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Research Excellence Framework 2014: Overview report by Main Panel A and Sub-panels 1 to 6

	Page
Main Panel A	1
International members' report	18
UOA 1: Clinical Medicine	25
UOA 2: Public Health, Health Services and Primary Care	28
UOA 3: Allied Health Professions, Dentistry, Nursing and Pharmacy	32
UOA 4: Psychology, Psychiatry and Neuroscience	39
UOA 5: Biological Sciences	43
UOA 6: Agriculture, Veterinary and Food Science	47

Main Panel A

Executive summary

1. The purpose of this report is to provide the higher education sector and other key stakeholders with an overview of life sciences¹ research in the UK, as submitted in the REF2014 units of assessment (UOAs) which constitute Main Panel A (MPA), and to provide key data on submissions and feedback on the process of assessment.
2. Over the period of the REF assessment both research in the UK and its impact on society for the medical, health, biological, agricultural, veterinary and food sciences sectors has been assessed as internationally excellent with a high proportion of submitted activity identified as world-leading.
3. Impact assessment was a new and important dimension of REF2014, to which external assessors from beyond the higher education sector made a much valued contribution. MPA was extremely impressed by the quality and breadth of impact described. MPA believes that the collection of impact case studies provide a unique and powerful illustration of the outstanding contribution that research in the fields covered by this panel is making to health, wellbeing, wealth creation and society within and beyond the UK.
4. MPA noted that basic science undertaken over the last two decades underpinned many of the impact case studies submitted, demonstrating a requirement to continue to invest in basic science and infrastructure over the long term. Members were encouraged that the translational pathway is now much better structured to realise the impact from basic science, but urge continued investment in high quality basic science and science infrastructure to ensure delivery of future impacts.
5. International MPA members considered REF2014 to have been an equitable and impartial process, which has extended from and improved upon the previous Research Assessment Exercise (RAE2008). Specifically, the impact component has served to highlight the considerable significance of research submitted to MPA on the world stage.
6. MPA was encouraged by the number of early career researchers (ECRs) submitted to each of the sub-panels and was distinctly impressed by the quality of their research outputs. However, there was some concern that not enough attention was being paid to their career pathway through to more senior positions.
7. MPA was pleased to see the healthy commitment to training at PhD level in most areas, but noted a concern in the lower numbers of doctoral degrees awarded in some areas.
8. Based upon these most encouraging findings, MPA believes that continued investment in UK life sciences research and increased support for biological science, agriculture, food and veterinary research is essential to capitalise upon this positive trajectory. This has to include emphasis on the training of young researchers and efforts for the translation and uptake of findings in continuing to build the UK's world-leading competitiveness in life sciences to create further great benefits for society in the UK and beyond.

¹ For the purposes of this report, 'life sciences' refers to medical, health, biological, agricultural, veterinary and food sciences.

Overview of submissions and results

9. In total, 304 submissions were made in the UOAs within MPA, of which eight were joint submissions, with 10 institutions making multiple submissions in the same UOA. There were 14,757 staff submitted by headcount, almost all being Category A. This was similar to the number of staff submitted in RAE2008 (15,539). This led to the assessment of 50,298 outputs, 304 impact templates, 1,621 impact case studies and 304 environment templates. The size of submissions varied greatly between higher education institutions (HEIs), ranging from three to 473 staff, with the median submission comprising 27 staff.

Table 1: Summary of submissions to REF2014 and RAE2008

		Number of submissions	Category A FTE ¹ staff	% change in Category A FTE staff	Category A and C staff headcount	Number of outputs	Outputs per Category A and C staff headcount	Number of impact case studies
MPA	2014	312	13,608	-3.4%	14,757	50,298	3.41	1,621
	2008	466	14,086		15,539	59,887	3.85	-
UOA 1	2014	31	3,571	+0.3%	3,926	13,405	3.41	383
	2008	84	3,562		4,101	15,416	3.76	-
UOA 2	2014	32	1,354	+12.7%	1,514	4,881	3.22	163
	2008	59	1,201		1,378	5,309	3.85	-
UOA 3	2014	94	2,748	-6.4%	3,016	10,358	3.43	351
	2008	135	2,936		3,288	12,574	3.82	-
UOA 4	2014	82	2,520	+3.4%	2,709	9,126	3.37	324
	2008	93	2,437		2,634	10,140	3.85	-
UOA 5	2014	44	2,373	-19.1%	2,492	8,608	3.45	272
	2008	65	2,934		3,074	12,245	3.98	-
UOA 6	2014	29	1,042	+2.7%	1,100	3,920	3.56	128
	2008	30	1,015		1,064	4,203	3.95	-

Note: For the purposes of data comparison, UOAs from RAE2008 are mapped onto REF2014 UOAs as follows: RAE UOAs 1-5 = REF UOA 1; RAE UOAs 6-8 = REF UOA 2; RAE UOAs 10-13 = REF UOA 3; RAE UOAs 9 & 44 = REF UOA 4; RAE UOAs 14 & 15 = REF UOA 5; RAE UOA 16 = REF UOA 6.

¹FTE = full-time equivalent

10. The overall research quality profile incorporating all three elements of the assessment (research outputs, impact and environment) for the six UOAs covered by MPA indicated that the field is internationally exceptionally strong with 37 per cent of all submitted material judged to be world-leading and an additional 44 per cent internationally excellent. Within each UOA, this

outstanding performance was spread across a very broad range of disciplines, and across research outputs, impact and environment. Within this overall positive REF profile there were characteristics specific to each sub-panel which are outlined in the output, impact and environment sections below and described in detail in the individual sub-panel reports.

Table 2: Overall quality profiles (FTE weighted averages)

UOA	Name	Average percentage of research activity judged to meet the standard for:				
		4*	3*	2*	1*	U
	Main Panel A	37	44	17	1	1
1	Clinical Medicine	39	44	15	1	1
2	Public Health, Health Services and Primary Care	39	41	17	3	0
3	Allied Health Professions, Dentistry, Nursing and Pharmacy	31	50	17	1	1
4	Psychology, Psychiatry and Neuroscience	38	40	19	2	1
5	Biological Sciences	37	46	15	1	1
6	Agriculture, Veterinary and Food Science	35	41	20	3	1

11. Table 2 shows the average overall quality profile for each UOA, and for all submissions made in MPA as a whole. The average was calculated by weighting each submission in the UOA (or main panel) by the number of FTE Category A staff in each submission. This method was also used to calculate the FTE-weighted average sub-profiles for outputs, impact and environment (tables 3, 6 and 7 below).

