Analysis and Outputs of HRB Grants Completed in 2008 & 2009

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Table of Contents

List of Tables

List of Figures

Analysis and Outputs of HRB Grants

Introduction

This report presents an analysis of HRB grants that completed in 2008 and 2009 and provides an initial overview of the outputs and outcomes arising from these grants. The purpose of the report is to provide management, the Board and Executive Team with strategically useful information in terms of the payback from research funded through the various HRB funding schemes. The report will also serve as a baseline for future HRB output reports, which will be important for monitoring trends in research output as the new HRB strategy becomes embedded. An important proviso is that the information described is merely provisional as the data was collected from End-Of-Grant (EOG) reports submitted four months following grant completion.

To obtain a more complete picture of outputs and outcomes from these grants, it will be necessary to systematically compile information for at least two years following the completion of the grant. This is due to the 'lag time' in the completion of research activities and the production of outputs and emergence of outcomes. Furthermore, previous impact assessment studies by the HRB and other funding agencies have shown that the ultimate impacts of health research – changes in health policy and practice, introduction of new treatments, improved health and wider economic benefits – may occur over an extended timeframe (i.e. 5-15 years). This is due to factors such as the need for consensus-building over multiple research studies, the gradual and cautious process of uptake and utilisation of research evidence by research end-users, and the difficulties associated with implementing research-based information, policy and guidelines into health practice and lifestyle improvements. Therefore, the information presented below should not be regarded as a complete picture of the outputs, outcomes and impacts of HRB grants that completed in 2008 and 2009, rather an initial presentation at the point of grant completion.

This report does not attempt to compare or benchmark the number or quality of HRB outputs with those produced by international health research funders. Currently, such a comparison would not be helpful given the disparity across funding agencies in terms of funding inputs, funding terminology, research classification and output collection (definition, point of collection etc). However a current focus of the ESF Evaluation Forum, of which the HRB is a member, is to develop a common framework for classifying health research and comparing research outputs across EU funding agencies. The existence of such a framework will enable a more meaningful and reliable comparison of outputs across international health research funders. The framework is currently in development and should be in use by mid 2011.

The key indicators that guided output data collection in EOG reports are listed below. This set of indicators is not exhaustive and is being developed on an ongoing basis. Note that the indicators listed relate to outputs only and do not include 'impact indicators', such as actual impacts on health service configuration, health policy changes, or econometric analysis of research outcomes. Such impact assessment entails qualitative analysis of case studies at a later stage, as described above.

Scientific outputs

- Scientific publications
- Scientific presentations
- Development of novel research techniques
- Scientific collaborations
- Scientific media outputs

Human capacity outputs

- Higher degrees attained
- Health professionals engaged in research

- Researchers progressing towards Independent Investigator

Health policy and practice outputs

- Generation of policy-relevant evidence and data
- Contribution to clinical guidelines and protocols
- Knowledge transfer events with research users
- Appointment of PIs to advisory roles
- Development of new diagnostics and treatments
- Development of new interventions for patient care
- Health service innovations, efficiencies and cost-savings

Economic, commercialisation and enterprise outputs

- Funds leveraged (national and international sources)
- Patent applications
- Licence agreements
- Spin-off companies created
- Commercialisation grants awarded
- Industrial collaborations established

1. Analysis of grants completed

An analysis was carried out of the distribution of HRB funding by grant type, broad research area, specific research field or disease category, and research institution.

1.1 Distribution by grant type

In relation to grant type, Figure 1 shows the breakdown of the 204 grants by grant type and Figure 2 shows the breakdown of overall spend (approx €45m) by grant type. As expected, Research Project Grants, the precursor of the Health Research Awards established in 2009, accounted for the largest number of grants (N=109) and the largest proportion of grant funding (€23m). The amounts awarded for individual project grants ranged from €81,176 to €322,114, with an average award of €211,009.

The second most common grant type was individual fellowship awards (N=55), accounting for 25 per cent of the total spend. Several types of fellowship grant completed in 2008 and 2009. Post-Doctoral Research Fellowships, which supported high-calibre post-doctoral researchers in a health-related field for up to three years, were the predominant fellowship type. Other fellowships targeted health professional groups. These included the Clinical Research Training Fellowships for medical graduates, the Nursing and Midwifery Fellowships, the Health Service Research Fellowships and Clinical Therapy Professional Fellowships. A small number of Cochrane Training Fellowships also completed during the period.

In addition, eight research programme grants concluded in 2008. These grants were awarded for a five-year programme of research in biomedical / clinical sciences or health services / population health sciences, with funding between €570,553 and €1,133,006. The combined value of all eight programme grants was almost €8 million, or just under a fifth of the total HRB spend. Furthermore, eleven Medical Research Charities Group (MRCG) grants, co-funded by medical charities, completed in 2008 and 2009. These grants aim to support biomedical research into specific diseases, including some rare diseases. As the scheme seeks to develop the capacity of the charities to act as research funders, each MRCG grant was administered through the relevant charity that then awarded the grant to researchers in various university and hospital settings. MRCG grants are funded to a similar level as Research Project Grants. Other types of grants completed included 14 Partnership awards, four

Health Information System Awards, two Ireland-Northern Ireland Cooperation Project Grants, and a Global Health Research Award.

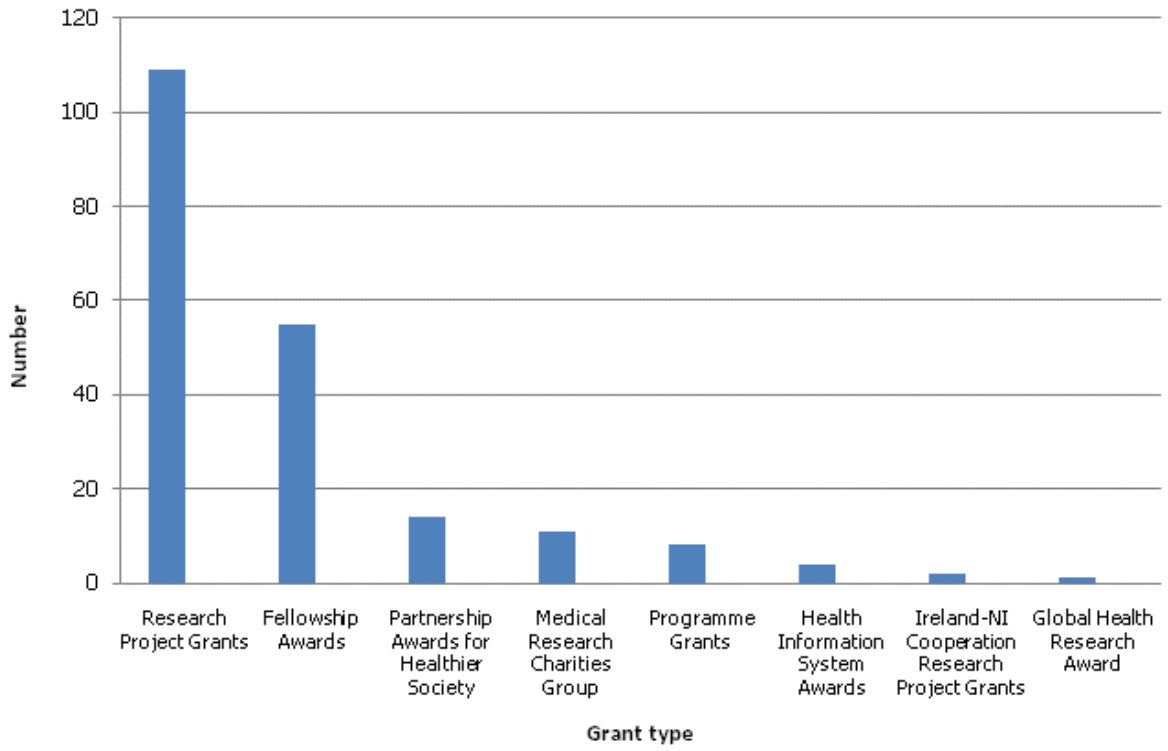

Figure 1: Breakdown of overall number of grants by grant type

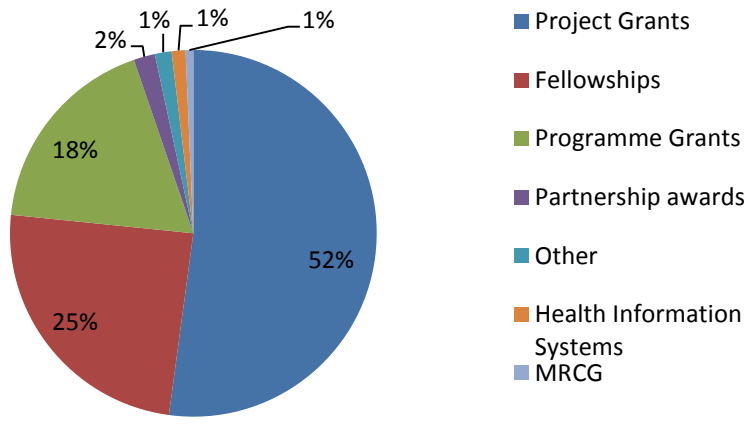

Figure 2: Breakdown of €45m overall spend by grant type

1.2 Distribution by broad health research areas

Figure 3 shows the breakdown of grants and funding across five broad health research areas – basic biomedical, applied biomedical, clinical research, health services research and population health

sciences. While some funding schemes, such as the different fellowship schemes, MRCG and Partnership Awards placed greater restrictions on the type of health research eligible for funding, Project grants and Programme grants were open to those in clinician / biomedical research and health services / population health research. Of interest was that the highest number of grants awarded was in the applied biomedical category, while the largest proportion of funding was in the basic biomedical category.

