The HRB also adopted more robust grant monitoring procedures including the introduction of detailed annual reporting, a requirement to request permission in real-time from the HRB if they need to shift their focus or to change objectives and a practice of granting short no-cost extensions to PIs - when well justified - to complete their research. Given these conditions, it would be expected that the proportion of grants completing all of the original objectives would increase over time. As is evident from Figure 3.4, the HRB's emphasis since 2010 on clarity in the application process, international peer review and on-going grant monitoring appear to have had a real impact in this regard.

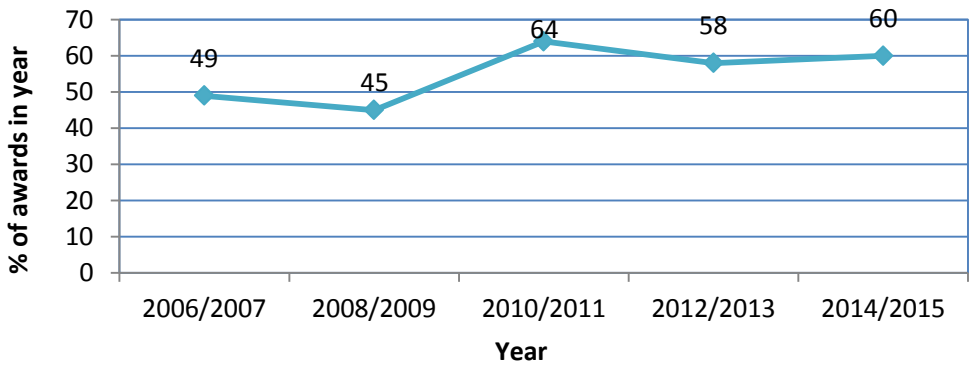


Figure 3.4: Percentage of grants, by year of award, achieving all of their objectives

4. Scientific dissemination

Scientific dissemination is at the core of the scientific process. It enables researchers to build on existing scientific knowledge and to develop collaborations with colleagues both nationally and internationally in order to advance particular areas of research. Important indicators of scientific dissemination activity include:

- publication of peer-reviewed scientific journal papers, especially in medium to high-impact international journals which have a wide readership and scientific credibility
- oral presentation of papers and presentation of scientific posters to peers at national and international scientific conferences
- invitations to present keynote papers at national and international scientific conferences

Summary of scientific dissemination outputs, compared to 2012/13, 2010/2011 and 2008/2009 reporting periods

Knowledge Production	2014/2015 (N=198 grants)	2012/2013 (N=134 grants)	2010/2011 (N=196 grants)	2008/2009 (N = 204 grants)
Peer reviewed publications				
No. peer-reviewed journal publications	693	584	470	526
Average no. of peer-reviewed papers/grant	3.5	4.5	2.4	2.5
No. publications per €1 million spend	12.6	13.3	8.6	11.6
Scientific presentations				
No. scientific presentations reported	1414	940	1427	1118
% PIs reporting scientific dissemination activity	72.2%	95.5%	87%	92%
No. of keynote presentations internationally	21	35	35	51

Key Finding

Peer reviewed journal papers

- 82% of grants completing in 2014/2015 reported at least one publication at the point of end of grant, which is comparable to the MRC metric of 85% over the same period.
- An average of 12.6 publications per €1 million spent was report, which is similar to previous reporting periods, although there was variation at the level of Grant Type and Broad Research Area.
- Infrastructure Awards performed particularly well, with the highest average number of papers per grant and per €1 million spent, an average citation impact of 1.75 times the world average, and almost one fifth of publications associated with this grant type in the top 10% of highly rated journals in their field.
- The broad research areas accounting for the most publications per award and per €1 million spend were Applied Biomedical Research, Clinical Research and Health Services Research.
- In terms of bibliometric indicators, Health Service Research had an average citation impact of 1.55 times the world average, over one fifth of publications in the top 10% of highly rated journals in their field, and a higher journal impact score than other HRB funded publications.

- Population Health Sciences publications also fared better than HRB aggregated results in terms of the number of publications in the top 10% of highly rated journals in their field (17.1%.)
- Over half of all publications were published in Open Access format, which reflects the findings of the 2013-16 Bibilometric Analysis that the top three journals used by HRB researchers in the 2013-2016 period were PLoS One (72 papers), BMJ Open (34 papers) and Cochrane Database of Systematic Reviews (26 papers).

Other means of scientific dissemination

- The most common types of other scientific publications were book chapters, health reports and articles in Professional Bulletins and many had a significant policy or clinical practice focus.
- HRB-funded researchers are very active in disseminating their work to peers at both national and international scientific events via conference presentation, keynote addresses, and had participated as invited speakers, conference organisers and session chairs in a large number of national and international events.
- Awards classified as Clinical Research and Health Services research accounted for a significant number of the total keynote invitations reported and 58% of all invitations to participate in national and international conferences.

4.1 Peer-reviewed scientific publications

Peer reviewed publications are an important primary output from research, since they communication information to peers to build a knowledge base and validate research quality. 82% of grants completing in 2014/2015 reported at least one publication at the point of end of grant, which is comparable to the MRC (85%).

A total of 693 peer-reviewed scientific publications[9] directly emerging from an investment of €55 million in 2014/2015 were reported. This was an average of 3.5 papers per grant, yielding a productivity rate of 12.6 publications per €1 million spent (or 1 paper for every €79k). This is very similar to the finding of 13.3 publications per €1 million spend for grants that completed in 2012/2013 (or 1 paper for every €75k), and better than the 8.6 publications per €1 million spent for grants that completed in 2010/2011 (or 1 paper for every €116k) and 11.8 publications per €1 million spend for grants that completed in 2008/2009 (or 1 paper for every €85k).

Papers that were in preparation, had been submitted to a journal for review or were accepted or in press (but not published) at the time of reporting were not included in the analysis, but it is hoped to capture them in future analysis at post-completion stage.

A Bibliometric Analysis of HRB-funded publications between 2013 and 2016[10], which would include as a subset the publications that emerged from awards that finished in 2014/2015, found that the publications from all grant types and broad research areas had and aggregated citation impact that were 1.3 times the world average, and greater than Ireland as a whole (although less than UK MRC and UK NIHR.) HRB-supported publications had almost 16% of the share of publications in the top 10% of highly rated journals in their field, which was higher than Ireland as a whole (11.5%) but lower than the UK MRC (22.9) and UK NIHR (20.4%). The journal impact sore was also greater than world average across all grant types and

[9] Publications reported by grant holders in end-of-grant reports were excluded from the analysis if the date of publication preceded the grant start date, if the paper was cited as in preparation, revision, accepted, or in press or if the subject matter of the paper was clearly unrelated to the grant objectives.

[10] J. Kosten and M. Hiney (2017) *A bibliometric analysis of research publication output supported by the Health Research Board (2013-2016)*. Health Research Board, Ireland.

broad research (1.2 times) and was above the journal impact score for Ireland as a whole, but lower than the MRC (1.75) and NIHR (1.51). It was also found that for all grant types, their citation impact was less than their journal impact score, indicating that the citation impact of these papers was greater than the citation impact of other publications in the same journal.

4.1.1 Distribution of peer-reviewed publications by grant type

Figure 4.1 shows the distribution of peer-reviewed publications by grant type for grants that completed in 2014/2015 and the proportion of the total investment of €55 million that each grant type received. Table 4.1 looks more closely at the cost of producing these publications as per €1 million spend and the cost per paper.

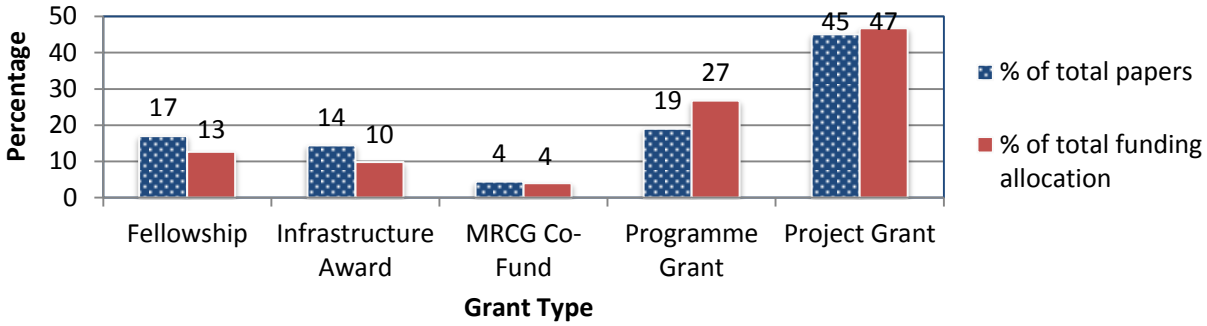


Figure 4.1: Breakdown of peer-reviewed publications by grant type

As can be seen from Figure 4.1 Project Grants produced almost half (45%) of all publications, an expected finding given that this grant type accounted for 47% of total funding. The average number of papers per Project Grant was 2.5 and there were 12.1 papers produced for every €1 million spend (a cost per paper of €82k).

Fellowship Awards were similar to Project Grants in terms of the average number of papers per fellowship (2.7), with a higher number of papers for every €1 million spend (17), and a lower cost per paper of €60k. Overall, Fellowship Awards accounted for 13% of funding awarded and produced almost 17% of the total publications.

Programme Grants (including the PhD Scholars Programme) produced 19% of total publications, while accounting for 27% of total funding. The average number of papers per Programme Grant of 11 would suggest a higher level of productivity that other grant types. However, when this grant type is examined in terms of cost per paper (€111k) and numbers of papers per €1 million spend (9), other grant types offer better return on investment for peer-reviewed publications. This is in keeping with observations from previous reporting periods that, on average, Programme Grants produce fewer papers per €1 million spend than Project Grants.

Table 4.1: Breakdown of publication rate and productivity by grant type

Grant type	Average no. papers per grant	No. papers per €1 million spend	Cost per paper
Programme Grant	11	9	€111,407
Project Grant	2.5	12.1	€82,344
Fellowship	2.7	17.0	€58,969
Infrastructure Award	25.0	18.5	€54,055
MRCG Co-Fund	2.6	14	€71,446

Infrastructure Awards have the highest average number of papers per grant at 25, producing 14% of papers with only 10% of the total funding. These awards display an excellent return on investment, with 18.5 papers produced per €1 million spent, with a low cost per paper (€54k).

The MRCG Co-fund scheme had 4% of the funding allocation, and accounted for 4% of total publications. The average number of papers per grant was 2.6 (similar to Project Grants and Fellowship Awards), with 14 papers per €1 million spent, at a cost per paper of €71k.

The *Bibliometric Analysis 2013-2016* found that publications associated with Infrastructure awards had an average citation impact of 1.75 times the world average, and that almost one fifth of publications associated with this grant type were in the top 10% of highly rated journals in their field. The ratio of citation impact to journal impact was particularly strong for Infrastructure awards, which suggests that publications arising from this grant type are regarded highly by peers, who site them in their own work more often than other papers in the same journals.

4.1.2 Distribution of peer reviewed publications by broad research area

Figure 4.2 shows the distribution of peer-reviewed publications by broad research area for grants that completed in 2014/2015 and the proportion of the total investment of €55 million that each grant type received. Table 4.2 looks more closely at the cost of producing these publications (per €1 million spend and cost per paper.)

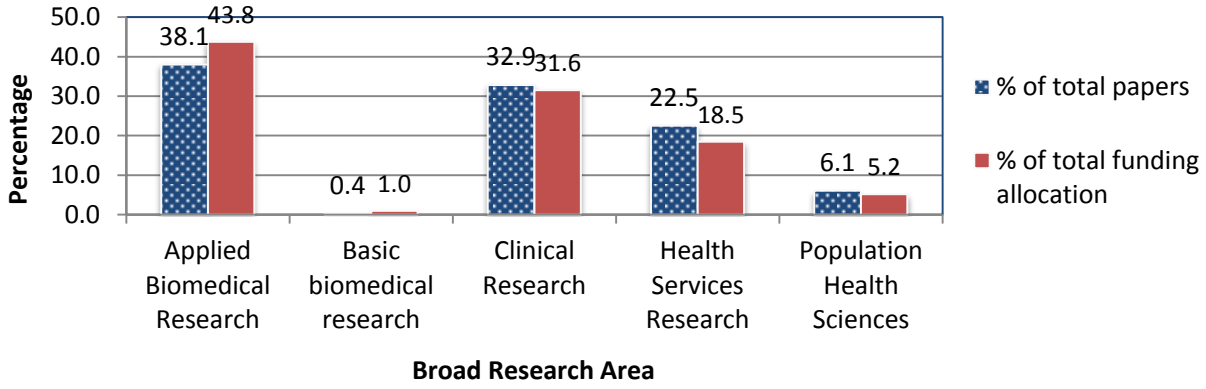


Figure 4.2: Breakdown of peer-reviewed publications by broad research area

Table 4.2 illustrates that the average number of peer reviewed publications per broad research area for all awards, and looks at the publication productivity in each area. From this it can be seen that there were a similar number of papers produced by awards classified as Applied Biomedical Research (3.5), Clinical Research (3.8) and Health Services Research (3.8), with awards classified as Population Health Sciences having slightly fewer (2.7) and Basic Biomedical Research having the least (1.0).

The broad research areas accounting for the most publications were Applied Biomedical Research (38.1%), followed by Clinical Research (32.9%), Health Services Research (22.5%) and Population Health Sciences (6.1%). These percentages reflect the total distribution of the €54.3 million investment across the five broad research areas.

In terms of productivity, that is, the number of papers produced per €1 million spend on awards classified according to the broad research areas, Health Services research produced the greatest number of papers (15.6), followed closely by Population Health (15.6). Awards classified as Clinical Research and Applied Biomedical Research produced 13.3 and 11.1 papers per €1 million spend, respectively, while awards classified as Basic Biomedical Research, were the least productive, producing 5.4 papers per 1 million spend.

Table 4.2: Breakdown of publication rate and productivity by broad research areas

Broad Research Area	Average no. papers per grant	No. papers per €1 million spend	Cost per paper
Basic Biomedical Research	1.0	5.4	€185,863
Applied Biomedical Research	3.5	11.1	€98,914
Clinical Research	3.8	13.3	€75,091
Population Health Sciences	2.7	15.0	€66,543
Health Services Research	3.8	15.6	€64,092

The *Bibliometric Analysis 2013-2016* found that publications associated with awards classified as Health Service Research had an average citation impact of 1.55 times the world average, that over one fifth of publications associated with this broad research area were in the top 10% of highly rated journals in their field, and these publications also had a higher journal impact score than other HRB funded publications. Publications associated with Population Health Sciences also fared better than HRB aggregated results in terms of the number of publications in the top 10% of highly rated journals in their field (17.5%).

4.1.3 Publishing platforms used

Figure 4.3 presents the type of publications that emerged from grants that completed in 2014/2015. The vast majority of researchers published in international peer reviewed journals (92.2% of total publications) and to a much lesser extent in national peer reviewed journals (2.3% of total publications.)

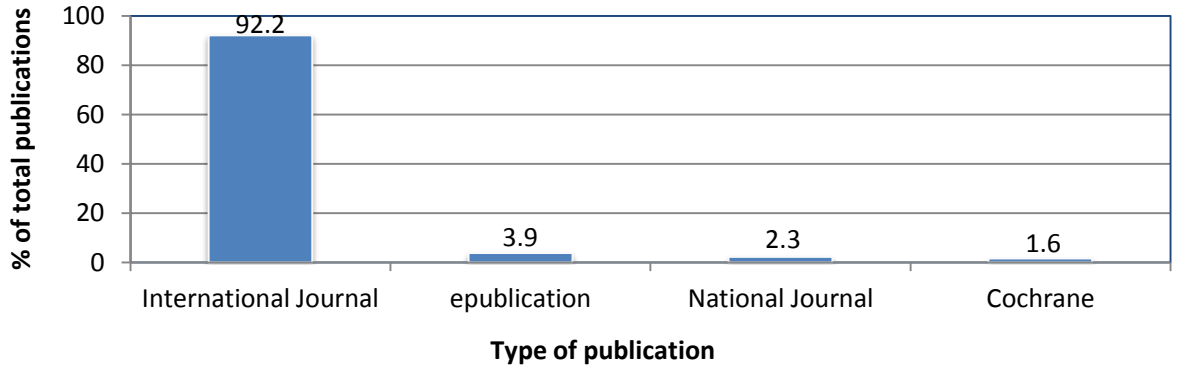


Figure 4.3: Breakdown of peer-reviewed publications by publication type

ePublications accounted for 4% of total publications in 2014/2015 (in 2012/13 and 2010/2011 the equivalent statistics were 17.1% and 16.3%, respectively). As all International Journals are now available online, this figure represents predominantly articles that are published online ahead of print. Eleven systematic reviews were published in the Cochrane Library, primarily by holders of Cochrane Training Fellowships, although four systematic reviews were published by a Health Research Centre.

As seen in Figure 4.4, the proportion of papers that are available on an open-access basis is 56%. This is the first time this figure has been reported so there is no historical data with which to compare it. However, figures reported in 2012/2013 identified that the number of articles published in the open access on-line journal PLoS One was 15, suggesting that grants completing in 2014/2015 were more likely to publish articles on open access platforms. This observation is confirmed by the Bibliometric Analysis of HRB publications 2013-2016, which found that the top three journals used by HRB researchers in the 2013-2016 period were PLoS One (72 papers), BMJ Open (34 papers) and Cochrane Database of

Systematic Reviews (26 papers). In some journals, HRB-funded publications were a considerable share of all Irish research output (e.g. BMJ Open, BMC Health Services Research).

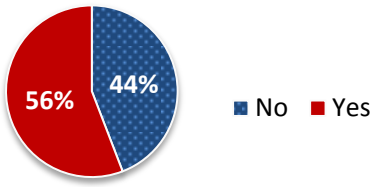


Figure 4.4: Papers available via open access

Table 4.3 presents a breakdown of the publication rate across the individual years from 2008-2015. 2014 showed an average (or slightly lower) rate of publications, with 296 publications (an average of 2.4 per grant or 8.9 per €1 million spent) reported by grants that completed their funding in 2014. However, 2015 had very high levels of publication, with almost 400 publications (5.4 average per grant or 18.4 per €1 million spent) resulting from grants that completed in 2015. This is primarily due to one Infrastructure Award. This eight year Health Research Centre Award which closed in 2015 singularly accounted for 98 publications.

Table 4.3: Summary of publication output 2008-2015

Year	Total no. papers	Aver. papers per grant	Papers per €1m funding	Average journal impact score (MNJS)
2008	234	2.5	10.3	4.4
2009	292	2.6	13.5	4.5
2010	230	2.2	9.5	4.2
2011	240	2.6	7.9	5.7
2012	165	2.8	10.5	N/A
2013	419	5.7	14.8	1.2*
2014	296	2.4	8.9	1.2*
2015	397	5.4	18.4	1.2*

** The Bibliometric analysis of HRB publications in the 2013-2015 did not break down journal impact score by year – 1.2 is the aggregate journal impact score across 2013-2015.*

While it is important to monitor the level of publication activity for HRB-funded research, the real value of publications is their placement in international peer reviewed journals with a wide readership among the academic community. One indicator of the potential reach and credibility of academic publications is the mean normalised journal score (MNJS) which is the average number of citations of all papers published in the same journal and field in the same year. This measure is frequently used as a proxy for the relative importance of a journal within its field, with journals with higher impact scores deemed to be more important than those with lower ones. Using these measures scientific journals can also be ranked at a global level (SJR Ranking)

From Table 4.3 it can be seen that the average MNJS was relatively consistent from 2008 to 2011 (4.4 to 5.7). A bibliometric analysis of publications 2013-2016 (which did not separate out MNJS by year) showed a considerably lower aggregate MNJS figure for publications in those years (although still above world average). It must be remembered however, that it citations accumulate over time for all journals, and that the journal impact score of more recent years would be expected to increase as more papers within that journal are cited.

For further interest, some examples of HRB-funded publications that featured in the top 200 highest ranking medical journals (as measured by Soccus SJR Ranking of medical journals[11]) are provided in Table 4.4. These publications ranged across all grant types and included research in basic and applied biomedical sciences, Clinical Research and Population Health Sciences and Health Services Research.

Table 4.4: Examples of publications in top ranked journals linked to HRB funded grants (SRJ ranking)

Grant Type	Article Title	Journal (Year published)	SJR Ranking
Fellowship	MicroRNAs: the fine-tuners of Toll-like receptor signalling.	Nature Reviews Immunology (2011)	**26.9**
Programme Grant	Succinate is an inflammatory signal that induces IL-1β through HIF-1α.	Nature (2013)	**21.9**
Project Grant	Simvastatin in Acute Respiratory Distress Syndrome	New England Journal of Medicine (2014)	**14.6**
Fellowship	Alcohol consumption and cardiovascular disease, cancer, injury, hospitalisation and mortality	The Lancet (2015)	**14.6**
Project Grant	The Irish health system and the economic crisis.	The Lancet (2012)	**14.6**
Programme Grant	Negative regulation of TLR4 via targeting of the proinflammatory tumour suppressor PDCD4 by the microRNA miR-21.	Nature Immunology (2010)	**13.3**
Programme Grant	Pellino3 targets the IRF7 pathway and facilitates autoregulation of TLR3- and viral-induced expression of type I interferons.	Nature Immunology (2012)	**13.3**
Programme Grant	Pellino3 ubiquitinates RIP2 and mediates Nod2-induced signalling and protective effects in colitis	Nature Immunology (2013)	**13.3**
Project Grant	Single-leg drop landing motor control strategies following acute ankle sprain injury	Science (2015)	**13.2**
Project Grant	Single-leg drop landing movement strategies, 6-months following an acute first-time lateral ankle sprain injury.	Science (2014)	**13.2**
Programme Grant	Targeting Toll-like receptors: emerging therapeutics?	Nature Reviews Drug Discovery (2010)	**11.7**
Fellowship	Productive mRNA stem loop-mediated transcriptional slippage: Crucial features in common with intrinsic terminators	Proceedings of the National Academy of Sciences of the USA. (2015)	**6.9**
Fellowship	Role of sortase-dependent pili of Bifidobacterium bifidum PRL2010 in modulating bacterium-host interactions	Proceedings of the National Academy of Sciences of the USA. (2013)	**6.9**
Project Grant	IL-25 and type 2 innate lymphoid cells induce pulmonary fibrosis.	Proceedings of the National Academy of Sciences of the USA. (2014)	**6.9**
Project Grant	The former annotated human pseudogene dihydrofolate reductase-like 1 (DHFRL1) is expressed and functional.	Proceedings of the National Academy of Sciences of the USA. (2011)	**6.9**
Project Grant	Targeted suppression of claudin-5 decreases cerebral oedema and improves cognitive outcome following traumatic brain injury	Nature Communications (2012)	**6.5**
Project Grant	CHOP regulates the p53-MDM2 axis and is required for neuronal survival after seizures	Brain (2013)	**6.1**

[11] Data retrieved from http://www.scimagojr.com/journalrank.php?area=2700

4.2 Other scientific publications

In addition to publications in peer reviewed journals, HRB-supported researchers published the outcomes of their research in a variety of ways at both national and international level (Table 4.5). Some of these publications, such as chapters in edited books, were reviewed by peers, while others, such as articles in professional bulletins, journal editorials, and reviews for popular magazines and industry bulletins were not. However, even when the publication output was not peer reviewed, it still served to disseminate the results of the research to a wider audience. Many of the non-journal publications have a significant policy or clinical practice focus.

Table 4.5: Other scientific publications emerging from grants that completed in 2014/2015

Publication type	National	International	Total
Book chapter	0	31	**31**
Health Report	8	3	**11**
Professional Bulletin	6	1	**7**
Guidelines	5	0	**5**
Review	0	3	**3**
Editorial	1	1	**2**
Total	**20**	**39**	**59**

Table 4.6 provides a comparison between 2014/2015 and 2012/2013 in terms of output of other scientific publications. This data illustrates that the most common types of other scientific publications were book chapters, health reports and articles in Professional Bulletins across grants that ended in both 2012/2013 and 2014/2015.

Table 4.6: Comparison of other scientific publications emerging from grants that completed in 2014/2015 and 2012/2013

Publication type	2014/2015	2012/2013
Book chapter	52.5%	44.9%
Health Report	18.6%	18.8%
Professional Bulletin	11.9%	14.5%
Guidelines	8.5%	4.3%
Review	5.1%	7.2%
Editorial	3.4%	5.8%
Handbook	0.0	2.9%
Practice Manual	0.0	1.4%

Table 4.7 provides examples of work that falls within the category of 'other publications'.

Table 4.7: Examples of other publications linked to HRB-funded awards

Grant Type	Type of publication	Description
Project Grant	Book chapter	Byrne WL, Tangney M. Bacteria as Gene Therapy Vectors for Cancer. In: Smyth Templeton N (ed.). Gene and Cell Therapy: Therapeutic Mechanisms and Strategies, Fourth edition. CRC Press, 2015.
Project Grant	Guideline	Ryan A, Ni Bhuachalla E, Power DG, O'Connor A (2014) Good Nutrition for Cancer Recovery, Cork City: Cityprint. 19,000 copies of 'Good Nutrition for Cancer Recovery' cookbook were printed and distributed to 74 locations around Ireland and the UK.
Fellowship	Professional Association Bulletin	Daly D, Begley C and Clarke M. (2012). Midwifery Matters - And how is the mother? World of Irish Nursing, 20(3); p21-22.
Project Grant	Editorial	Coughlan, H., & Doyle, M. (2015). Youth mental health in Ireland: a lot done, more to do? Irish Journal of Psychological Medicine, 32(01), 5-8.
Fellowship	Book chapter	O'Regan N, Fitzgerald J, Molloy D, Meagher D, Timmons S. Early Detection of Delirium: Prodromal Features. In: Alonso R, editor. Delirium. Diagnosis, Management and Prevention. New York: Nova Science Publishers, Inc., 2014:35-68.
Project Grant	Health Report	Donoghue O, O'Connell M, Kenny RA. (2016). Walking to Wellbeing: Physical Activity, Social Participation and Psychological Health in Irish Adults Aged 50 years and Older. TILDA topic report. Available from www.tilda.ie
Programme Grant	Invited Review	Dunne RA, McLoughlin DM (2012) Physical treatments. Medicine 40: 672-673.
Project Grant	Health Report	Cannon, M., Coughlan, H., Clarke, M., Harley, M., & Kelleher, I. (2013). The Mental Health of Young People in Ireland: A report of the Psychiatric Epidemiology Research across the Lifespan (PERL) Group.
Project Grant	Health Report	de Siún, A., O'Shea, E., Timmons, S., McArdle, D., Gibbons, P., O'Neill, D., Kennelly, S.P. & Gallagher, P. (2014). Irish National Audit of Dementia Care in Acute Hospitals. Cork: National Audit of Dementia Care. The report directly led from the ODCACS study (pilot of 6 hospitals embedded within ODCACS study)

4.3 Conference presentations (oral and poster)

The extent to which researchers present their work to peers at national and international scientific conferences is an indicator of international involvement and recognition, and the desire to disseminate their research results.

