MRC Medical Research Council

MRC Translational Research 2008-2018

Evaluation Report: Bibliometric analysis (Annex A2.5)

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Contents

Annex A2.5 Bibliometric Analysis

This Annex describes the bibliometric analysis of publication output of MRC awards as part of the MRC's 10-year translational research evaluation, conducted between October 2018 and July 2019. It covers all publication output stemming from awards funded over a 10-year period from 2008 to 2017. The overall MRC portfolio included all types of award. This data is compared to publication output of other top international funders of biomedical research, namely the US National Institutes of Health and Wellcome. While the three research funders have somewhat different scope of research and scale of activity, the bibliometric analysis developed comparable datasets for the three funders and provided robust quantitative information. All data and figures produced in the bibliometric analysis are available in a supplementary data book. The bibliometric analysis was conducted by Science-Metrix and compiled by Technopolis Group.

1 Methods

The primary purpose of the bibliometric analysis was to calculate the citation uptake of publications supported by the three funders in various data sources, such as guidelines, patents and clinical trials. It also enabled the comparison of the relative performance of MRC translational research funded via different initiatives. An important assumption underlying such analyses is that citations are a good proxy for contributions to scientific knowledge. While citations are generally used to acknowledge the positive influence of one piece of research on another, there can be other reasons for accumulating citations.[1]

The MRC recognises the limitations of metrics and hence the need to use metrics responsibly in interpreting those to assess scientific impact. The MRC/UKRI is a signatory of the San Francisco Declaration on Research Assessment (DORA)[2] and so refrains from using journal impact factor to assess scientific quality. Citations calculated for the MRC portfolio should be used as contribution to the evidence base within the scientific discourse.

1.1 Database selection: The Web of Science

The Web of Science (WoS) database (Clarivate Analytics) offers comprehensive coverage of the most cited scientific literature in the natural and the health sciences, and in engineering through its Science Citation Index Expanded database; for the period of the present study (2008–2017), this database includes approximately 17 million peer-reviewed articles and conference papers, 5 million of which are in the health sciences, published in 14,000 journals, across 176 sub-disciplines.

A language bias exists in the WoS in that this database mainly includes papers written in English. While this is not problematic for the fields of natural science and engineering, as the majority of their output appears in English, the bias is more pronounced in the social sciences and humanities. Researchers from these fields tend to publish in regional journals or books, which are often written in the local language and may therefore not be covered by the database. This creates a bias in search results toward research published in English in these fields. This limitation should not however influence the results of this study as the study is heavily focused on the health sciences, mostly published in English, and the focus of the study is the research outcomes of UK and US funding agencies, which are most likely published in English as well.

[1] For example, one article may be contradicting another; the author would in that case use a citation to highlight the article being contradicted. An article may also use citation to reference general background information or in another case to refer to principal foundation on which the new piece of knowledge is built. These varying citation behaviours are all treated equally in analyses of scientific impact, which are blind to the differences between them.
[2] https://sfdora.org

1.2 Identification of relevant publications

In the case of the MRC, a list of publication output was provided from the ResearchFish® database, which contains publications (linked to awards) contributed by award holders. MRC awards with a starting data after January 2008 were stratified into three types: directed translational, non-directed (researcher-led) translational and non-translational. Whilst, the directed translational awards, and associated papers, were identified by the name of the associated funding initiative, the remaining awards were identified as translational or not, by the use of a machine learning algorithm of the Dimensions tool from Digital Science. This tool looked at the title and abstract data of the awards and classified them as to their translational intent at the outset of the research. The directed translational and research-led translational awards were then grouped as the MRC's translational portfolio for the sake of the bibliometric analysis.

For the NIH and Wellcome awards, it was not possible to accurately determine an equivalent to the directed translational portfolio, so the awards were simply split on translational intent based on the same Dimensions tool working on title and abstract data.

The first step consisted of building a data set of publications that mention any of the three funders in the acknowledgements by using a set of keywords specific to the funders. The data set was further improved by using complementary sources of information, such as the Research Portfolio Online Reporting Tools (RePORTER) for NIH publications, Europe PubMed Central (EPMC) for Wellcome publications and Gateway to Research (GtR) for MRC publications.

The second step consisted of building a list of grant number patterns for each funder using regular expressions that were subsequently queried in the acknowledgement text of the data set in order to identify potential grant numbers. The last step consisted of matching exactly the list of grants provided by the MRC to the potential grant numbers that were identified by the query while disregarding non-alphanumeric characters. This resulted in the funders' preliminary portfolios of publications.

While this methodology is quite effective at building the funders' portfolios with virtually no false positives, their comprehensiveness relies on the goodwill of authors to acknowledge their funders adequately, which is a common problem in scientific publishing. A substantial number of authors acknowledge their funders' contribution without disclosing the grant numbers, others make errors in the grant numbers, while others do not mention their funders at all.