12. REF2014 has demonstrated that UK research in life sciences is in a very strong position worldwide and overall quality has increased markedly since RAE2008. When compared with the equivalent UOAs from RAE2008, the proportion of research outputs assessed as world-leading (4*) has substantially increased, from 12 per cent to 24 per cent. The research environment supporting such excellence is also strong, and appears to have improved since the 2008 exercise, although given differences between the two assessment exercises, the environment profiles are not directly comparable.

13. The improved quality of research MPA observed is consistent with international comparative data (see the 'Analysis' section of www.ref.ac.uk under 'Results & submissions'). A major contributing factor has been the greatly increased funding of the biomedical and health sectors provided by the National Institute of Health Research (NIHR) since 2006, and over a similar time period, increased funding for translational research by the research councils and the medical charities. MPA also observed noticeable increases in multi-authored, multidisciplinary and international collaborative research.

14. MPA believes that there has been a genuine increase in output quality. Some of the increase may be explained by, for example, an enhanced level of professionalism in the HEIs with regard to assessing research quality, including greater selectivity of outputs. Although there have been some changes to the assessment process, there has been continuity in the standards of

assessment since RAE2008, with approximately one third of panellists having participated in RAE2008.

15. Since impact was not assessed in RAE2008, direct comparison of this aspect is not possible. Overall, MPA was impressed with the breadth and depth of outstanding impacts submitted in our UOAs. The average MPA profile in terms of reach and significance showed that 61 per cent of impact was judged to be outstanding (4*) and an additional 30 per cent very considerable (3*). That this is an accurate descriptor of the UK's ability to translate its research in this sector into health, societal and economic benefit both nationally and overseas, albeit based on an earlier foundation of buoyant and sustained investment over the last 20 years, was fully endorsed by international and user members of MPA.

16. MPA acknowledges that HEIs undertake a mixture of activity, all of which is valuable. REF2014 is an exercise which assesses the excellence of research, and MPA is aware that submissions will have varied in their selectivity. This variance is important to note when comparing quality profiles in order to inform reputational benchmarks.

Panel working methods

17. Across all elements of the assessment, both the main panel and the sub-panels adhered to the published criteria and working methods. The main panel oversaw the assessments carried out by the sub-panels, with a particular focus on ensuring consistent standards of assessment, calibrated to reflect international standards of excellence. The sub-panels assessed material in the following order: outputs, impact and then environment. Panel members did not take any part in the assessment of submissions from institutions in which they declared a major conflict of interest.

Main panel working methods

Calibration exercises

18. For each element of assessment (outputs, impact and environment), MPA undertook a calibration exercise to mock-assess and discuss a sample of submitted material. These calibrations sought to ensure that there was a common understanding of the star levels and approaches to assessment across the sub-panels, and that views and lessons from MPA could be fed directly into sub-panel discussions, both by the sub-panel chairs, and by MPA members in attendance at each meeting. Sub-panel members and assessors also undertook calibration exercises to ensure consistency of approach and understanding before assessment of each element began. These exercises were supplemented by further sub-panel discussions about both individual items and general issues as they arose.

Roles of international and user members

19. International and user members of MPA played a major role in bringing external perspectives to the assessment process and in ensuring consistency between sub-panels. Members attended each set of sub-panel meetings, and moved between different sub-panels. While not being asked to score any of the submissions themselves, they took part in the calibration exercises and attended both MPA and sub-panel meetings. They provided much valued knowledge exchange between the sub-panels and international benchmarking which was crucial to ensuring the processes used for assessment were robust and the outcomes credible in an international arena. This was especially important for the impact case studies since there were no previous comparators, and user members representing government, industry and the third sector were invaluable in providing an external perspective on the reach and significance of impacts outside academia.

20. The international members have compiled a report in which they describe their views of the assessment and its implications for the UK life sciences sector (see Annex 1).

21. The international members noted that the six sub-panels each had unique overall strengths and made specific contributions to academic research excellence. Valuable insight on the governance of the REF processes conducted by MPA was gained following a discussion by the international members in a separate meeting after the quality profiles had been approved by MPA, and some of these views are embedded within this report.

Resolving common issues encountered by sub-panels

22. One of the key roles of MPA was to provide a forum for the discussion of issues arising during assessment, such as dealing with co-authorship claims and individual staff circumstances. Sub-panel chairs were invited to raise issues at each MPA meeting, and discussions ensured consistency across the main panel.

Reviewing and approving assessment outcomes

23. MPA regularly reviewed emerging quality profiles and discussed variance between sub-panels. The ongoing process of reflection fed back into sub-panel meetings and, when appropriate, was used to recalibrate discussions. This was done at a sub-panel level; sub-profiles for individual submissions were not examined or compiled until all scoring was complete. The main panel thoroughly reviewed the pattern of outcomes across the UOAs, and was assured that the assessment had been carried out fairly and equitably between the six UOAs, prior to approving the results.

Role of the secretariat and IT support

24. MPA members found the logistical support of the REF exercise to be very effective and support staff highly knowledgeable. The importance of the expert advice and service provided by the secretariat cannot be overstated and this proved to be essential to the evaluation and played a central role in the uniform application of the criteria of judgment. The frequent attendance of the REF Manager at main panel and sub-panel meetings was very helpful in providing uniform interpretation of evaluation criteria across the four main panels. In addition, all panel members benefited from the IT support engendered by the operation and accessibility of the REF website, the security of entry, the ease of acquiring data and the ready and functional communication.

Sub-panel working methods

25. 17 UOAs from RAE2008 had been amalgamated to form the six REF UOAs covered by Main Panel A. The sub-panels found that these broader UOAs facilitated greater consistency in the assessment and created a multidisciplinary environment to positively address cultural and disciplinary differences. While the broader UOAs required larger sub-panels with more diverse expertise, and considerable workloads, they were capable of dealing with many different submissions (94 submitting units in UOA 3 and 82 in UOA 4) or very large individual submissions (UOA 1 ranged from 14.5 FTE to 449.82 FTE, for example), and the sub-panel chairs found that they were able to divide up the workload fairly, according to expertise. In a few instances when this was not considered possible, some new subject-specific output assessors were recruited. Calibration exercises were undertaken by sub-panels before each part of the assessment.