Of the 198 grants completing in 2014/2015 that reported on their activities, 72.2% of grant holders reported some type of scientific dissemination event to present their HRB-funded research findings. This is lower that figures from 2008/2009, 2010/2011 and 2012/13 grants, where a total of 92%, 87% and 95.5%, respectively, of grant holders had presented the results of their HRB-funded research at scientific meetings. However, it is important to note that the overall number of scientific presentations was significantly increased from 940 in 2012/2013 to 1,414 in 2014/2015, highlighting that HRB-funded researchers are very active in sharing their work.

Importantly for networking and academic recognition, HRB-funded researchers are very active on both the national and international scientific stage.

4.3.1 Distribution of conference presentations by grant type

Figure 4.5 looks at the number of dissemination activities per grant type, and Figure 4.6 looks at number of dissemination activities per €1 million spend per grant type (both oral and poster) at national and international conferences.

Presentations (both oral and poster) at scientific meetings were the most common scientific dissemination type reported. Recipients of the MRCG Co-fund and Infrastructure awards were the most active in this regard.

Invitations to deliver keynote talks at international conferences are also an important indicator of scientific recognition and prestige among the international community. HRB grant holders whose awards completed in 2014/2015 delivered 30 keynote talks at international scientific conferences. These keynote talks reported in 2014/2015 were almost exclusively (97%) reported by Project Grants and were predominantly (66.7%) given at international conferences.

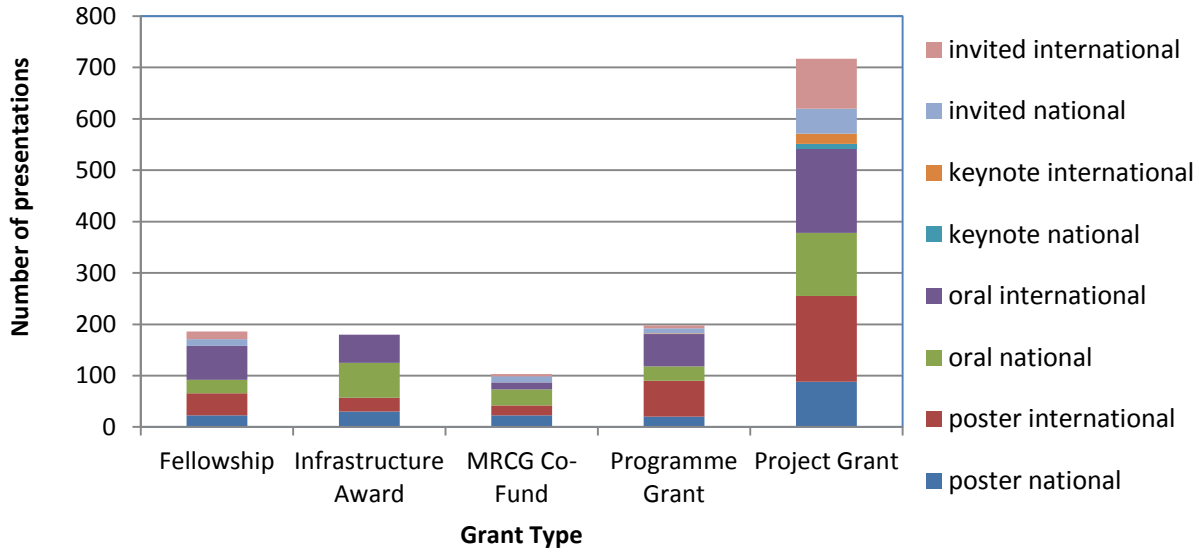


Figure 4.5: Number and type of scientific presentations per grant type

Other indicators of scientific recognition and prestige are being invited to participate in a conference, to chair a scientific session or to become involved in the organising committee for a conference. In all of these indicators HRB researchers performed well, both nationally and internationally across all grant types. In total, HRB researchers reported invitations to speak at 84 national and 122 international scientific meetings, chairing of one national and international scientific sessions, and involvement in the organising committee of 11 national and six international scientific conferences.

In terms of scientific productivity, Figure 4.6 shows that across all grant types oral presentations at national and international conferences yielded the most dissemination outputs per €1 million spend, followed by poster presentations at national and international conferences.

Of all grant types, the MRCG Co-fund scheme produced the highest number of oral and poster presentations (national and international) per €1 million spend. Infrastructure awards performed well in terms of number of oral presentations (national and international) per €1 million spend, the most productive type of scientific dissemination output per €1 million spend for Fellowships Awards were most oral presentations at international conferences.

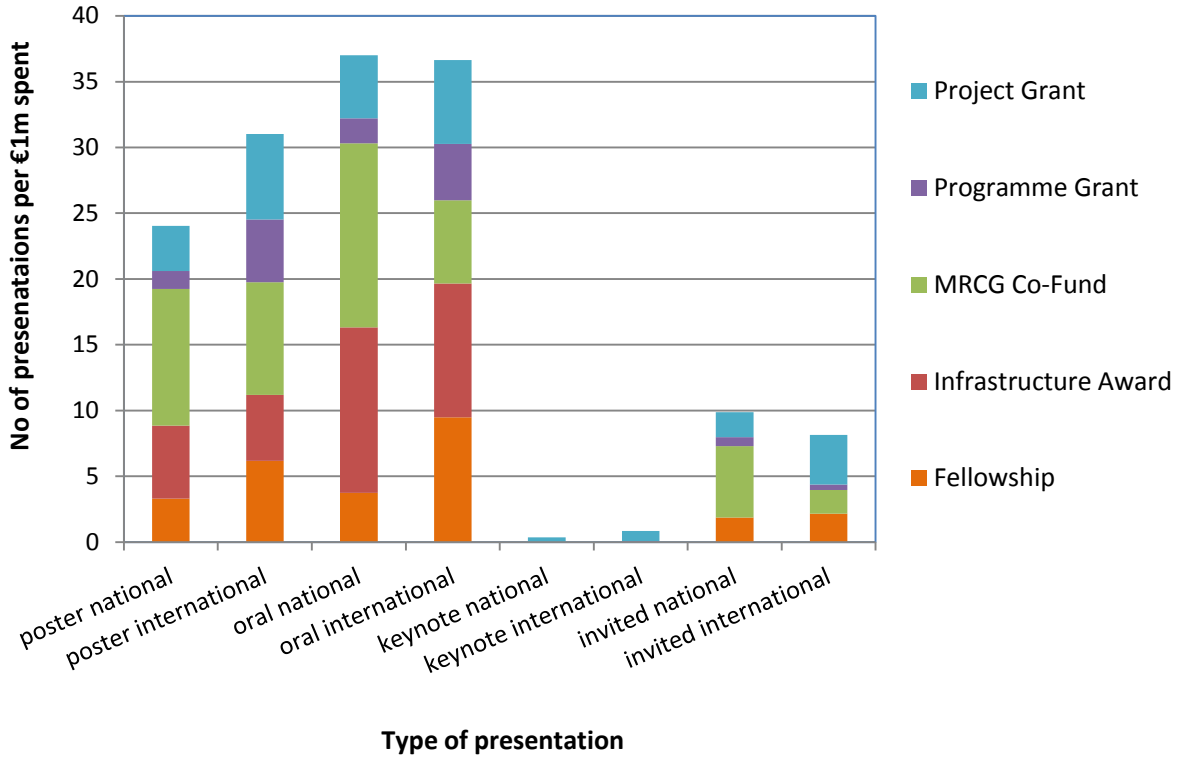


Figure 4.6: Number and type of scientific presentations per €1 million spend per grant type

4.3.2 Distribution of conference presentations by broad research area

Figure 4.7 looks at the number of scientific dissemination outputs per broad research area, while Figure 4.8 looks at number of scientific dissemination outputs per €1 million spend per broad research area (both oral and poster) at national and international conferences.

In terms of areas of strength, awards classified as Applied Biomedical Research, Clinical Research and Health Services Research reported the most outputs across all dissemination types, but in particular, oral and poster presentations at national and international conferences.

In terms of keynote invitations which are an important indicator of international credibility and prestige, awards classified as Population Health Sciences reported no outputs although such awards reported a small number of invitations to speak at both national and international conference. Awards classified as Clinical Research and Health Services research accounted for a significant number (n=20) of the total keynote invitations reported and 58% of all invitations to participate in national and international conferences. Applied Biomedical Research awards accounted for a further 38% of speaker invitations to national and international conferences and 10 keynote invitations.

In terms of productivity, the pattern was quite similar. Awards classified as Health services research were the most productive per €1 million spend in terms of oral presentations at international conferences (12.2 outputs), national conferences (9.2) and poster presentational at international conferences (8.42). Awards classified as Clinical Research, Applied Biomedical Research and Population Health Sciences were somewhat less productive per €1 million spend in these categories of outputs although very similar in pattern. Awards classified as Biomedical Research were the least productive per €1 million spend across all categories of outputs.

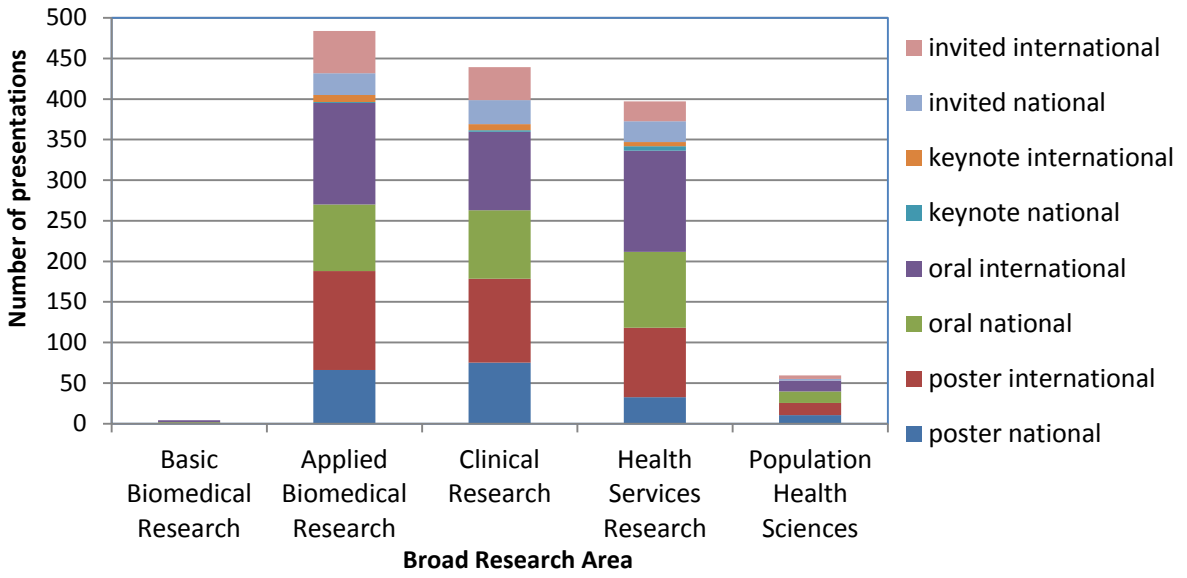


Figure 4.7: Number and type of scientific presentations per broad research area

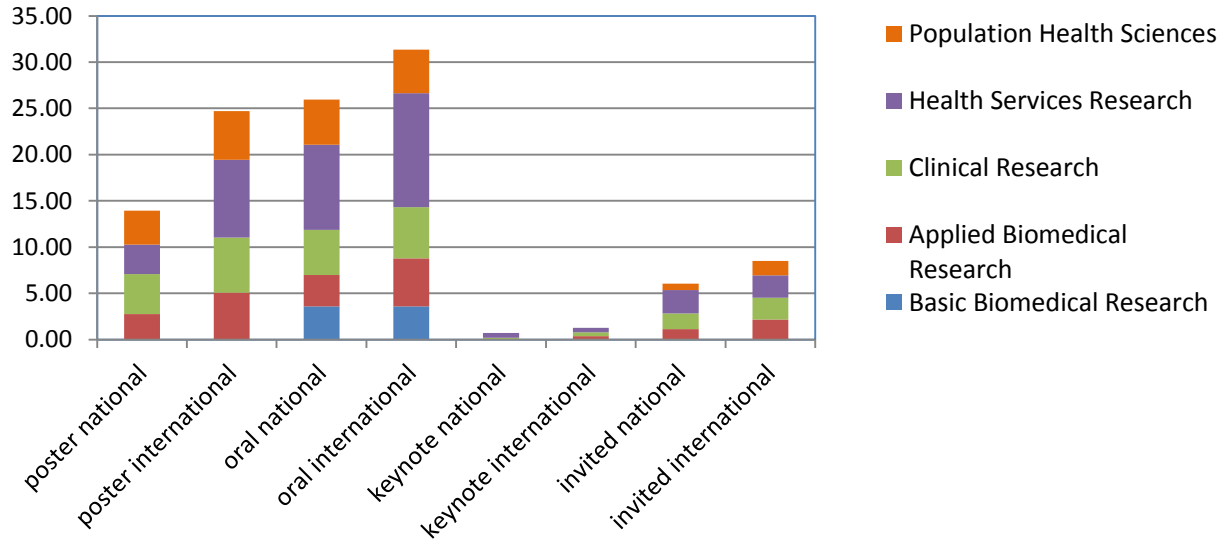


Figure 4.8: Number and type of scientific presentations per €1 million spend per broad research area

5. Capacity-building and leadership

A key strategic objective for the HRB is to embed research in the health system by:

- building capacity for research at some level among health professionals and other professional backgrounds who can contribute to a multi-disciplinary research environment
- supporting young researchers as they progress up the career ladder towards independent investigators

Measures of success in terms of capacity-building include not only the development of human capacity but indicators of the extent to which HRB researchers are advancing their field, and of the quality and impact of grant holder's research as perceived by their peers through recognition and academic awards.

Summary of capacity building outputs, compared to 2012/2013, 2010/2011 and 2008/2009 reporting periods

Research Capacity Building	2014/2015 (N=198 grants)	2012/2013 (N=134 grants)	2010/2011 (N=196 grants)	2008/2009 (N=204 grants)
Human capacity outputs				
No. research related posts created	385	422	280	296
No PhD students trained	93	133	72	88
No. post-doctoral researchers supported	154	130	92	112
% of cohort from health professional background	43.6%	32.2%	29%	NA*
Recognition and academic awards				
% of awards reporting indicator of recognition	42.9%	70%	75% (2011 only)	NA

** NA – data on all metrics is not available for every reporting period.*

Key Finding

Posts created via HRB awards

- 385 research-related posts were supported by the 198 HRB grants that reported on this metric.
- Project Grants accounted for 74% of the posts created through HRB awards that completed in 2014/2015 and was the most productive in terms of posts created per €1 million of spend.
- Post-doctoral researchers were the largest grouping (40%), the majority being employed on Project and Programme Grants. Post-graduate students accounted for 20of the total posts.
- The most cost-effective grant type in terms of creating posts was the Project Grants, which created an average of 11 posts per €1 million spend at an average cost of €91k per post.
- The proportion of the total post-graduate students and post-doctoral researcher posts in Population Health Sciences and Health Services Research have shown a substantial increase in 2014/2015 in comparison to the figures reported from grants that completed in 2008/2009.
- It was also noted that there are higher numbers of post-doctoral researchers compared to post-graduate students in patient oriented and health services research in particular. This may be due to the inherent complexity of these research areas, and the requirement to align the research personnel requested with the scale, complexity and methodology of the projects.

- Almost half of positions were filled by people from a health professional background, which is an increase on the numbers recorded for the 2012/2013 and 2010/2011 reporting periods. Of these 45 were registered for a higher degree, either MSc (n=2), MD (n=4) or PhD (n=39).

Next destination

- By far the most common follow-on employment role reported was as a post-doctoral researcher (26.2%) or a research role (as a research assistant, research nurse or midwife, or research associate – 10.4%).
- 5.2% of personnel were back working in full time clinical practice (either as a doctor or a nurse/midwife), 27 people had secured lectureship posts, while ten more obtained dual lecturer/clinical appointments. 17 people had moved into science administration (71% of who had biomedical science backgrounds); while another 18 had secured industry R&D posts and only 13 of the 385 people supported on HRB grants were unemployed.
- A higher proportion (81%) of researchers were staying in Ireland or Northern Ireland in comparison to 2012/2013 (71%) and 2010/2011 (77.5%), which presumably reflects the improving economy in Ireland in recent years and the increasing availability of employment.

Awards, prizes and other recognition

- Research prize, medals or other acclaim was the most common type of recognition reported. HRB researchers were also invited to participate in international scientific bodies, and to contribute as keynote speakers, session chairs and on organising committees at international scientific conferences.
- Health Services Research accounted for only 23% of total spend, the productivity of this type of award with regards to awards/prizes/recognition outputs was the highest at 8.7 outputs per €1 million spend.
- The type of awards and recognition that HRB and UK MRC researchers attract is somewhat different. For HRB research prizes, medals or other acclaim are the most common, while for MRC invitations to present papers and keynotes at conferences are the most common. Relatively speaking HRB researchers received a significantly greater percentage of prestigious/honorary or advisory positions on external bodies that their MRC peers, while a higher proportion of MRC researchers were granted membership to a learned society.

5.1 Personnel outputs

5.1.1 Types of personnel funded

In total, 385 research-related posts were supported by the 198 HRB grants analysed that completed in 2014 and 2015. The equivalent statistics from the 134 completed grants reported on in 2012/2013, the 196 completed grants reported on in 2010/2011 and the 204 completed grants reported on in 2008/2009 were 422, 280 and 296 posts, respectively. A breakdown of the roles of personnel on the grants supported by the HRB is given in Figure 5.1, while Table 5.1 analyses the amount spent per €1 million on posts, and the average cost per post.

Post-doctoral researchers were the largest grouping, accounting for 40% (n=154) of posts on HRB funded awards, the majority being employed on Project and Programme Grants. Post-graduate students accounted for 20% (n=77) of the total posts. This is a substantial decrease from the 133 post-graduate students reported by grants finishing in 2012/2013, unsurprisingly given the fact that there were two large PhD Scholars Programmes that finished in 2012/2013, and the PhD Scholars Programme that completed in 2014 employed only eight students.

63 people (19% of total posts) were categorised by the PI as 'research assistants', primarily employed on Project Grants. This figure included researchers who were not perusing a post-graduate qualification as part of their work on the grant, many of whom were health professionals. There were 52 people (13.5% of total posts) categorised by the PI as having a 'researcher', 'clinical researcher' or 'clinical research nurse' role, with the majority being employed on Project and Programme Grants. This group consisted primarily of doctors, nurses and allied health professionals. A total of 28 people held project management, administrative or technical roles (47.3% of total posts).

5.1.2 Distribution of posts by grant type

Figure 5.1 shows the broad distribution of posts across HRB grant types in 2014/2015 while Figure 5.2 shows the distribution of posts supported by HRB awards, broken down by post type and grant type. Table 5.1 shows the breakdown of the average cost of posts per €1 million spend.

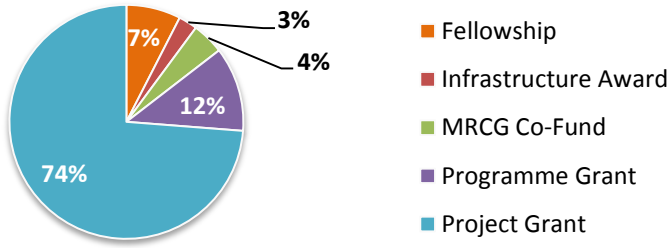


Figure 5.1: Breakdown of total number of posts created by grant type

Overall, Project Grants accounted for 74% (n=284) of the posts created through HRB awards that completed in 2014/2015, which reflected the number of awards in this grant type (126 of 198 awards). In terms of the costs of these posts, there were 11 posts created per €1 million spend on Project Grants, at an average cost of €90k per post. Programme Grants (n=45), accounted for 27% of the total funding, and they accounted for almost 11.7% of total posts (primarily post-graduate and post-doctoral posts.) There were 3 posts created per €1 million spend by Programme Grants, at an average cost of €327k per post.

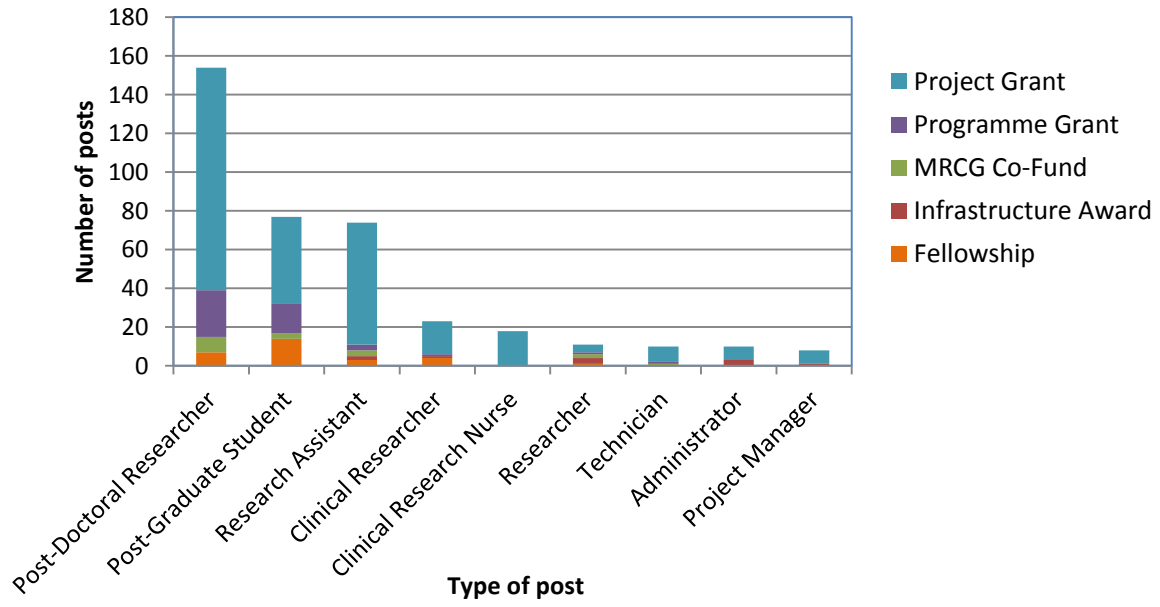


Figure 5.2: Number and role of personnel funded on HRB grants per grant type

The Infrastructure Awards created 10 posts; this represented a low return on investment in terms of posts created as there were 1.85 posts created per €1 million spend at an average cost of €541k per post. However, given the nature of three of the four Infrastructure awards, this figure is not surprising. A further 29 posts were created on Fellowship Awards completing in 2014/2015, an average of 4.2 posts per €1 million spend, and a cost of €240k per post. The MRCG Co-fund scheme created 17 posts at a cost of €130k each, with 8 posts created on average per €1 million spent.

The most cost-effective grant type in terms of creating posts was the Project Grants. These created an average of 11 posts per €1 million spend at an average cost of €91k per post.

It was not possible to compare grant types across reporting periods from 2008 onwards, since grant type was categorised somewhat differently for earlier reporting periods.

Table 5.1: Breakdown of posts by grant type and per €1 million spend

Grant type	Award total (€)	% Total spend	No of posts	Posts per €1M spend	Average cost (€) per post
Infrastructure Award	€5,405,469	9.83	10	1.85	€540,547
Programme Grant	€14,705,753	26.75	45	3.06	€326,795
Fellowship	€6,958,312	12.66	29	4.17	€239,942
MRCG Co-Fund	€2,214,816	4.03	17	7.68	€130,283
Project Grant	€25,691,437	46.73	284	11.05	€66,905
Grand Total	**€54,975,787**	**100.00**	**385**	**7.0**	**€142,794**

5.1.3 Distribution of posts by broad research area

Figure 5.3 shows the distribution of total numbers of posts created distributed by broad research area. From this it can be seen that grants categorised as Biomedical Research accounted for 32% of total posts, of which 1% were in basic biomedicine and 31% were in applied biomedicine. This is a significant reduction from the 58% of total posts attributed to biomedical sciences reported from grants completed in 2012/2013.

Grants focused on Clinical Research accounted for 30% of posts created, while Health Services Research and Population Health Sciences accounted for the remaining 24% and 14% of posts created, respectively, a significant increase from the combined value of 20% of total posts reported by these areas in grants that completed in 2012/2013. This data illustrates that the HRB's drive to increase funding to Population Health Sciences and Health Services Research rather than basic and applied biomedical research is having a tangible effect.

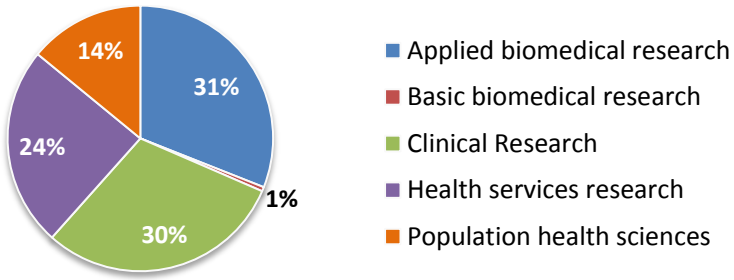


Figure 5.3: Breakdown of total number of posts created by broad research area

Figure 5.4 shows the distribution of posts supported by HRB awards, broken down by post type and broad research area. Table 5.2 shows the breakdown of post types by broad research area and number per million spend.

Post-doctoral posts were the most common type of post created through HRB awards (40%), followed by post-graduate student posts (20%) and research assistant posts (19.2%). In terms of their association with broad research areas, Applied Biomedical Research, Clinical Research and Health Services Research accounted for the majority (85.4%) of posts created through HRB awards. However, in terms of productivity, that is number of posts created per €1 million spend, awards classified as Population Health Sciences accounted for 18.8 posts per €1 million spend, more than double the number of posts created by the next most productive broad research area, Health Services Research (9.9 posts per €1 million spend). Clinical Research awards and Applied Biomedical awards produced 6.6 and 4.9 posts per €1 million spend respectively.