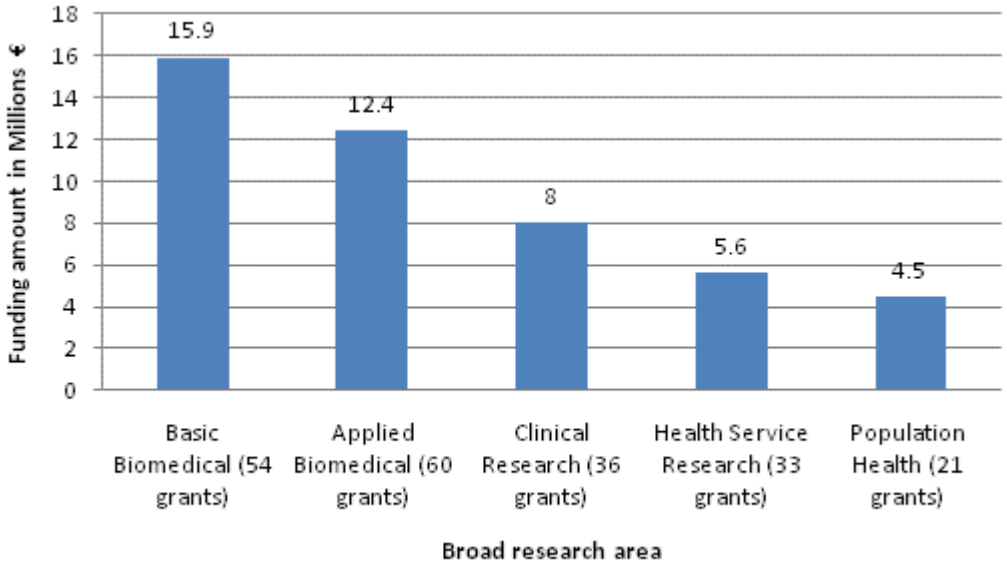

Figure 3: HRB funding amounts across five broad research areas

1.3 Distribution by specific field/disease category

In order to examine the breakdown of the 204 grants by specific field / disease category, grants were classified according to the Health Research Classification System developed by the UK Clinical Research Collaboration, now widely used by funding agencies in the UK and Europe. Figure 4 shows the classification of grants broken down by funding amounts. The highest level of funding was for grants in cancer-related research (approx €7m in total), ranging from studies of the genetic underpinning of cancer and molecular mechanisms of tumour growth, to health policy studies on the impact of tobacco control and health services research on palliative care for terminally ill cancer patients.

Studies classed as Generic Health Relevance concerned research that is relevant to all diseases and conditions, or to general health and well-being. It is applicable to any research that cannot be attributed to a particular disease or condition, or to normal function of a specific type of cell or system. Public health research, epidemiology and health services research that is not focused on specific conditions would be included in this category. If a research grant is deemed relevant to more than five Health Categories it is also classed as Generic Health Relevance. Studies classified as 'Other' are those for which specific conditions or diseases cannot be attributed to any of the named categories, including conditions of unknown or disputed aetiology. The category also includes some types of social services research - for example, one 2008 grant which examined children's experience of disclosure of sexual abuse was classified as 'Other'.

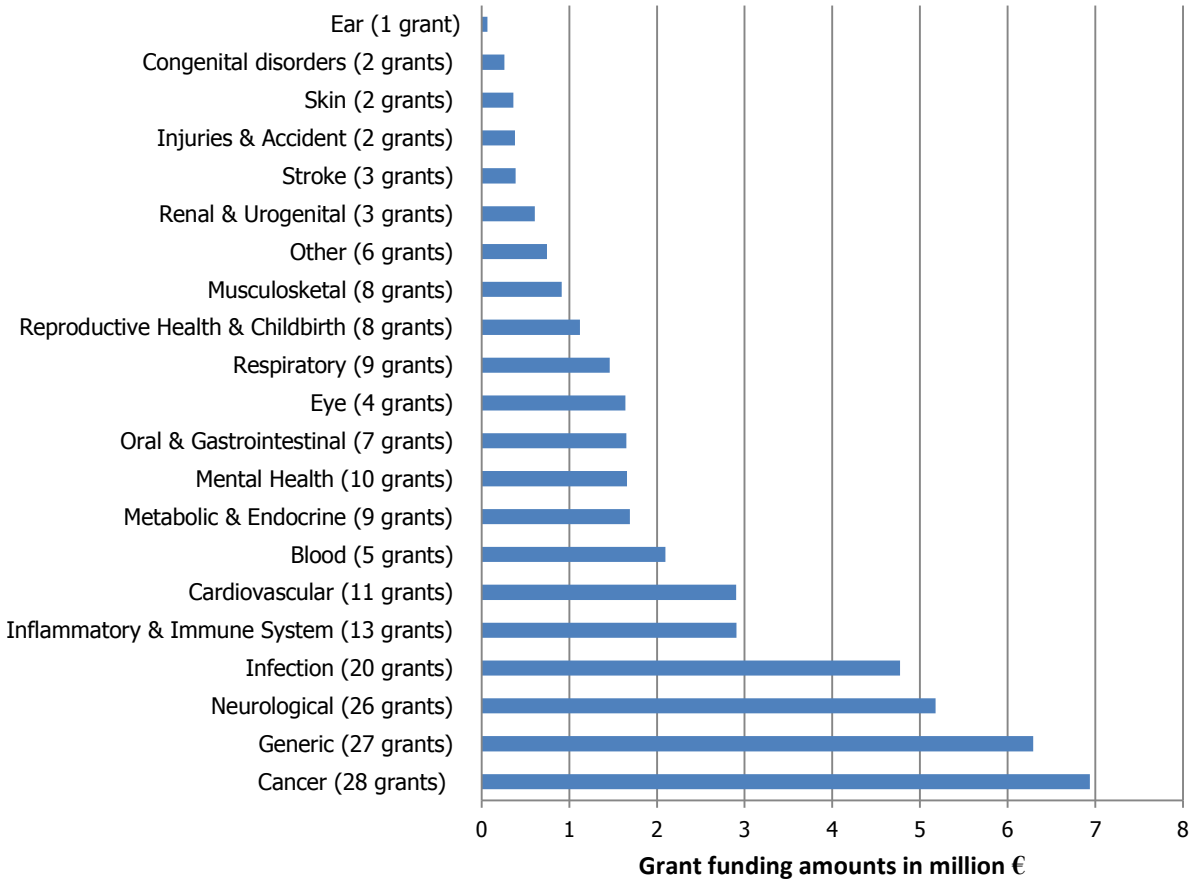

Figure 4: Funding allocated by disease categories (UK Health Research Classification System)

1.4 Distribution by host institution

In relation to the location and hosting of HRB grants, Table 1 shows the host institutions of grant recipients as well as the institutions where the research was actually conducted. Note the variances within institutions in the number of grants hosted (i.e. administered) versus the number of grants where the research was actually carried out within the institution. This variation relates to grants carried out in hospital settings but administered through the affiliated university. In addition, for MRCG grants the charity is regarded as the host institution as the HRB issues grant payments to the charities under this scheme. However, the research is executed by research teams based mainly in universities and hospitals (in some cases, internationally).