Methods of allocation and approach to assessing outputs

26. All sub-panels allocated outputs as far as possible according to the expertise of the sub-panel members and output assessors. This was done by using the research groups provided by the submitting unit, by reviewing the outputs individually (by journal and output title); or in the case

of Sub-panel 2, allocating the outputs randomly as the sub-panel judged that the disciplines submitted in UOA 2 are inter-linked and complementary, thus all the sub-panel members (other than the user member) were qualified to make an initial assessment of the scores of outputs. User members and impact assessors with appropriate research expertise also assessed outputs on some sub-panels.

27. Each output was assessed by at least two panellists, and sub-panels regularly reviewed both progress and individual scoring behaviour in order to ensure consistency across the sub-panel.

28. In developing the output sub-profiles, all the sub-panels used the same method of assigning star levels to outputs. Each output was graded as 4*, 3*, 2*, 1* or 'U', according to the starred level descriptors.

29. There were very few requests for double-weighted outputs within MPA sub-panels. Where they occurred, each case was judged on its own merit as to whether it met the criteria for double weighting.

30. Outputs were cross-referred to other sub-panels for advice, where the sub-panel lacked the expertise to assess it (see table 5 below).

Methods of allocation and approach to assessing impact

31. In addition to the academic sub-panel members, there were 51 user sub-panel members and impact assessors across the six sub-panels, representing a range of research user experience in industry, clinical services, research commissioning and policy making. Each impact item was assessed independently by at least three panellists, including one user member/impact assessor and two academic sub-panel members. During this phase, members of MPA worked across all six sub-panels, to promote common operating procedures, best practice and calibration. Allocation of impact was done according to the expertise of the assessors.

32. Scores were agreed through discussion either in scoring groups or in full sub-panel plenary sessions, and plenary sessions were used to check for consistency and to discuss contested cases. Panellists were made aware of their own scoring behaviour in comparison to others and if any areas of concern were identified, these were addressed with further discussion.

33. In developing the impact sub-profiles, all the sub-panels used the same method of assigning star levels to case studies and impact templates. Each case study and each impact template was graded as 4*, 3*, 2*, 1* or 'U', according to the starred level descriptors. Case studies and impact templates that were judged to be on the borderline between two of the starred levels were assigned a grade of 3.5, 2.5, 1.5 or 0.5. Where this occurred, the case study/template contributed to the impact sub-profile by assigning half of its grade to each of the two starred levels that the borderline grade fell between. For example, if there were four case studies in the submission, each case study contributed 20 per cent to the impact sub-profile (the impact template contributed the remaining 20 per cent). If one of the case studies was graded as 3.5, it contributed 10 per cent at 4* and 10 per cent at 3* to the impact sub-profile.

Methods of allocation and approach to assessing environment

34. Each environment template was allocated to and scored by at least three panel members. Scores were agreed through discussion, either in scoring groups or in full sub-panel plenary sessions, and plenary sessions were used to check for consistency and to discuss contested cases. Sub-panels used the REF4 data to look at trajectory data for a unit, for example in increases in research income or PhD numbers over the REF assessment period. From the

provided data it was not possible for the panels to make use of the data per FTE with any certainty.

35. In developing the environment sub-profiles, all the sub-panels used the same method of assigning star levels to the submitted material. Each section of the environment template was graded as 4*, 3*, 2*, 1* or 'U', according to the starred level descriptors. A section of the environment template that was judged to be on the borderline between two of the starred levels was assigned a grade of 3.5, 2.5, 1.5 or 0.5. Where this occurred, that section of the environment template contributed to the environment sub-profile by assigning half of its grade to each of the two starred levels that the borderline grade fell between.

Overview of research outputs

36. The weighted average outputs sub-profiles for each of the six UOAs covered by MPA is shown in table 3.

Table 3: Outputs sub-profiles (FTE weighted averages)

UOA	Name	Average percentage of research activity judged to meet the standard for:				
		4*	3*	2*	1*	U
	Main Panel A	23.9	51.1	22.1	1.9	1.0
1	Clinical Medicine	23.1	53.5	21.3	1.1	1.0
2	Public Health, Health Services and Primary Care	22.6	48.6	25.0	3.1	0.7
3	Allied Health Professions, Dentistry, Nursing and Pharmacy	21.4	55.7	20.1	1.9	0.9
4	Psychology, Psychiatry and Neuroscience	25.9	45.8	24.6	3.0	0.7
5	Biological Sciences	29.3	48.9	19.1	1.3	1.4
6	Agriculture, Veterinary and Food Science	18.2	50.7	27.7	2.6	0.8

37. Consistent with the overall high international quality profile of research in the fields of life sciences in relation to research outputs, all six UOAs performed well. Compared to RAE2008, the outputs sub-profile had improved (in some cases considerably) for all subject areas covered by MPA. As well as the improvement since RAE, the main panel noted the differences in quality profiles between UOAs, and the likely reasons for these are covered in the individual sub-panel reports below.

38. For MPA, almost all research outputs were in the form of peer-reviewed publications, and table 4 below shows a breakdown of output types submitted in each UOA, and for MPA as a whole. Where a sub-panel agreed to a double weighting these outputs are counted twice, and where a reserve was not scored it is not included in these numbers.

Table 4: Output type

	Output type	MPA	UOA 1	UOA 2	UOA 3	UOA 4	UOA 5	UOA 6
A	Authored book	45	0	5	13	10	16	1
B	Edited book	7	0	0	6	1	0	0
C	Chapter in book	55	0	0	25	16	6	8
R	Scholarly edition	1	0	0	0	0	1	0
D	Journal article	50,043	13,387	4,861	10,248	9,086	8,577	3,884
E	Conference contribution	40	7	4	14	4	4	7
U	Working paper	3	0	0	0	3	0	0
P	Devices and products	1	0	0	1	0	0	0
F	Patent/published patent application	28	10	0	15	0	3	0
N	Research report for external body	57	1	11	36	1	0	8
O	Confidential report for external body	1	0	0	0	0	0	1
G	Software	1	0	0	0	0	1	0
H	Website content	4	0	0	0	4	0	0
T	Other	12	0	0	0	1	0	11

Note: where no outputs were submitted to MPA, the output type has been omitted from this table.