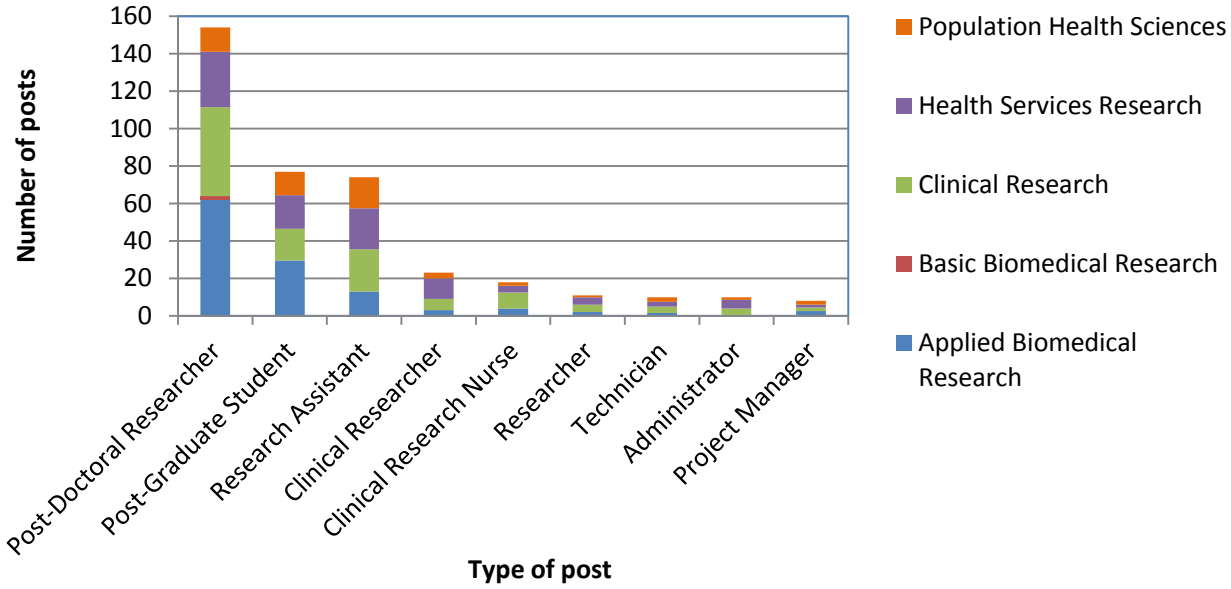


Figure 5.4: Number and role of personnel funded on HRB grants per broad research area

Table 5.2: Breakdown of posts by broad research area and number per €1 million spend

Grant type	Award total (€)	% Total spend	No of posts	Posts per €1M spend	Average cost (€) per post
Basic Biomedical Research	€557,588	1.0%	2	3.6	€278,794
Applied Biomedical Research	€24,052,124	43.8%	118	4.9	€203,832
Clinical Research	€17,346,075	31.6%	115	6.6	€150,835
Health Services Research	€10,158,661	18.5%	96	9.6	€105,819
Population Health Sciences	€2,861,338	5.2%	54	18.9	€52,987
Grand Total	**€54,975,786**	**100%**	**385**	**8.72**	**€158,453**

Table 5.3 provides a comparison from 2008 to 2015, by broad research area, of the total number of PhD students (Table 5.3a) and post-doctoral researchers (Table 5.3b). The figures are presented as a percentage of the total numbers for each two year period. The data shows a continuing and significant decrease in the proportion of post-graduates and post-doctoral researchers funded in Basic Biomedical Research across the eight year period.

The reduction in the number of post-graduate students, categorised as being involved in Applied Biomedical Research in 2014/2015 in comparison to the 2012/2013 period, can be accounted for by the completion of the two PhD Scholars Programmes in 2013, both of which were categorised as Applied Biomedical Research and inflated the proportion of Post-Graduate student posts. Aside from that outlier, the data for both Post-Graduate Students and Post-Doctoral Researchers follows the trend of a reduction in the number of posts created by Biomedical research, as the proportion of total posts that are categorised as Applied Biomedical Research has shown a year-on-year decline since 2008.

Table 5.3a: Comparison of post-graduate students* supported by HRB awards, by broad research area, from 2008-2015

Broad research area	2014/2015	2012/2013	2010/2011	2008/2009
Basic Biomedical	0%	4.1%	11%	15%
Applied Biomedical	33.9%	63.1%	39%	39%
Clinical Research	21.5%	17.9%	18%	18%
Health Services Research	27.5%	13.8%	24%	17%
Population Health	14%	1%	8%	11%

** Includes all people registered for a PhD or MSc regardless of whether they were categorised as post-graduate students or another personnel type by the PI at the time of reporting.*

Table 5.3b: Comparison of post-doctoral researchers* supported by HRB awards, by broad research area, from 2008-2015

Broad research area	2014/2015	2012/2013	2010/2011	2008/2009
Basic Biomedical	1.3%	11.8%	24%	29%
Applied Biomedical	40.3%	44.1%	59%	55%
Clinical Research	30.8%	21.8%	11%	11%
Health Services Research	19.2%	17.7%	4%	2%
Population Health	8.4%	4.5%	2%	4%

** Excludes all people registered for a PhD or MSc (even if categorised as a post-doc by the PI at the time of reporting), and people categorised as administrators, technicians or research assistants.*

Tables 5.3a and 5.3b also suggest that the HRB's efforts to promote research in the areas of Population Health Sciences and Health Service research are driving job creation. The proportion of the total Post-Graduate Student and Post-Doctoral Researcher posts which are in these areas have shown a substantial increase by 2014/2015 in comparison to the figures reported from grants that completed in 2008/2009.

It is interesting to note that there are higher numbers of post-doctoral researchers compared to post-graduate students in patient oriented and health services research in particular. This may be due to the inherent complexity of these research areas, and the requirement to align the research personnel requested with the scale, complexity and methodology of the projects.

Taken as a whole across the eight years, the figures in Table 5.3a and 5.3b, show that biomedical research (basic and applied combined) accounted for 41.6% of post-docs and 33.9% of PhDs. This statistic confirms the need for initiatives such as the ICE post-doctoral scheme which is targeted at increasing the capacity within population health sciences and health services research.

5.1.4 Professional background of personnel

An ambition of the *HRB Strategic Business Plan 2010-2014* is to increase the number of health professionals engaged in research at some level, either in training or as researchers. Table 5.4 presents a breakdown of the professional background of personnel employed on HRB-funded awards by the type of grant on which these personnel were employed.

In total, of the 385 personnel reported on, 154 came from a health professional background, representing 43.6% of the total personnel cohort. This is an increase on the numbers recorded for the 2012/2013 and 2010/2011 reporting periods, of 136 health professional personnel (32.2% of total cohort) and 82 health professional personnel (29% of total cohort) respectively.

45 of the health professionals supported by awards that completed in 2014/2015 were registered for a higher degree, either MSc (n=2), MD (n=4) or PhD (n=39). For strategic information purposes, the health professional groupings have been separated out. The category of Nursing and Midwifery includes those from a nursing, midwifery, and clinical research nursing background (22% of this group had registered for either an MSc or a PhD), while the category of Other Health Professional includes personnel with a background in allied healthcare professions other than physiotherapy or speech and language therapy. The category of 'Other' includes one administrator, a post-graduate student and 2 post-doctoral researchers, who are employed largely on grants classified as Health Services Research.

Table 5.4: Professional background of personnel employed on HRB-funded grants by grant type

Background	Fellowship Award	Infrastructure Award	MRCG Co-fund	Programme Grant	Project Grant	Total
Administrator		2			3	**5**
Biomedical science	6	5	14	27	119	**171**
Dentistry					10	**10**
Engineer					4	**4**
Epidemiology & public health	1			1	3	**5**
Geosciences					3	**3**
Health economics	2			3	16	**21**
Laboratory technician			1	2	8	**11**
Medical doctor	7	2	2	1	18	**30**
Nursing & Midwifery	5				22	**27**
Other					6	**6**
Other health profession	6			3	9	**18**
Physics or Chemistry				3	7	**10**
Physiotherapist	1					**1**
Psychology or behavioural science				5	36	**41**
Social science		1			13	**14**
Speech & language therapist	1					**1**
Statistics or Mathematics					5	**5**
Student					2	**2**
Total	**29**	**10**	**17**	**45**	**284**	**385**

It is also interesting to look at the background professions of personnel employed across the broad research areas (Table 5.5). As might be expected from an award categorised as applied biomedical, the eight PhD students supported by the PhD Scholars programmes were from a biomedical sciences background.

The personnel employed on the other Programme Grants, which were primarily categorised as Applied Biomedical Research and Clinical Research (three were categorised as combined Clinical Research and Health Services Research), were from a varied background (including several health professionals) but were predominantly from biomedical sciences. Likewise, the MRCG Co-fund awards were almost exclusively categorised as Applied Biomedical Research (one was combined Applied Biomedical and Clinical Research), and attracted primarily biomedical scientists, as well as one technician and two medical doctors. The Infrastructure Awards were classified as a combination of Clinical Research or Health Services Research and employed mainly biomedical scientists and medical doctors.

Project Grants supported almost three quarters (74%) of those with health professional backgrounds of some type. This grant type also attracted personnel from many different professional backgrounds, and for the first time in 2015, five people with a statistics or mathematics background and three with a geoscientific background were supported through Project Grants. There was also an increase in the number of engineers supported on this grant type, from three reported in 2012/2013 to four from grants completing in 2014/2015. The Fellowship schemes also attracted a wide variety of backgrounds, many of whom were health professionals.

Table 5.5: Professional background of personnel on HRB-funded awards by broad research area

Background	Applied biomedical research	Basic biomedical research	Clinical research	Health services research	Population health sciences	Total
Administrator	0.5		2	2	0.5	**5**
Biomedical science	87.5	2	51.5	13.5	16.5	**171**
Dentistry			2.5	6.5	1	**10**
Engineer	3				1	**4**
Epidemiology & Public Health	1.5		1.5	1	1	**5**
Geosciences					3	**3**
Health economics	1		3.5	15.5	1	**21**
Laboratory technician	2		4	2.5	2.5	**11**
Medical Doctor	8		10	7	5	**30**
Nursing & Midwifery	4		10	9	4	**27**
Other			2	4		**6**
Other health profession	0.5		5.5	11	1	**18**
Physics or Chemistry	3.5		4	2.5		**10**
Physiotherapist			1			**1**
Psychology or behavioural science	5		13	13.5	9.5	**41**
Social science	1		2	7	4	**14**
Speech & Language Therapy			0.5	0.5		**1**
Statistics or Mathematics			0.5	1	3.5	**5**
Student	0.5		1		0.5	**2**
Total	**118**	**2**	**114.5**	**96.5**	**54**	**385**

5.2 Current employment destination of personnel

Grant holders were asked to provide information on the current employment posts of research personnel supported by HRB grants. Figure 5.5 shows the overall breakdown of current employment posts.

Consistent with the 2008/2009, 2010/2011 and 2012/2013 figures, by far the most common follow-on employment role reported was as a post-doctoral researcher (26.2% of personnel) or a research role (as a research assistant, research nurse or midwife, or research associate – 10.4% of total personnel). 10.9% of personnel were still completing (or had just commenced) a PhD degree, which was also consistent with figures from the previous reporting periods. While the percentages might be slightly different, the same pattern was observed for UK MRC research employees over the 2014/2015 reporting period.

A further 5.2% of personnel were reported to be back working in full time clinical practice (either as a doctor or a nurse/midwife). 27 people had secured lectureship posts, while ten more obtained dual lecturer/clinical appointments. 17 people had moved into science administration (71% of whom had biomedical science backgrounds); while another 18 had secured industry R&D posts. One person had been employed in science publishing. Those classified as "Other" includes one person who had retired, two on maternity leave, two who had returned to train as teachers and one person who was working as a scientist for the Garda Forensic lab. Thankfully, at the time of reporting only 13 of the 385 people supported on HRB grants were unemployed. The current occupation of a further 2 was unknown.

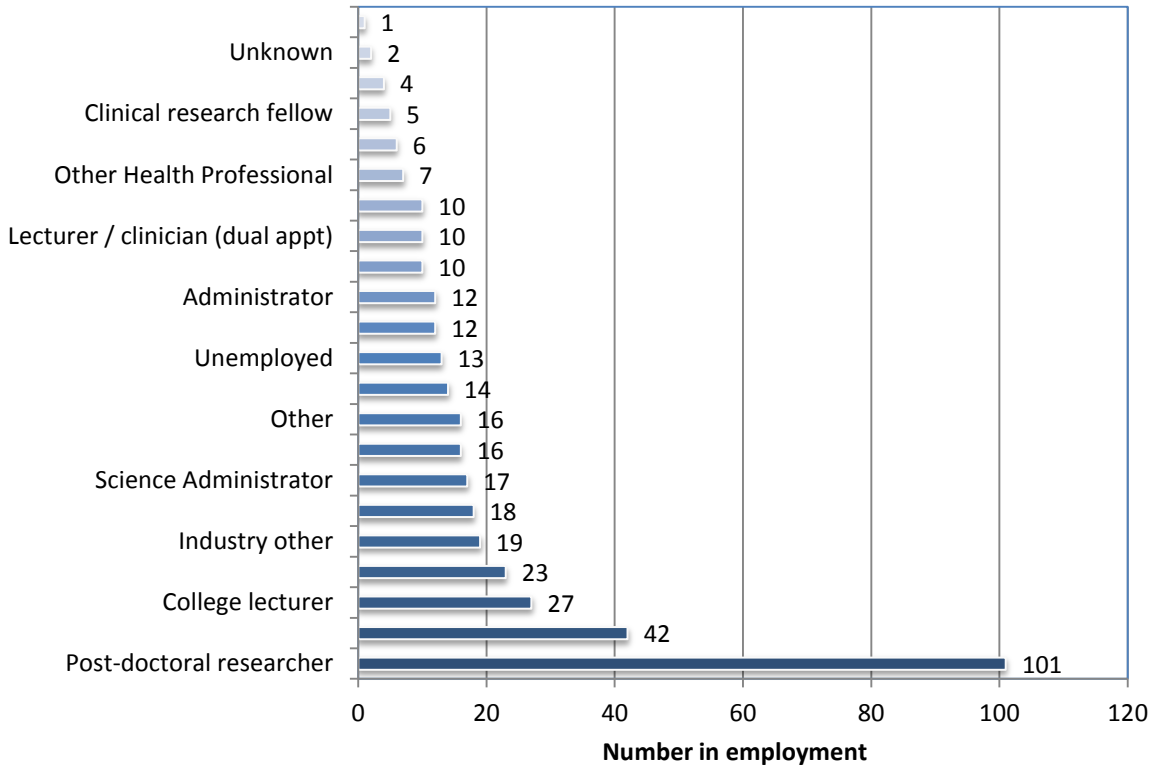


Figure 5.5: Current employment of HRB grant personnel

5.2.1 Current location of personnel

Table 5.6 looks at the country of current employment for personnel supported by HRB awards that completed in 2014/2015. As might be expected the majority of personnel (81%) were employed in Ireland or Northern Ireland. The current location of 2 personnel was unknown, while the remainder were based overseas. The most common locations were the UK (N=23), the US (N=15), Other European Countries (N=9), Germany (N=6) and Australia / New Zealand (N=4).

Table 5.6: Country in which personnel are currently working /residing

Country of employment or residence	Number
Ireland/Northern Ireland	311
United Kingdom	23
United States of America	15
Other European Country	9
Germany	6
Australia/New Zealand	4
France	4
Spain	4
Africa	3
Asia	2
Canada	2
Unknown	2
Total	**385**

Table 5.7 provides a comparison between the grants that completed in 2014/2015 and those that completed in 2012/2013 and 2010/2011. From this it is evident that there are a higher proportion (81%) of researchers staying in Ireland or Northern Ireland in comparison to 2012/2013 (71%) and 2010/2011 (77.5%). This presumably reflects the improving economy in Ireland in recent years and the increasing prevalence of available jobs.

Table 5.7: Country in which personnel are currently working/residing - comparing 2014/2015, 2012/2013 and 2010/2011

Country of employment or residence	2014/2015	2012/2013	2010/2011
Ireland/Northern Ireland	80.8%	71.3%	77.5%
United Kingdom	6%	4.5%	5.7%
United States of America	3.9%	4.3%	4.6%
Other European Country	2.3%	0.7%	1.4%
Germany	1.6%	0.5%	1.8%
Australia/New Zealand	1%	2.1%	0.4%
France	1%	1.2%	1.1%
Spain	1%	0	0.7%
Africa	0.8%	2.1%	4.6%
Asia	0.5%	1.2%	1.4%
Canada	0.5%	0	0
Unknown	0.5%	11.8%	0.4%
South America	0	0.2%	0
China	0	0.	0.4%

The increase in personnel staying in Ireland corresponds with a decrease in the number of personnel moving to work in the USA (3.9% of 2014/2015, compared to 4.3% in 2012/2013 and 4.6% in 2010/2011). Although there is no corresponding increase in the number of personnel relocating to the UK, there are 50 personnel who were employed by grants completing in 2012/2013 whose location is unknown, in comparison to only 2 personnel from grants that completed in 2014/2015.

5.3 Recognition and research awards

Grant-holders whose grants completed in 2014/2015 were asked if they, or any members of their HRB-funded team, had received any awards or recognition related to their research during the period of the grant. Awards and recognition received by grant-holders gives an indication of the quality and potential impact of grant-holders' research as perceived by their peers nationally and internationally. In this context, it was encouraging that 42.9% of the 198 grants analysed reported that either they or a member of their team received at least one type of award or recognition, and reported a total of 377 awards or recognition. This is slightly lower than the percentage of total grants reporting awards and recognition that were reported by the MRC for its researchers during the same period (52%).

The type of recognition or award reported by HRB researchers is shown in Figure 5.4. By far the most common form of recognition was a research prize, medal or other acclaim. This category includes, for example, travel awards and bursaries, prizes for best paper or poster at a national or international scientific conference. HRB-supported researchers were also invited to participate in international scientific bodies such as advisory scientific committees and journal and book editorial boards, and to contribute as keynote speakers, session chairs and on organising committees at international scientific conferences.

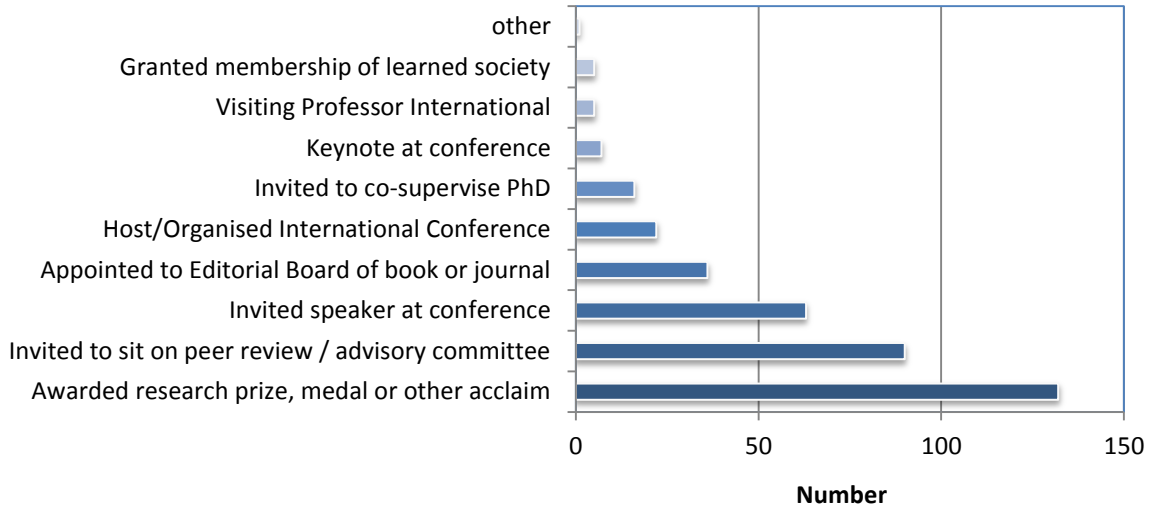
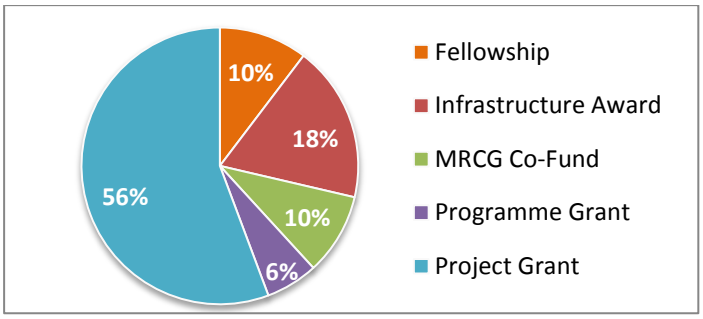


Figure 5.6: Number of grants reporting different types of research awards and recognition

5.3.1 Distribution of awards and recognition by grant type

Figure 5.7 looks at the number of awards and recognitions by grant type. It shows that Project Grants accounted for 56% of the reported awards, prizes and peer recognition and had outputs of 8.2 awards per €1 million spent. Fellowship awards accounted for 10% of reported awards but were similar to Project Grants in terms of outputs, with 5.6 prizes, awards or recognition per €1 million spent. Programme Grants had a lower return on prizes, comprising 6% of the total reported awards, with the lowest output of only 1.6 awards, prizes or peer recognitions per €1 million spent.

The Health Research Centre Infrastructure award accounted for 18% of the total prizes and acclaims, amounting to 12.8 prizes, awards or recognitions per €1 million spent. As was the case for a number of other metrics, the MRCG Co-fund award, while accounting for only 10% of total reports of prizes, awards and recognition, yielded an average of 16.3 awards, prizes or recognition outputs per €1 million spend, by far the most productive of all the grant types.



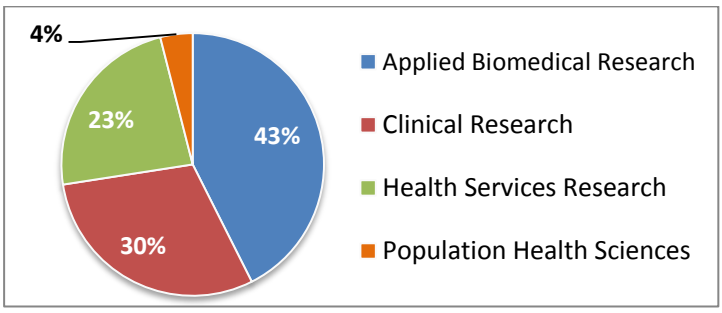
No. awards/prizes/recognition per 1 million spend	
Fellowship	5.6
Infrastructure Award	12.8
MRCG Co-Fund	16.3
Programme Grant	1.6
Project Grant	8.2

Figure 5.7: Research awards and recognition broken down by grant type and number per €1 million spend

5.3.2 Distribution of awards and recognition by broad research area

Figure 5.8 looks at the number of awards and recognitions by broad research area. It shows that while awards classified as Health Services Research accounted for only 23% of total spend, the productivity of this type of award with regards to awards/prizes/recognition outputs was the highest at 8.7 outputs per €1 million spend.

Applied Biomedical Research and Clinical Research accounted for 43% and 30%, respectively, of the reported awards, prizes and peer recognition outputs but their productivity per €1 million spent (6.7 and 6.5 outputs, respectively) was considerably less than Health Services Research awards. Population Health accounted for only 2% of the total spend, but also had the lowest number of outputs per €1 million spend.



No. awards/prizes/recognition per 1 million spend	
Applied Biomedical Research	6.7
Clinical Research	6.5
Health Services Research	8.7
Population Health Sciences	5.2

Figure 5.8: Research awards and recognition broken down by broad research area and number per €1 million spend

5.3.2 Comparison of awards and recognition outputs of HRB and UK MRC

It is interesting to compare the types of awards and recognition being obtained by HRB-supported researchers with those of UN MRC supported researchers. While the categories used by both organisations are not completely compatible, there is enough commonality to make some direct comparisons in Figure 5.5.

From Figure 5.5 it is clear that the type of awards and recognition that HRB and UK MRC researchers attract is somewhat different. For HRB researchers, research prizes, medals or other acclaim are the most frequent type of recognition achieved, while for MRC researchers invitations to present papers and keynotes at conferences are the most common type of recognition. Relatively speaking HRB researchers received a significantly greater percentage of prestigious/honorary or advisory positions on external

bodies that their MRC peers, while a higher proportion of MRC researchers were granted membership to a learned society.

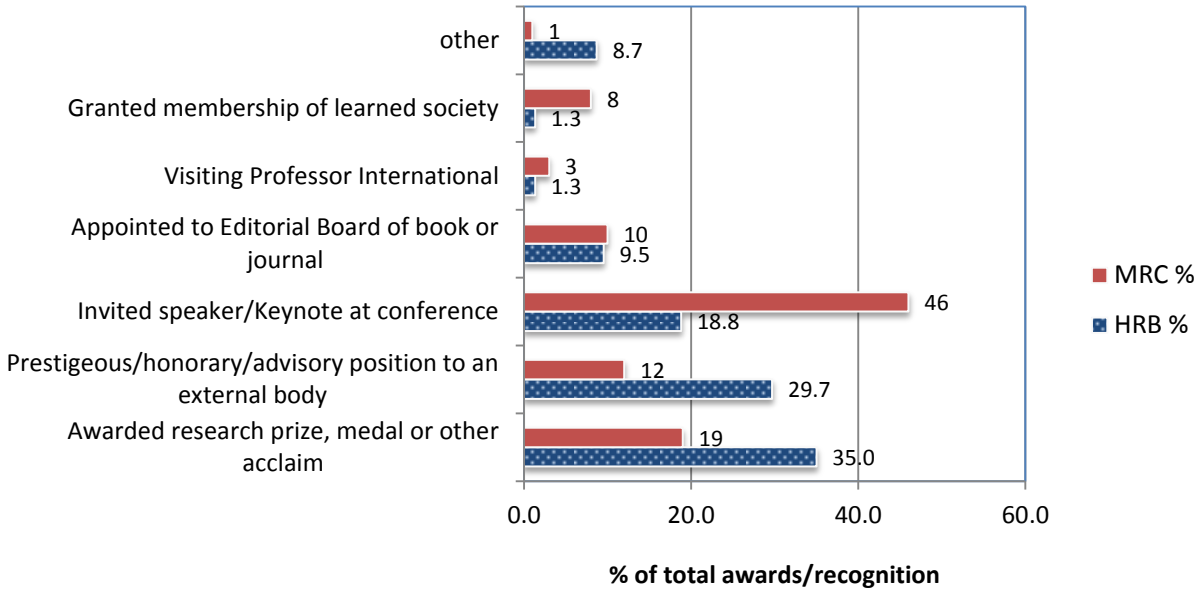


Figure 5.9: Comparison of HRB and MRC research awards and recognition patterns 2014/2015

5.3.3 Examples of recognition and awards outputs

Table 5.98 provides some examples of the types of research awards and recognition outputs reported by PIs whose grants completed in 2014/2015 as being linked to their award.