Table 1: Distribution of HRB grants by Institution

Institution	**Host Institution** ***N***	**Site of research** ***N***
University College Dublin	48	42
Trinity College Dublin	45	36
NUI Galway	24	25
RCSI	21	18

Institution	Host Institution *N*	Site of research *N*
University College Cork	17	12
Main Teaching Hospitals (St James, Beaumont, Mater, St Vincent's, CUH, UCHG)	8	33
Other Hospitals	7	10
MRCG Charities	7	0
NUI Maynooth	7	7
Dublin City University	6	6
Research Institute for a Tobacco Free Society	3	3
Irish Society for Quality and Safety in Healthcare	2	2
National Cancer Institute (USA)	2	2
Queens University Belfast	2	2
The Rehab Group	1	1
Health Service Executive	1	1
Dundalk IT	1	1
Athlone IT	1	1
University of Limerick	1	1
Robert Gordon University of Aberdeen	0	1
Total Grants	204	204

2. Analysis of research personnel employed on HRB grants

HRB grants enable the creation of high-skilled jobs both directly, through the employment of research staff on the grant, and indirectly – for instance, research support jobs in the public and private sector. In total, almost 300 research-related jobs were directly created through HRB grants that completed in 2008 and 2009, including positions for 190 research staff (such as post-doctoral researchers, clinical research fellows, research nurses, and technical and support staff) and 106 postgraduate students.

A breakdown of the total research personnel supported on HRB grants is provided in Figure 5; a breakdown by personnel place of origin is provided in Figure 6; and a breakdown of personnel type by grant type is provided in Figure 7. Note that MD students are included in the category 'Clinical Medicine / Clinical Research Fellows'.

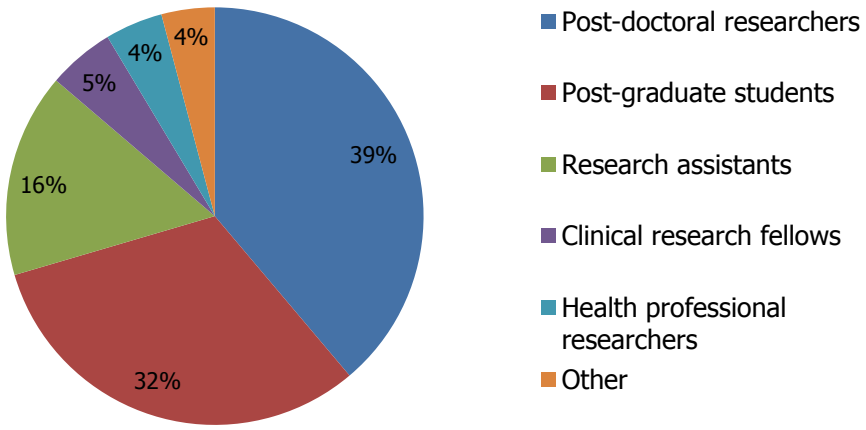

Figure 5: Overall breakdown of personnel funded on HRB grants

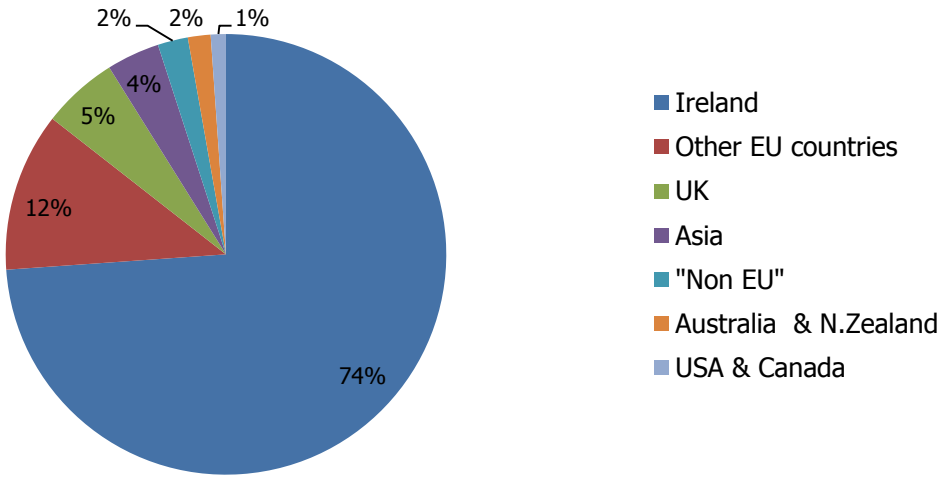

Figure 6: Breakdown of personnel by place of origin

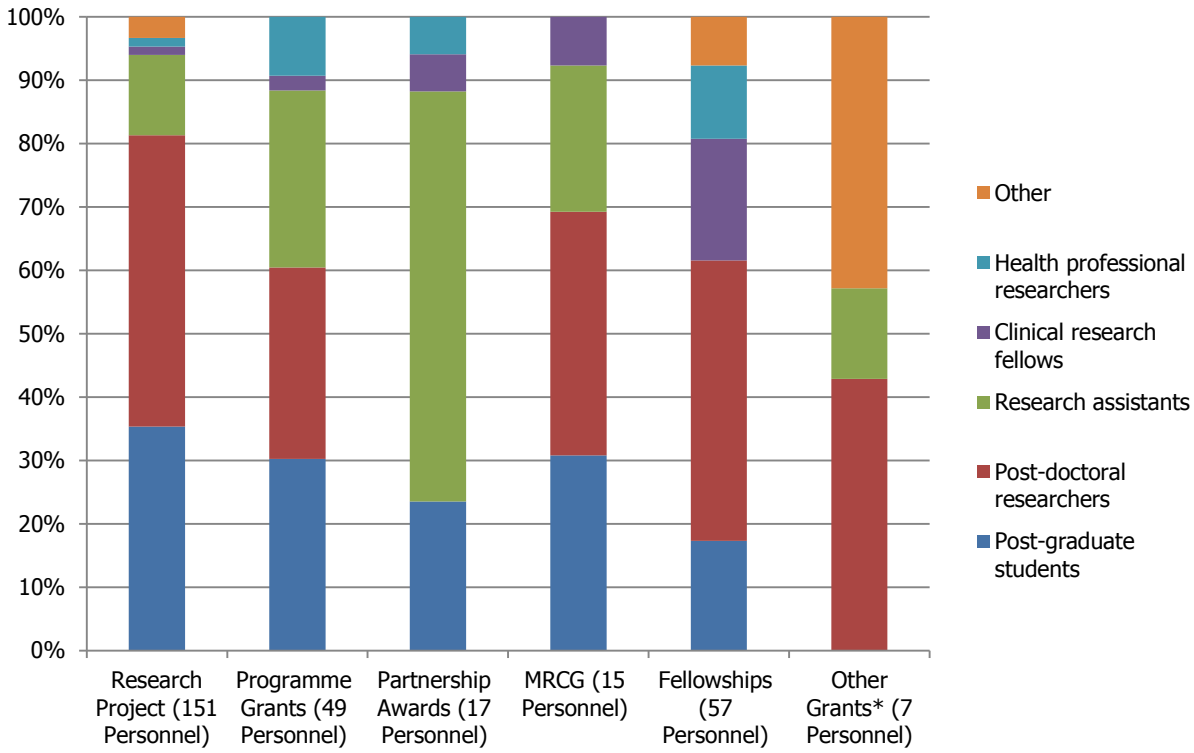

Figure 7: Breakdown of personnel by grant type

* Other grants are Health Information System awards (4 grants), Ireland-Northern Ireland Cooperation Research Project Grants (2 grants), Global Health Research Awards (1 grant).

2.1 Employment destinations of personnel

Grant holders were asked to provide information in relation to the current employment positions of research personnel supported by HRB grants.

Figure 8 shows the overall breakdown of current employment positions. The most common subsequent employment position for the almost 300 personnel funded by HRB grants was post-doctoral research in a higher education institution or other research setting. Ten per cent of the cohort were conducting PhD research and a further 10 per cent had secured tenured lectureship positions ('Lecturers'). Of note was that 13 per cent had moved on to a predominantly health service-based position (including medical clinicians and allied health professionals), with the intention of continuing their research interests in a part-time capacity. The 'Other' category comprised individuals who were mostly based outside of research in their current employment or individuals who were unemployed. Of further interest was that 99 per cent of the 106 postgraduate students were in current employment, 10 per cent students based outside of Ireland. Post-doctoral positions in the USA and the UK were the most common destinations for this overseas-based cohort.