A final quality filter was applied to the funders' preliminary portfolios by removing articles that were published within six months or before the award start date. This removed 10% of the MRC publications, 9% of Wellcome publications and 5% of the NIH publications. The resulting portfolios are referred to the "full portfolio" in the data book:

	Number of awards	'translational' awards*	'non-translational' awards*	Number of publications linked to awards
MRC	7,799	3,045	4,693	46,695
Wellcome	12,994	1,460	5,554	29,285
NIH	152,350	31,787	67,582	439,654

* Note that classification is based on auto coding by Dimensions; not all awards could be coded

The MRC clearly stands out for its mean number of publications per grant (6.0) compared to the Wellcome and the NIH (2.3 and 2.9, respectively). This is probably due to the fact that not all publications could be identified as legitimate output of awards in scope for the relevant funding period, leading to varying recall rates across funders' portfolios. In the case of the

MRC portfolio, high recall rates are expected as award holders report on linked publications in ResearchFish®, even where grant numbers are not cited in the publications' acknowledgement section. In the case of the Wellcome portfolio, however, only about half of the publications identified in the first step described above were successfully matched to a relevant grant number. The discrepancy, affecting primarily the NIH and Wellcome portfolios, however, should not be regarded as an impediment to the study, since the portfolios still contain a sufficiently large number of publications to infer representative statistics for all three funders, even if they are not exhaustive. It is assumed that the publication portfolios identified this way do not inherently incorporate either a positive or negative quality bias compared to the full portfolio.

Nevertheless, stability intervals were calculated for direct uptake metrics. These inform on the uncertainty of bibliometric indicators by providing a range within which a computed score could likely fluctuate in response to a change in the underlying set of publications that was used to compute it. Stability intervals are built by randomly resampling, with replacement, a group's papers to produce many resamples of equal size to the group's number of papers. This analysis confirmed that the three datasets allow for a robust analysis of uptake.

1.3 Publication count and citation uptake indicators

1.3.1 Number of publications, using the full counting method

This indicator is the number of publications for a given entity (in this case, a funder), calculated using a method known as *full counting*. Using this method, each entity receives a full count of 1 for each publication. For example, if a publication is supported by the MRC and Wellcome, both get full credit for that publication.

Data based on full counting indicate only which funding agencies are involved in the production of an article, regardless of their individual contribution, while recognising that one might have contributed more than the others.

1.3.2 Share of papers cited

This is the share of the funders' portfolio of publications that were cited at least once (also referred to the citation uptake) by different document sources. In this study, we analysed the following sources:

- Peer-reviewed publications indexed in PubMed as clinical trials;[3]
- Peer-reviewed publications indexed in PubMed as practice guidelines;
- Clinical trials indexed in ClinicalTrials.gov[4];
- Patents filed at the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO);
- Guidelines published by the UK National Institute for Health and Care Excellence (NICE) and indexed in EPMC and in PlumX.

Shares for both direct and indirect citation uptake are presented. A direct citation uptake is a citation made directly by a document in a given source to a publication contained in a funder's

[3] More specifically, these include those indexed as "clinical trial", "clinical trial, phase I", "clinical trial, phase II", "clinical trial, phase III", "clinical trial, phase IV", "controlled clinical trial", "pragmatic clinical trial" and "randomized controlled trial". Click here for a definition of PubMed publication types.

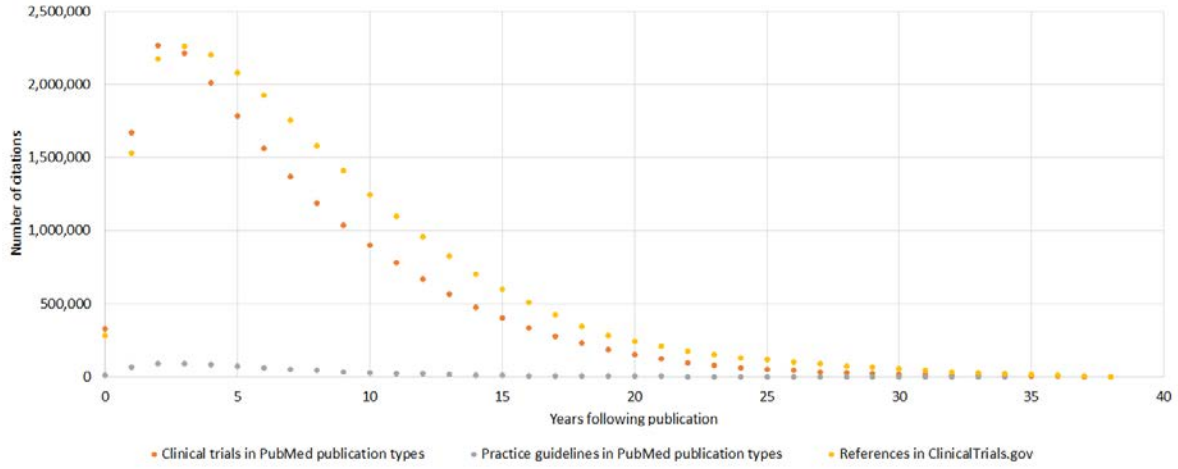
[4] A note on the uptake in ClinicalTrials.gov: Publications listed in clinical trials are categorised into two groups: "references", which are publications cited by the trials, and "results", which are publications that disseminate the trials' findings. Filing such information in the database is voluntary, with little or no oversight, and an investigation of the database revealed that many result publications were erroneously classified as references. In order to ensure that the uptake of the funders' portfolios in clinical trials was adequately measured, only references published the same year or prior to the start of the trials were considered.