Table 5.8: Examples of research awards and recognition received by HRB-supported researchers

Recipient	Details of Award/Prize/Recognition
Dr. Denis O'Mahony **Research Project Grant**	In April 2015, Dr. O'Mahony was an invited keynote speaker at the International Association of Gerontology & Geriatrics European Region congress held in Dublin (April 23-26). The title of his keynote address to the congress was: "Inappropriate prescribing in older people: why it matters and how to prevent it."
Dr. Niamh O'Regan **Health Professional Fellowship**	An article published by Dr. O'Regan won the Elsevier / Harold Ellis Prize 2013 in association with the International Journal of Surgery. O'Regan NA, Fitzgerald J, Timmons S, O'Connell H, Meagher D. Delirium: A key challenge for perioperative care. Int J Surg 2012. Epub 2013/01/02.
Dr Abel Wakai **Health Research Award**	The project's Research Fellow, Dr. Aileen McCabe, won a travel award from the Society for Academic Emergency Medicine (SAEM) and presented the findings of the study at the SAEM 2015 Annual Meeting in San Diego, California, USA.
Prof Mary Cannon **Health Research Award**	Professor Cannon was listed as one of the top 3,000 international researchers in the Thomson Reuters "The World's Most Influential Scientific Minds" 2014 Report. She was one of only eleven Irish researchers included in the report and the only Irish woman listed
Prof David Henshall **Health Research Award**	Professor Henshall was awarded the Robert Bentley Todd Medal for Teaching and Research in Neuroscience, Royal College of Surgeons in Ireland (2014)
Prof David Coleman	Professor Coleman was elected as a Member of the Royal Irish Academy (Science) in March 2015 (ceremony on 29th May 2015) - partly due to his achievements in

Recipient	Details of Award/Prize/Recognition
Health Research Award	research on practical aspects of minimising microbial contamination in water networks and dental units.
Prof Tom Fahey **Infrastructure Award**	Prof Tom Fahey. James M. Flaherty Visiting Professorship, Ireland Canada University Foundation, ICUF (2016). Prof Fahey was visiting Professor to the Departments of Family Medicine at the University of Toronto and the University of British Columbia.
Dr Deborah Wallace **Health Research Award**	Dr Wallace was awarded the Barbara Knox Medal for Research from the Irish College of Ophthalmologists
Dr. Denis O'Mahony **Research Project Grant**	Enterprise Ireland Life science & Food Commercialisation Award in recognition of the successful creation of the spin-out company, Clinical Support Information Systems (CSIS), created for the purpose of commercialising the STOPP/START software prototype created by the UCC STOPP/START research team (Dr Denis O'Mahony, Prof. Stephen Byrne, Prof. Cormac Sreenan, Dr. Ken Brown, Dr. Cristin Ryan and Mr Sean Og Murphy). The award was made to the UCC research team in October 2011 at Enterprise Ireland's annual 'Big Ideas' research showcase in Dublin in October, 2011.

6. Collaborations and partnerships

The development of collaborations and partnerships with national and international researchers, charities, policy makers and health bodies is an important indicator of the quality and potential future impact of HRB-funded research. The development of collaborations is also vital to enable leveraging of research funding.

Summary of research collaboration and partnership outputs, compared to 2012/2013, 2010/2011 and 2008/2009 reporting periods

Research collaborations and leveraged funding	2014/2015 (N=198 grants)	2012/2013 (N=134 grants)	2010/2011 (N=196 grants)	2008/2009 (N = 204 grants)
Research collaborations and partnerships				
Total no. new collaborations	413	278	415	384
% of new collaborations with health bodies	18.6%	14%	10%	NA
Further funding leveraged				
No. additional research awards	180	149	113	117
Total value of leveraged funding	€41.8 M	€39.5 M	€34.8 M	NA*
Amount leveraged per Euro of HRB investment	€0.76	€0.89	€0.64	NA

Key Finding

Collaborations and partnerships

- 72% of HRB grant-holders reported the establishment of 413 new collaborations or partnerships during the lifetime of their HRB grant, which is considerably higher than the 48% of MRC award recipients who reported on this metric in the same reporting period. However, the number of collaborations established on average by award was 2.9 for HRB awards and 5.8 awards that established at least one collaboration.
- Almost three quarters of all collaborations reported were those involving an academic researcher, either in Ireland or based overseas.
- There were a significant number of collaborations established with health bodies who were either policy-focused or service delivery-focused, health charities or voluntary and community groups. The proportion of collaborations established with health bodies increased from 10% of total new collaborations in 2010/2011 to 19% of total new collaborations in 2014/2015.
- The most popular reason for collaborating with academic or industry partners was to gain access to infrastructure, materials, cohorts and datasets, followed by sharing of data, expertise and research findings and networking.
- There was an average productivity of 7.6 collaborations per €1 million spend. However, the number and cost of collaborations varied widely depending on the grant type and broad research area.
- Awards categorised as Applied Biomedical Research, Clinical Research and Health Services Research were most likely to establish both national and international academic collaborations and collaborations with national health service providers.

Leveraged funding

- 41% of PIs secured 180 additional awards in 2014/2015, with a combined total value of €41.8 million, which was an increase of over €2 million on the 2012/2013 reporting period. Per euro of HRB investment this accounts for €0.76 leveraged funding.
- The 2014/2015 figure compares well with the equivalent metric for UK MRC researchers, who reported instances of further funding in 47% of awards.
- Almost 45% of leveraged funding came from non-exchequer sources in Ireland and oversees such as the EU, charities and industry.
- Project Grants accounted for 69% of all leveraged awards, and 70% of the total amount leveraged, which represented a return on investment of €1.13 million for every €1 million spend on this grant type.
- Over half (54%) of all leveraged funding was associated with Applied Biomedical Research awards and a further 28% was associated with Clinical Research awards - these broad research areas also accounted for the highest return on investment in terms of leveraged funding.
- Nine grant-holders had secured follow-on technology development or commercialisation grants from Enterprise Ireland.
- Health Services Research awards also leveraged more funding from EU Framework programmes (FP6 and FP7) than either Clinical Research or Applied Biomedical Research.

6.1 Development of research collaborations

From the 198 completed grants analysed in 2014/2015, 144 grant-holders (72% of total) reported the establishment of 413 new collaborations or partnerships during the lifetime of their HRB grant. This is considerably higher than the 48% of MRC award recipients who reported the establishment of collaborations in the same reporting period. However, the way in which this question is asked by the MRC is slightly different, in that they require tangible evidence (e.g. co-publication, co-funding.) which may account for a lower reporting rate than the HRB. A more interesting comparison is the number of collaborations established on average by award. For the MRC the average number of collaborations per award that established at least one collaboration was 5.8, while for the HRB it was 2.9 collaborations.

6.1.1 Bibliometric indicators of collaboration

The Bibliometric Analysis of HRB publications 2013-2016 (of which the publications in this report form a subset) indicated that for both HRB and its benchmark units, the largest share of publication output resulted from international collaboration, at around 50% to 60%. For HRB funded internationally co-authored papers, there has been a steady upward trend over time and such papers have risen from 33.8% (2000-04) and 43.8% (2008-12) to 48% of all HRB publications in the 2013-16 publication period.

The proportion of publications resulting from national collaboration or from no collaboration outside of the authors' institution differs per benchmark unit. For the HRB, both publication types had more or less an equal share (around 25%). This was also the case for UK MRC (though the share is lower, around 20%). There was strong collaboration between Irish institutions and university hospitals, and with institutions worldwide, that have resulted in co-authored publications.

6.1.2 Distribution by types of collaborations

A breakdown of the 413 new collaborations reported on, by type of collaboration, is provided in Figure 6.1. As can be seen, almost three quarters (72%) of all collaborations reported were those involving an academic researcher, either in Ireland or based overseas.

Many researchers also sought to collaborate in some way with industry partners, either national or international (N=58). It should be noted that 'international' in terms of company description refers to the type of company, for example a multinational company based either in Ireland or elsewhere, while 'national' in this sense refers to Irish-owned companies.

The number of industry collaborations, as a proportion of all collaborations established was less than the figure reported from grants ending in 2012/2013, from 31% to 12%. This reduction brings it more in line with the 2010/2011 reporting period when 8% of new collaborations were with industry, suggesting the high proportion of industry collaborations in 2012/2013 was an anomaly rather than an emerging trend. In that reporting period, a number of Translational Research Awards completed, which contributed to this high number.

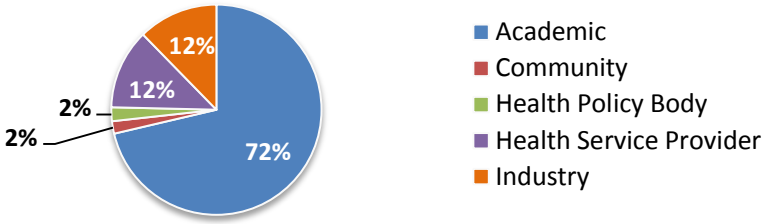


Figure 6.1: Breakdown of collaborations formed by HRB-funded researchers by type

Given that the HRB seeks to have an impact on policy and practice, it was good to note that there were a significant number of collaborations established with health bodies who were either policy-focused or service delivery-focused, health charities and voluntary and community groups. The proportion of collaborations established with health bodies increased from 10% of total new collaborations in 2010/2011 and 14% in 2012/2013 to 19% of total new collaborations in 2014/2015.

6.1.3 Purpose of collaborations

Researchers were also asked about the aim of their collaboration with another group or organisation. Figure 6.2 sets out the reasons cited (there could be more than one reason selected). Of the aims reported, the most popular reason for collaborating was to gain access to infrastructure, materials, cohorts and datasets, which was 37% of the total response. 25% of the response cited undertaking joint research with academic or industry partners as their reason for collaborating. Sharing of data, expertise and research findings and networking were also important aims of collaboration with academic and industry partners, accounting for 25% and 13% of the total response respectively. For collaborations established with health bodies undertaking joint research with academic or industry partners was the most important aim, accounting for 21% of collaborations.

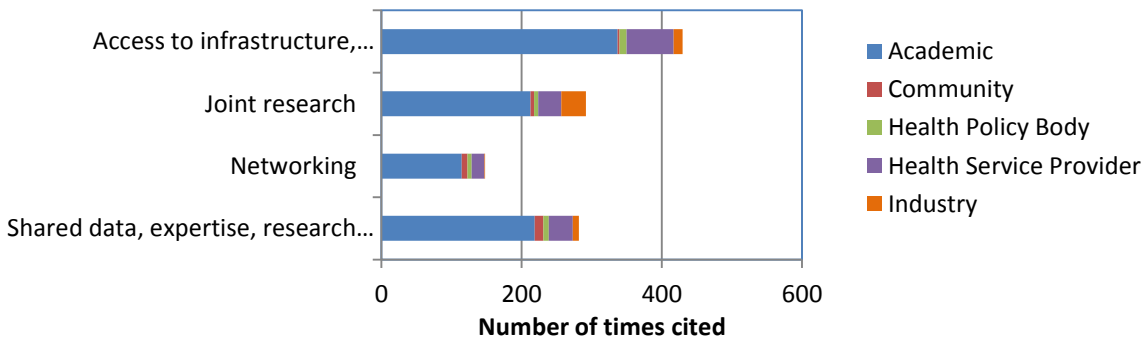


Figure 6.2: Cited reasons for establishing a new collaboration

6.1.4 Distribution of collaborations by grant type

The Bibliometric Analysis of HRB publications 2013-2016 (of which the publications in this report form a subset) found that the grant type 'Capacity-building & Leadership' had the largest share of publications resulting from international collaboration. At the same time, this grant type's share of non-collaborative publications was lower than the share of such publications at the aggregate level of the HRB, while publication output within the boundaries of the same country was similar to the HRB's share of national collaboration. International co-authored publications arising from 'Co-funded Awards' (which includes MRCG Co-funded awards had citation scores of over twice the world average (2.22). For 'Infrastructures & Networks' non-collaborative publications yielded the highest citation impact (2.23), well over twice the world average, while internationally co-authored publications had an MNCS that was lower than the HRB aggregate, and just slightly above world average.

Analysis of collaboration activity by grant type for the 196 awards analysed for this report is presented in Figure 6.3. Overall, there was an average of 2.1 collaborations established per award, an identical figure to the 2012/2013 reporting period. This relates to an overall average productivity of 7.6 collaborations per €1 million spend. However, the number and cost of collaborations varied widely depending on the grant type.

Project grants accounted for over two thirds of all collaborations reported in 2014/2015 (68% of total), with 11 collaborations established per €1 million spend. Fellowship Awards accounted for 17% of the total number of collaborations, and in terms of productivity were similar to Project Grants, with 10 collaborations per €1 million spend. Programme Grants were considerably less productive, producing an overall average of only 2 collaborations per €1 million spend.

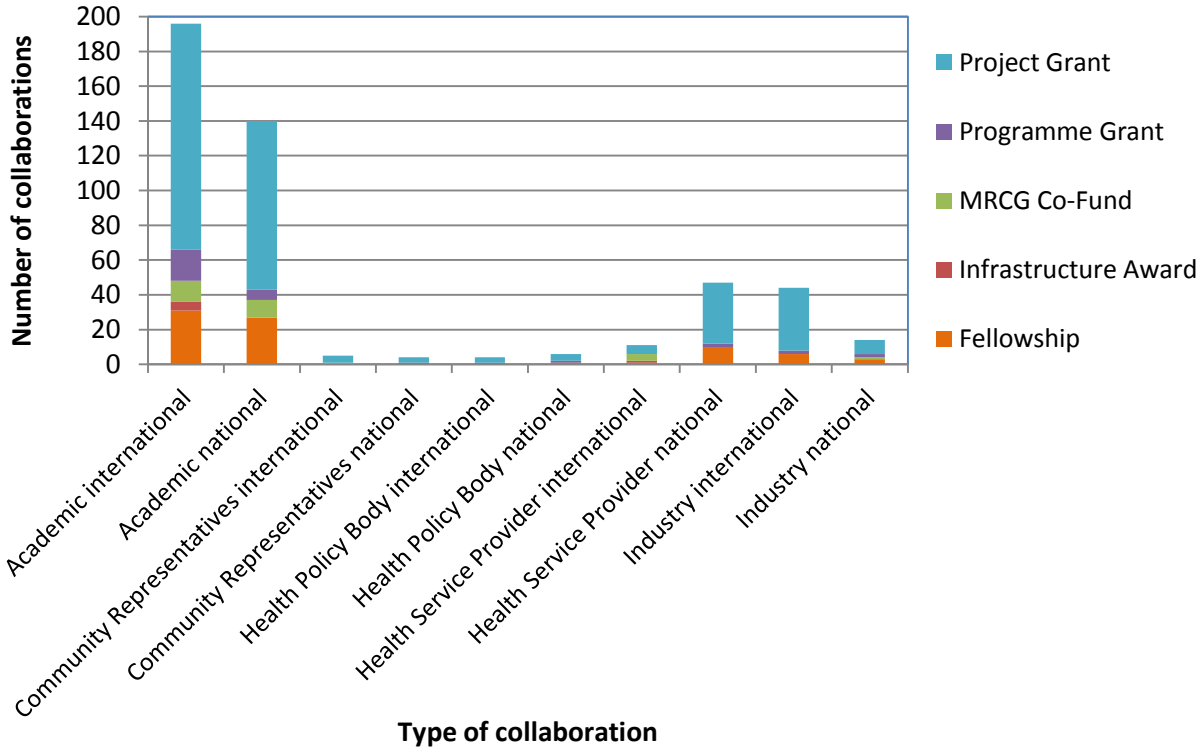


Figure 6.3: Type of collaboration established by grant type

The four Infrastructure Awards were the least productive in terms of forming collaborations, producing seven collaborations, or one collaboration per €1 million spent. The most productive grant type was the MRCG Co-fund, which produced 12 collaborations per €1 million spend. 22 of the 27 MRCG collaborations

were with academic partners, both national and international, while the majority of the remaining seven collaborations were with international health service providers.

6.1.5 Distribution of collaboration by broad research area

Figure 6.4 looks at type of collaboration established by broad research area. From this it is evident that awards categorised as Applied Biomedical Research, Clinical Research and Health Services Research were most likely to establish both national and international academic collaborations (261 collaborations) and collaborations with national health service providers (55 collaborations). Unsurprisingly, collaborations with health policy bodies and community representative organisations were most prevalent for awards categorised as Population Health Sciences and Health Services Research awards (13 collaborations). In terms of industry collaboration, awards almost exclusively categorised as Applied Biomedical Research and Clinical Research sought these collaborations (57/58 collaborations).

The Bibliometric Analysis of HRB publications 2013-2016 indicated that publications arising from the broad research area of Health Services Research and Clinical Research had the highest citation impacts of non-collaborative publications, with values well above world average.

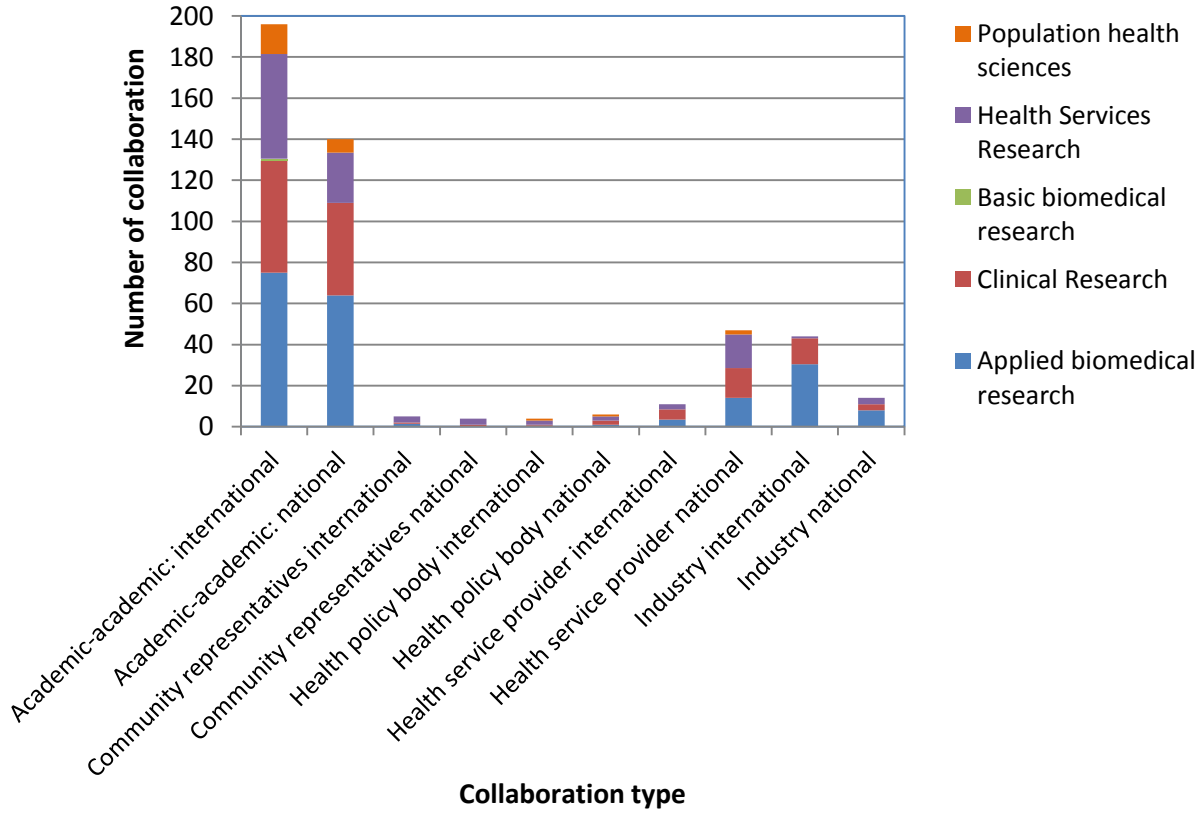


Figure 6.4: Type of collaboration established by broad research area

6.2 Further funding leveraged

In the case of HRB grants that completed in 2014/2015, 180 additional awards were obtained on the back of research findings derived in whole or part from the original HRB grant. This was an increase on the 149 additional awards secured by HRB grant holders in the 2012/2013 reporting period. The combined total value of these leveraged awards was €41.8 million, which was an increase of over €2 million on the €39.5 million leveraged by grant holders in the 2012/2013 reporting period. Per euro of HRB investment this accounts for €0.76 leveraged funding. Almost €24.6 million came from Irish exchequer sources such as the HRB, SFI and Enterprise Ireland, while €17.1 million came from non-exchequer sources in Ireland and oversees such as the EU, charities and industry.

Table 6.1 shows the number and value of these 180 leveraged awards according to their funding source, nationally and internationally, while Table 6.2 compares leveraged funding sources across reporting periods. In terms of EU and other collaborative awards, funding may have been awarded on the basis of participation (rather than primary leadership) of the PI within a wider research consortia, and the amounts shown in these cases reflect the allocation to the PI, as opposed to the total value of the award.

Table 6.1: Number and value of awards leveraged by HRB-supported researchers

	Amount leveraged (€)	Number	% of total output	Average value (€)
Exchequer				
HRB	€11,570,015.50	42	27.7%	€275,476.56
Science Foundation Ireland	€11,154,158.00	32	26.7%	€348,567.00
IRCSET/IRC	€1,348,515.00	18	3.2%	€74,917.50
Enterprise Ireland	€541,149.00	9	1.3%	€60,127.67
Non-Exchequer				
EU Framework Programmes	€4,474,408.00	8	10.7%	€559,301.00
EU Other	€3,667,851.00	5	8.8%	€733,570.00
Charity: National	€3,400,661.00	17	8.1%	€200,038.88
Other: National	€2,542,994.00	17	6.1%	€149,587.88
Charity: International	€1,106,247.00	9	2.6%	€122,916.33
Other: International	€1,093,348.00	10	2.6%	€109,334.80
Industry: International	€479,800.00	7	1.1%	€68,542.86
Philanthropic	€325,000.00	3	o.8%	€108,333.33
Industry: National	€54,800.00	3	0.1%	€18,266.67
Total	**€41,758,946**	**180**	**110%**	**€231,994**

Overall, 41% of PIs were successful in securing additional funding on the back of their HRB award that completed in 2014/2015, an increase from 35% in 2012/2013 and comparable to the 42.5% reported for the 2010/2011 reporting period. The 2014/2015 figure compares well with the equivalent metric for UK MRC researchers, who reported instances of further funding in 47% of awards. However, MRC researchers reported an average number of instances of further funding, for researchers who reported further funding, of 4.33, while for the HRB the average number of instances was 2.25.

In terms of non-exchequer funding, EU Framework programmes and other international sources of funding accounted for almost half of this type of funding (47.5%). Given that the HRB has invested considerable resources in promoting, encouraging and helping Irish health Researchers to participate in European funding programmes, this proportion not surprising.

Table 6.2 illustrates the breakdown of funding leveraged by grants completed in 2014/2015 in comparison to those which ended in 2012/2013 and 2010/2011.

Table 6.2: Funding leveraged by grants completed in 2014/2015 in comparison to 2012/2013 and 2010/2011

	2014/2015	2012/2013	2010/2011
Exchequer			
HRB	€11,570,015	€10,804,174	€6,448,756
Science Foundation Ireland	€11,154,158	€5,603,990	€12,669,935
Enterprise Ireland	€1,348,515	€671,927	€515,326
IRCSET/IRC	€541,149	€626,127	€540,108
JPI (HRB/SFI funding)	0	€90,000	
Teagasc	0	€88,000	
IBTS	0	0	€300,000
Non-Exchequer			
EU Framework Programmes	€4,474,408	€13,916,028	0
Other National	€2,542,994	€2,677,343	€443,411
Charity International	€1,106,247	€1,319,366	€716,271
Other International	€1,093,348	€1,155,509	€1,772,659
Charity National	€3,400,661	€954,711	€3,703,952
Medical Research Council UK	0	€719,000	0
Industry: National	€54,800	€587,579	€791,823
Philanthropic	€325,000	€130,000	0
European Research Council	0	€80,000	0
EU Other	€3,667,851	0	€6,681,534
Industry: International	€479,800	€55,180	€184,000
Total	**€41,758,947**	**€39,478,934**	**€34,767,775**

6.2.1 Distribution of leveraged funding by grant type

The number of successful applications for funding, distributed by grants type is shown in Figure 6.5, while the value of awards leveraged as a percentage of the total additional funding secured and per €1 million spend are shown in Figure 6.6. These figures should be interpreted with caution as some grant-holders may not yet have submitted applications for further funding by the end-of-grant stage.

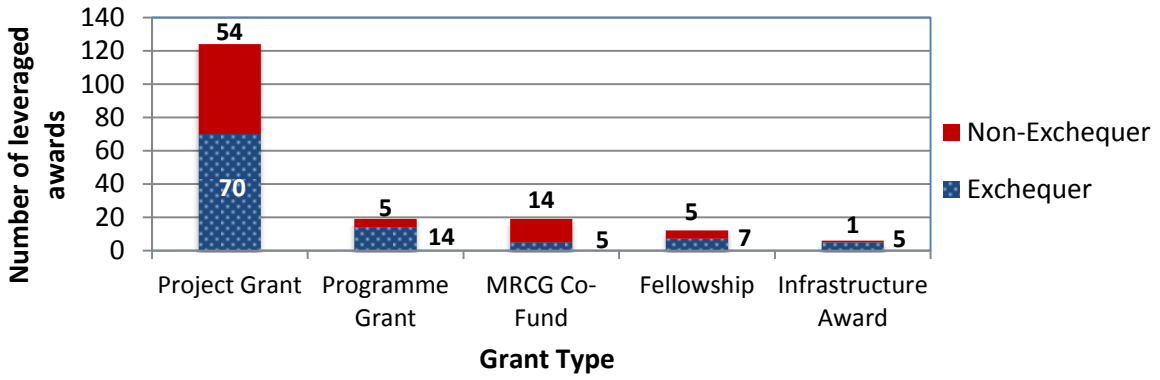
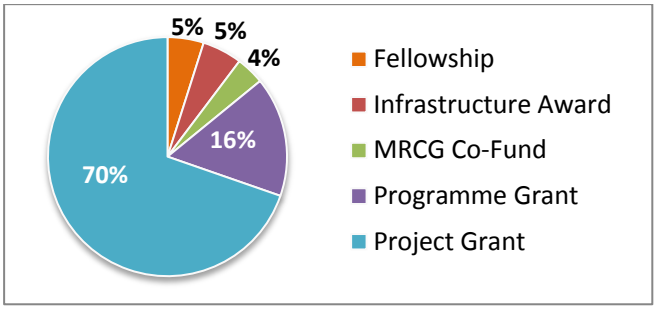


Figure 6.5: Number of leveraged awards (Exchequer and non-exchequer) by grant type

Project Grants were very successful in leveraging additional funding, from both exchequer and non-exchequer sources, and accounted for 69% of all leveraged awards, and 70% of the total amount leveraged. This represented a return on investment of €1.13 million for every €1 million spend on this grant type. Programme Grants accounted for 11% of the total number of leveraged awards, and represented 16.2% of the total value of leveraged awards. This represented a return on investment of only €460K per €1 million spent. The size of these awards varied hugely from €2K for a HRB Summer Research Scholarship to €1.75 million for an EU FP7 award (as part of a €5.94 million award).