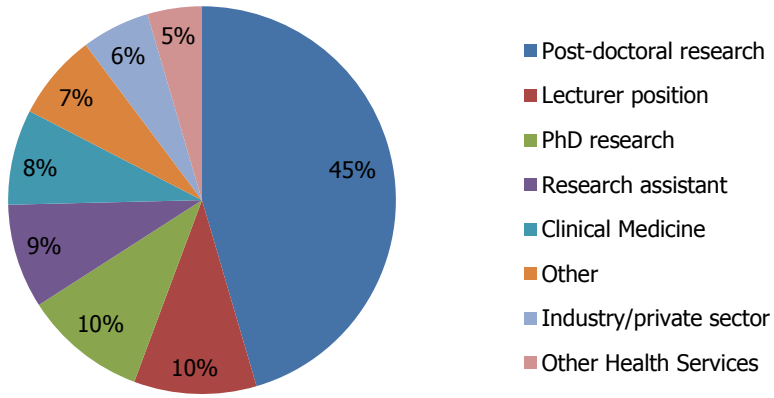

Figure 8: Current employment positions of HRB grant personnel

3. Analysis of outputs from HRB grants

3.1 Scientific outputs

3.1.1 Scientific publications

The 204 grants that completed in 2008 and 2009 produced a total of 526 peer-reviewed scientific publications, of which 73 per cent were original research articles. For grants completing in 2008, 234 publications were produced from an investment of €22.79m, yielding a productivity rate of 10.3 publications per million euro spent (or 1 paper for every €97,393). Grants completing in 2009 produced 292 publications from an investment of €21.68m, equating to an improved productivity rate of 13.5 publications per million euro spent (or 1 paper for every €74,247). Reliable benchmark data from other funders is not currently available but will be obtained through an outputs framework in development by the ESF Evaluation Forum.

Figure 9 shows the distribution of all research publications by grant type. As can be seen project grants produced over half of all publications, an expected finding given that this scheme accounted for half of total allocated funding. Similarly, fellowships accounted for approximately one quarter of all grants awarded and produced just over one quarter of the total publications. Eight programme grants completed in 2008 and 2009 and produced 15 per cent of total publications. This larger relative share of publications is also an expected finding given that programme grants run for five years (as opposed to three years for projects and fellowships), theoretically allowing for more time during the award period to achieve publication of results. Moreover, the scale and synergies of larger research groups funded through programme grants should make these awards more productive than standard grants.

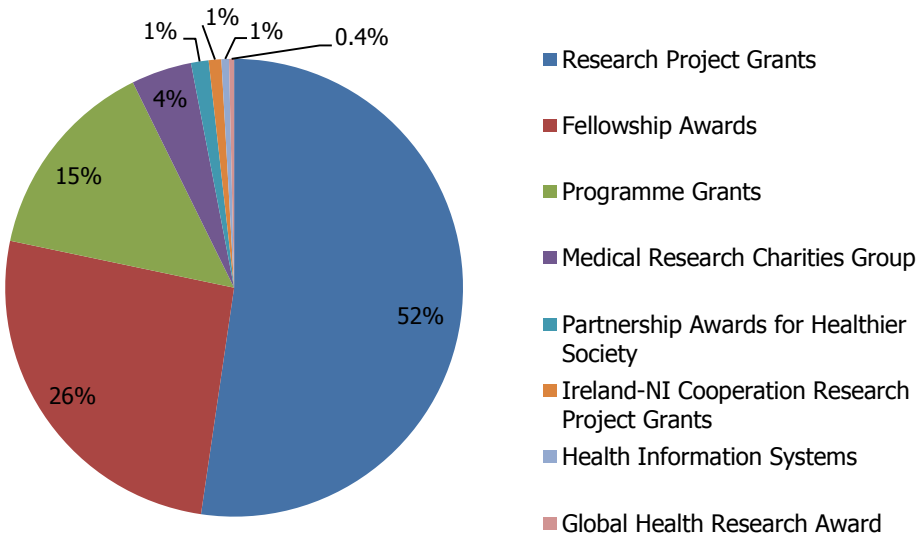

Figure 9: Breakdown of peer-reviewed publications by grant type

3.1.2 Journal impact factors

Figure 10 shows the breakdown of peer-reviewed publications by impact factor level, according to Thomson-Reuters Journal Citation Reports (2009 edition). It must be noted that impact factors are an imperfect measure of the quality and importance of published research and there are significant field-specific variations in journal impact factors. For example, research in largely populated fields (e.g. biomedical sciences) will necessarily have higher impact factors due to higher levels of articles and citations compared to smaller fields (e.g. health services research). However, the calculation of impact factors does give some indication of the significance and prestige of publications produced and in this context it is encouraging that over half of publications are within the medium impact category, with a further third of high to very high impact.

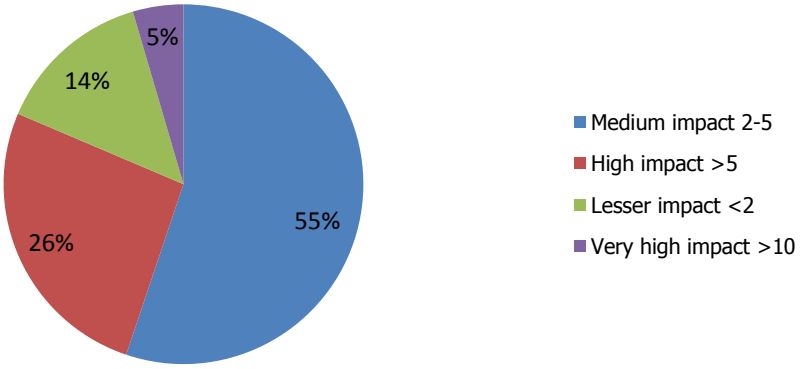

Figure 10: Journal impact factor levels of HRB-funded publications

A breakdown of the overall publication rate and average journal impact factor per grant type is illustrated in Table 2. In terms of publication rate per €100,000 spent, three-year MRCG co-funded grants were the most productive (1.6 papers). As expected, five-year programme grants that funded large multi-disciplinary groups predominantly in the biomedical field, produced publications that featured in journals with the highest average impact factor (4.94). However, it was perhaps disappointing that this figure was not significantly higher, considering the scale and duration of programme grants relative to the other grant types. For further interest, a list of HRB-funded publications that featured in the ten highest impact journals (i.e. as measured by journal impact factor) is included in Table 3. It is notable here that the top six publications as per JIF were produced through grant types other than programme grants. Of course, success in relation to the output and quality of peer-reviewed publications produced through any funding mechanism should ultimately be assessed through field-normalised citation impact. While such an analysis was beyond the scope of this particular report, it is hoped to include such an analysis in future reports.

Table 2: Breakdown of publication rate and average impact factor by grant type

Grant Type	Average no. papers produced per grant	No. papers per €100,000	Average journal impact factor
Project	2.6	1.2	4.66
Programme	9	0.9	4.94
Fellowship	2.5	1.3	3.98
MRCG*	2.2	1.6	4.06
Partnership	0.5	0.9	2.21
Other*	1.3	0.8	4.62

* Other category comprises four Health Information System awards, two North-South cooperative project grants, and one Global Health Research award. MRCG grant amounts include the charities' contribution.

Table 3: Top ten HRB-funded publications as per journal impact factor

Grant Type / PI	Article Title	Journal	Journal Impact factor	No. citations to date
Project Grant PI - Dr Ross Manus (TCD)	Smyth DJ, et al. (2008) Shared and distinct genetic variants in type 1 diabetes and celiac disease	New England Journal of Medicine	47.05	104
Project Grant PI - Dr Ross Manus (TCD)	Hunt KA et al (2008) Newly identified genetic risk variants for celiac disease related to the immune response.	Nature Genetics	34.28	151
MRCG project grant PI - Dr Abhay Pandit (NUIG)	O'Rourke S, Keeney M, Pandit A (2010) Non-viral polyplexes: Scaffold mediated delivery for gene therapy	Progress in Polymer Science	23.75	N/A
Cancer Prevention Fellowship - Dr Gwen Murphy (NCI)	Laiyemo AO, Murphy G, et al. (2008) High-risk adenoma recurrence and the utility of the post-polypectomy colonoscopy surveillance guidelines.	Annals of Internal Medicine	15.52	41
Post-doctoral fellowship (Dr Katherine Johnson, TCD)	Bellgrove, M.A., Chambers, C.D., Johnson, et al (2007) Dopaminergic genotype biases spatial attention in healthy children	Molecular Psychiatry	15.05	18
Project Grant PI – Dr Aidan Corvin (TCD)	O'Dushlaine C, Kenny E, Heron E, Donohoe G, Gill M, Morris D, Corvin A. (2010) Molecular pathways involved in neuronal cell adhesion and membrane scaffolding contribute to schizophrenia and bipolar disorder susceptibility.	Molecular Psychiatry	15.05	N/A
Programme Grant PI - Prof Dermot Kenny (RCSI)	Edwards RJ, et al. (2007) Bioinformatic discovery of novel bioactive peptides.	Nature Chemical Biology	14.61	24
Programme Grant PI – Prof Des Fitzgerald (UCD)	Pidgeon GP, Tamosiuniene R, Chen G, Leonard I, Belton O, Bradford A, Fitzgerald DJ (2004). Intravascular Thrombosis following Hypoxia-Induced Pulmonary Hypertension: Regulation by Cox-2	Circulation	14.6	42
Programme Grant PI – Prof Des Fitzgerald (UCD)	Belton O, Duffy A, Toomey S, Fitzgerald DJ. (2003) Cyclooxygenase isoforms and platelet vessel wall interactions in apoE knockout mouse model of atherosclerosis.	Circulation	14.6	90
Programme Grant PI – Prof Tim Foster (RCSI)	Fitzgerald, J.R., Foster, T.J., and Cox, D. (2006). The interaction of bacterial pathogens with platelets.	Nature Reviews Microbiology	14.31	70

3.1.3 Scientific presentations

The extent to which researchers present their work to scientific peers at national and international scientific meetings is an indicator of scientific success and international involvement.