portfolio, while an indirect citation uptake is a citation made indirectly by a document thought the intermediary of another article. For instance, if Paper A is cited by Paper B, which is then cited by Paper C, this is a direct citation uptake from Paper A to Paper B and an indirect citation uptake from Paper A to Paper C. If Paper A is cited by both Paper B and Paper C, which are both cited by Paper D, this is counted as two indirect citations uptake from Paper A to Paper D.

Conference papers were excluded from some analyses when their uptake in a given source was negligible. The funders' portfolios actually contain a very small number of conference papers (less than 1% of their portfolio for all three funders). The share in uptake was calculated for the whole of the funders' portfolios (referred to "all papers" in the data book) as well as for strictly those publications that are published in a journal of the health sciences (referred to "health sciences papers" in the data book), as per Science-Metrix' classification of journals.

The analyses are presented for a restricted number of years depending on how quickly the sources typically take up the scientific literature in the form of citations. For instance, patents take up the publications at a much slower pace than the scientific literature itself. It is necessary to allocate sufficient amount of time after publication so that the full contribution to the scientific and technological communities can be robustly evaluated. Recently published papers have not yet reached their full potential, it is therefore premature to assess their full impact relative to older, well established papers. Performing comparative analyses when not enough time has elapsed for papers to accumulate citations could lead to biases across funders. In order to assess an appropriate citation window, the number of years it takes for publications to reach their peak in citation count was calculated, for each uptake source. At that point, the impact of the publications can be assessed accurately.

For example, the following graph displays the number of citations all articles in the WoS collectively obtain by years following their publication, according to different uptake sources. For two of the three sources, the peak is observed around year 2, which is why articles two years of age or younger are excluded from the analyses for these specific sources. A similar approach was carried out to determine the appropriate citation window for patents and NICE guidelines.



1.3.3 Normalised share of papers cited by year

This is the share of the funders' portfolio of publications that were cited at least once by a given document source, normalised by the same share at the 'world level' (i.e., the share for all the publications in the WoS cited at least once by the same source), calculated by year. A weighted average of all years is then calculated by removing the years with a relatively small number of publications (i.e., below 100) to ensure chronological stability in the data

comparable to that of the world, as small samples are known for their sporadic year-to-year fluctuating behaviour. A score below 1 indicates a share of uptake below the world level, a score equal to 1 indicates a comparable share, and a score above 1 indicates a share of uptake above the world level.

Considering that the sources mostly cite articles in the health sciences (except for patents), and that the funders' portfolios are disproportionately focused on that very domain compared to the whole of the WoS (30% of WoS publications are in the Health Sciences as opposed to over 75% for the three funders), this indicator is only computed for Health Science publications. Calculating it for all publications would have resulted in scores well above 1 for all funders and across all dimensions, offering little insight on the funders' relative performance.

For example, a score of 1.44 for direct uptake of MRC papers in NICE guidelines indicates that the funder's papers are cited at least once in NICE guidelines 44% more often than the all WoS papers in the Health Sciences.

1.3.4 Classification by sector

Every author on the publications contained in the funders' portfolios was assigned to a sector according to their affiliation. The sectors are the following:

- Academic (includes universities and colleges, either public or private);
- Government (includes government departments, ministries and agencies at every level: federal, state, provincial, municipal, etc.);
- Health (includes hospitals and clinics, either public or private);
- Pharmaceutical industry (includes private companies that concentrate most of their activities in pharmaceutics);
- Other public (includes public affiliations that are not covered by any of the other sectors, mostly independent research centres);
- Other private (includes private companies that do not concentrate most of their activities in pharmaceutics).

An author can be affiliated to multiple sectors.

1.3.5 Share of papers that include any given sector

This is the share of the funders' portfolio of publications that include a given sector, presented for every one of the sectors listed previously.

1.3.6 Share of papers cited by the private sector

This is the share of the funders' portfolio of publications that were cited at least by one publication that includes at least one author affiliated to the private sector.

1.3.7 Relative citation scores

Counting citations may be used as a proxy for measuring contributions to subsequent knowledge generation; however, because citation practices vary between the disciplines and sub-disciplines of science, simple counting would create unwanted biases in the results. To correct these potential distortions, individual publications are evaluated relative to the average citation rate for publications in the same field or subfield and published in the same year; the normalization also accounts for the type of publication because review articles are usually more cited and include more references than journal articles. This measure is known as the relative citation (RC) score and it is instrumental in computing the highly cited publications score presented below.