39. In arriving at individual scores for journal articles it was the content of the output that was being assessed, irrespective of the journal publication vehicle or the impact factor of that journal. The provision of citation data from Scopus by the REF team was available to all six sub-panels and, while mindful of its limitations, panellists found this a valuable additional tool for informing peer-review of outputs at the margins. Citation data were only used where these provided a positive indicator of academic uptake (typically if there was any disagreement between those assessing the output).

40. Submission of multi-authored outputs was common. On the whole, outputs driven by large teams were regarded as being strong indicators of multidisciplinary, international, translational or 'big data' research and as reflecting an increasing emphasis on 'team science' and the use of large facilities and populations to tackle the complex research questions posed by the health and biological sciences sector. In the assessment of co-authored outputs, the sub-panels frequently sought to assure themselves that the submitted individual, if not the lead or corresponding author on an output of six or more authors, made a substantial contribution to the output. While the statement of author contribution was seen as often helpful, there remained unease that this was

not always clear, and could be difficult to resolve by audit of the submitting HEI. In looking forward to future exercises, MPA welcomes the increasing practice of journals to include full statements of author contributions at the end of the publication.

41. International MPA members also commented that the collaborative environment encouraged by an approach to big science cannot result in anything but a plethora of multi-authored outputs, many of which are very valuable. It is therefore essential that the approach to evaluation ensures that future REF exercises promote large-scale collaborative research.

42. The clearer guidance surrounding both clearly-defined and complex individual staff circumstances ensured that diverse staff could be returned with fewer than four outputs, allowing recognition for excellent research undertaken by staff, irrespective of their circumstances or the length of time they have had to conduct research.

43. The wide expertise and multi-disciplinary background of panel members meant that the sub-panels rarely found it necessary to cross-refer research outputs, either within MPA or to UOAs of the other main panels (see table 5).

Table 5: Cross-referrals

UOA	Name	Cross-referrals out to other sub-panels			Cross-referrals in from other sub-panels		
		Within MPA	Outside MPA	Total out	From within MPA	From outside MPA	Total in
	Main Panel A	29	151	180	29	516	545
1	Clinical Medicine	0	0	0	7	37	44
2	Public Health, Health Services and Primary Care	10	4	14	1	34	35
3	Allied Health Professions, Dentistry, Nursing and Pharmacy	3	16	19	1	23	24
4	Psychology, Psychiatry and Neuroscience	3	28	31	2	105	107
5	Biological Sciences	2	88	90	16	253	269
6	Agriculture, Veterinary and Food Science	11	15	26	2	64	66

44. In MPA, the submission of the same output twice to a UOA by the same HEI was used only very rarely, as was double weighting of outputs. There were nine requests for double weighting, of which seven were accepted.

Overview of impact

45. When compared to RAE2008, the transforming factor in REF2014 was the use of case studies to capture the impact of research. The 2014 REF is the first such exercise to include a formal assessment of research impact, not only in the UK but (to our knowledge) anywhere in the world. The main panel agreed that the attribution of a 20 per cent weighting for the impact element to the overall quality profile of a submission was appropriate.

46. In most submissions, a general trend was evident across outputs, impact and environment scores. In a few submissions however, high impact was achieved despite modest scores for outputs and environment, for various reasons including the time lag between carrying out the research underpinning the impact and the impact itself. MPA concluded that, whilst it is possible to have high research impact in the absence of a strong research environment, in most cases the one reinforces the other.

47. MPA was extremely impressed by the quality and breadth of research impacts described. The UOAs in MPA received, in total, 304 impact templates and 1,621 impact case studies, with the number of case studies submitted per submission ranging from 2 to 46. Overall, 91 per cent of the submitted impacts were judged to be outstanding or very considerable in terms of their reach and significance.

Table 6: Impact sub-profiles (FTE weighted averages)

UOA	Name	Average percentage of research activity judged to meet the standard for:				
		4*	3*	2*	1*	U
	Main Panel A	60.9	30.2	7.4	0.8	0.7
1	Clinical Medicine	76.4	19.6	3.3	0.3	0.4
2	Public Health, Health Services and Primary Care	68.3	26.5	5.2	0.0	0.0
3	Allied Health Professions, Dentistry, Nursing and Pharmacy	47.2	40.8	10.4	0.6	1.0
4	Psychology, Psychiatry and Neuroscience	60.9	29.1	8.1	1.6	0.3
5	Biological Sciences	47.8	41.1	9.5	0.6	1.0
6	Agriculture, Veterinary and Food Science	64.3	20.9	10.3	2.8	1.7

48. As the sub-panels assessed submissions, the main panel reviewed the average impact sub-profiles being awarded in each UOA.

Impact case studies

49. A wide range of impacts was evident through the case studies. They included increased life expectancy, reduced morbidity and improved quality of life (for example, as a result of new drugs, vaccines, procedures, interventions and educational programmes); reduced risk of future illness; improved knowledge transfer; improved efficiency and productivity of services; improved safety; improvement in the environment; and a significant contribution to industry, the UK economy and culture. Many research programmes described in the impact case studies had led to a change in clinical guidelines and/or national policy, particularly via the UK National Institute for Health and Care Excellence (NICE).

50. The calibration exercises and real-time interchange between sub-panels via MPA members (as described in the working methods above) proved invaluable for ensuring consistent assessment of impact. The 4* category contained some truly exceptional impacts in terms of their reach and significance, whereas others still worthy of 4*, were somewhat less exceptional but nevertheless outstanding.

51. The main panel recognised that the link between research and impact may be non-linear and difficult to demonstrate, and this exercise confirmed that the narrative case study largely succeeded in capturing the complex links between research and impact. MPA noted that the case study format was very successful, though future submissions could be strengthened if HEIs were proactive in collecting more qualitative and quantitative data evidencing the reach and significance of the impact. International MPA members cautioned against attempts to 'metricise' the evaluation of the many superb and well-told narrations describing the evolution of basic discovery to health, economic and societal impact.