Figure 11 shows the breakdown of scientific presentations delivered by HRB-funded personnel. Of grants completing in 2008 and 2009, a total of 92 per cent of grant holders presented the results of their HRB-funded research at scientific meetings and conferences. Importantly, HRB-funded grant holders appear to be very active on the international scientific stage as presentation at international conferences was the most common dissemination type.

Invitations to deliver keynote presentations at international conferences are also an important indicator of scientific recognition and prestige among the international community. It is, therefore, very encouraging that HRB grant holders delivered 51 keynote presentations at international meetings.

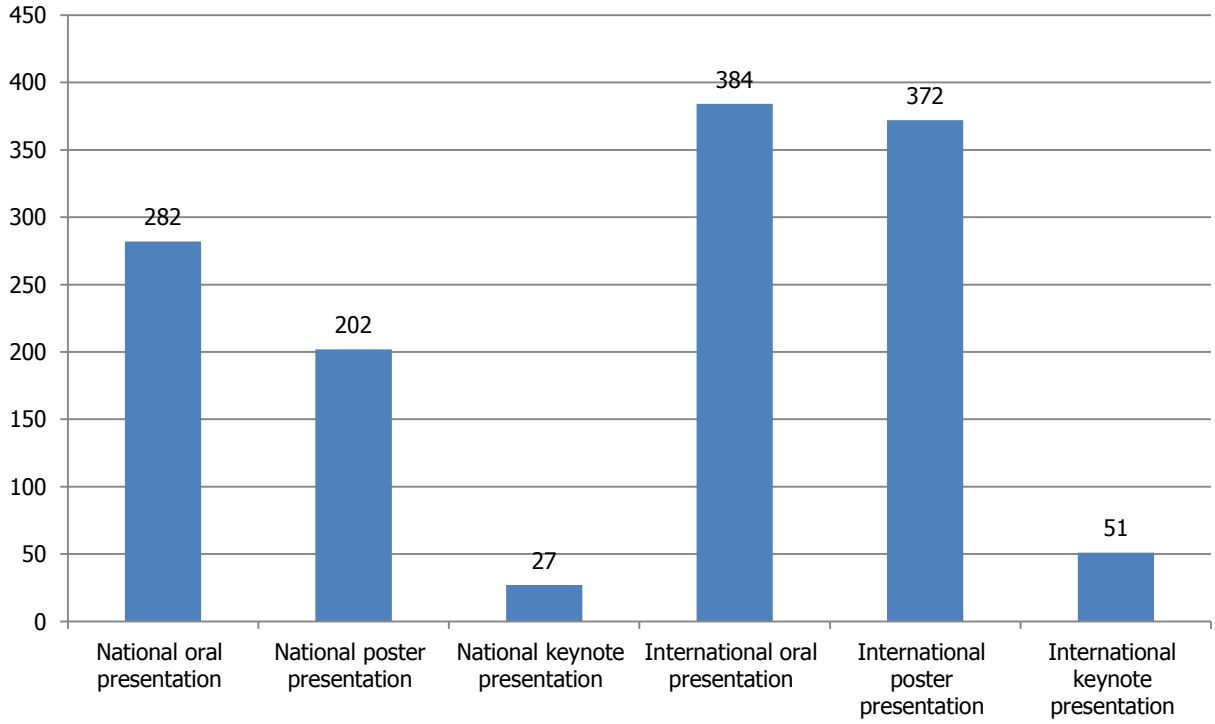

Figure 11: Scientific presentations by HRB grant holders

3.1.4 Scientific collaborations

Development of collaborations and linkages with national and international colleagues is of increasing importance in scientific research. From grants completing in 2008 and 2009, 72 per cent of grant holders established a new scientific collaboration during the lifetime of the HRB grant. Table 4 shows the breakdown of the overall number of new collaborations (N=384) formed according to the institutional affiliation of the collaborating partner. Links with colleagues based in national and international universities were the most common forms of collaboration established by HRB grant holders.

Table 4: No. collaborations established by institution type of collaborating partner

Organisation Type	No. collaborations established
University	296
Hospital	40
Research institute	20
Government department	12
Industry	10
Other	6

The breakdown of new collaborations by collaboration type is shown in Figure 12. Formal (ie structured, with a specific goal), international collaborations were the most frequently cited new collaboration type. The most common form of collaboration reported was one involving a scientific peer in an overseas university.

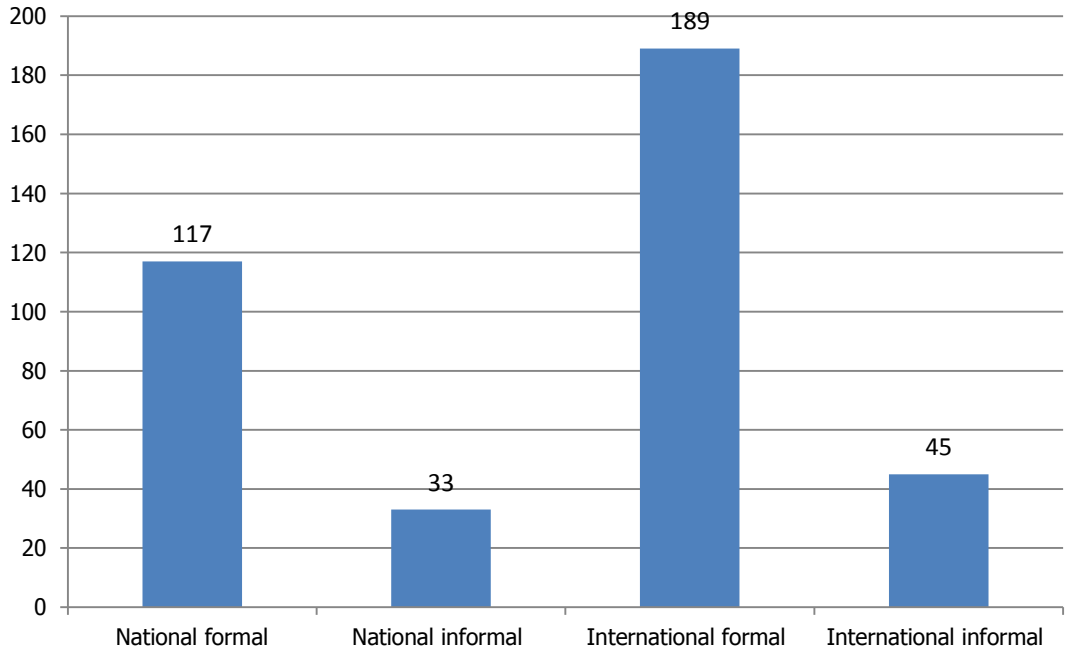

Figure 12: Breakdown of collaborations by type

The breakdown of international collaborations according to the resident country of the collaborating partner is shown in Table 5. The majority of new collaborations were made with organisations and individuals in the UK and USA, in total accounting for 68 per cent of new international linkages.