Value (€) of leveraged awards secured per €1 million spend	
Project Grant	€1,132,549
MRCG Co-Fund	€721,113
Programme Grant	€460,487
Infrastructure Award	€415,620
Fellowship	€294,121

Figure 6.6: Leveraged awards broken down by grant type and amount leveraged per €1 million spend

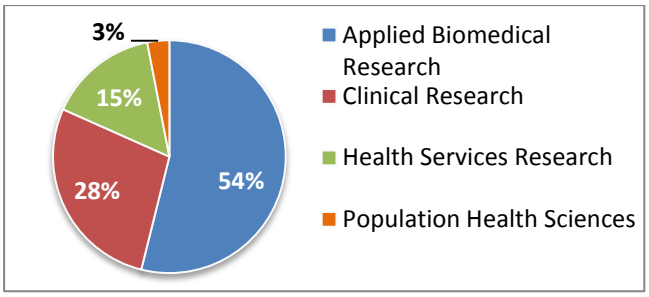
6.7% of the total leveraged funding was awarded to Fellowship holders (N=12) - this was a reduction from the 12.1% reported by Fellowship Awards that completed in 2012/2013 and brings the figure back in line with the metric of 7% in the 2010/2011 reporting period. However, these awards accounted for 4.9% of the total value of leveraged awards, or a return on investment of €294K for every €1 million spend, which is an increase from the 3% of total value or €117K per €1 million spend reported in the 2012/2013 reporting period.

The value of individual leveraged awards varied greatly, from €15K for a charity award for diabetes research, to €1 million for an AMBER Centre Award. The Infrastructure Awards reported 6 leveraged awards, which accounted for 5.4% of the total value of the leveraged awards, represented a return on investment of €416K per €1 million spend. The value of funding leveraged by individual Infrastructure Grants varied from €90K for a HRB Cochrane Fellowship to €630K for a HRB Primary Care Clinical Trials Network Ireland Award. Holders of MRCG Co-fund awards reported securing 19 additional awards, valued at 3.8% of the total value of leveraged awards. This represented a good return on investment of €721K for every €1 million spend on this grant type.

6.2.2 Distribution of leveraged funding by broad research area

Figure 6.7 looks at the amount of leveraged funding obtained by broad research area and its value per 41 million spend, while Figure 6.7 looks at the distribution of funding sources across the broad research areas. These figures should be interpreted with caution as some grant-holders may not yet have submitted applications for further funding by the end-of-grant stage.

From Figure 6.7 it can be seen that over half (54%) of all leveraged funding was associated with awards classified as Applied Biomedical Research and a further 28% was associated with Clinical Research awards. Awards in these broad research areas also accounted for the highest return on investment in terms of leveraged funding, with Applied Biomedical Research and Clinical research yielding €810k and 764k of leveraged funding per €1 million spend, respectively. Awards classified as Health Services Research and Population Health Sciences, although they only accounted for 15% and 5%, respectively, of the total amount of leveraged funding, were, nonetheless only slightly less productive in terms of the amount of funding leveraged per €1 million spend on these broad research areas.



Value (€) of leveraged awards secured per €1 million spend	
Applied Biomedical Research	€810,677
Clinical Research	€764,081
Health Services Research	€711,527
Population Health Sciences	€621,065

Figure 6.7: Leveraged awards broken down by broad research area and amount leveraged per €1 million spend

From Figure 6.8 it can be seen that HRB funding was leveraged across all broad research areas, while SFI leveraged funding was confined to Applied Biomedical and Clinical Research. In fact, Applied Biomedical and Clinical Research awards did well in leveraging funding across a range of exchequer and non-exchequer sources nationally and internationally.

Health Services Research awards also leveraged funding from a range of national and international sources, with the exception of SFI, which is not surprising given the more biomedical orientation of SFI. Awards classified as Health Services Research did particularly well in leveraging funding from the HRB, charity, philanthropic and EU schemes. Leveraging of funding from Population Health Sciences awards was confined to the HRB, small national agencies and industry (but only where there was a clinical component to the research.) Interestingly, Health Services Research awards also leveraged more funding from EU Framework programmes (FP6 and FP7) than either Clinical Research or Applied Biomedical Research.

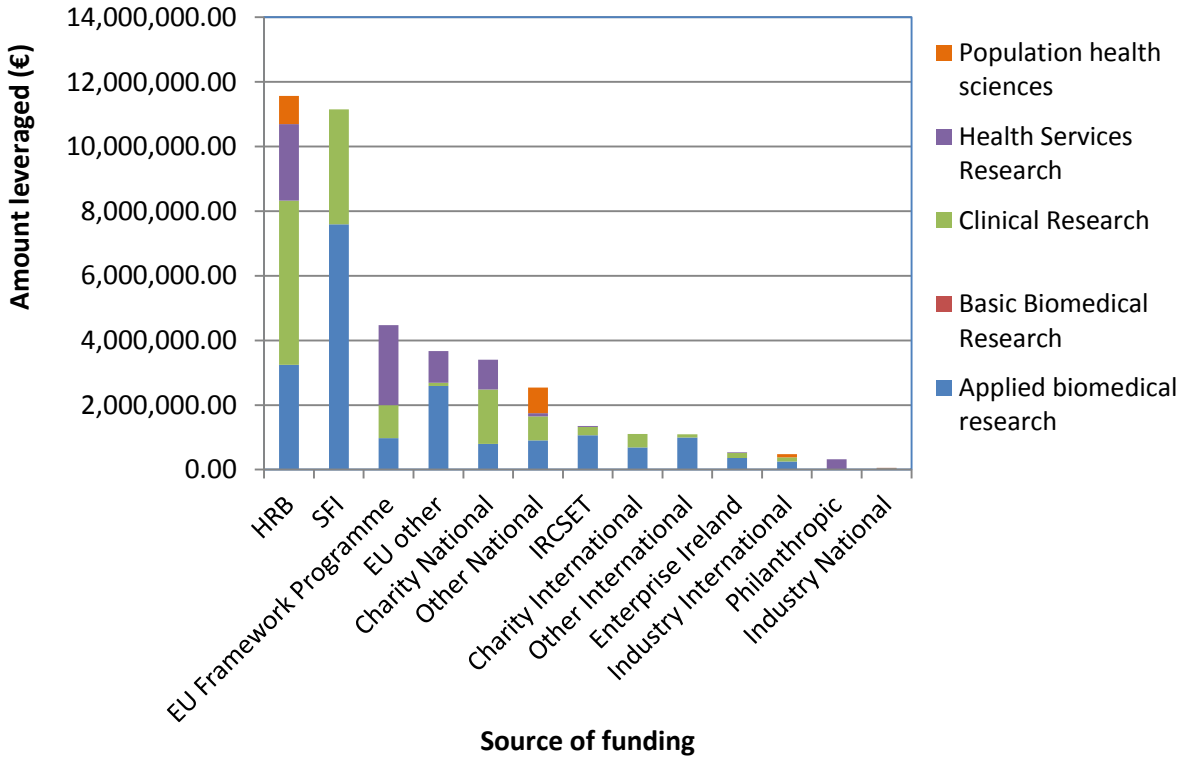


Figure 6.8: Source of funding broken down by broad research area

6.2.3 Examples of leveraged funding

Table 6.3 provides examples of the type of leveraged funding secured by awards that completed in 2014/2015.

Table 6.3: Examples of leveraged awards

Grant	Details of additional grants leveraged
MRCG Co-fund award	1. HRB €100,000; Ignoring the nonsense: Personalized medicine for genetic lung disease 2. IRCSET €87,000; Irish Research Council PhD Studentship to Mr. Paul Loftus. EBPPG/2014/109 "Examining the role of a novel stromal cell protein CD362/Syndecan-2 in the breast tumour microenvironment."
Postdoc Fellowship in Translational Medicine	1. SFI €124,672; Novel biomarkers for early diagnosis of diabetic nephropathy 2. IRCSET €96,000; Promoting resolution of renal inflammation 3. HRB €330,000; Sodium Intake in Chronic Kidney Disease (STICK): A Randomised Controlled Trial.
Translational Research Award	1. Enterprise Ireland €14,760; Validating a panel of serum biomarkers to inform surgical intervention for prostate cancer - Commercial Case Feasibility Support grant - Ref CF20130043Y 2. HRB €286,000; Ketamine for depression relapse prevention following electroconvulsive therapy: a randomised pilot trial 3. SFI €1,743,303; BCL-2 family proteins and cellular bioenergetics in the control of cell survival: Towards novel predictive and prognostic markers for disease progression and therapy responses in colorectal cancer patients 4. Other €70,000; TCIN Translational Neuroscience Award: A role for activation of the innate inflammatory response and the kynurenine pathway in the pathogenesis of depression and in the therapeutic response to ECT 5. HRB €99,920; Health Research Board Research Enhancement Awards 2012: Telomere length, depression and ECT - an enhancement award to The EFFECT-Dep Study: enhancing the effectiveness of electroconvulsive therapy in severe depression and understanding its molecular mechanism of action
Health Research Award	1. EU Framework Programme €1,751,852; Development and clinical trials of a new Software ENgine for the Assessment & optimization of drug and non-drug Therapy in Older peRsons (acronym: SENATOR; grant agreement no. 305930) 2. EU Other €2,499,838; ERC Advanced Grant: A radical approach for improved glaucoma treatment (Oculus). 3. IRCSET €72,000; P2X7 receptor signalling in neonatal seizures 4. Other €64,500; DCU Daniel O'Hare Ph.D. Scholarship to Alan Harrison. 5. HRB €329,995; To validate the feasibility of targeting the interaction between key mitochondrial proteins, in order to generate novel therapeutics for the treatment of triple negative breast cancers 6. SFI €1,702,562; Profiling "immune signatures' predictive of outcome in Staphylococcus aureus infection: Advancing next generation vaccine design"- Offered
Research Project Grant	1. SFI €1,080,000; National Transgenic & Germ Free Facility

7. Influencing policy and practice

Translating research into improved policies and practices is a strategic driver for the HRB. This translation occurs in many different ways, but engagement – communicating and exchanging information and expertise – between researchers, the public and policymakers is crucial. Indicators that HRB supported researchers are working to achieve outputs and outcomes in this realm include:

- efforts to place research evidence such that it can contribute to the development of policy development and improvements in clinical practice
- contribution to the development of clinical guidelines

Summary of policy and practice outputs, compared to 2012/2013, 2010/2011 and 2008/2009 reporting periods

Health policy and clinical practice outputs/influences	2014/2015 (N=198 grants)	2012/2013 (N=134 grants)	2010/2011 (N=196 grants)	2008/2009 (N = 204 grants)
No. policy and practice outputs	105	127	99	84
% grants reporting policy and practice outputs	26.8%	38%	24%	20%
No. policy/practice outputs per €1 million spend	1.9	2.9	1.8	0.9

Key Finding

- PIs reported 105 policy and practice outputs from 53 grants or 27% of all analysed grants, which is similar to the 23% UK MRC grant holders who reported policy influences in 2014/2015.
- Although the percentage of grants reporting policy/practice outputs was slightly lower in 2014/2015 than in 2012/2013 (38%) the number of grants reporting policy and practice outputs continues to increase year on year.
- 54.3% of all outputs reported were presentation of finding to relevant stakeholders (policy makers, health managers etc.) through seminars, workshops and face-to-face meetings.
- The likelihood of a PI seeking to have a policy or clinical practice influence was strongly associated with the type of research being undertaken, with HSR, Population Health Sciences and to a lesser extent Clinical Research being the most productive in terms of outputs per €1 million spend.
- Results were cited in influential policy and clinical practice documents such as Clinical Guidelines, clinical reviews, policy documents, and government reports or had an influence on the training or education of health professionals or policy makers.

7.1 Health policy and practice outputs and influences

One of the HRB's core objectives is to encourage the uptake of evidence generated through HRB research investment in the development of policy and the improvement of clinical and public health practice. Therefore, a key metric in terms of assessing the potential impact of HRB-funded research relates to outputs and activities that have the potential to influence health policy, clinical practice and patient care. Researchers can ensure that the evidence generated by their HRB-funded research has the potential to influence policy and practice in many ways, including by:

- publication of reports, guidelines, policy briefs, handbooks and so on that are targeted at health policy-makers or practitioners
- interactions with research beneficiaries/users in health policy or clinical practice sectors (e.g. meetings, seminars hosted)
- advisory roles or expert group memberships (e.g. guideline committee, policy development group) instances of their HRB-funded research being cited in key clinical or health policy documents
- research findings being used to inform the education or training of health professionals or policy-makers

HRB grants holders would appear to be increasingly active in this regard. In total, PIs whose grants completed in 2014/2015 reported 105 policy and practice outputs from 53 grants or 27% of all analysed grants. This is similar to the 23% UK MRC grant holders who reported policy influences in 2014/2015.

Although the percentage of grants reporting policy/practice outputs was slightly lower in 2014/2015 than in 2012/2013 (38%) it is important to note that that the number of grants reporting policy and practice outputs continues to increase year on year.

7.1.1. Distribution of policy and practice outputs by type

Table 7.1 shows the breakdown of the reported policy/practice outputs and influences by sub-type in 2014/2015. From this it can be seen that a common approach by researchers to placing their research results in the policy and clinical practice spheres was to present their finding to relevant stakeholders (policy makers, health managers etc.) through seminars, workshops and face-to-face meetings. This approach accounted for 54.3% of all outputs reported. Researchers also participated in expert panels developing clinical guidelines or policy (7.6% of reports). Various forms of dissemination via specialist publications, policy reports and briefings, Cochrane reviews, newsletters, professional body websites or as submissions to consultation processes were also reported (20.1% of reports).

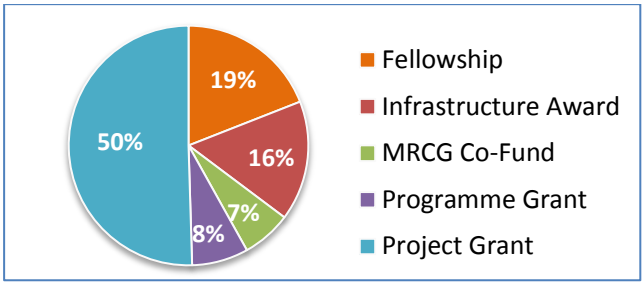
Table 7.1: Breakdown of policy/practice outputs and influences by type

Output/influences sub-categories	% grants
Hosted or presented research findings at a stakeholder seminar or workshop	27.6%
Meetings with policy makers, health managers, or other key users to present discussions/findings	26.7%
Produced practice or treatment guidelines or a policy report/ brief or booklet	11.4%
Coverage in specialised medical of healthcare publications	9.5%
Advisory role, or member of policy/guideline expert panel or working group	7.6%
Influenced training or education of health professionals and/or policy makers	6.7%
Submitted research to a national consultation process	4.8%
Research featured in newsletter, or on website, of a professional body	4.8%
Citation in Clinical Guidelines, Clinical Reviews or Systematic Reviews	1%

The results emerging from HRB-funded grants were cited in influential policy and clinical practice documents such as Clinical Guidelines, clinical reviews, policy documents, government reports (11.4% of reports) or had an influence on the training or education of health professionals or policy makers (6.7% of reports).

7.1.2 Distribution of policy and practice influences by grant type

In terms of the distribution of policy and practice outputs across grant type, Figure 7.1 shows that Project Grants accounted for 50% of all reported policy and clinical practice outputs, resulting in 2.1 outputs per €1 million spend. Fellowship Awards accounted for 19% of outputs reported, and were more productive (2.9 per €1 million spend) than Project Grants. Programme Grants accounted for 8% of reported outputs, and a productivity of 0.8 outputs per €1 million spend. This figure is a little surprising given that 54% of the Programme Grants were in the clinical or health research space. Unsurprisingly, given that they were exclusively in the clinical and health research space, the Infrastructure Awards report a high productivity for this metric, accounting for 16% of the total reported policy and practice output, at 3.1 outputs per €1 million spent.



No. of reported policy/practice influences per €1 million spend	
MRCG Co-Fund	3.2
Infrastructure Award	3.1
Fellowship	2.9
Project Grant	2.1
Programme Grant	0.5

Figure 7.1: Policy and practice outputs, broken down by grant type and number per €1 million spend

Finally, the MRCG Co-fund scheme was the most productive in terms of policy and practice outputs (3.2 per €1 million spend) even though the majority (96%) of MRCG Co-fund awards were categorised as Applied Biomedical Research, and might not be expected to have a focus on this metric. Unlike the information reported from grants completing in 2012/2013, the outputs reported were not exclusively participation in expert advisory groups and presentation of research findings at workshops and seminars, but also include coverage in medical publications and inclusion of results in the National Rare Disease Plan, which may be more likely to result in policy and practice changes.

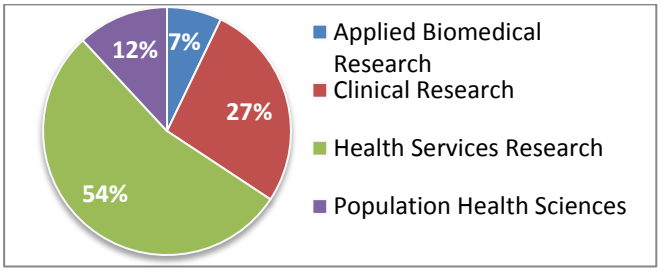
7.1.3 Distribution of policy and practice influences by broad research area

The likelihood of a PI seeking to have a policy or clinical practice influence will be associated to a large extent with the type of research being undertaken. Therefore, research in the clinical, population health and Health Services Research areas might be expected to be more productive in terms of attempting to influence policy or clinical practice.

This is verified in Figure 7.2, where these broad research areas accounted for 93% of all policy and clinical practice influences. However, this distribution was somewhat different when the number of outputs per €1 million spend was considered. Using this metric, Health Services Research-focused grants in particular had the highest number of outputs (5.6) per €1 million spend, although this was a slight reduction from the 6.6 outputs per €1 million reported by grants completing in 2012/2013. Awards classified as Population Health Sciences were only slightly less productive, accounting for 4.4 outputs per €1 million spend.

On the other hand, awards categorised as Applied Biomedical Research and Clinical Research, were considerably less productive when the number of outputs per €1 million spend was considered. This is not an entirely surprising result, since these types of awards would be more focused on outputs in the categories of knowledge production and capacity building, rather than in influencing policy and clinical practice. This is borne out by the statistics. Clinical Research awards accounted for 27% of total number of

outputs, but these amounted to only 1.6 outputs per €1 million spend, while Applied Biomedical Research awards accounted for 39% of all outputs but only 0.3 outputs per €1 million spend.



No. of reported policy/practice influences per €1 million spend	
Applied Biomedical Research	0.3
Clinical Research	1.6
Health Services Research	5.6
Population Health Sciences	4.4

Figure 7.2: Policy and practice outputs, broken down by broad research area and number per €1 million spend

There were no policy or practice outputs reported by the three grants classed as Basic Biomedical Research. Again, this suggests that the HRB's drive to move away from basic biomedical research towards patient-oriented, health services research and population health sciences is having an effect.

Figure 7.3 looks at distribution of policy and practice influence by type across the broad research areas. This compares levels of output (as a proportion of the total funding awarded) as opposed to numbers of outputs, to normalise comparison across different broad research areas.

Figure 7.3 shows that researchers on awards classified as Health Services Research used all mechanisms available to them, and in particular; hosting stakeholder workshops and seminars or presenting their research finding at such events, and meeting with policy-makers, health managers and other key service users to discuss the implications of their research findings. This latter mechanism was also the most popular mechanisms used to try and have an influence on developments in policy or clinical practice by researchers in Population Health Sciences, although they also used a broad range of mechanisms to a lesser extent. Researchers in awards classified as Clinical Research were most likely to produce policy and clinical practice guidelines, policy reports or policy briefings and to disseminate these to key service stakeholders through seminars and meetings.

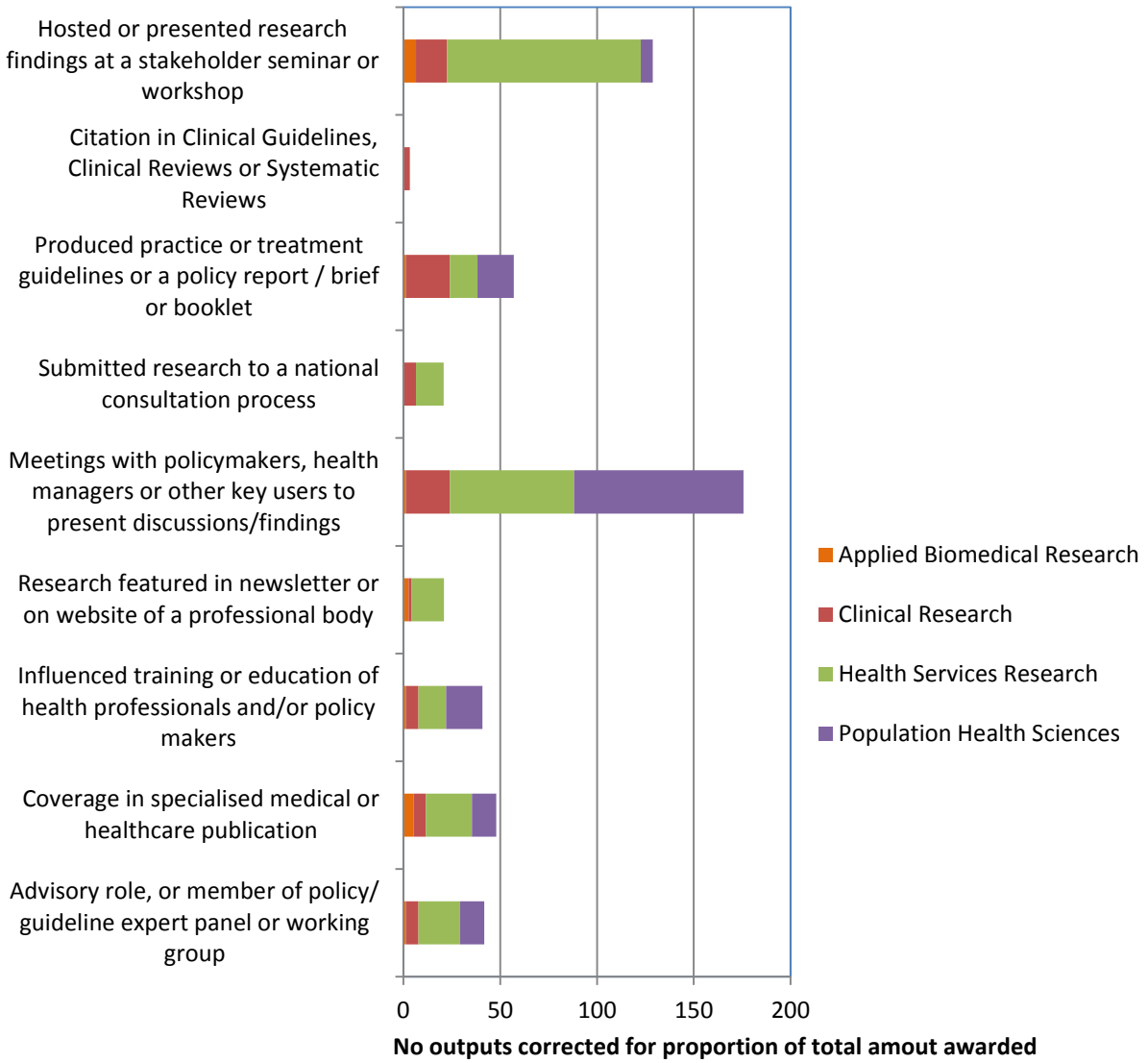


Figure 7.3: Policy and practice outputs per broad research area broken down by output type

7.1.4 Examples of policy and practice influences

Table 7.2 provides some examples of the type of policy and practice outputs reported for this metric by PIs whose grants completed in 2014/2015.

Table 7.2: Examples of policy and practice influences arising from HRB-funded awards

Grant Type	Type of policy and practice outputs	Details of policy/practice output
MRCG Co-fund Award	Advisory role or member of policy /guideline expert panel or working group.	Dr Lynch is a member of the working group of National Clinical programme for Rare Diseases since Jan 2014. One of the aims of this programme is to improve the education of Health Care Professionals.
Health Professional Fellowship	Submitted research evidence to a national consultation process	Secretary of the Cork Challenging Behaviour Working Group: Developed Cork city and county-wide guidelines for the Assessment and Management of Challenging Behaviour in Adult Inpatients in

Grant Type	Type of policy and practice outputs	Details of policy/practice output
		collaboration with other stakeholders from hospitals across Cork city and county (implemented May 2014). This work required discussion and collaboration between representatives from multiple clinical and non-clinical disciplines as well patient advocacy to ensure that the guidelines met the requirements of all future stakeholders.
MRCG Co-fund Award	Coverage in medical publication	An article highlighting the disease gene discovery research of Dr Lynch's group was published in the Irish Medical Times
ICE Award	Influenced training or education of health professionals and/or policy makers	The research contributes to the curricula for health professionals who receive their training at The National Cytopathology Training School at the Coombe Women and Infants University Hospital. To date 92 people have been trained through this facility.
KEDS Supplement	Meetings with policymakers, health managers or other key users to present/discuss findings	Prof Cannon's team met with the Minister for Mental Health, Kathleen Lynch, TD to brief her on their findings. She also attended the launch event and wrote the foreword to the Research Report. They also met Senator Averil Power and Martin Rogan, Assistant Director for Mental Health with the HSE to brief them on their findings.
Health Research Award	Published practice or treatment guidelines or standards	Update of STOPP/START criteria
Health Professional Fellowship	Hosted or presented research findings at a stakeholder seminar or workshop	Designed and delivered 2-day workshops for occupational therapists on addressing driving related issues in their clinical practice. These workshops were funded through the HRB Knowledge Exchange and Dissemination Scheme Grant (KEDS). The focus of the workshops was on the research evidence on assessing fitness to drive emerging from the findings of the HRB funded research (PhD study) and international research. The main focus of the 2-day workshops was to assist the therapists translate and apply the research evidence into their own clinical practice. The 2-Day workshop was repeated on three occasions in 2013 and 2014, with 122 occupational therapists from various practice areas across the country attending.