52. The quality of writing also varied widely, even between cases from the same institution and in any one UOA. This appears to be due to the strategy employed by a number of HEIs of using professional writers to develop and present their impact submissions, while others relied entirely or in part on academic staff. Neither strategy was uniformly successful. One aspect of impact assessment on which panellists felt there was need for further clarification within the guidance was on the nature of evidence required to show that public engagement-based research impact had gone beyond 'business as usual' in engaging audiences.

53. The best impact case studies in MPA were characterised by a clear and compelling narrative linking the research programme to the claimed impact; verifiable evidence (qualitative or quantitative) to support the claimed impact provided within the text of the case study (and, if research at multiple HEIs had contributed to the same impact, evidence of the contribution of the submitting HEI); and (where appropriate) spread of the impact beyond the immediate beneficiaries to a much broader and possibly global audience.

54. Most low-scoring impact case studies were characterised by lack of objective evidence of the reach and significance of the impact claimed. Low scores were also given to relatively superficial impacts or where evidence of use and uptake was lacking. Impact with excellent future promise but modest current reach or significance also attracted lower scores.

55. Encouragingly, only 17 of the 1,621 impact case studies submitted in the MPA sub-panels as a whole were scored as unclassified. In most cases this was due to the case study failing to satisfy one of the eligibility criteria rather than having little or no impact in terms of reach and significance.

56. In commenting upon the impact assessment, the international members considered that REF2014 illustrates, in particular by way of the submitted impact cases, the increasing contribution that multidisciplinary teams can make to innovation and translational research. The process of bringing new insights and innovations to market requires an understanding of complex problems as well as a team composition with a breadth of disciplinary backgrounds and competencies, some of which lie beyond the boundaries of each of the six UOAs covered by MPA.

57. As table 6 shows, even after the extensive calibration and review processes described in the working methods, there was significant variation in impact profiles across the six sub-panels. It should be noted that, in some areas, many of the strongest case studies were based upon a long translational pathway and supported by funding streams that are no longer in existence.

58. Given that all panellists were initially unfamiliar with this part of the assessment (although a few members did participate in a pilot exercise reported in November 2010²), an impact case study calibration exercise was carried out across the four main panels to consider the overall comparability of impact assessment, using impact case studies in fields with cross-disciplinary

² See the background section of www.ref.ac.uk.

relevance including health and social policy. Members of each main panel took part in the exercise. Although impact case studies submitted to MPA on average scored more highly than did those in Main Panels B, C or D, this calibration exercise suggested that scores allocated by MPA members were in line with those given by members of other main panels for the same case studies. This supports the conclusion that the impact case studies submitted to MPA UOAs accurately reflect the outstanding reach and significance of impact in the life sciences.

Impact templates

59. Overall, the impact templates demonstrated a wide range of approaches taken by submitting HEIs to strengthen the links between research and impact, including leadership roles, various kinds of partnership and networking with industry and policy makers, governance and quality control structures, staff training programmes, incentives and rewards, and public engagement activities. The fact that no impact templates were scored unclassified indicated that by 2013, every submitting HEI could demonstrate an approach to supporting and enabling impact from research conducted within the unit. In most cases there was evidence from the templates that HEIs were prioritising further investments in this area.

60. The impact template was considered to be a fair, but not flawless, way of assessing a submitting unit's infrastructure and activities for supporting impact. MPA was of the opinion that in any future assessment, as support for impact becomes mainstreamed into the core business of HEIs, the impact template could be merged with the environment template.

User involvement in the assessment

61. User members of MPA were invaluable in providing a 'research user' perspective on impact. They made substantial contributions to the calibration exercises and iterative panel learning about impact assessment, and the range of external members could be extended in future exercises.

Overview of research environment

62. In general, the research environments assessed by all the sub-panels appear to have improved in terms of their vitality and sustainability when compared to RAE2008. However, any comparisons should be undertaken with caution due to the differences between RAE2008 and REF2014 UOAs, including the shorter time period covered by the REF and the differences in reporting of income and student numbers in the two exercises.

63. The weighted average of environment sub-profiles for each of the six UOAs covered by MPA is shown in table 7.

Table 7: Environment sub-profiles (FTE weighted averages)

UOA	Name	Average percentage of research activity judged to meet the standard for:				
		4*	3*	2*	1*	U
	Main Panel A	58.9	32.5	7.4	1.1	0.1
1	Clinical Medicine	59.4	36.1	4.5	0.0	0.0
2	Public Health, Health Services and Primary Care	70.7	25.8	2.2	1.3	0.0
3	Allied Health Professions, Dentistry,	50.1	35.5	13.4	1.0	0.0

	Nursing and Pharmacy					
4	Psychology, Psychiatry and Neuroscience	58.3	28.7	10.6	2.3	0.1
5	Biological Sciences	57.9	36.1	4.5	1.5	0.0
6	Agriculture, Veterinary and Food Science	68.9	22.4	6.0	2.1	0.6

64. As the sub-panels assessed the environment submissions, MPA considered the FTE-weighted average environment sub-profiles in each UOA.

Assessment of environment

65. MPA agreed that the weighting attributed to the environment element of the assessment was appropriate.

66. The approach to assessing environment in REF2014 was more structured than in RAE2008, and there is further room for improvement. The data submitted in REF4 provided the total research income and research doctoral degrees awarded for a submitted unit (not just for the submitted staff). Time trends were considered helpful in assessing environments; however, because it was not possible to calculate the research income or research doctoral degrees awarded per FTE for the submitted unit as a whole, the usefulness of the data overall was limited.

67. International MPA members commented that the environment component appeared to be the most difficult domain to assess in terms of discriminating between different submissions.