Table 5: Breakdown of international collaborations by location of collaborating partner

Country	Number
United Kingdom	86
USA	71
Germany	13
Canada	9

Country	Number
France	8
Australia	7
Japan	5
Holland	5
Sweden	5
Austria	4
Switzerland	3
Spain	3
Italy	3
New Zealand	2
China	2
Belgium	2
Various other countries	1

3.1.5 Development of novel research techniques

The development or application of innovative, cutting-edge research technologies is an important indicator of the extent to which HRB grant holders are at the international forefront of their respective research fields. HRB grant holders were, therefore, asked in EOG reports if in the course of their HRB grant period, they had developed or established a novel research technique or piece of research infrastructure:

- New to their laboratory / research programme or facility
- New to Ireland
- New to the Field / World (Not previously in use anywhere)

Figure 13 shows the number of grant holders reporting the development/application of research techniques or methodologies according to the degree of novelty. Of interest was that a significant number of grant holders (N=26) reported that they had developed a scientific or research technique novel to the entire field of research. Some examples include:

- Prof Paul McLoughlin and his group (UCD) developed a new technique for identifying and quantifying changes in pulmonary vascular structure. The initial application of this technique has already been published and a further refinement will be published shortly.

- Dr Aidan Corvin and his group (TCD) developed the 'SNP ratio test', a novel method of analysing molecular pathways in genome-wide association data. This is now being used by other groups investigating the genomics of common human diseases.

- Prof Catherine Comiskey and her doctoral student (TCD) developed a novel analytical mathematical solution to an integral equation and then applied this solution for the first time worldwide to the problem of estimating the incidence of untreated opiate use in Ireland.

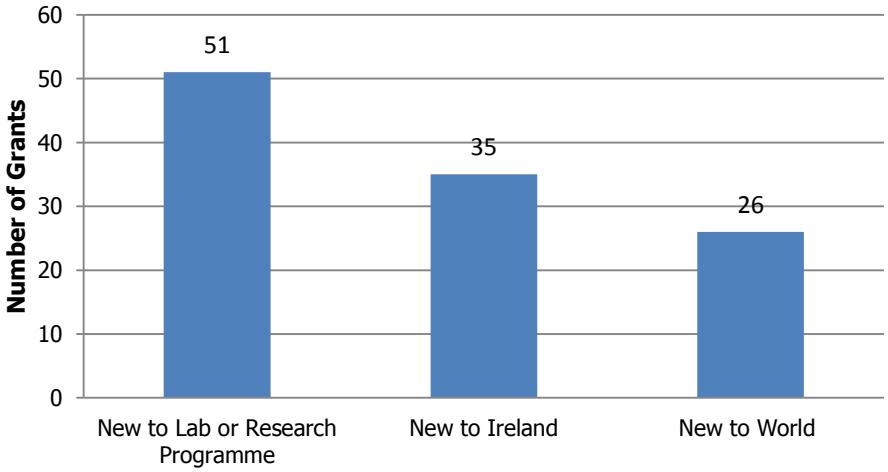

Figure 13: Breakdown of application of research techniques by level of novelty

3.1.6 Scientific media outputs

Wider dissemination of research findings to non-scientific audiences is critical for improving the public understanding of science and more specifically, to promote of the benefits and value of health research.
When asked about the level of coverage of their research in the media and public fora, 21 per cent of grant holders reported presenting their findings to lay audiences via various channels.

Figure 14 shows the distribution of non-scientific dissemination events reported by HRB grant holders according to the media type. Of encouragement in this regard was the high number of newspaper articles and radio interviews that reported findings from HRB grants (a caveat is that grant holders were not asked if the media coverage was positive or negative, or if HRB funding was acknowledged).

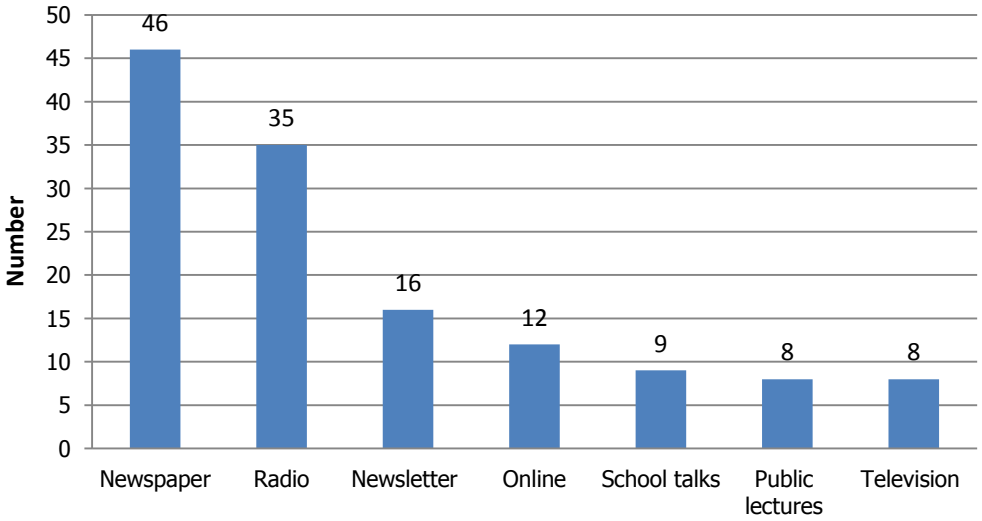

Figure 14: Breakdown of dissemination events by media type

3.2 Human capacity outputs

3.2.1 Higher degrees attained

From HRB grants concluding in 2008 and 2009, 106 post-graduate students were supported. Of this group, 87 completed a PhD, 10 completed an MD, and nine completed an MSc. Figure 15 shows the number of degrees completed across the five broad research areas. As expected given the predominant allocation of funding for biomedical and clinical research grants, almost three-quarters of PhDs completed were in these fields, while approximately a quarter were in the fields of population health sciences and health services research.

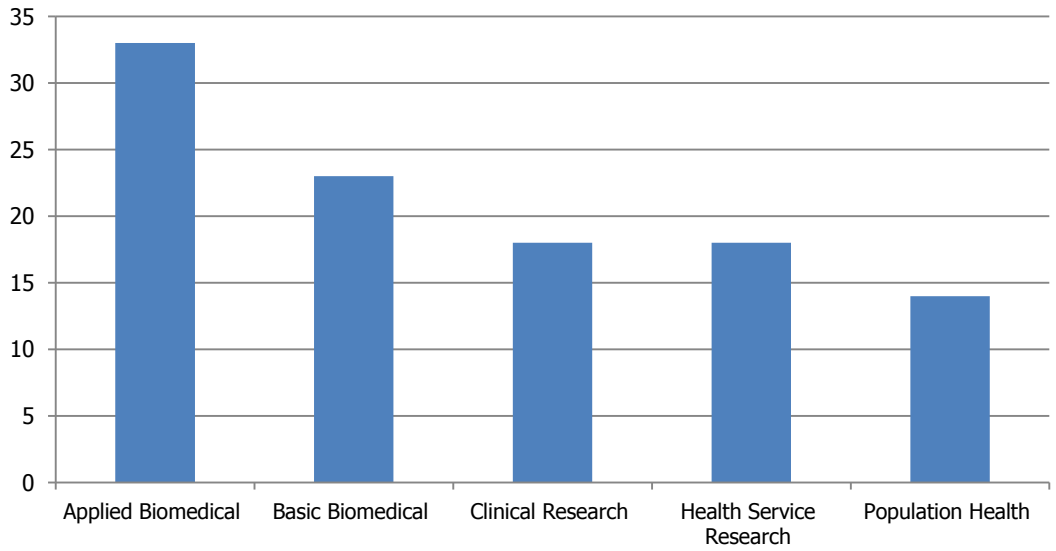

Figure 15: Number of post-graduate degrees completed in five broad research areas

3.2.2 Health professionals engaged in research

A key strategic objective of the HRB is to embed research in the health system by building capacity for high-quality research among health professionals. HRB grants that completed in 2008 and 2009 contributed to this objective by providing health professionals with the opportunity to undertake advanced research training through completion of a post-graduate qualification through participation in a HRB-funded project or programme as a member of the research team. Table 6 shows the areas of research in which health professionals salaried through the HRB grant were engaged, and the manner of their engagement (It should be noted that the figures are most likely a significant underestimate due to a technicality of the End-of-Grant report – i.e. some PIs may have classified health professionals working on the grant as post-graduate students, research assistants or post-doctoral researchers. The report form will be amended to ensure that attainment of more reliable data on health professional engagement will be possible in future reports).