8. Engagement with patients and the public

Wider dissemination of research findings to non-scientific audiences is vital for improving the public understanding of science, for recruiting patients to clinical trials and engaging the public in the design and conduct of research, and for promoting the benefits and value of health research to non-scientific stakeholders. Such activities include:

- coverage of research in the national and international press
- presentations to lay audiences (general public, patient groups, school talks etc.)
- radio or television interviews relevant to their HRB-funded research; reference to their research in newsletters or online publications
- press releases describing significant research findings

Summary of policy and practice outputs, compared to 2012/2013, 2010/2011 and 2008/2009 reporting periods

Engagement with patients and the public - outputs	2014/2015 (N=198 grants)	2012/2013 (N=134 grants)	2010/2011 (N=196 grants)	2008/2009 (N = 204 grants)
No. broader dissemination activities	258	188	122	NA*
% PIs reporting broader dissemination activity	47.5%	50%	35%	NA
No. dissemination events per €1 million spend	4.69	4.6	2.2	NA

** Questions on engagement outputs were not included in the 2008/2009 survey*

Key Finding

- 47.5% of grant holders reported 258 public and patient engagement outputs which is slightly lower that the equivalent metric reported by UK MRC researchers of 59% in the 2012/2015 period, but represents a year on year increase in public and patient engagement activities by HRB researchers.
- Presentation of research findings to public and patient groups was the most popular medium, followed by dissemination in the print media.
- There was a significant increase in PIs reporting the issue of a press release describing their research, and a dramatic increase in the number of PIs using social media.
- MRCG Co-fund awards, while small in number, were very productive in terms of public engagement outputs per €1 million spend (15.4).
- Awards classified as Population Health Sciences and Health Services Research had the most engagement outputs per €1 million spend, at 8.9 and 7.3, respectively.

8.1 Patient and public engagement outputs

When asked if they had engaged in wider dissemination of their research to patients and the public through various fora, 47.5% of grant holders reported 258 outputs in this area. This is a slight decrease

(2.5%) on the percentage of grant holders reporting engagement in this type of activity from the 2012/2013 reporting period, however there is an increase of 37% in the number of engagement activities being reported. This figure is also slightly lower that the equivalent metric reported by UK MRC researchers of 59% in the 2012/2015 period.

8.1.1 Distribution of engagement outputs by type

Table 8.1 shows a breakdown of public/patient engagement outputs by type. From this it can be clearly seen that presentation to various stakeholder groups including school children was a popular form of communication, accounting for 32% of non-peer dissemination outputs reported by researchers. Publishing research in a newspaper, conducting an interview or issuing a press release were also popular forms of communications, accounting for a combined 32% of dissemination outputs reported by researchers.

Table 8.1: Breakdown of public and patient engagement activity by type

Type of activity	No. of outputs
Presentation to / interactions with patients, charities, advocacy groups or public	72
Coverage in local, regional or national general press	54
Press release issued on subject of HRB-funded research	30
Produced material (i.e. information booklet) for patients or the public	24
Radio or TV interview in Ireland	22
Social media coverage	16
Popular magazine feature or other popular media	15
School talk on subject of HRB-funded research	10
Interacted with school students	8
Radio or TV interview in another country	5
Coverage in international general press	2
Total	**258**

Table 8.2 illustrates the year-on-year increase of dissemination of scientific findings to patients and the public from 2010 to 2015. In the 2014/2015 reporting period, there was a swing from higher coverage in international press in 2012/2013 to higher levels of national coverage. There was also a significant increase in PIs reporting the issuing of a press release describing their research in 2014/2015. Unsurprisingly, there has been a dramatic increase in the number of PIs using social media, increasing from one social media activity reported in 2012/2013 to 16 reported in 2014/2015.

Table 8.2: Public and patient engagement activity - comparing 2012/2013 and 2010/2011

Type of activity	2014/2015	2012/2013	2010/2011
Presentation to / interactions with patients, charities, advocacy groups or public	27.9%	36.7%	34.1%
Coverage in local, regional or national general press	20.9%	16.5%	34.1%
Press release issued on subject of HRB-funded research	11.6%	8.5%	2.4%
Produced material (i.e. information booklet) for patients or the public	9.3%	13.3%	0
Radio or TV interview in Ireland	8.5%	6.4%	7.3%
Social media coverage	6.2%	0.5%	0

Type of activity	2014/2015	2012/2013	2010/2011
Popular magazine feature or other popular media	5.8%	5.9%	0
School talk on subject of HRB-funded research	3.9%	1.1%	0
Interacted with school students	3.1%	3.2%	0
Radio or TV interview in another country	1.9%	1.6%	0
Coverage in international general press	0.8%	6.4%	22%

Figure 8.1 shows the distribution of dissemination events reported by HRB grant holders according to the media type. In the same manner as grants that ended in 2012/2013, in 2014/2015 presentations to lay audiences (general public, patients/patient groups, school talks etc.) was by far the most popular method chosen to communicate with a wider audience, accounting for 28% of all reported outputs. However, HRB researchers were also very successful in getting their research covered in the print and broadcast media, which between them accounted for almost 32% of coverage. Just over 14% of reported dissemination was through references to their research in popular magazines and newsletters or via patient leaflets or brochures. The 'Other' category refers to interactions with school students, participation in science fairs and so on.

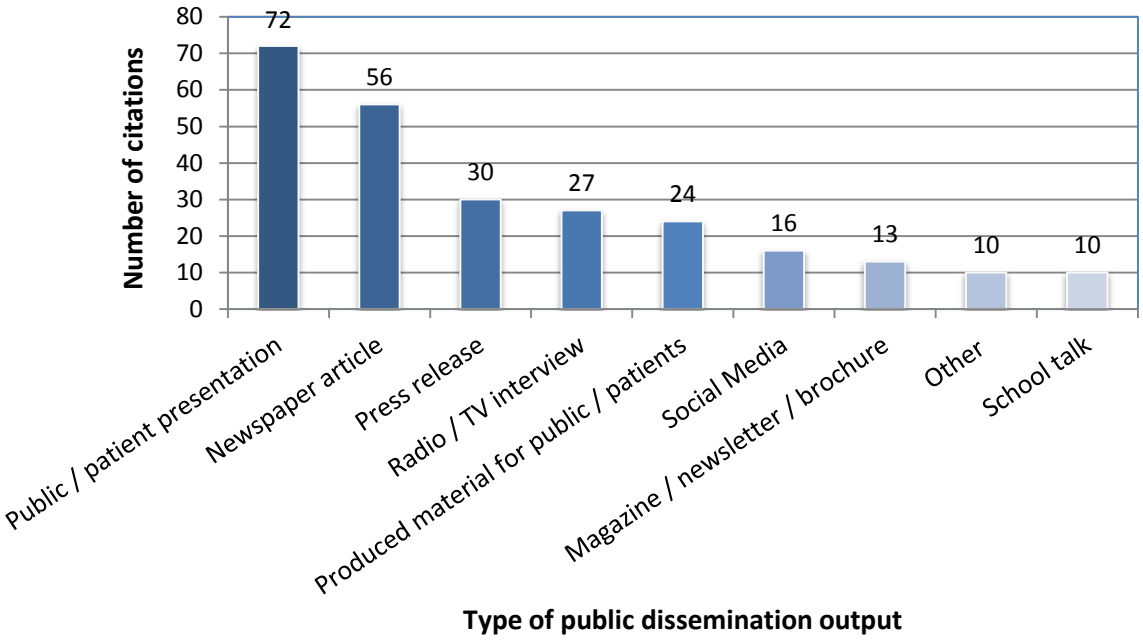
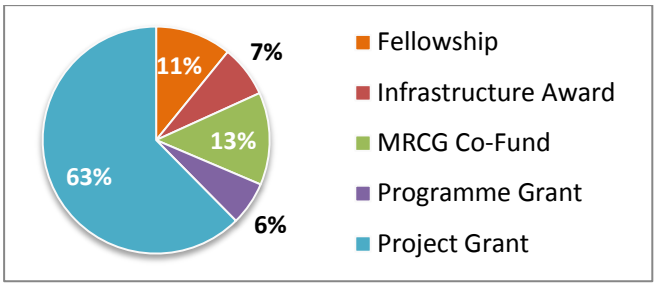


Figure 8.1: Breakdown of dissemination events by media type

8.1.2 Distribution of engagement outputs by grant type

The distribution of dissemination outputs broken down by grant type and outputs per €1 million spend is shown in Figure 8.2. Unsurprisingly given their nature, MRCG Co-fund awards, while small in number, were very productive in terms of public engagement outputs per €1 million spend (15.4), followed by Project Grant and Fellowship Awards holders, who were also active in disseminating their research findings to a wider audience, and accounted for 6.3 and 4 outputs per €1 million spend, respectively. The Infrastructure Awards were also reasonably active in disseminating research findings, reporting 3.5 outputs per €1 million spent. The Programme Grants were less productive with regards to wider dissemination, reporting 1.1 outputs on per every €1 million spent.



No. of reported public/patient engagement outputs per €1 million spend	
Fellowship	4.1
Infrastructure Award	3.5
MRCG Co-Fund	21.9
Programme Grant	1.1
Project Grant	6.3

Figure 8.2: Public and patient engagement outputs, broken down by grant type and number per €1 million spend

The distribution of dissemination outputs broken down by media type and by grant type is shown in Figure 8.3. The most common types of output overall were presentations of research findings to patient and public groups, and via broadcast and print media. Project Grant in particular used these methods to disseminate their research findings. Project Grant recipients were also the only ones to provide talk to school children about their work.

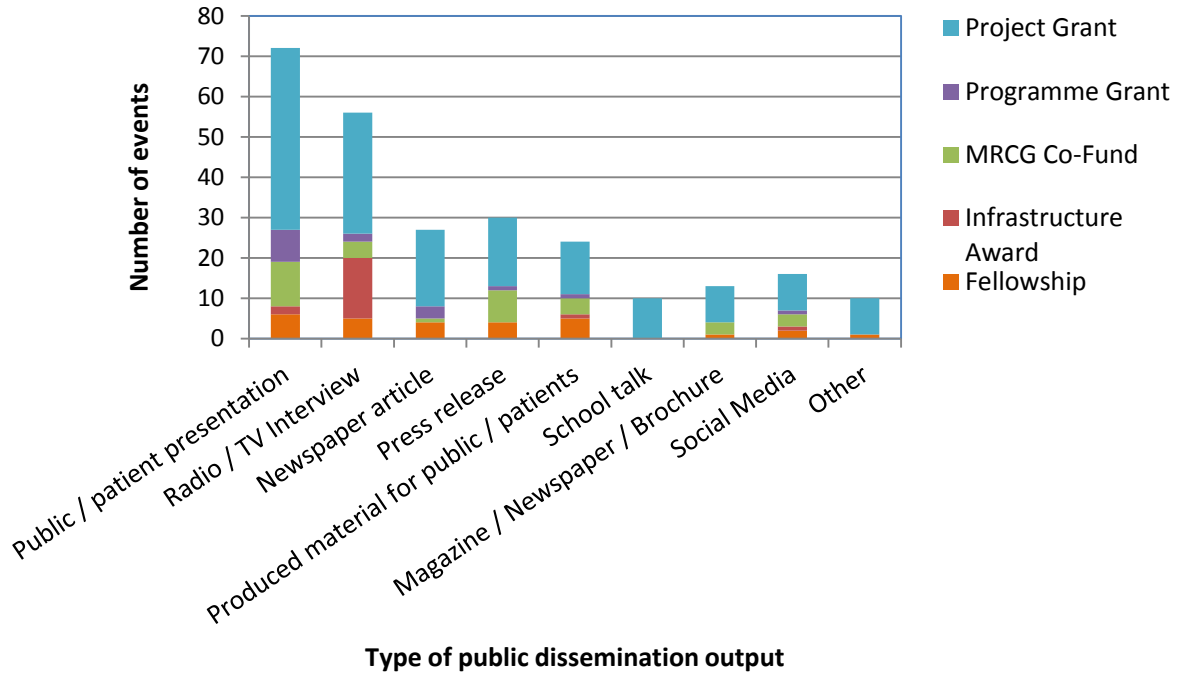


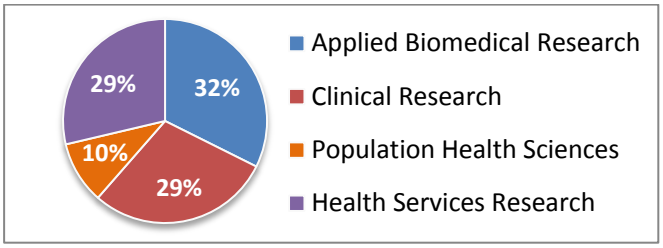
Figure 8.3: Public and patient engagement outputs broken down by media and grant type

8.1.3 Distribution of engagement outputs by broad research area

The percentage distribution of dissemination outputs and spend per €1 million investment across the broad research areas is shown in Figure 8.4, while the distribution of dissemination outputs broken down by media type and by broad research area is shown in Figure 8.5.

Figure 8.4 shows that the there was a similar number of dissemination outputs for awards classified as Applied Biomedical Research (32%), Clinical Research (29%) and Health Services Research (29%), with the remaining 10% of dissemination outputs associated with awards classified as Population Health Sciences.

In terms of productivity for this indicator however, awards classified as Population Health Sciences and Health Services Research had the most outputs per €1 million spend, at 8.9 and 7.3, respectively. Awards classified as Clinical Research and Applied Biomedical Research were somewhat less productive per €1 million spend, at 4.3 and 3.5 outputs, respectively.



No. of reported public/patient engagement outputs per €1 million spend	
Applied Biomedical Research	3.5
Clinical Research	4.3
Health Services Research	7.3
Population Health Sciences	8.9

Figure 8.4: Public and patient engagement outputs, broken down by broad research area and per €1 million spend

In terms of the type of dissemination outputs used by researchers, Figure 8.5 shows that presentation of research findings to public and patient groups was the most popular medium, followed by dissemination in the print media. Production of materials for lay readers and publication in popular media outlets (print, broadcast and social media) were also used by researchers across all broad research areas. School talks were used only be researchers associated with Applied Biomedical Research and Clinical Research.

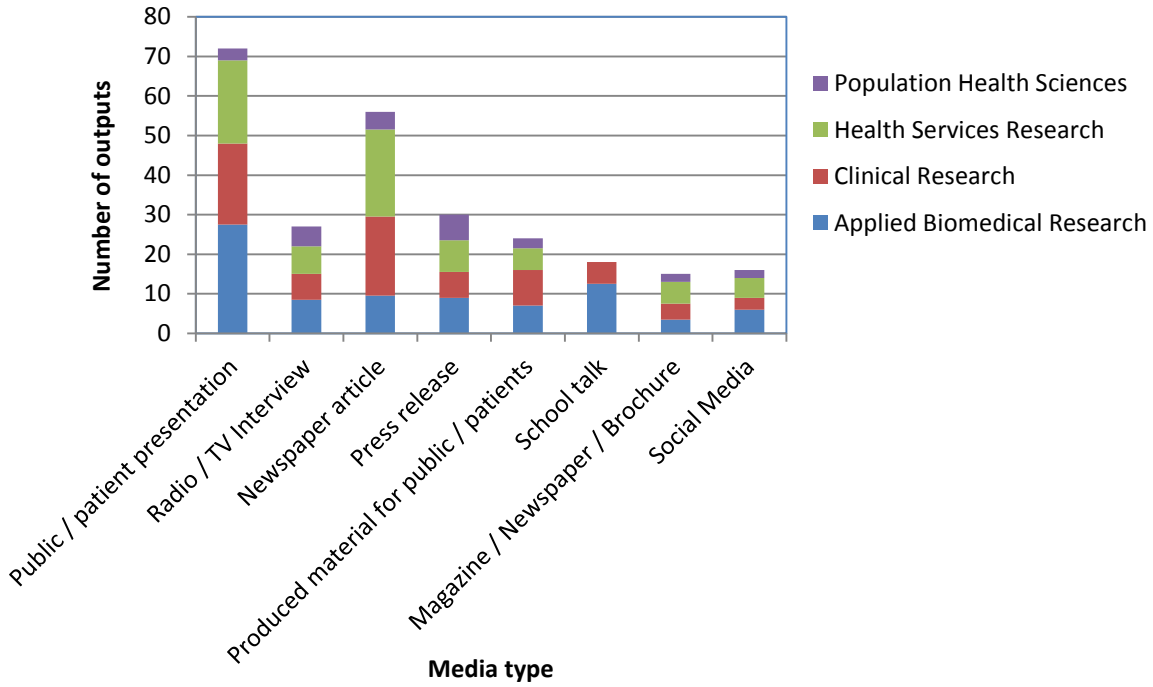


Figure 8.5: Engagement outputs broken down by media type and broad research area

8.1.4 Examples of public and patient engagement activities

Table 8.3 provides some examples of the type of public and patient engagement activity in which HRB funded PIs and their teams engaged in order to communicate the results of their research beyond the scientific community.

Table 8.3: Examples of public/patient engagement outputs arising from HRB-funded awards

Grant Type	Type of engagement	Description of engagement activity
KEDs Supplement	Social Media	On the day of the launch, the Twitter hashtag #youthpsychirl was trending on Twitter
Health Research Award	Coverage in Irish Press	Results obtained from this study were published in the journal PlosPathogen in 2015. This publication received significant media attention in the Irish Examiner, Drug Discovery & Development and MedicalXpress.
Health Research Award	Radio or TV interview in Ireland	There was widespread media coverage in the television, radio and print press of the research report launch. There were two live radio interviews, one on RTE Radio 1 Morning Ireland and one on East Coast FM. There were also radio sound bites on national and local radio news bulletins throughout the day. There was news footage on the RTE News at One, Six-One News and Nine O'clock News and on the Five-Thirty News on TV3. There was also a piece involving interviews about the data as a feature on Newstalk Radio's Global Village some weeks later.
KEDs Supplement	Interaction with School students	EPIDEMIC: Going Viral was a week long, summer workshop for 14 to 16 year-old students offered by the TCD, Biochemistry and Immunology Department and hosted at Science Gallery. The program equipped participants with insight into virology, immunity, infection and vaccination through game building, challenges, as well as opportunities for research and laboratory experiments.
Health Research Centre	Coverage in International press	Research into the epidemiology of malpractice claims was selected for press release by BMJ Open and received significant coverage internationally (particularly Northern America and Australia). The findings were covered by CNN and Fox news.
Health Research Award	Radio or TV interview abroad	One of the team was interviewed for Florida Psychiatric Association Podcast 'The Experts Speak' on Perceptions of Aging.
Health Research Award	School talk	The PI gave a talk to 4th, 5th and 6th year students in Nenagh College in April 2016 on her HRB funded research and the dangers of obesity. She also discussed career options for Biology Degree graduates.
Cochrane Training Fellowship	Social Media	Discussion with athletes and other international researchers via Twitter
Health Research Award	Press release	TCD Press release on physical activity report 'Walking 150 Minutes per Week Associated With Improved Wellbeing In Over-50s'. Featured in Irish Independent, Irish Health and Health Canal, linked to the launch of the National Physical Activity plan January 2016
Health Professional Fellowship	Produced material (i.e. information booklet) for patients or the public	Produced an information pamphlet regarding the diagnosis, prognosis and treatment options for Cardiac Syndrome X/Microvascular Angina that were made available to the public in all outpatient departments at CUH and MUH.
Health Research Award	Presentation to / interaction with patients, charities, advocacy groups or the public	Three dissemination events were hosted in Dublin, Tullamore and Cork. These events were co-hosted with two key disability organisations (1) Inclusion Ireland - a national advocacy organisation for people with intellectual disability and family members (2) the National Federation of Voluntary Bodies - the national organisation representing 62 intellectual disability providers nationwide. This is, the first time Inclusion Ireland and the National Federation of Voluntary Bodies have co-hosted events.
MRCG Co-fund	Press release	Press release on UCD website and in the School Newsletter

Grant Type	Type of engagement	Description of engagement activity
Award		revealing the inequity in EU rare disease research funding across Europe revealed in in the PI's paper
Health Research Award	Popular media	New Yorker Profile on the PI. Title: The *E. Coli* Made Me Do It Author: James T. Rosenbaum
Health Research Award	School talk	An interactive lecture/demonstration: "ImmuneWars: bugs and beyond" was developed to introduce the immune system and how it protects from infection, and an annual primary schools outreach program at TCD has been established. To date 158 children have been welcomed to TCD, an event at the Royal Dublin Society hosted 86 children, 2 primary schools (54 children) were visited, and the PI participates annually in Trinity Access Program Maths and Science Exploration Week.

9. Research tools, materials and methods

The development or application of novel research tools, materials, methodologies and/or technologies is an indicator of the extent to which HRB grant holders are advancing research within their field both nationally and internationally. They may include new biological models, biobanks and datasets, new techniques and so on. Although they are usually generated to advance the objectives of a specific project, they may be used more widely by other researchers and can facilitate new lines of enquiry or accelerate research in related fields.

Summary of research tools, materials and methods outputs, compared to 2012/2013, 2010-2011 and 2008/2009

Development of research tools, materials and methods	2014/2015 (N=198 grants)	2012/2013 (N=134 grants)	2010/2011 (N=196 grants)	2008/2009 (N=204 grants)
No. new material/methods developed	96	112	85 (2011 only)	NA
Avg. no. developments per €1 million spend	1.8	2.9	1.6	0.6

Key Finding

- One third of awards reported the development of one or more (up to five) novel tools, materials or methods wholly or partly as a result of their HRB grant, which is slightly higher than the MRC figure of 28% for this metric in 2014/2015, but is a decrease on the 2012/2013 HRB figures.
- The most common type of research tool, material or method developed was the accumulation of biological samples or a biobank, the development of a novel experimental assay or method, new databases or datasets or the development of a new or expanded cohort. This distribution is similar to previous reporting periods.
- Project Grants produced by far the highest number of novel materials or methods (80% of reports), and were the most productive in terms of outputs per €1 million spend (average 3.0).
- Awards classified as Applied Biomedical Research accounted for over half (57%) of all reported development of novel materials or methods.
- Health Services Research awards predominantly reported the development of cohorts, datasets and virtual infrastructure, while for Population Health Sciences awards the most commonly reported tools, materials or methods were assays, for example for genetic markers, epidemiological biobanks and training materials.

9.1 Development of novel research materials or methods

Of the 198 grants analysed in 2014/2015, 66 (33.3%) of grant holders reported the development of one or more novel research materials or methods wholly or partly as a result of their HRB grant. Of these, 16

reported more than one (up to 5) new research materials or methods. This is slightly higher than the 28% of reported research tools or methods reported by MRC researchers in 2014/2015, but are a decrease on the HRB 2012/2013 reported figure of 52%. However, this decrease may be representative of the increased funding of health services research and population health science, which are less likely to produce new materials and methods than biomedical research.

As shown in Table 9.1, the most common type of research material developed was the accumulation of biological samples or a biobank (n=25), followed by the development of a novel experimental assay or method (n=18). Novel database or dataset creation (N=13), followed by the development of a new or expanded cohort (N=11) were also highly cited. It was not possible to do a direct comparison between the HRB and the UK MRC of the type of research tool, material or methods used, as these are classified differently between the two agencies.

Table 9.1: Number of novel research materials/methods developed by type

Type of material/method developed	No. developed (HRB)
Biological samples/Biobank	25
Experimental assay or method	18
Database/ dataset	13
New or expanded cohort	11
Animal model of disease	7
Other	7
New or improved research infrastructure	6
Data analysis technique	4
Physiological assessment or clinical outcome measure	2
New research software	2
Total number of new research materials/methods	**96**

** MRC does not categorise novel tools, materials or methods in an identical manner*

Table 9.2 illustrates that the types of research materials and methods developed were similar between the 2012/2013 and 2014/2015 reporting periods with only two notable differences; a reduction in the number of new data analysis techniques from 13% of total new materials/methods in 2012/2013 to 4% in 2014/2015, and a reduction from 5.4% to 0 in the number of training protocols and manuals developed. However, as new training for health care professionals is captured under policy and practice outputs, this may reflect the HRB's shift from basic biomedical to patient oriented, population health sciences and health services research.

Table 9.2: Number of novel research material/methods developed by type – comparing 2014/2015, 2012/2013 and 2008/2009

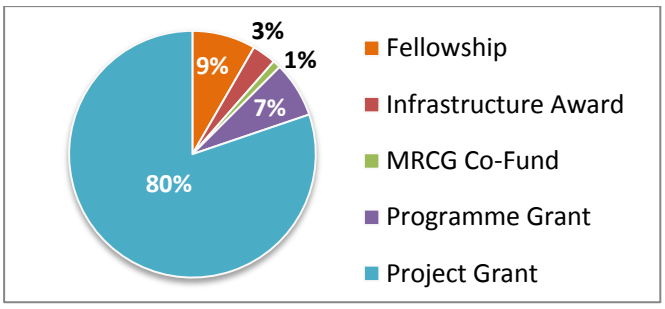
Type of material/method developed	2014/2015	2012/2013	2010/2011
Biological samples/Biobank	26%	16.1%	8.2%
Experimental assay or method	18.8%	15.2%	11.8%
Database/ dataset	13.5%	19.6%	17.6%
New or expanded cohort	11.5%	0	0
Animal model of disease	7.3%	6.3%	9.4%
Other	7.3%	0	0

Type of material/method developed	2014/2015	2012/2013	2010/2011
New or improved research infrastructure	6.3%	8%	8.2%
Data analysis technique	4.2%	13.4%	11.8%
Physiological assessment or clinical outcome measure	2.1%	8%	11.8%
New research software	2.1%	1.8%	8.2%
Physiological assessment or clinical outcome measure	1%	0	0
Training protocol, computer-delivered	0	5.4%	0
Structured education manual	0	3.6%	0
Management guidelines	0	1.8%	0
Application for Android tablet	0	0.9%	0
Computational model	0	0	7.1%
Cell Line	0	0	5.9%

9.1.1 Distribution of materials/methods by grant type

Figure 9.1 shows how the development of novel materials/methods was distributed across grant types and the number of novel materials/methods developed per €1 million spend overall per grant type. Project Grants produced by far the highest number of novel materials or methods (80% of reports), followed by Fellowship Awards (9%) and Programme Grants (7%).