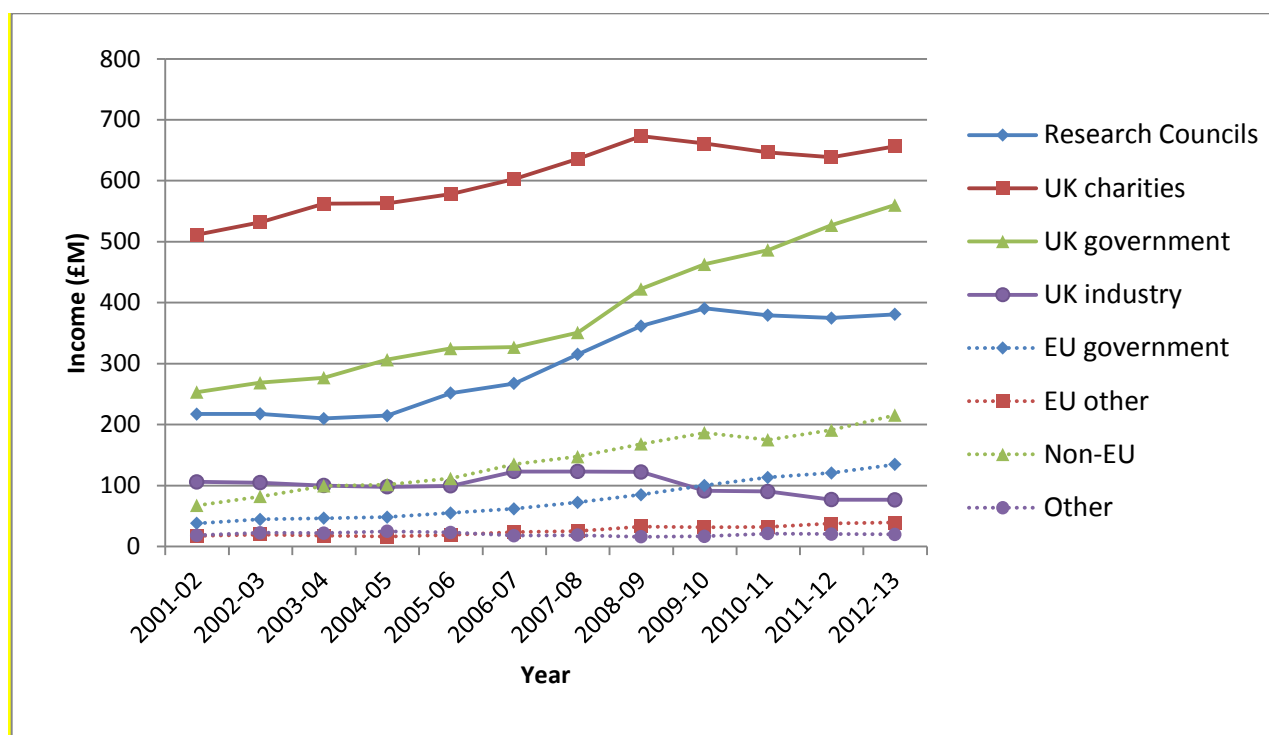
68. Both sub-panels and the international members of MPA noted that a small number of institutions appeared to have employed high performing staff from overseas on fractional contracts (frequently 0.2 FTEs), who had little apparent connection to the UK HEI, in order to enhance their output profile. Such behaviour was not considered useful to the assessment of the true quality of research in the UK.

Research income

69. MPA was of the opinion that the increase in quality of the research environment since RAE2008 is partly the result of the increased funding from NIHR, with the establishment of new infrastructure such as Biomedical Research Centres and Units, the School for Primary Care Research and the Collaborations for Leadership in Applied Health Research and Care³. Graph 1, illustrating all research income reported by HEIs from 2001-02 to 2012-13 in MPA subjects, shows clearly the large increase in UK government investment (which includes NIHR) since 2007-08,

³ www.nihr.ac.uk/about/nihr-infrastructure.htm

Graph 1: Research income in MPA subjects reported to HESA by UK HEIs (figures adjusted to 2012-13 prices)



70. It should be noted that NIHR funding was focused on England, although researchers in Scotland, Wales, and Northern Ireland had access to specific NIHR schemes and the devolved administrations had their own analogous funding schemes. Also, such investment was only accessible to health-related UOAs. MPA believes that research in Biological Sciences (UOA 5) has increasingly been concentrated on high-performing research groups so that the markedly improved research profile in this UOA has likely been achieved by this increased focus. Such focus also applies to Agriculture, Veterinary and Food Science (UOA 6), but in this case it appears to have been inward investment by the HEIs themselves against declining external income that has maintained research quality. The total income by spend included in submissions in MPA UOAs is listed in table 8.

Table 8: Total research income (£000s in 2012-13 prices) reported in REF2014

UOA	Name	Research Income by Spend 2008-2013 [REF 4b & REF 4c] (£000s)
	Main Panel A	13,256,095
1	Clinical Medicine	6,183,349
2	Public Health, Health Services and Primary Care	1,591,395
3	Allied Health Professions, Dentistry, Nursing and Pharmacy	952,183
4	Psychology, Psychiatry and Neuroscience	1,360,022

5	Biological Sciences	2,474,857
6	Agriculture, Veterinary and Food Science	694,290

71. Over the last 10 years, there has also been a more collaborative approach from all funders, working in partnership, to encourage translation of research into health, societal and economic benefits. These crucial activities were stimulated by publication of the report chaired by Sir David Cooksey in 2006, 'A review of UK health research funding'⁴, and the subsequent establishment of the government Office for Strategic Coordination of Health Research (OSCHR). The decision to maintain government funding of science despite the downturn in the economy over the REF assessment period has undoubtedly added to the strong performance of the UOAs in MPA. On average, there was £1.4 billion of research income reported each year during the RAE2008 period; for REF2014 this has increased to an average of £2 billion each year. Although the figures are not directly comparable (due to differences in the rules for submitting income to REF), this increase nevertheless reflects a real uplift in government funding of biomedical and health research in the period 2008-2013.

72. Whilst increases were seen in Research Councils and charity funding, the most significant increases were evident in funding from the European Union and in funding from other government bodies, especially NIHR in England and comparable bodies in the devolved UK administrations. Funding from UK industry fell both in financial terms and as a proportion of the overall funding.

73. Looking forward to the next assessment period, any disinvestment in life sciences research funding will result in a particularly detrimental effect on impact because of the extended time period needed to realise the benefits of research at a time when HEIs and funders have put in place specific mechanisms to encourage translation. The Research Councils and the medical charities have also contributed greatly to strengthening the research environments in cognate areas by establishing the critical mass of researchers in the form of subject-specific research centres, consortia and networks. In relation to health research, the charity sector is, collectively, the single largest funder in UK universities. The sector provides the direct costs of undertaking research and is crucially dependent on block grant from the UK funding bodies to support the academic environment in which this research takes place. The outcomes of REF2014 for the life sciences show that this partnership has been extraordinarily successful.