Table 6: Health Professionals' engagement in HRB-funded research

		Medical Clinicians	Nurses	Dentists	Other

Broad research area	Basic biomedical	0	0	0	0
	Applied biomedical	10	0	0	0
	Clinical research	12	1	0	2
	Health services research	3	5	0	1
	Population health	2	0	6	0
Training received	Post graduate qualification	15	6	0	0
	Participation in research project	12	0	6	3

3.2.3 Researchers progressing towards independent investigator

A related strategic objective of the HRB is to build capacity for high-quality health research by supporting young researchers as they progress up the career ladder towards independent investigators. The HRB grants completing in 2008 and 2009 provided advanced training and experience to 84 post-doctoral researchers, through both projects/programmes grant funding and individual fellowship awards. Table 7 shows the broad research areas in which these post-doctoral level researchers were engaged. Of concern here is the very low proportion of post-doctoral level researchers in population health sciences and health services research (less than 10%). However this is an inevitable result of historically low levels of PhD students being trained in these disciplines. As the number of PhD students in these areas is now increasing due to targeted HRB funding (e.g. the PhD Scholars Programme in Health Services Research), we would expect to see a subsequent increase in post-doctoral researchers in these fields being funded by the HRB in future years.

Table 7: Researchers advancing towards PI status (by broad research area)

Broad study area	No. post-doctoral researchers
Basic Biomedical	37
Applied Biomedical	29
Clinical Research	10
Health Service Research	3
Population Health	5

3.3 Health policy and practice outputs

A key area in terms of assessing HRB-funded research relates to health sector impacts and specifically, the generation of outputs and outcomes that may influence health policy, clinical practice and patient care. In EOG reports, grant holders were asked to outline the outputs produced and activities undertaken that may lead to an impact in these areas. The findings are described below in

terms of overall proportion of grants producing an output in each category, together with some examples relating to each output.

3.3.1 Generation of policy-relevant evidence and data

A total of 17 grants (8%) produced evidence or data with the direct intention of informing health policy formulation or revision. For example, a research project carried out at TCD led by Prof Catherine Comiskey sought to estimate the prevalence and incidence of opiate use in Ireland. This project has provided policy makers with greater evidence of the incidence of opiate use, including geographical data. This will enable greater evidence-based placing of treatment facilities.

3.3.2 Contribution to clinical guidelines and protocols

A total of 21 grants (10%) contributed to improved clinical practice through development of new treatments, interventions or clinical guidelines. For example, a project grant led by Dr Lorraine Kyne (Mater / UCD) that investigated the hospital superbug *Clostridium difficile* contributed to the development and validation of a clinical prediction tool for recurrent *C. difficile* infection (CDI). This simple, reliable and accurate tool will help clinicians in identifying high-risk patients most likely to benefit from measures to prevent recurrent CDI infection. This tool will also be of great value in selecting high-risk patients for clinical trials of novel agents to prevent recurrent CDI. The same grant produced national treatment guidelines for the surveillance, diagnosis and management of *C. difficile* in Ireland. Also, information on antimicrobial resistance patterns produced on the grant have led to the curtailment of fluoroquinolone antibiotics in many healthcare facilities in Ireland. The group also identified risk factors for failure of CDI treatment with metronidazole, which will help clinicians in deciding which antimicrobial agent to use as first line in patients with CDI.

3.3.3 Knowledge transfer events with research users

An encouraging 28 grants (14%) disseminated results of research to 'users' such as policy-makers. For
example, a Partnership Award led by Prof Luke Clancy (Research Institute for a Tobacco Free Society) evaluated the quality of smoking cessation services in Ireland. As part of a research-based initiative to improve the quality of training, the research group developed a database to collect evaluative information and organised training workshops for smoking cessation service providers and managers in three parts of Ireland. A report was subsequently issued to all service providers throughout Ireland with recommendations aimed at improving the quality of service.

3.3.4 Appointment of PIs to advisory roles

A combined total of 21 grant holders (10% of the overall number) reported being appointed to advisory roles to government or policy-makers and attributed this, in part, to the findings of their HRB grant. For
example, a project grant study led by Dr Ciaran Simms (TCD) of wheelchair design and occupant safety during a road traffic accident has provided evidence in relation to changes that should be made to wheelchairs to increase safety. The PI and a key collaborator from industry are now members of the National Standards Authority of Ireland working group on wheelchairs and Best Practice Guidelines group for wheelchair transportation.

3.3.5 New or improved interventions and services for patient care

Nine grants (4%) produced results which have led to more effective non-pharmaceutical treatments or interventions to improve patient care. For example, Dr Susan Smith (TCD) was PI on a project grant that involved a randomised controlled trial designed to evaluate the effectiveness of a psychological, family-based intervention to improve diabetes-related outcomes in patients with poorly controlled type 2 diabetes. The results of the study, which involved 121 diabetic patients, showed

that integrating family members into the patient's treatment process and changing negative and/or inaccurate illness perceptions or beliefs in patients with poorly controlled type 2 diabetes resulted in improved health and psychological well-being.

3.3.6 Development of new diagnostics and treatments

A total of 17 grants (8%) contributed to the ongoing development of diagnostic assays, promising new treatments or therapeutic tools in order to improve patient care. For example, research conducted under a five-year programme led by Prof Pete Humphries (TCD) has led to the pre-clinical development and validation of a novel gene therapy for common eye diseases such as retinitis pigmentosa that leads to blindness in those affected. The group based in TCD are moving into human clinical trials to evaluate the effectiveness of this innovative therapy.

3.3.7 Health service innovations, efficiencies and cost-savings

A total of 18 grants (9%) developed innovative technologies to benefit clinical practice or improve health service delivery. For example, a clinical research training fellowship holder (Dr Paul Gallagher, Cork University Hospital) designed and tested a novel medication review system for use by health professionals to manage drug prescribing to older people, with the aim of minimising medication-related problems and improving patient safety. Implementation of the system to older patients on admission to hospital resulted in highly significant improvements in prescribing quality at the time of hospital discharge compared to usual hospital care alone. There were significant and sustained reductions in the prescription of unnecessary and potentially harmful drugs as well as a reduction in the under-use of clinically beneficial drugs. Routine application of the system to older patients has the potential to improve patient safety and minimise adversity and related healthcare costs.

Other grants identified potential cost savings to the health system. For example, a Nursing and Midwifery fellowship holder (Ms Zena Moore, RCSI) carried out the first study in Ireland aimed at determining the effect and cost of repositioning patients three-hourly at night time on the number of pressure ulcers that developed among older persons, nursed in 12 long stay settings. The study used a novel repositioning technique and compared it to usual care among 213 participants enrolled into the study. Not only did the novel repositioning technique result in far fewer pressure ulcers among older patients, it was also shown that using this technique in the hospitals where the study was conducted would yield an annual cost saving of €250,676 when compared to usual care.

3.4 Economic, commercialisation and enterprise outputs

Through its various funding schemes, the HRB also strives to make an impact on the knowledge economy and encourages HRB grant holders to commercialise and exploit their research findings where appropriate. In EOG reports, grant holders are asked to outline any research commercialisation activities undertaken as well as other economic outputs generated as a result of their HRB funding. A summary of the findings are outlined below.

3.4.1 Funds leveraged

In total, 117 additional grants were secured by 41 per cent of grant holders on the back of research findings from their original HRB grant (the total value of funds leveraged through the grants was not possible to include in this analysis). Figures 16 and 17 show the breakdown of these 117 leveraged grants according to the funding source of the grant, nationally and internationally. While the vast majority of leveraged grants were awarded by national funding sources including the HRB, a significant number of grants were awarded by international sources, contributing a non-exchequer gain to the Irish economy. When considering leveraged funding it is necessary to consider that some new grants may have been awarded on the basis of the participation (rather than primary leadership)

of the PI within a wider research consortia. This may be particularly the case for EU grants, which require a consortium of European researchers to be established for an application to be eligible. Nevertheless, the allocated funds of a multi-million EU FP7 grant to individual PIs are usually very significant.