The number of novel materials or methods developed per €1 million spend was also the highest for Project Grants, at 3.0 per €1 million spend while Fellowships resulted in 1.1 novel research materials or methods per €1 million spent.



No. novel materials/methods per €1 million spend	
Fellowship	1.1
Infrastructure Award	0.6
MRCG Co-Fund	0.5
Programme Grant	0.5
Project Grant	3.0

Figure 9.1: Novel material/methods broken down by grant type and number per €1 million spend

The MRCG co-fund scheme accounted for only 1% of reports on this metric, while Infrastructure Awards accounted for 3% of reports. However, all three were similar in terms of the number of novel materials or methods developed per €1 million spend (0.5/0.6). Given that Project Grants account for 67% of Biomedical Grants awarded, it is unsurprising that these produced the most novel research materials and methods.

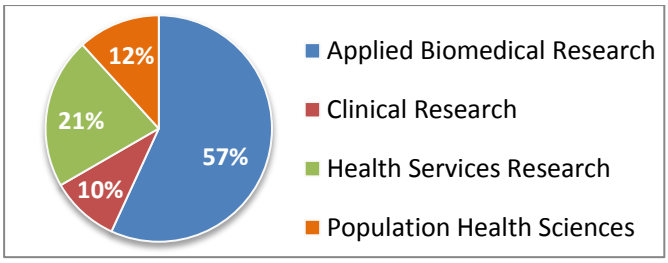
9.1.2 Distribution of materials and methods by broad research area

Figure 9.2 shows how the development of novel materials/methods were distributed across broad research areas and the number of novel materials/methods developed per €1 million spend overall per broad research area.

Awards classified as Applied Biomedical Research accounted for over half (57%) of all reported development of novel materials or methods. The most commonly reported materials and methods developed were biological samples/biobanks (13) or assays (11), with five PIs reporting the development of animal models of disease.

Awards classified as Clinical Research (or which had a Clinical Research component) accounted for one fifty of all reported novel tools, materials or methods developed. These predominantly included the development of assays (5), cohorts (5) and infrastructure (4). In this sense, infrastructure almost exclusively referred to development of virtual research infrastructures, such as European networks of researchers.

Health Services Research and Population Health Sciences awards reported similar number of novel tools, materials and methods. Unsurprisingly, awards classified as Health Services Research predominantly reported the development of cohorts, datasets and virtual infrastructure, while for Population Health Sciences awards the most commonly reported tools, materials or methods were assays, for example for genetic markers, epidemiological biobanks and training materials. No awards classified as Basic Biomedical Research reported the development of novel tools, materials or methods.



No. novel materials/methods per €1 million spend	
Applied Biomedical Research	3.0
Clinical Research	1.9
Health Services Research	1.5
Population Health Sciences	7.9

Figure 9.2: Novel material/methods broken down by broad research area and number per €1 million spend

While awards classified as Applied Biomedical Research might have accounted for a large share of novel materials or methods, Population Health Sciences was by far the most productive in terms of novel materials or methods developed per €1 million spend (7.9 as compared to 3.0 for Applied Biomedical Research). Clinical Research and Health Services Research had similar returns per €1 million spend (1.9 and 1.5, respectively.)

9.1.3 Examples of materials and methods developed

Table 9.3 provides some examples of the types of materials and methods developed or refined by HRB funded researchers whose awards completed in 2014/2015.

Table 9.3: Examples of the types of materials and methods developed from HRB-funded awards

Grant Type	Type of novel material/method	Description
Project Grant	Experimental Assay or method	Method for using tele-pathology to link expert pathologist annotation of tissue sections with laser capture micro dissection for proteomic analysis.
Project Grant	Biological samples/ Biobank	A biobank of brain tissue samples from Irish patients operated on for intractable temporal lobe epilepsy was developed.
Fellowship	Data analysis technique	It was demonstrated that an established practice in previous economic evaluations of PCCTs - using length of stay to control for unobserved heterogeneity - weakens the internal and external validity of cost-effect

Grant Type	Type of novel material/method	Description
		estimates. Subsequently, time-to-consultation following hospital admission was identified as having a systematic association with PCCT impact on cost, and new methods for incorporating intervention timing into analyses were developed that minimise endogeneity concerns. Publications have established a new standard in economic evaluation of PCCTs with observational data: one where LOS is not used to control for unobserved heterogeneity and timing of the intervention is always incorporated into analyses.
Infrastructure award	New or Expanded Cohort	Establishment of a cohort of 931 older adults (>70 years) recruited from 15 general practices in Ireland. Baseline wave 1 data collection occurred in 2010 and wave 2 data collection was completed in 2012. Wave 3 data collection is planned for phase 2 of the CPCR activities. Data collected includes adverse drug event (ADE) interviews, patient questionnaires and GP medical record reviews.
Project Grant	Animal model of disease	Immuno-deficient mouse models were tested for the development of Oesophageal cancer xenograft models, resulting in successful transplant and growth of tumour cell lines and xenograft cancer tissues.
Project Grant	Dataset or Database	Development of a large database of adverse drug reactions (ADRs) in unselected elderly patients hospitalised with acute illness. This has been very useful for comparison with other datasets compiled by researchers working in the area of ADR pharmacoepidemiology and ADR prevention, in particular the GerontoNet research group.
Project Grant	New or improved research Infrastructure	The research infrastructure in the area of pharmacotherapy optimisation in older people has improved greatly through HRB funding. In the area of clinical trials in particular, there is now the capacity to conduct large scale multi-centre RCTs through the support and co-ordination of the CRF-C at UCC.
Project Grant	Software	The Structured Pharmacist Review of Medication (SPRM) running on clinical decision support software (CDSS) platform has been developed as part of the HRB 2010 grant. SPRM/CDSS was used as the single time point intervention in the second single centre RCT within the HRB project and has been shown to significantly reduce the incidence of hospital-acquired Adverse Drug Reactions (ADRs) in acutely ill older people.
Project Grant	Clinical outcome measure	Caspase-3 IHC and Caspase-3 serum activity assays as a prognostic biomarker for advanced, stage III and stage IV colorectal cancer

10. Health sector innovations

Health research is the basis for many products and innovations in the commercial life sciences, medtech and biotech sectors as well as treatment and service innovations in the healthcare sector. Such products and innovations can emerge through ideas or new intellectual property, or the application or enhancement of existing ideas or intellectual property.

Summary of health sector innovations, compared to 2012/2013, 2010/2011 and 2008/2009 reporting periods

Health sector innovations	2014/2015 (N=198 grants)	2012/2013 (N=134 grants)	2010/2011 (N=196 grants)	2008/2009 (N = 204 grants)
No. health sector innovations	54	43	48	32
% grants reporting health sector innovations	20.7%	24.6%	21%	15%
No. health sector innovations per €1 million spend	1	1	0.9	0.7

Key Finding

- 20.7% of grants that completed in 2014/2015 reported that their HRB-funded research had either directly led to or contributed to the development of a total of 54 innovations.
- Almost twice as many HRB awards were linked to the development of one or more healthcare innovations than UK MRC awards. However, the average number of healthcare innovation outputs per MRC award was higher than per HRB awards (2.0 as opposed to 1.3 outputs.)
- The development of a new, or refinement of an existing, therapeutic intervention that was based on a new drug or a new indication for an existing drug was the most common output for both the HRB and UK MRC.
- Collectively, disease management strategies, decision support tools and care models and service outputs accounted for almost 28% of HRB outputs, which was more than double the equivalent statistic for UK MRC outputs.
- 44% of interventions were in early stage development, a further 39% were in the late stages of development or were being tested and refined as part of the award, and a further 17% of healthcare innovations had been adopted on a large scale.
- Projects Grants accounted for 65% of reported healthcare innovations and were distributed across almost all types of innovations.
- 74% of healthcare innovation outputs were developed by Applied Biomedical or Clinical Research awards, and of these, 16 had already attracted further funding to develop their innovations.
- Health Services Research awards focused on the development of care models, disease management strategies, clinical decision tools and preventative interventions, while Population Health Sciences awards focused on assessing new drug indications, care models, clinical decision tools and behavioural interventions.

10.1 Health sector innovations

Grant-holders were asked whether their HRB-funded research led to, or significantly contributed to, the development or application of any health-related innovations. Such innovations were defined broadly to include products (e.g. diagnostics, drugs, devices), non-drug interventions, health IT systems, clinical decision support tools, disease management strategies, clinical care models and so on. Grant-holders were also asked about the stage of development of the innovation along the discovery-development continuum and were asked to provide a description of the innovation.

In total, 41 awards (20.7% of total grants) that completed in 2014/2015 reported that their HRB-funded research had either directly led to or contributed to the development of a total of 54 innovations. This is slightly higher than the 2012/2013 (24.6% of total awards reported 43 innovations), 2010/2011 (21% of total awards reported 48 innovations) and 2008/2009 figures (15% of total awards reported 32 health innovations).

The number of HRB awards in 2014/2015 that reported the development of one or more healthcare innovations is also higher than the equivalent figure reported by UK MRC researchers (12% of total awards) for 2014/2015. However, the average number of healthcare innovation outputs per MRC award was higher than per HRB awards (2.0 as opposed to 1.3 outputs.)

Table 10.1 shows the breakdown of the 54 innovations by type. The development of a wide range of healthcare interventions was reported including diagnostic, prognostic, preventative and therapeutic interventions. The most common single type of healthcare innovation reported was the development of a new, or refinement of an existing, therapeutic intervention that was based on a new drug or a new indication for an existing drug (22% of reports). Collectively, Disease management strategies, decision support tools and care models and service outputs accounted for over a quarter of HRB reported innovations, while new ICT-based technologies accounted for 11% of reported new healthcare innovations.

Table 10.1: Number of HRB-funded healthcare innovations in development by type

Type of healthcare innovation	Number developed
Therapeutic intervention: New drug or Indication	12
Strategy to manage disease or condition	7
New ICT- based technology	6
Therapeutic intervention: Cell or Gene Therapy	5
Care model or service	4
Clinical Decision Support Tool	4
Diagnostic Tool: Non-Imaging	4
Prognostic tool	2
Preventative Intervention: Behavioural Risk Modification	2
Preventative Intervention: Physical/Biological Risk Modification	2
Therapeutic Intervention: Vaccine or Immunotherapy	2
Diagnostic Tool: Imaging	1
Other	1
Preventative Intervention: Nutritional or Chemoprevention	1
Therapeutic Intervention: Surgery	1

As shown in Table 10.2, the increase in the numbers of interventions was due to a large number of new therapeutic interventions involving a new drug or a new indication of an existing drug in 2014/2015 that was not reflected in the 2012/2013 reporting period. Furthermore, grants that completed in 2014/2015 had a significant increase in the number of reported new strategies to manage a disease or condition, or new ICT-based technologies. The increase in these innovations highlights the HRB's drive to facilitate the creation of knowledge which can quickly be adapted to a clinical setting.

Table 10.2: Breakdown of healthcare innovations - comparing 2014/2015, 2012/2013 and 2010/2011

Type of healthcare innovation	2014/2015	2012/2013	2010/2011	UK MRC 2014/2015
Therapeutic intervention: New drug or Indication	22.2%	11.6%	18.8%	29%
Strategy to manage disease or condition	13%	2.3%	4.2%	6 %
New ICT- based technology	11.1%	0	10.4%	7%
Therapeutic intervention: Cell or Gene Therapy	9.3%	2.3%	8.3%	6%
Care model or service	7.4%	25.6%	4.2%	1%
Clinical Decision Support Tool	7.4%	7%	2.1%	5%
Diagnostic Tool: Non-Imaging	7.4%	16.3%	16.7%	16%
Prognostic tool	3.7%	2.3%	6.3%	5%
Preventative Intervention: Behavioural Risk Modification	3.7%	7%	12.5%	4%
Preventative Intervention: Physical/Biological Risk Modification	3.7%	4.7%	0	1%
Therapeutic Intervention: Vaccine or Immunotherapy	3.7%	2.3%	0	4%
Diagnostic Tool: Imaging	1.9%	0	2.1%	6 %
Other*	1.9%	0	2.1%	3%
Preventative Intervention: Nutritional or Chemoprevention	1.9%	2.3%	0	1%
Therapeutic Intervention: Surgery	1.9%	0	0	2%
Therapeutic Intervention: Psychological/Behavioural	0	14%	10.4%	6%
Therapeutic Intervention: Medical Device	0	2.3%	2.1%	3%

** 'Other' includes Therapeutic intervention – physical, Therapeutic intervention – radiotherapy, Products with applications outside of medicine and Therapeutic intervention – complimentary.*

Table 10.2 also includes a comparison with equivalent UK MRC percentages for medical products and intervention by type in 2014/2015. From this it can be see that 'Therapeutic Intervention: Drug or Indication' was the most common output for both HRB and MRC. However, HRB had a greater percentage of service delivery related outputs (e.g. Strategy to Manage Disease or Condition; Care Model or Service; Clinical Decision Support Tool) that the MRC. On the other hand, the MRC had more outputs by percentage of diagnostic tools, both imaging and non-imaging. The MRC also reported that 6% of its Healthcare Innovation outputs were Psychological/Behavioural Therapeutic Interventions, while the HRB had no outputs in this category.

Figure 10.1 plots the stages of development of the innovations. 44% of interventions were in early stage development, while a further 39% of interventions were in the late stages of development or were being tested and refined as part of the award. In terms of uptake of innovations, PIs reported that 17% (N=9) of their innovations had been adopted on a large scale.

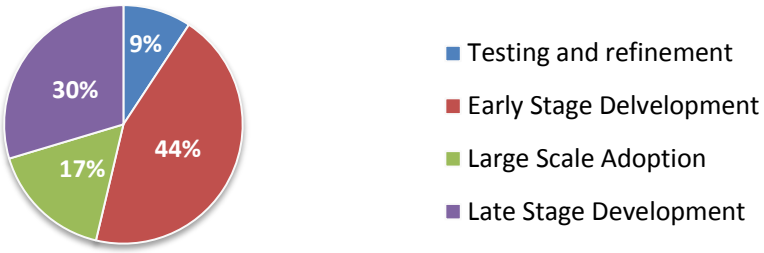
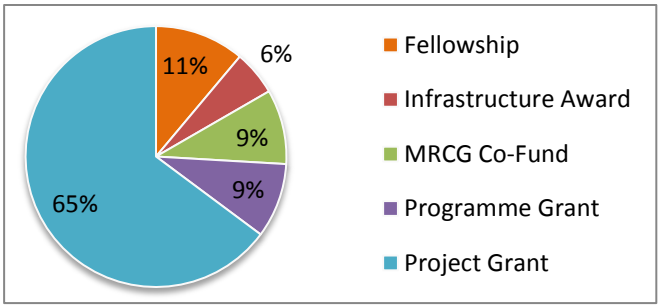


Figure 10.1: Stages of development of HRB-funded health innovations

10.1.1 Distribution of healthcare innovation by grant type

Figure 10.2 shows the distribution of healthcare innovation types by grant type and number of outputs per €1 million spend, while Figure 10.3 shows the distribution of healthcare innovations by type across grant types.

Projects Grants accounted for 65% of reported healthcare innovations and were distributed across almost all types of innovations (excluding development of radiotherapies and psychological/behavioural therapies). In terms of productivity, there were 1.4 innovations reported per €1 million spend on Project Grants.



No. of healthcare innovation outputs per €1 million	
Fellowship	0.9
Infrastructure Award	0.6
MRCG Co-fund	2.3
Programme Grant	0.3
Project Grant	1.4

Figure 10.2: Healthcare innovation outputs broken down by grant type and number per €1 million spend

Fellowship Awards and Programme Grants accounted for 11% and 9% of reported healthcare innovations, respectively, but had productivity levels of below 1 per €1 million spend, of 0.9 and 0.3 outputs, respectively. Outputs from Fellowship Awards were distributed across a range of outputs, while the type of healthcare innovation emerging from Programme Grants was confined primarily to the development of new drugs and other biologics.

MRCG Co-fund awards reported five healthcare innovations and, as has been observed for other metrics, this scheme again has the highest productivity per €1 million spend, at an average of 2.3 innovations. The types of healthcare innovations emerging from MRCG Co-fund awards was limited to Therapeutic intervention: Gene or Cell therapy, Diagnostic Tool: Non-Imaging and Therapeutic intervention: Vaccine or Immunotherapy, which reflects the predominant focus of this scheme in biomedical research. The Infrastructure Awards, which accounted for 6% of total three healthcare innovations, all ICT-based tools, which is an output of 0.6 per €1 million spent.

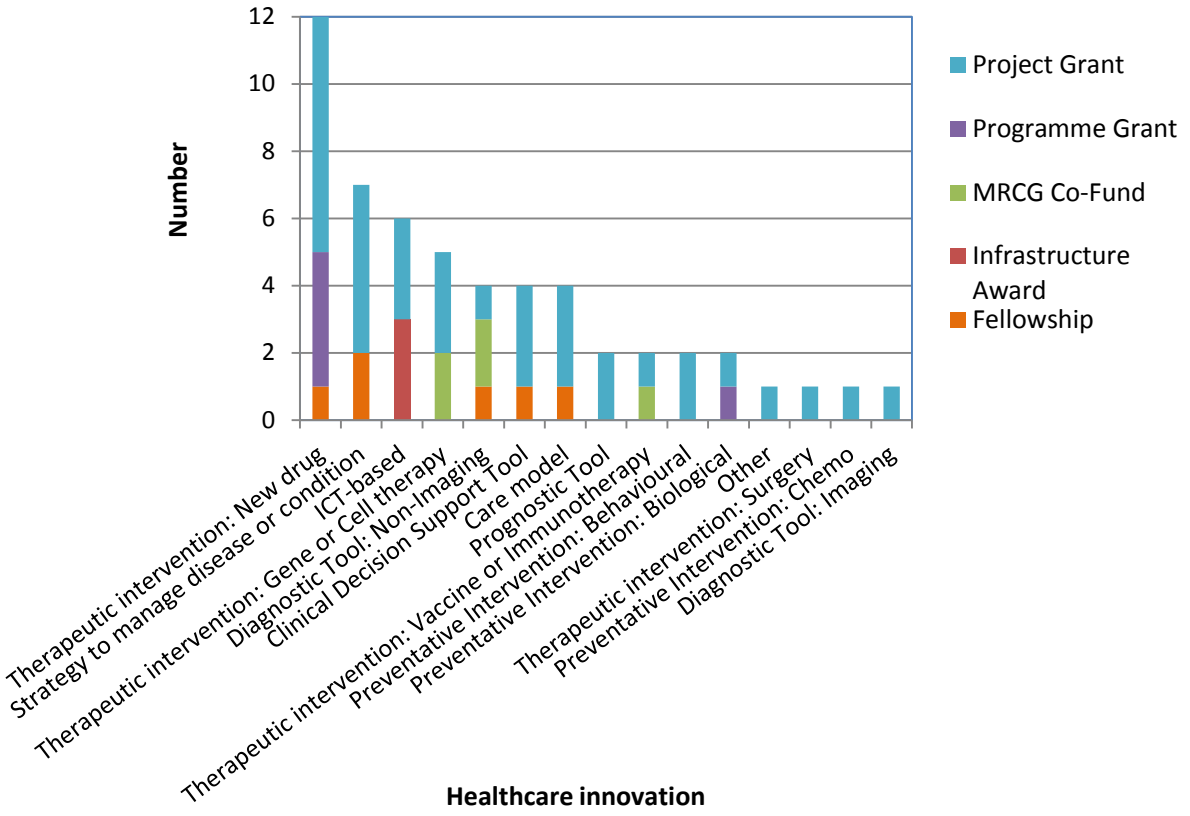
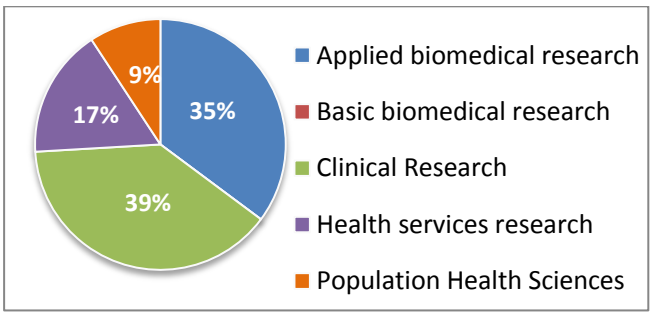


Figure 10.3: Healthcare innovation outputs broken down by innovation and grant type

10.1.2 Distribution of healthcare innovations by broad research area

Figure 10.3 shows the distribution of innovations by broad research area and per € million spend. Of the 54 healthcare innovations reported, 30 (74%) were developed by grants categorised as applied biomedical or Clinical Research. Of these, 16 had already attracted further funding to develop their innovations (one from industry). These innovations were spread across a number of grant types (Health Research Awards, MRCG Co-fund Awards, Translational Research Awards Post-Doc Fellowships in Translational Medicine and an ICE Award.)



No. of healthcare innovation outputs per €1 million	
Population Health Sciences	1.8
Clinical Research	1.2
Health Services Research	0.9
Applied Biomedical Research	0.8
Basic Biomedical Research	0

Figure 10.4: Healthcare innovation outputs broken down by broad research area and number per €1 million spend

Grants categorised as population health and Health Services Research accounted for the remaining 26% of reported healthcare innovations (N=14). These were spread across a number of grant types (Health

Professional Fellowships, Post-doctoral Fellowships, Health Research Awards, ICE Awards and Health Research Centres). Unsurprisingly, given the focus of these awards, the types of healthcare interventions reported were mainly targeted at improvement of care models, clinical decision making and strategies for disease management (N=14), behavioural, psychological, biological or chemotherapy-based preventative interventions (N=4) and new indications for existing drugs (n=2). Eight PIs reported having attracted further funding (two from industry) to continue the development of their work.

Figure 10.5 looks in more detail at the type of health healthcare innovations reported by broad research area.

Unsurprisingly, the type of research being undertaken was reflected in the type of healthcare innovations reported. For example, grants categorised as Clinical Research reported healthcare innovations across the spectrum while applied biomedical awards were focused on the development of new drugs, gene therapies, vaccines, prognostic and diagnostic markers. Health services research awards featured strongest in the development of care models, disease management strategies, clinical decision tools and preventative interventions. Population health awards focused primarily on assessing new drug indications, care models, clinical decision tools and behavioural interventions.

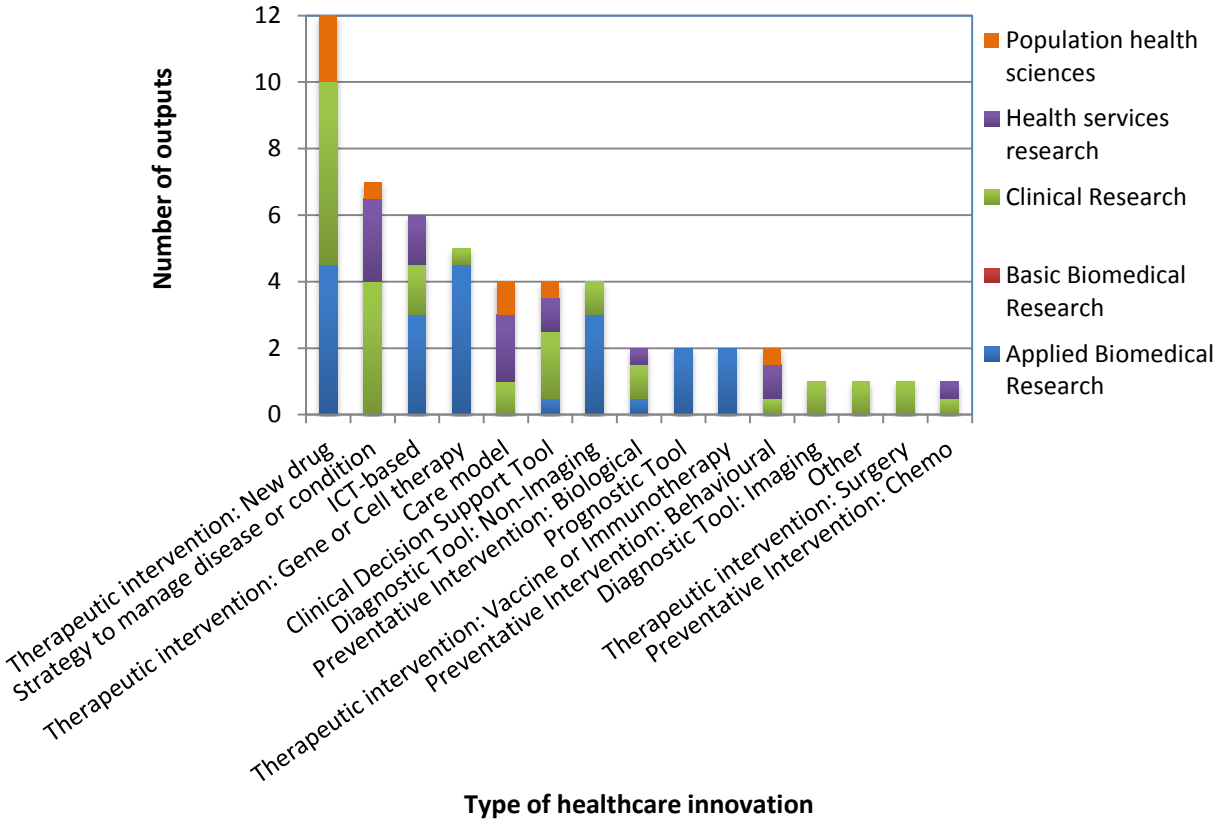


Figure 10.5: Healthcare innovation outputs broken down by broad research area and innovation type

10.1.3 Examples of health sector innovations

Table 10.3 presents some examples of the types of healthcare innovations developed or refined by PIs whose grants completed in 2014/2015.