74. An observation commented on by all of the sub-panels is that, while the outputs and impact components did not appear to differ much with unit size, the research environment often strengthened in proportion to the size of the submission due to improved critical mass, sustainability and infrastructure. In smaller units, some concern was expressed about the sustainability of research when the profile of the research environment was low.

75. Overall assessment of research environments indicated high vitality and potential for sustainability.

Early career researchers and doctoral training

76. MPA was encouraged by the number of early career researchers (ECRs) submitted to each of the sub-panels and was distinctly impressed by the quality of their research outputs.

77. The total combined head count of Category A and C staff submitted in MPA UOAs (14,671) included 19 per cent ECRs (2,782).

⁴ <https://www.gov.uk/government/organisations/cooksey-review>

78. An important component of the environment is training and capacity building. Collaborative studentships with industry and with research charities, such as the Wellcome Trust, were also commented upon as being a positive stimulus to research capacity in specific fields. It was noted that across MPA there were differences in the number of PhD awards between the UOAs and the rate of increase in awards over the REF assessment period (see table 9).

Table 9: Doctoral awards 2008-2013

	Doctoral degrees awarded					Change in degrees awarded 2008-09 to 2012-13	Percentage change in degrees awarded 2008-09 to 2012-13
	2008-09	2009-10	2010-11	2011-12	2012-13		
MPA	5,236	5,468	5,652	5,847	6,201	965	18.4%
UOA 1	1,464	1,530	1,526	1,605	1,699	235	16.0%
UOA 2	316	289	320	362	391	74	23.5%
UOA 3	924	947	965	993	1130	206	22.2%
UOA 4	938	1,125	1,127	1,185	1,266	328	35.0%
UOA 5	1,258	1,242	1,361	1,323	1,355	97	7.7%
UOA 6	335	335	354	380	361	26	7.6%

79. UOA 5 and UOA 6 saw a much smaller increase in PhD awards compared to other UOAs in MPA. This in part might be explained by the introduction of four year studentships during the REF assessment period. Some concern was expressed about the postdoctoral opportunities after PhD and difficulties in transiting from a first postdoctoral position to early career researcher. Within the clinical, primary care, clinical neuroscience, clinical psychology, psychiatry, and veterinary fields (UOA 1, UOA 4 and UOA 6) in particular, there remain some concerns over how clinical training could negatively impact on research training by interruptions caused by long periods dedicated to clinical work in order to fulfil accreditation criteria. On a broader scale, it will also be important to understand how exercises such as the REF impact on academics' ability to undertake research that crosses disciplinary, departmental or sector-specific boundaries.

Equality and diversity

80. For all the sub-panels, it was clear that since RAE2008 there has been significant attention given to issues of equality and diversity. MPA was pleased to note that a very high proportion of units or their institutions had received Athena SWAN Silver or Bronze awards⁵. MPA also welcomed the efforts in REF2014 to recognise clearly defined and complex individual circumstances (such as ECRs, maternity/paternity leave, carer obligations and the impact of temporary adverse circumstances in the workplace) and greatly valued the help of the Equality and Diversity Panel (EDAP) in providing essential guidance on complex circumstances.

⁵ www.ecu.ac.uk/equality-charter-marks/athena-swan

Interdisciplinary working

81. There is evidence from REF2014 that research in the life science fields is moving much more towards interdisciplinary activity. Building on decades of fundamental research, many investigators are now creating models of increasing complexity across multiple disciplines and scales. In looking forward, interdisciplinary research should be seen as more than simply an additional 'subject' but a way of working that incorporates the knowledge, methods and approaches of more than one disciplinary field.

82. The best interdisciplinary research requires both structural support (considering challenges such as how staff budgets, research grants and undergraduate programmes can be shared between departments) and an enabling culture within an academic institution. Leading such research requires an awareness of the nature of, and difference between, disciplinary communities, their values and boundaries. It is fostered by a participatory model of leadership which subsumes individual egos, encourages learning as much as possible about the different ideas and practices of collaborators, and gives permission to make observations and recommendations.

83. Whilst MPA commended the overall research environments across all UOAs, it appeared that the ongoing expansion of interdisciplinary research, especially in relation to the study of complex issues and 'grand challenges' by large cross-disciplinary groupings, will require further deliberate planning, establishment and resourcing by HEIs to ensure that they have the capacity, infrastructure and culture to address these.

Sub-panel reports

84. Whilst MPA had common approaches and noted many common issues, each UOA has specific characteristics. In the reports by each sub-panel, the key messages from REF2014 are presented for HEIs, research groups, research funders, and service users in respect of moving forward to further increase research quality and impact.

Report of the international members of Main Panel A

International members

Professor Alan Barrett, University of Texas Medical Branch, USA

Professor Jack Gauldie, McMaster University, Canada

Professor Mi Ja Kim, University of Illinois at Chicago, USA and University of Rwanda

Professor Bruce Murphy, University of Montreal, Canada

Dr Frans van der Ouderaa, Leyden Academy on Vitality and Ageing, Netherlands

Professor Erica von Mutius, University of Munich, Germany.

Summary

- The REF is an impartial and highly significant evaluation of the investment made in research in the UK and the impact of these advances on society and the UK economy. It is the boldest, largest and most comprehensive exercise of its kind of any country's assessment of its science.
- The international members have been strongly and favourably impressed with the quality and effectiveness of the leadership and capabilities shown by the Chair of Main Panel A and the Deputy Chair, as well as the Chairs of Sub-panels 1-6.
- We judge that the actions and operations of each of the sub-panels were carried out conscientiously, with fairness and rigor of discussion and examination. The commitment of each sub-panel member was extraordinary and the composition of the sub-panels was broad and appropriate.
- We found that the calibration exercises were the backbone of this evaluation process.
- The strongly favourable evaluation of output in this REF exercise accurately reflects the high international standard of research in the UK covered by MPA. Recognition of this excellence can be seen across the world.
- For the first time we believe the aspect of impact of research has been systematically and broadly evaluated. We greatly applaud the current process by which impact with its various elements has received its considerable emphasis.
- We are favourably impressed with the extent and comprehensiveness of the funding consortia formed between government, funding agencies, charities and industry over the past 10 years.
- We believe it is clear that UK science has had a very high return on investment and is world-leading in many areas of both fundamental and applied research in the life sciences.