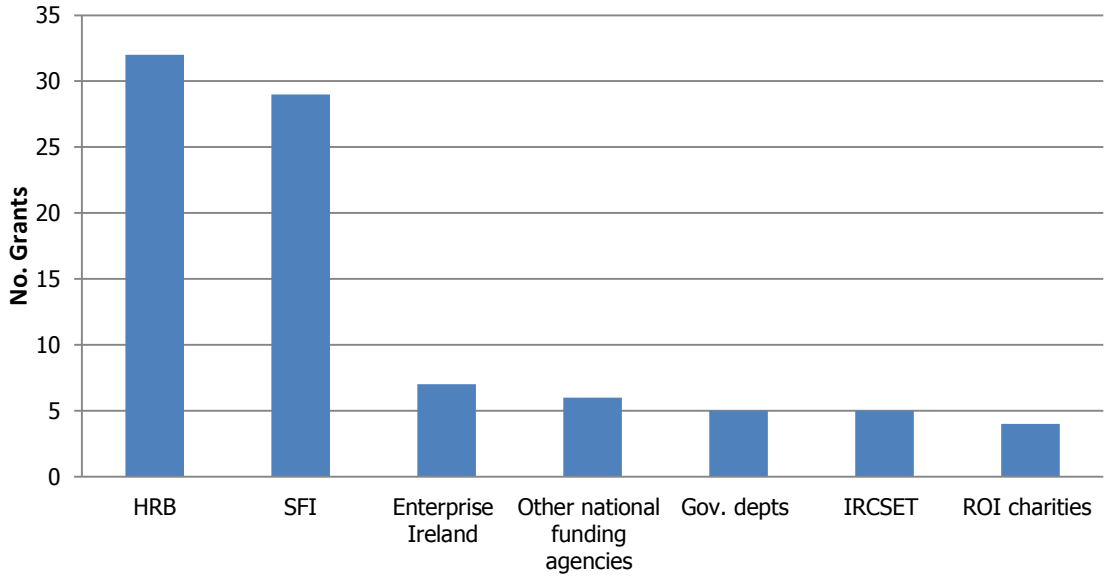

Figure 16: Grants leveraged from national sources

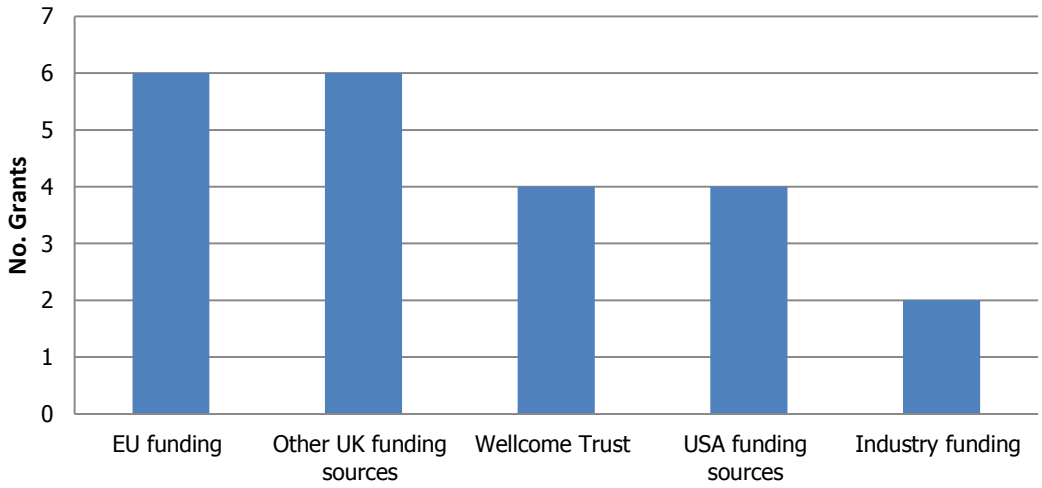

Figure 17: Grants leveraged from international sources

The attainment by grant holders of follow-on funding based on the findings of the HRB grant is an indicator of how successful that grant was in developing a longer-term, sustainable programme of research. Table 8 shows the success of PIs funded under the various grant schemes in securing further funding. Notably, programme grant holders were the most successful in securing additional funding. This is an expected finding as five-year programme grants provide PIs with the additional time and resources to establish a sustainable, internationally competitive research programme for which the pursuit and acquisition of further research funding is an absolute imperative. A disappointing statistic was the proportion of partnership grant holders who attained follow-on funding (7%), given that an objective of this seed-funding scheme was to bring multiple partners together to collaborate and provide the basis for grant applications to project and programme schemes.

Table 8: Proportion of grant holders by funding category that secured new grants

Grant Type	% PIs securing additional funding
Programme Grants	100%
Health information system awards	75%
Research Project Grants	46%
Medical Research Charities Group	36%
Fellowship Award	31%
Partnership Awards	7%

3.4.2 Patent applications

In total, seven grants generated results that led to at least 12 patent applications, of which 10 have been granted to date. A further nine grant holders stated their intention to apply for a patent based on the findings of their HRB grant. This represents significant commercialisation activity when one considers that much of the HRB grant portfolio funds research not directly relevant to bio-industry or the generation of intellectual property (e.g. population health sciences and health services research). Some examples of HRB grants that generated patent applications are described below.

- Patents arose from a research project grant held by Dr. John Lowry in NUI Maynooth entitled 'Real-time simultaneous monitoring *in vivo* of glutamate and H2O2 in brain tissue, using a novel implantable polymer-enzyme composite device'. This project applied for and was issued several patents for glutamate monitoring technology.

- A UCC-based project project led by Dr Declan Soden in the Cork Cancer Research Centre led to a patent for an internal tissue (endoscopic) electroporation device. The technology facilitates the permeabilisation of otherwise poorly permeable tissue i.e. the tumour. The technology has been demonstrated to work in the successful treatment of inoperable canine colorectal cancers without the aid of surgery or other ablation methods.

- A serendipitous finding in another project led by Professor Bernard Mahon in NUI Maynooth led to the award of a patent for a novel anti-microbial peptide effective against MRSA (called Maynosin). The researchers will pursue the development of this antibiotic through Enterprise Ireland. The work brought a new insight into the link between infection and asthma, and offers a possible drug for commercial development.

- Through an MRCG grant, Dr Abhay Pandit of NUIG's department of biomechanical engineering, secured a patent for use of a biodegradable nanoshell for delivery of targeted treatment for the skin disorder Epidemolysis Bullosa.

- A patent was secured by a team led by Professor Colin Hill, Dept of Microbiology in UCC, for the development of novel 'lantibiotics', to be used against hospital acquired antibiotic resistance bacteria.

3.4.3 Licence agreements

Two HRB grants have contributed to, or directly led to, license agreements between academic institutions, PIs and biotech or pharmaceutical companies. For example, Dr Lowry's research into brain glutamate monitoring technology described above, for which a patent was awarded, has led to licensing agreements for two types of sensors. The agreements have been signed with a Dutch pharmaceutical company for the development of sensor technology.

3.4.4 Commercialisation grants awarded

The acquisition by grant holders of market development grants from agencies such as Enterprise Ireland is an indicator of research commercialisation activity and further development of a product towards the market. At least six HRB grant holders reported obtaining one of these product development grants. For example, Dr Soden's project described above, which led to a patent for an internal tissue (endoscopic) electroporation device, has been demonstrated to work in an animal model. The potential of the technology now needs to be validated in a Phase I trial in cancer patients with inoperable tumours. The PI has secured an Enterprise Ireland Technology Development Grant to advance the development of this technology to market.

3.4.5 Spin-off companies created

At least two campus spin-off companies are in development as a partial result of HRB grant funding. One grant holder and her collaborators are in the process of setting up a campus company to licence bioinformatics software developed through research grants including the HRB grant. Dr Lowry in NUI Maynooth has recently established a spin-out campus company (Bluebox sensors) to capitalise on findings from multiple research projects including several HRB and SFI grants.

3.4.6 Industrial collaborations established

HRB grant holders established at least 10 formal collaborations with industry during the funding period of the HRB grant. The industrial collaborating partners range from large pharmaceutical companies such as Pfizer to SEM's and biotech companies such as Zycare and Cellix Ltd. The nature of the collaborations varies from formal research collaborations and provision of material and resources to co-development of new treatments. This is in line with the findings of a extensive HRB survey of all active HRB grant holders in early 2010 which sought to establish a baseline of academic-industry collaborations (as part of a wider Forfas mapping study). The HRB survey showed that just over 10 per cent of HRB grant holders had established an industrial collaboration for different objectives e.g. formal research collaboration, product development, resource provision.

4. Conclusions and next steps

The analysis displayed in this report demonstrates a wide variety of outputs produced by HRB-funded research in terms of scientific output, capacity-building, health sector and economic benefits. When compared to the level of outputs collated from previous years' end of grant reports, the indications are that HRB funded research is producing more research outputs of a improving quality, clearer and more robust policy and practice outputs, and significantly increased research commercialisation activity in the form of patents applied for and secured. Furthermore, several indicators point to a generally internationally competitive and internationally engaged HRB-funded research community. It is intended that the data generated for this report will serve as a baseline for future output reports, which will be important for monitoring trends in research output as the new HRB strategic plan becomes embedded in the system.

In relation to next steps it will be important for the HRB to:

- systematically track these outputs and outcomes into the future as they manifest into tangible health and economic impacts, to enable the HRB to promote the value and benefits of health research, and to better understand the factors that influence research impact
- conduct impact assessment studies, through the use of case studies and other qualitative methodologies, to enable a more detailed analysis of health sector benefits and economic gains accruing from HRB grants in the longer term
- benchmark and compare the quality of outputs and outcomes produced through HRB-funded research against those produced in other countries