1.3.8 Highly cited publications at the 10% level

To calculate this indicator, the 10% most cited publications in the database are identified using the RC scores of publications, as presented above. Then, the fraction of an entity's publications falling among these highly cited publications (HCP) is computed; this gives the $HCP_{10\%}$ score of that entity. A score above 10% indicates performance above expectation, while a score below 10% indicates the opposite. This indicator is often used as a proxy to examine research excellence because of the high concentration of citations (close to 45%) in this group of publications.[5]

2 Results

2.1 Overview

Quantitative analysis of publication outputs in terms of citation and uptake metrics into translational outcomes (NICE guidelines, patents, clinical trials) shows that the MRC awards are achieving at least as good a result as those awards funded by the NIH and Wellcome in the same period.

Table 1 below shows that, e.g. 2.7% of MRC-associated papers in the health sciences, published 2008-2015, are directly cited by clinical trials indexed in ClinicalTrials.gov. This compares well with rates of 2.4% of NIH-associated papers and 2.0% of Wellcome-associated papers. Normalising by year against all health sciences papers indexed in the Web of Science for that period, gives the MRC a score of 1.66, where 1.0 is the world average, and the NIH and Wellcome score 1.49 and 1.27, respectively. Across the four categories it is only in US patents where the MRC papers underperform those of the other two funders, and even here the MRC papers score well above world averages.

Table 1: Overview of direct uptake of papers - funders comparison

	Share of papers cited*			**Normalised score**		
	MRC	NIH	Wellcome	**MRC**	NIH	Wellcome
NICE guidelines (2008-2013)	**0.6%**	0.3%	0.4%	**1.44**	0.69	0.84
USPTO patents (2008-2011)	**5.8%**	9.5%	6.6%	**1.68**	2.76	1.95
EPO patents (2008-2011)	**3.2%**	3.0%	2.7%	**2.60**	2.46	2.19
Clinical trials indexed in ClinicalTrials.gov (2008-2015)	**2.7%**	2.4%	2.0%	**1.66**	1.49	1.27
PubMed Practice Guidelines (2008–2015)	**3.4%**	2.2%	1.8%	**1.59**	0.96	0.85

*All data represent papers indexed in the Health Sciences.

2.2 Detailed comparison of funders' portfolio

We can unpack these figures and compare results of the full publication portfolio for the three funders with those where awards were classified as 'translational'. In all cases, translational awards achieve statistically significant, higher uptake in guidelines, patents and clinical trials.

[5] Bornmann, L., Leydesdorff, L., & Wang, J. (2013). Which percentile-based approach should be preferred for calculating normalized citation impact values? An empirical comparison of five approaches including a newly developed citation-rank approach (P100). *Journal of Informetrics*, *7*(4), 933–944.

Table 2: Direct uptake of papers in NICE guidelines

	All awards portfolio*			Translational awards		
	MRC	NIH	Wellcome	MRC	NIH	Wellcome
Number of papers (2008–2013)	13,789	133,490	8,843	4,843	24,485	1,340
Share of papers cited	0.6% (0.5-0.7)	0.3% (0.3-0.3)	0.4% (0.2-0.5)	0.8% (0.5-1.0)	0.5% (0.4-0.6)	1.0% (0.5-1.6)
Normalised score	1.44 (1.14–1.80)	0.69 (0.62–0.76)	0.84 (0.56–1.15)	1.84 (1.25–2.44)	1.20 (0.97–1.40)	2.04 (0.90–3.34)

*All data represent papers indexed in the Health Sciences. Stability intervals are included in parentheses, based on a bootstrap method that involves 500 resamples with replacement and a 95% stability level.

Table 3: Direct uptake of papers in USPTO patents

	All awards portfolio*			Translational awards		
	MRC	NIH	Wellcome	MRC	NIH	Wellcome
Number of papers (2008–2011)	5,620	54,419	2,845	1,999	10,222	413
Share of papers cited	5.8%	9.5%	6.6%	6.9%	15.0%	7.5%
Normalised score	1.68	2.76	1.95	1.97	4.33	2.21

*All data represent papers indexed in the Health Sciences.

Table 4: Direct uptake of papers in EPO patents

	All awards portfolio*			Translational awards		
	MRC	NIH	Wellcome	MRC	NIH	Wellcome
Number of papers (2008–2011)	5,620	54,419	2,845	1,999	10,222	413
Share of papers cited	3.2% (2.7–3.6)	3.0% (2.9–3.1)	2.7% (2.1–3.3)	3.9% (3.0–4.7)	4.7% (4.3–5.1)	3.9% (2.2–5.7)
Normalised score	2.60 (2.20–3.01)	2.46 (2.35–2.59)	2.19 (1.68–2.72)	3.18 (2.44–3.95)	3.81 (3.49–4.15)	3.94 (1.93–5.88)

*All data represent papers indexed in the Health Sciences. Stability intervals are included in parentheses, based on a bootstrap method that involves 500 resamples with replacement and a 95% stability level.