Table 10.3: Examples of health sector innovations in development arising from HRB-funded awards

Grant Type	Type of innovation	Description of innovation
Health Research Award	Care model	This facet of the project allowed patients to decide what level of treatment they wanted (simple or complex) and then measured their level of satisfaction with each. Industry supported the provision of implants for those who wanted them. They also looked at various other characteristics of people who chose each kind of treatment and their level of satisfaction. This allowed the PI to develop a model and simple predictor for who is likely to benefit from more complex treatment, thereby saving time and money.
Health Research Centre	ICT-based	Development of a web-based platform which guides GPs through the process of medication review. The platform has been amended based on study feedback and will be tested in a larger scale randomised controlled trial in 2016.
Health Research Award	Diagnostic Tool: Imaging	Means of imaging and determining the extent of cerebral vascular border zones.
Health Research Award	Preventative Intervention: Biological	Trustwater electrochemically activated solution technology has been adapted to automatically minimise microbial contamination of water networks supplying wash hand basins in two separate healthcare facilities. The application minimises contamination in circulating water and in washbasin taps.
Health Research Award	Therapeutic intervention: Surgery	Using total knee replacement surgery as a model for the evaluation of ischaemic preconditioning treatment, a proof of concept study was conducted in knee replacement patients to assess the effect of this technique on patient outcome. Ischaemia-reperfusion injury is an important consideration in the post-surgical patient, with both oxidative stress and endothelial dysfunction being well-known elements of this injury. A key finding of this study was that patients who received ischaemic preconditioning prior to surgery displayed a reduction in markers of oxidative stress and endothelial dysfunction. These findings suggest that patients that undergo ischaemic preconditioning may have improved outcomes following knee replacement surgery.
MRCG Co-fund Award	Diagnostic Tool: Non-Imaging	Three new genetic tests were developed based on discoveries from this research. The three tests were clinically validated at the Molecular Lab our Lady's Children's Hospital Crumlin. The tests are now in routine use for diagnostics. Test requests can be, and have been, made from doctors all over the country.
Health Professional Fellowship	Strategy to manage disease or condition	Four self-educational videos on pelvic floor muscle exercises (PFME) and leaking urine were developed in collaboration with the women's health physiotherapists in the Rotunda hospital (as part of the linked KEDS award). The videos are used widely by all health professionals in the Rotunda Hospital to teach women the importance of and how to do PFME.
Health Research Award	Therapeutic intervention: New drug or intervention	Simvastatin was found to be highly cost-effective at one year compared to placebo, being associated with both a small QALY gain and cost saving. This will be the subject of ongoing research and a manuscript is being prepared.
Health Research	Prognostic Tool	The PI collaborated closely with clinicians based at St. Vincent's Hospital to develop and patent a novel method called

Grant Type	Type of innovation	Description of innovation
Award		OncoMasTR, which can predict the likelihood of recurrence in women who present with breast cancer. This technology can be used to categorise early stage breast cancer patients into groups based on their risk of recurrence, and thus it is designed to aid both clinicians and patients in making informed treatment decisions. Engagement with potential licensees and key industry players has taken place in the form of meetings with indigenous diagnostics companies such as OncoMark Ltd, who have expressed an interest in the future licensing of this technology and a patent application has been submitted.
MRCG Co-fund Award	Therapeutic intervention: Gene or Cell therapy	The PI developed an adeno-associated viral (AAV) vector carrying the CLN1 gene, and another AAV vector carrying the CLN2 gene. They validated the ability of the AAV/CLN1 vector to treat mice with CLN1, which suggests a strong potential for this "drug" to treat INCL patients.
Post-Doctoral Fellowship	Clinical Decision Support Tool	The PI developed an application for android tablet which helps ED nurses assess the symptoms of those experiencing ACS

11. Intellectual property and commercialisation activity

The primary focus of HRB-funded research investment is the generation of opportunities for improved healthcare delivery, better health outcomes and the generation of research evidence to inform policy and improve clinical practice. The successful commercial exploitation, or "commercialisation", of health research can result in economic benefits through job creating and the development of products and services, by converting scientific and technological advances into marketable products or industrial processes.

Summary of economic/commercial activity, compared to 2012/2013, 2010/2011 and 2008/2009 reporting periods

Commercial and enterprise activity	2014/2015 (N=198 grants)	2012/2013 (N=134 grants)	2010/2011 (N=196 grants)	2008/2009 (N = 204 grants)
No. patents filed	24	16	11	12
No. licenced technologies developed	2	5	3	3
No. start-ups/spin-outs established or in train	4	2	2	2
No. industry collaborations established	58	88	25	10

Key Finding

- HRB researchers whose awards completed in 2014/2015 were active in the enterprise arena, with a total of 104 outputs reported
- 24 patents were filed by grants that ended in 2014/2015, an increase of eight from 2012/2013 grants, and four PIs reported an output in terms of start-up companies.
- Of the four start-ups reported in 2014/2015 two companies hire a combined 13 employees and both have secured additional funding. Another start-up has secured EU Horizon 2020 funding while one new spin-out is yet to secure additional funding
- Project Grants accounted for the greatest number of commercialisation outputs of all types, representing 1.4 outputs in this category per €1 million spend.
- Applied Biomedical Research are the most likely to produce commercialisation outputs of all type, and accounted for over 60% of commercialisation outputs, with a productivity of 1.1 outputs per €1 million spend.
- PIs reported 58 instances of new or strengthened academic–industry collaborations from 25 awards (12%), which is slightly higher than the equivalent statistic reported by the UK MRC of 8% of all awards with this type of output in 2014/2015.
- Conducting joint-research projects, with both Irish and international industry partners, was the most commonly cited reason for collaboration with industry partners. Sharing data and expertise and obtaining access to either materials or infrastructure were also important reasons academic-industry collaboration.

11.1 Commercialisation and enterprise activity

An increasingly important indicator of the impact of publicly-funded research in Ireland is the proportion of research grants that are producing outputs which can be commercialised and the level of collaboration between the academic and industrial sectors. HRB-funded researchers were asked if their research findings had commercial potential and if so, to what extent they had pursued this opportunity in terms of intellectual property protection and various commercialisation routes. Grant-holders were also asked if they had established industry collaborations.

11.1.1 Distribution of commercialisation and enterprise outputs by type

A summary of the reported outputs for 2014/2015 and a comparison with outputs for the 2012/2013, 2010/2011 and 2008/2009 reporting periods is presented in Table 11.1.

Table 11.1: Number of commercial outputs by type – comparison of reporting periods

Output Type	2014/2015 No.	2012/2013 No.	2010/2011 No.	2008/2009 No.
Filed invention disclosure or in discussions with TTO	5	20	9	9
Patents filed (includes pending or lapsed status)	24	16	11	12
Licenced technologies	2	5	3	3
Start-ups established or in train	4	2	2	2
Academic-industry collaborations established	58	88	25	10
Commercialisation grants secured from EI	9	5	4	6
Total	**104**	**136**	**54**	**42**

From Table 11.1 it can be seen that HRB researchers whose awards completed in 2014/2015 were again active in the enterprise arena, with a total of 104 outputs reported. Although there has been a reduction in commercial outputs from 2012/2013, the numbers reported in 2014/2015 are still significantly higher than those reported in 2010/2011 and 2008/2009.

Figure 11.1 shows the distribution of commercialisation outputs across type. Patenting was the most common commercialisation output, followed by funding support from Enterprise Ireland to further develop a commercial idea. 11% of reported outputs were invention disclosure forms (IDFs) that were under consideration by the Technology Transfer Office of the Host Institution. There were four start-ups reported in 2014/2015. Of these, two companies hire a combined 13 employees and both have secured additional funding. Another start-up has secured EU Horizon 2020 funding while one new spin-out is yet to secure additional funding. Two technologies have been licenced exclusively to industry.

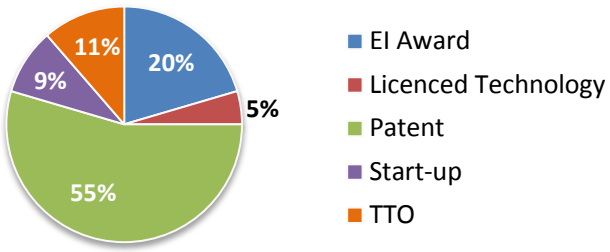


Figure 11.1: Distribution of commercialisation outputs by type

In terms of the jurisdiction of filing, of the 24 patent filings reported, six were filed with the EU Patents Office three with the US Patents Office, two with the UK Patents Office, one with the Irish Patent Office, while three patents were filed under the Patent Cooperation Treaty (PCT)[12] and the jurisdictions of the final nine patents were not specified.

For grants that completed in 2014/2015, only five HRB grant holders (2.5% of total) reported that they had discussed the commercial potential of their work with a university Technology Transfer Office or potential industry partner. However, 24 patents were filed by grants that ended in 2014/2015, an increase of eight from 2012/2013 grants, which suggests that interaction with TTOs was higher than reported.

11.1.2 Distribution of commercialisation outputs by grant type

Figure 11.2 shows the distribution of commercialisation outputs (start-ups, licenced technologies, patents, Enterprise Ireland commercialisation awards and copyright), reported for grants that completed in 2014/2015, broken down by grant type. From this it is clear that the greatest number of commercialisation outputs of all types arose from Project Grants (N=36), representing 1.4 outputs in this category per €1 million spend. The Programme Grants produced 3 commercial outputs, resulting in an overall productivity of 0.2 outputs per €1 million spend for Programme Grants.

There were no commercial outputs reported for the Infrastructure Awards, while Fellowship Awards produced two commercialisation outputs, and had an overall productivity of 0.3 outputs per €1 million spend.

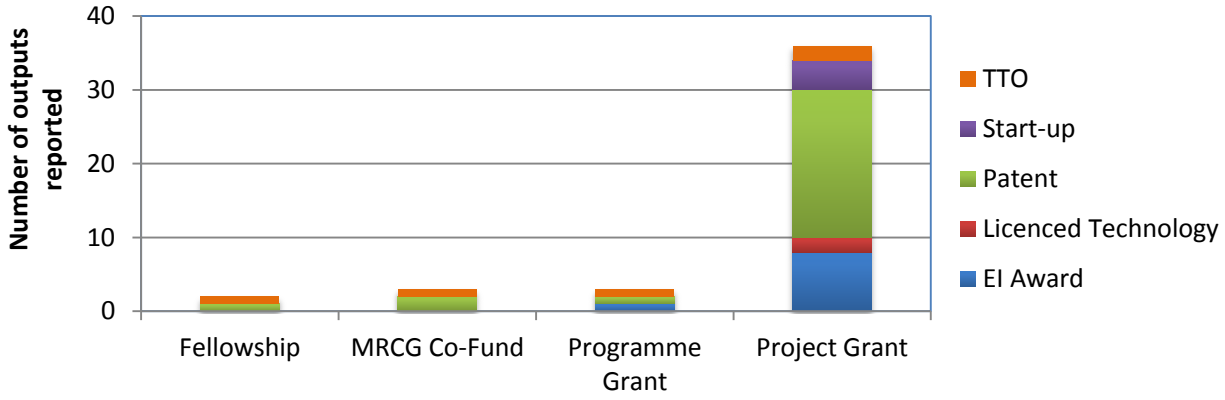


Figure 11.2: Distribution of commercialisation outputs by grant type

11.1.3 Distribution of commercialisation outputs by broad research area

The distribution of broad research areas in which grants with commercialisation outputs were categorised is show in Figure 11.3. From this it is clear that grants that are focused on Applied Biomedical Research are the most likely to produce commercialisation outputs of all type. This broad research area accounted for over 60% of all commercialisation outputs, and reached 1.1 outputs per €1 million spend.

[12] By filing one international patent application under the PCT, applicants can simultaneously seek protection for an invention in 148 countries throughout the world.

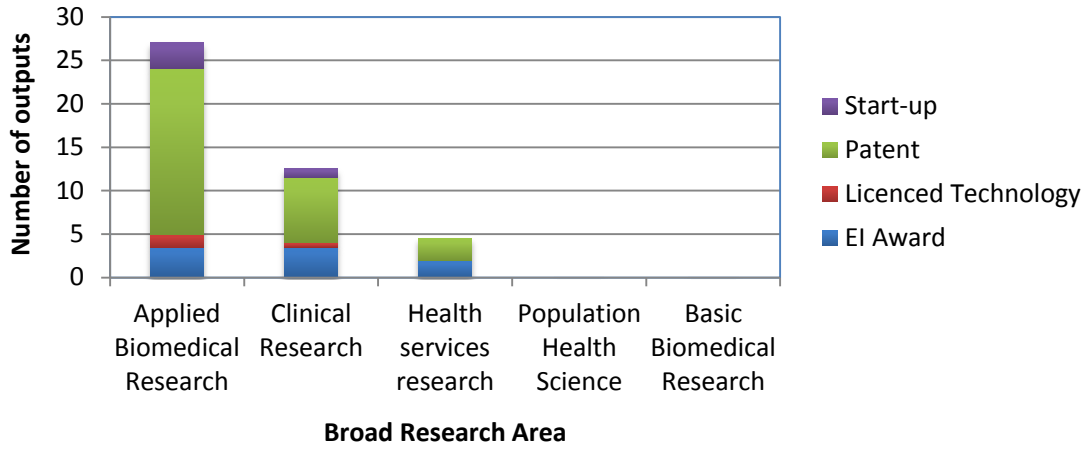


Figure 11.3: Distribution of commercialisation outputs by broad research area

Clinical research accounted for over 17% of commercialisation outputs and a productivity of 0.7 outputs per €1 million spend. Health services research accounted for 10% of the commercialisation outputs, with 4.5 outputs in total and productivity rates of 0.4 outputs per €1 million spend. Basic biomedical and population health research grants did not report any commercialisation outputs from grants ending in 2014/2015.

11.2 Establishment of collaborations with industry

PIs whose grants ended in 2014/2015 reported 58 instances of new or strengthened academic – industry collaborations from 25 awards (12%). This is slightly higher than the equivalent statistic reported by the UK MRC of 8% of all awards with this type of output in 2014/2015. This is a decrease from the unusually high figure of 88 collaborations reported in the 2012/2013 reporting period.

Figure 11.4 shows the reasons cites by researchers for establishing a collaboration of some type with an industry partner, and whether this industry partner was national or international. Collaboration for the purpose of conducting joint-research projects, with both Irish and international industry partners, as the most commonly cited reason for collaboration. Sharing data and expertise and obtaining access to either materials or infrastructure were also important reasons cited by HRB researchers.

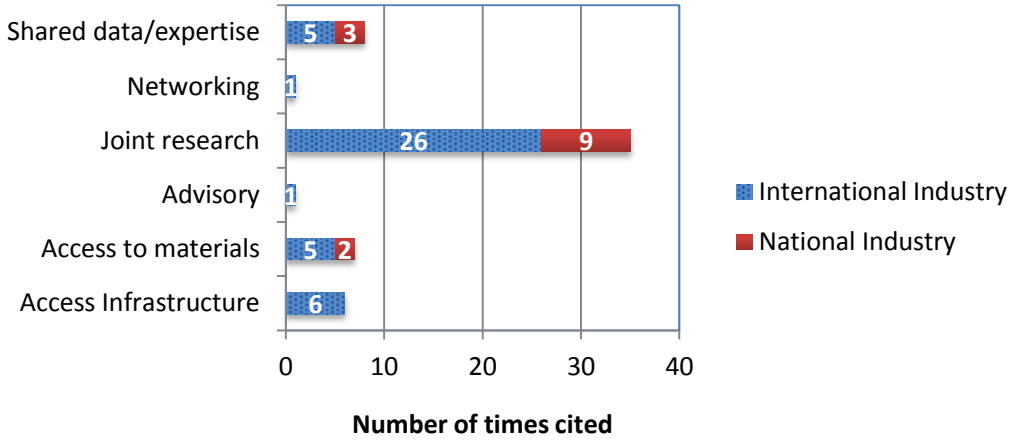


Figure 11.4: Cited reasons for establishing new industry collaborations (national or international)

11.2.1 Examples of commercialisation outputs

Table 11.2 provides examples of the type of commercialisation outputs reported by researchers whose grants completed in 2014/2015.

Table 11.2: Examples of commercial activities

Activity Type	Details of activity
Start-up company	Early stage company in the ever-growing biomaterials market. The company provides a design, development and fabrication service for customised biomaterial solutions. The focus is on the development of robust and reliable scaffold structures, the development of linking systems to attached therapeutics including drug molecules, genes, growth factors and other factors which limit immunogenic responses and or stimulate integration of the biomaterial into the body. The team has specialist knowledge in the development of technologies for soft tissue repair, neural regeneration, and cardiovascular tissue regeneration. Based on significant in-house R&D, the company employs 11 employees and has secured €2,586,000 funding of additional funding .
Licenced Technology	The PI completed contract research on an innovative therapy and assigned royalty-free and exclusive use of the data to the company.
Patent Filed	1. "A Method of Assessing Cancer Status in a Breast Cancer Patient". EP 2110665 A1 2. WIPO Patent, WO2013/087943 A1 "P2X7 antagonists as frontline or adjunctive treatment against status epilepticus" (2013). International application number PCT/EP2012/075867 3. Method for Opening Tight Junctions (European Patent Office; Serial No. 15165530.5. Divisional

12. Conclusion

The data described in this report demonstrates a wide variety of outputs produced by HRB-funded research in terms of scientific output, capacity-building, policy and practice outputs and health sector and economic benefits.

When compared to the 2008/2009, 2010/2011 and 2012/2013 analysis, the data shows that HRB-funded research completing in 2014/2015 shows that HRB researchers continue to be highly productive across the full range of Payback Categories, with increases in many metrics, compared to previous reporting periods. The number of award reporting outputs was found to be very similar to the UK MRC, although the number of outputs per MRC award tended to be higher, which is understandable given the difference in scale of these awards.

From the trends observed in previous reporting periods, it was predicted that shift in investment away from basic and applied biomedical research since 2010 would result in a decrease in peer-reviewed publications and commercialisation outputs/opportunities. Instead, this report found that there was an increase in the number of 'scientific productivity' markers such as peer-review papers and presentation events at scientific conferences, indicating that HRB researchers in all broad research areas are increasingly internationally competitive.

In particular, the productivity of awards classified as HSR has increased from previous reporting periods across almost all Payback Categories. The results from this report and the Bibliometric Analysis 2013-2016 show that Irish HSR researchers are highly regarded internationally, as evidenced by their success in attracting more EU funding, international recognition and publication citations than other broad research areas of HRB research.

Overall, grants in HSR, PHS and Clinical Research produced the most health policy and practice outcomes, healthcare innovations and provided the most research training opportunities for health professionals. Grants in Applied Biomedical Research were the most likely to produce commercialisation outputs of all types. Therefore, in terms of delivering on a key HRB objective of improving people's health and health care provision, HRB funded research appears to be producing the type of outputs that have the potential to have real impact in this area.

The new HRB funding initiatives in Clinical Research, Health Services Research and Population Health Sciences, based on a multi-disciplinary collaborative funding model, along with the emphasis placed by international peer review panels on methodological rigour, ensures that only high-quality research is funded with the potential for both scientific, health and economic impact. Therefore, any future decreases in scientific productivity metrics will be more than offset by a concomitant increase in health sector outcomes such as development of healthcare innovations (e.g. interventions, therapies) and influences on policy and practice (e.g. clinical guidelines, policy briefs, advisory roles) which tend to be associated with these broad research areas.

Appendix 1: Impact Assessment ("Payback") Framework

Based on the Payback Framework of Buxton and Hanney

Impact Category	Indicators
Knowledge Production	○ Peer reviewed publications and citations ○ Other publications such as books, book chapters, editorials or bulletins ○ Presentations to national and international conferences ○ Research reports and 'grey literature' produced ○ Cochrane systematic reviews produced or findings included in a review
Research capacity-building and leadership	○ Education and training of personnel such as clinicians, health professionals and scientists ○ Higher degrees, such as PhD, obtained by research personnel ○ Retention rates of research personnel in national research system ○ Research personnel attracted from overseas ○ Spin-off projects developed and further research funding leveraged ○ Development and use of novel research techniques ○ Establishment of new datasets, databases or research data lodged in national database ○ New national/international collaborations or strategic partnerships formed with other research teams, industrial partners or health agencies ○ Level of all-Ireland collaboration and benefits accruing from this ○ Internationalisation of research: Involvement of HRB-funded researchers with EU and global health research initiatives
Informing policy, practice and product development	○ Influencing national and international research policies and strategies ○ Dissemination and knowledge-transfer events or networks established with research 'users', such as policy-makers and health professionals ○ Advisory roles of HRB-funded researchers to government or policy-makers ○ Commissioned reports or projects from government departments or agencies ○ Policy briefing papers, practical handbooks and other grey material produced and disseminated to research users such as policy-makers and health professionals ○ Contribution of research to clinical treatment or best practice guidelines ○ Evidence of public outreach and dissemination through media and other fora
Health sector benefits and innovations	○ Contribution of HRB-funded research to health promotion initiatives ○ Randomised control trials completed and new interventions established as a result ○ Numbers of patients enrolled on clinical trials or engaged with studies undertaken in clinical research facilities supported by the HRB ○ Contribution of HRB-funded research to actual health benefits within Irish population ○ Savings to the health system through gains in health service efficiency, improved primary care or introduction of preventative health measures, where research and evidence generated by HRB-funded researchers contributed to this ○ Increased availability of local pool of evidence and evidence "generators" to Irish health policy-makers and health practitioner

Impact Category	Indicators
Economic, commercial and enterprise benefits	○ Improved international reputation of Ireland for health and medical research (e.g. by attracting pharma industry R&D and collaborative partnerships with HRB-funded researchers; invited keynote addresses to international conferences; involvement of HRB-funded researchers in international research programmes) ○ Patents and other IP applications and award of commercialisation support grants to develop marketable products or devices ○ Licence agreements and revenues generated as a result ○ Spin-out companies or formal collaborative partnerships between researchers and industry ○ Success of HRB-funded personnel in attaining additional research funding, for example though the EU's Framework Programmes ○ Success of HRB-funded researchers in commercialising the outcomes of their research (through invention disclosures, patents, licences, formation of start-up and spin-out companies) ○ Success of HRB-funded researcher in obtaining EI funding for further development of potentially viable enterprise outputs of the research.

Appendix 2: Summary of key outputs from 2014/2015 End-of-Grant reports by grant type

Impact Category / Key Indicator (No.)	Project Grants (129 grants)	Fellowship Awards (41 grants)	Programme Grants (12 grants)	MRCG Co-funded (12 grants)	Infrastructure Award (4 grants)
Amount invested (€)	**€25.7 million**	**€7.0 million**	**€14.7 million**	**€2.2 million**	**€5.4 million**
Scientific outputs					
No. peer-reviewed publications (N=693)	318	121	122	31	101
Mean no. peer-reviewed publications per grant	2.5	3	10.2	2.6	25.3
No. publications per €1 million spend	12.1	17.0	9.0	14.0	18.5
Average cost per paper	€82,344	€58,969	€111,407	€71,446	€54,055
Research capacity outputs					
No. of personnel (N=385)	284	29	45	17	10
No. PhD degrees (N=93)	57	18	15	3	0
No. health professionals trained (N=154)	114	23	13	2	2
No. research collaborations established (N=413)	281	70	28	27	7
No. collaborations established per €1 million spend	11	10	2	12	1
Policy and practice outputs					
No. policy/practice outputs (total=105)	53	20	8	7	17
No. policy and practice outputs per €1m spend	2.1	2.9	0.5	3.2	3.1
No. of patient/public engagement outputs (total=258)	161	28	16	34	19
No. patient/public engagement outputs per €1 million spend	6.3	4.0	1.1	15.4	3.5
Healthcare innovation outputs					
No. health innovations developed (total=54)	35	6	5	5	3
No. healthcare innovations per €1 million spend	1.4	0.9	0.3	2.3	0.6

Impact Category / Key Indicator (No.)	Project Grants (129 grants)	Fellowship Awards (41 grants)	Programme Grants (12 grants)	MRCG Co-funded (12 grants)	Infrastructure Award (4 grants)
Leveraging and commercialisation outputs					
No. leveraged additional grants (total=180 grants worth €41.8 million)	124	12	19	19	6
Amount of exchequer/non-exchequer funding leveraged	€15,469,042 / €13,627,758	€606,189 / €1,440,400	€6,286,987 / €484,819	€583,000 / €1,014,132	€1,668,620 / €578,000
No. patents filed or pending (N=24)	20	1	2	1	0
No. licenced technologies developed (N=2)	2	0	0	0	0
No. start-ups companies established or in train (N=4)	4	0	0	0	0
No. industrial collaborations established (N=58)	44	9	4	1	0
No. commercialisation outputs per €1 million spend	1.4	0.3	0.2	1.4	0

Appendix 3: Summary of key outputs from 2014/2015 End-of-Grant reports by broad research area

Impact Category / Key Indicator (No.)	Applied Biomedical Research (N=77)	Basic Biomedical Research (N=3)	Clinical Research (N=61)	Health Services Research (N=42)	Population Health Research (N=16)
Amount invested (€)	**€24.1 million**	**€0.6 million**	**€17.4 million**	**€10.2 million**	**€2.9 million**
Scientific outputs					
No. peer-reviewed publications (N=693)	265.5	3	228.5	155	41
Mean no. peer-reviewed publications per grant	3.3	1	3.8	3.8	2.7
No. publications per €1 million spend	11	5.4	13.2	15.3	14
Average cost per paper	€90,592	€185,863	€75,913	€65,540	€69,789
Research capacity outputs					
No. of personnel (N=385)	118	2	114.5	96.5	54
No. PhD degrees (N=93)	31.5	0	20	27.5	14
No. health professionals trained (N=154)	62	2	47.5	29.5	13
No. research collaborations established (N=413)	159.5	1	123	104.5	25
No. collaborations established per €1 million spend	6.6	1.8	7.1	10.3	8.7
Policy and practice outputs					
No. policy/practice outputs (total=105)	7.5	0	28.5	56.5	12.5
No. policy and practice outputs per €1m spend	0.3	0	1.6	5.6	44
No. of patient/public engagement outputs (total=258)	83.5	0	75	74	25.5

Impact Category / Key Indicator (No.)	Applied Biomedical Research (N=77)	Basic Biomedical Research (N=3)	Clinical Research (N=61)	Health Services Research (N=42)	Population Health Research (N=16)
No. patient/public engagement outputs per €1 million spend	3.5	0	4.3	7.3	8.9
Healthcare innovation outputs					
No. health innovations developed (total=54)	19	0	21	9	5
No. healthcare innovations per €1 million spend	0.8	0	1.2	0.9	1.8
Leveraging and commercialisation outputs					
No. leveraged additional grants (total=180 grants worth €41.8 million)	97	0	50	27.5	5.5
Amount of exchequer/non-exchequer funding leveraged	€12,259,248/€7,237,536	€0/€0	€9,060,701/€4,196,106	€2,418,889/€4,810,221	€875,000/€901,246
No. patents filed or pending (N=24)	15	0	6.5	2.5	0
No. licenced technologies developed (N=2)	1.5	0	0.5	0	0
No. start-ups companies established or in train (N=4)	3	0	1	0	0
No. industrial collaborations established (N=58)	38.5	0	15.5	4	0
No. commercialisation outputs per €1 million spend	1.1	0	0.7	0.4	0