Table 5: Direct uptake of papers in clinical trials indexed in ClinicalTrials.gov

	All awards portfolio*			Translational awards		
	MRC	NIH	Wellcome	MRC	NIH	Wellcome
Number of papers (2008–2015)	25,905	231,923	16,689	8,710	42,234	2,858
Share of papers cited	2.7% (2.5–2.9)	2.4% (2.4–2.5)	2.0% (1.8–2.3)	4.1% (3.7–4.5)	3.4% (3.2–3.5)	3.3% (2.6–4.1)
Normalised score	1.66 (1.55–1.78)	1.49 (1.45–1.52)	1.27 (1.13–1.41)	2.47 (2.22–2.74)	2.04 (1.95–2.15)	2.14 (1.69–2.63)

*All data represent papers indexed in the Health Sciences. Stability intervals are included in parentheses, based on a bootstrap method that involves 500 resamples with replacement and a 95% stability level.

Table 6: Direct uptake of papers in PubMed Practice Guidelines

	All awards portfolio*			Translational awards		
	MRC	NIH	Wellcome	MRC	NIH	Wellcome
Number of papers (2008–2015)	25,905	231,923	16,689	8,710	42,234	2,858
Share of papers cited	3.4%	2.2%	1.8%	5.4%	3.1%	1.5%
Normalised score	1.59	0.96	0.85	2.38	1.42	0.83

*All data represent papers indexed in the Health Sciences.

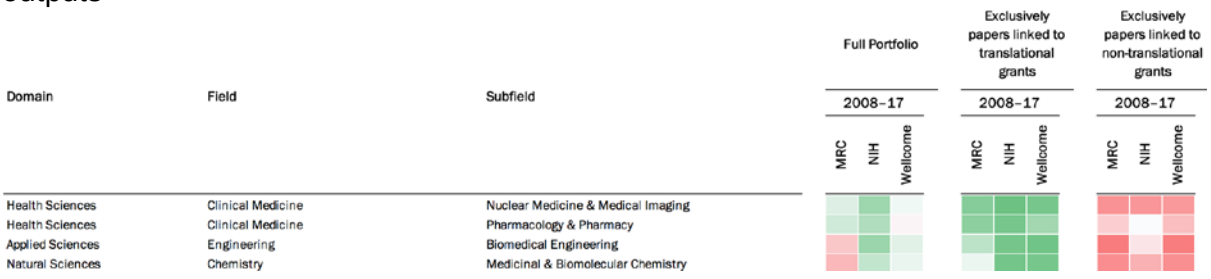
Table 7, below, includes some basic bibliometric indicators about the funders' portfolios. The MRC-associated papers have higher shares of public/private co-authorship, in particular co-authorship with the pharmaceutical industry; and this co-authorship share grows further on the papers exclusively linked to translational awards. MRC's international co-publication share of 55% is significantly higher than that of the NIH but is below that of Wellcome publications. US researchers thus appear more 'self-reliant' in conducting biomedical research than UK researchers. Citation indicators are broadly similar across the three funders.

Table 7: Bibliometric indicators

	All awards portfolio			Translational awards		
	MRC	NIH	Wellcome	MRC	NIH	Wellcome
Share of co-publication (2008-2017)						
Share of public/private co-publications	6.8%	5.7%	6.1%	7.9%	8.3%	9.0%
Share of papers with at least one author affiliated to the pharmaceutical industry	3.4%	1.8%	2.8%	4.1%	2.5%	3.8%
Share of international co-publication	54.9%	30.0%	60.7%	53.7%	29.9%	64.6%
Citation indicators (2008-2015)						
Average of relative citations	2.03	1.71	2.08	1.98	1.73	2.09
Share of the highly cited papers at the 10% level	25.3%	21.4%	25.8%	24.6%	21.9%	24.8%

Looking at funders' publication output according to different fields and subfields of science and award type shows that the strongest difference between translational and non-translational award outputs are in Nuclear Medicine & Medical Imaging, Pharmacology & Pharmacy, Biomedical Engineering, and Medicinal & Biomolecular Chemistry. Translational awards preferentially focus on these more applied areas of science.

Figure 1: Heatmap of scientific areas for translational and non-translational award publication outputs



Trend analysis of normalised score values over the years, where robust calculation makes it possible to compare changes in uptake of funders' publications, shows some interesting

pattern. For example, the MRC-associated papers show the greatest increase in uptake in clinical trials between 2009-2014, when compared with other funders. The MRC translational research portfolio makes a significant increase to a normalised value of 2.61. The trend is less discernible for uptake in patents: the NIH portfolio performs best in US patent uptake, while the MRC portfolio in European patent uptake. Note that a normalised score above 1 indicates a share of uptake above the world level.

Figure 2: Trend analysis of normalised share of cited papers (health sciences) in clinical trials as indexed in ClinicalTrials.gov

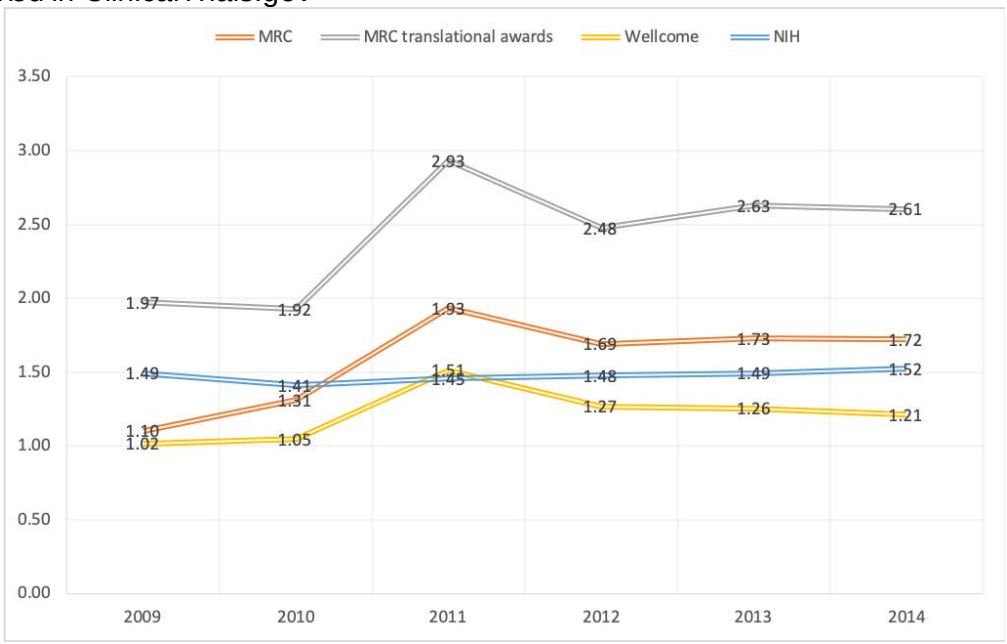


Figure 3: Trend analysis of normalised share of cited papers (health sciences) in USPTO patents

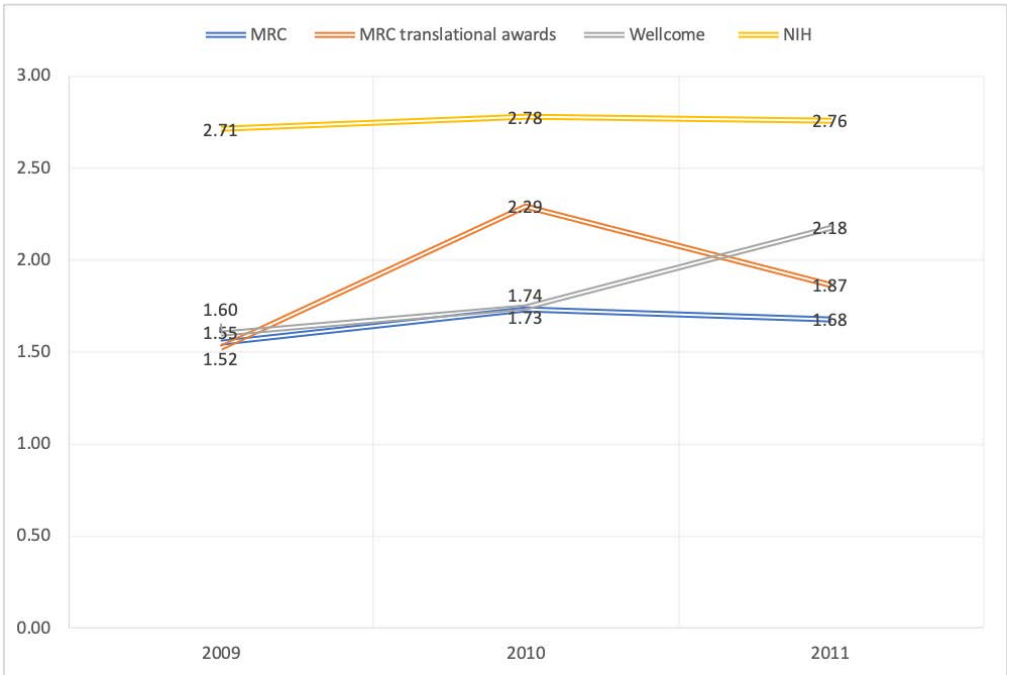
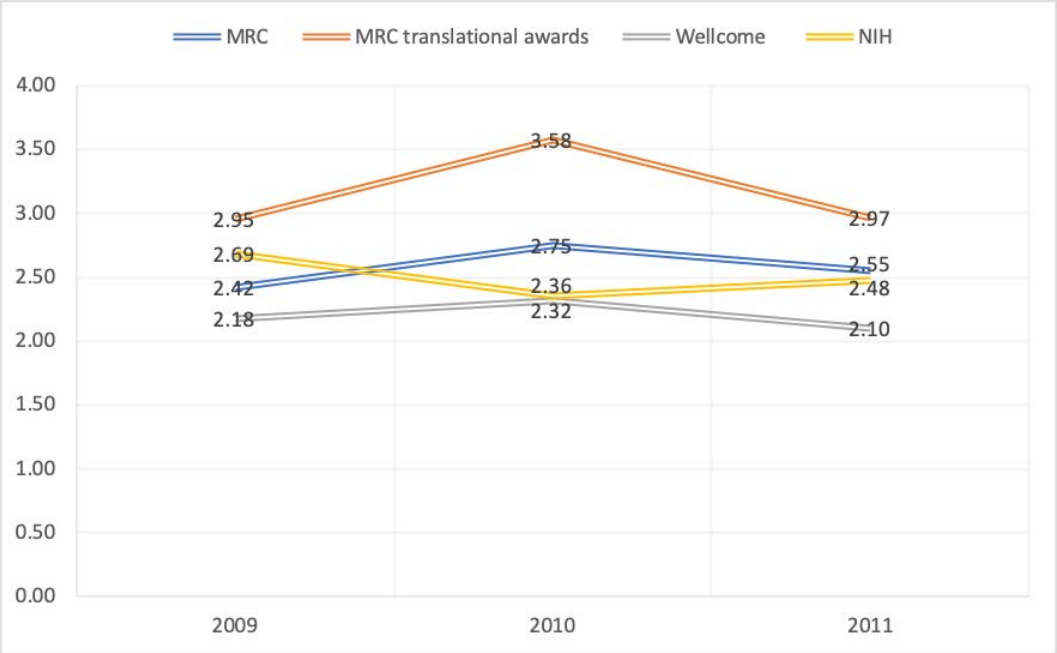


Figure 4: Trend analysis of normalised share of cited papers (health sciences) in EPO patents



2.2 Detailed analysis of the MRC portfolio

The MRC portfolio can be further stratified according to whether the translational awards were supported strategically by Directed translational funding. Initiative-level information for the NIH and Wellcome awards were not available. While papers emerging from MRC translational awards[6] shows that these papers are generally subject to a higher level of uptake into translational outcomes, papers emerging exclusively from Directed translational funding tend to show the highest level of uptake (with the exception of US patents (Table 8).

Table 8: Direct uptake of papers – Stratified MRC portfolio

	Share of papers cited*			**Normalised score**		
	All awards	Translational awards	Directed translational awards	All awards	Translational awards	Directed translational awards
NICE guidelines (2008-2013)	0.6%	0.8%	1.5%	1.44	1.84	3.71
USPTO patents (2008-2011)	5.8%	6.9%	5.7%	1.68	1.97	1.71
EPO patents (2008-2011)	3.2%	3.9%	4.0%	2.60	3.18	3.64
Clinical trials indexed in ClinicalTrials.gov (2008-2015)	2.7%	4.1%	5.0%	1.66	2.47	2.95

*All data represent papers indexed in the Health Sciences.

[6] MRC translational awards include Directed translational funding, and Non-directed (researcher-led) awards, the latter in case translational intent at application stage was captured by Dimension.

Table 8a: Direct uptake of papers – Stratified MRC portfolio and specific initiatives

	Share of papers cited					
	All awards	Translational awards	Non-directed grant funding for translation	Directed translational awards	Methodology	BMC / DPFS / DCS
NICE guidelines (2008-2013)	0.6%	0.8%	0.4%	1.5%	2.7%	0%
Clinical trials indexed in ClinicalTrials.gov (2008-2015)	2.7%	4.1%	3.4%	5.0%	5.5%	4.2%

* Directed translational awards: Methodology, Biomedical Catalyst (BMC), Developmental Pathway Funding Scheme (DPFS), Developmental Clinical Studies (DCS)

Bibliometric indicators reporting on work conducted jointly with the private sector suggest higher level of engagement for Directed translational awards. Interestingly, share of international co-publication for the same set of awards falls significantly compared to other awards.

Table 9: Bibliometric indicators – Stratified MRC portfolio

	All awards portfolio		
	All awards	Translational awards	Directed translational awards
Share of co-publication (2008-2017)			
Share of public/private co-publications	6.8%	7.9%	9.5%
Share of papers with at least one author affiliated to the pharmaceutical industry	3.4%	4.1%	4.2%
Share of international co-publication	54.9%	53.7%	43.7%
Citation indicators (2008-2015)			
Average of relative citations	2.03	1.98	2.02
Share of the highly cited papers at the 10% level	25.3%	24.6%	23.6%

Table 10 provides data on uptake of papers linked to Directed translational awards. Care should be taken with these data given that the numbers of awards within some initiatives are very small. However, an idea of the different aims of various initiatives can be seen in how many awards produced papers which saw uptake in US patents (e.g. 25% of Industrial Collaboration Awards), and clinical trials (43% of JPRCI awards).

Table 10: Awards linked to MRC translational initiatives

Translational initiatives	Number of awards	% of awards producing papers with uptake in		
		ClinicalTrials.gov	NICE guidelines	US Patents
AZ Mech of human disease	15	0%	0%	0%
Biomarkers	41	15%	0%	15%
BMC/DPFS/DCS	169	9%	0%	3%
CiC	75	7%	0%	0%
ExpMed ('08 & '11)	32	31%	0%	9%
Industrial Collaboration Award	20	5%	5%	25%
JPRCI	14	43%	7%	29%
Methodology	105	17%	6%	2%
Models of Human disease	21	19%	0%	29%
P2D	32	0%	0%	0%
Regenerative Medicine (RMRC)	6	0%	0%	0%
Regenerative Medicine (UKRMP)	19	0%	0%	0%
Stratified Medicine	6	33%	0%	0%
TSCRC	52	6%	2%	13%
Overall Directed translational portfolio	**607**	**12%**	**1%**	**6%**
Overall Non-directed translational portfolio	**963**	**17%**	**3%**	**19%**

An analysis of co-funding of MRC papers associated exclusively with translational awards shows that

- Top (by number of papers) overall co-funders of MRC-associated papers were NIHR, Wellcome, EU, and the NIH; top charity co-funders were CRUK and BHF, and top private sector co-funder was GSK
- Papers co-funded by GSK, Pfizer, the NIH and BHF had the higher share of papers associated with $HCP_{10\%}$ compared to other co-funders
- Papers co-funded by pharmaceutical companies (Pfizer and GSK) had the highest rate of co-authorship with hospitals, followed by NIHR, NIH and charities.

Detailed information on co-funding and other bibliometric indicators is available in the supplementary data book.

2.3 Indirect uptake of papers

Looking at second-generation citations of publication output, i.e. funders' papers cited by other papers that in turn are cited in guidelines, patents and clinical trials, show similar patterns to the direct uptake of funders' papers, but with higher share of papers cited indirectly. For example, Table 11 shows that nearly a fifth of all MRC-associated papers, 2008-2015, are cited by papers which themselves are cited in clinical trials; normalised score indicates that these values are more than double that of what is expected for the 'world average'.

Table 11: Indirect uptake of papers – funder comparison

	Share of papers cited*			Normalised score		
	MRC	NIH	Wellcome	MRC	NIH	Wellcome
NICE guidelines (2008-2013)	3.0%	1.6%	1.9%	2.09	1.08	1.33
USPTO patents (2008-2011)	28.1%	32.5%	29.3%	2.22	2.55	2.32
EPO patents (2008-2011)	14.7%	15.2%	16.6%	2.64	2.70	2.99
Clinical trials indexed in ClinicalTrials.gov (2008-2015)	19.2%	15.7%	16.0%	2.10	1.61	1.75

*All data represent papers indexed in the Health Sciences.

Interestingly, looking at the indirect uptake of papers exclusively linked to translational MRC awards (Table 12) shows that while there is noticeably greater uptake into NICE guidelines and clinical trials for these papers, this is less obvious for patents. The general increase of normalised score values compared to direct uptake of MRC-associated papers may be an indication that MRC research is more at the discovery end of the translational pipeline and may be at least one step removed from the ultimate uptake into translational outcomes.

Table 12: Indirect uptake of papers – Stratified MRC portfolio

	Share of papers cited*			Normalised score		
	MRC	MRC translational	MRC Directed translational	MRC	MRC translational	MRC Directed translational
NICE guidelines (2008-2013)	3.0%	4.2%	7.1%	2.09	2.89	4.92
USPTO patents (2008-2011)	28.1%	28.7%	25.3%	2.22	2.27	2.20
EPO patents (2008-2011)	14.7%	15.6%	13.7%	2.64	2.88	2.89
Clinical trials indexed in ClinicalTrials.gov (2008-2015)	19.2%	24.3%	27.1%	2.10	2.62	2.80

*All data represent papers indexed in the Health Sciences.

4 Summary of key numbers associated with the MRC publication portfolio

The bibliometric analysis shows that the MRC is achieving at least as good a result as top global medical research funders, Wellcome and NIH, over the same period of time, according to a number of quantitative metrics.

Overall, the MRC awards over the ten-year period (2008–2017) produced 46,695 publications that included

- 124 papers which were cited in NICE clinical guidelines;
- 325 papers which were cited in EPO patents;
- 647 papers which were cited in USPTO patents;
- 907 papers which were cited in clinical trials indexed in ClinicalTrials.gov;
- 980 papers which were cited in practice guidelines in PubMed publication types.