1. International members of MPA were involved from the beginning of the REF exercise and had input at all times to the approach and intent of the evaluation methods and processes to be employed by the sub-panels. International members of MPA attended all of the MPA meetings and nearly all of the sub-panel meetings during the entire exercise. Our goal was to bring an external and international outlook and benchmark to the evaluations. This mandate was endorsed and encouraged at each stage of the exercise by the Chair of MPA as well as the chairs of all of the sub-panels. We had ample opportunity to have input and it is our unanimous opinion that

these views were heard and integrated into the evaluation process. We further believe this REF exercise is the boldest, largest and most comprehensive exercise of its kind of any country's assessment of its science. We found it to be a fair and impartial evaluation of the investment made in research in the UK over the period of evaluation as well as the impact these advances have had on society and the UK economy.

Secretariat

2. We found the logistic support of the REF exercise to be very effective and highly knowledgeable. The importance of the exceptional expert advice and service provided by secretariat cannot be overstated. They effectively dealt with every question that arose regarding the process. Their understanding of the process, their timely reminders of the criteria of evaluation and their interpretation of these criteria when questions arose proved to be essential to the evaluation. Their knowledgeable advice concerning the regulations of the exercise played a central role in the uniform application of the criteria of judgment. The frequent attendance of the REF manager, at main panel and sub-panel meetings was very helpful in providing uniform interpretation of evaluation criteria across the four main panels.

3. In addition, our efforts, as well as those of panel members benefited from the informatics support engendered by the operation and accessibility of the REF panel members' website, the security of entry, the ease of acquiring data and the ready and functional communication.

Main Panel A and Sub-panels 1-6

4. We are strongly and favourably impressed with the quality and effectiveness of the leadership and capabilities shown by the Chair and Deputy Chair of MPA as well as all of the Chairs of the sub-panels (SPs) that were recruited for the exercise. All showed an in depth understanding of the process and all were able to bring consensus to the evaluations without sacrificing the rigor or impartiality of the exercise across the panels. We consider them and their quality to be a highly significant strength of the 2014 REF process.

5. Absolute avoidance of conflict of interest is an essential aspect of any peer evaluation. We found that it was addressed at all levels with well-defined and rigorous procedures. We found the operation and discussion of all of the sub-panels to be collegial and coherent. Evenness of evaluation across sub-panels and related issues were raised during the calibration exercises and were effective in interpretation and refinement of the process. We observed absolutely no evidence within any of the panels of manipulation or seeking to positively influence the status of any chair or panel member's constituency.

6. We judge that the actions and operations of each of the sub-panels were carried out conscientiously, with fairness and rigor of discussion and careful examination. The commitment of each sub-panel member was extraordinary throughout, in that it required countless hours, not only of evaluation, but also of interpretation of output, impact and other elements of a wide range of UK research. We are of the view that the composition of the sub-panels was broad and suitable and provided the needed breadth of experience and expertise to evaluate the spectrum of research in a fair and competent manner.

7. The International members noted that the six sub-panels each had unique overall strengths and made specific contributions to academic research excellence. Submissions in SP 1 comprised numerous high quality outputs with attendant evidence of major contributions to improvements in clinical practice both nationally and internationally. The submissions evaluated by SP 2 and SP 3 had made major contributions to both national and international guidelines and policy in their multiple areas. Similarly, SP 4 focused on neurobiology, psychology and psychiatry

and successfully evaluated outputs of high quality, many of which had been translated into clinical practice. Like SP 1, SP 5 had high quality outputs and these had been translated into major international advances in science and technology. Finally, outputs from SP 6 represented a balance of both basic and applied research which have led to major contributions to the practice of agriculture, veterinary and food science both nationally and for the European Union as a whole. In the latter case, the more applied outputs did not necessarily attract scores at the highest starred level, nonetheless have given outstanding return on investments. This is of particular significance considering that the research income in SP 6 was the lowest of the six areas in MPA. We note also that SP 3 covered a much larger number of units of assessment compared to the other SPs.

Evaluation criteria

8. We consider the REF to be an equitable and impartial process that has been extended from and improved over the previous RAE exercise. The process added since the last evaluation, specifically impact, was highly useful and served to highlight the significance of UK science. The criteria for evaluation of both impact and environment could be improved, as these showed some variability of evaluation among sub-panels, but this may in part be due to the themes of the SPs as stated in the previous paragraph. Although we considered this variability to be minor, the issue could be assuaged by further clarification of the evaluation criteria.

Outputs

9. Panellists were tasked with assessment of the output principally in the form of scientific publications. The mandate was to assess the quality of the research presented and without consideration of the status of the journal where it was published. This mandate was frequently emphasised by the MPA chair as well as by the chairs of all of the sub-panels, prior to and throughout the procedure. It was remarkable to note that panel members had thoroughly read all of the publications assigned to them. It was clear that, despite the large number of papers that each was assigned to review, the evaluators could discuss the manuscripts they had reviewed in depth. Some had as many as 900 outputs to review.

10. In general, the perceived journal profile did not influence the evaluation of any outputs across the various panels. Outputs were evaluated for their value and content. A 'glass half full', rather than 'glass half empty' approach was very useful as the basic tenet of overall evaluation. We wish to emphasise that the collegiality and respect shown for inter-professional collaboration throughout the REF deliberation was exemplary.

11. There was an approximate 30 per cent overlap in membership from the previous RAE, providing some consistency of evaluation between the two exercises. We consider that the overall increased NIHR funding seen since 2006 and decisions to maintain government science funding in times of economic hardship have had a positive influence in the increased quality of the outputs evaluated in this REF over previous RAEs, and put the UK in a very strong position worldwide in research. The international members were of the opinion that this investment must continue to maintain the competitive international leadership of UK academic research. We believe that evaluation of output in this REF exercise was conducted in considerably greater depth, and accurately reflects the high international standard of research in the UK that falls within the mandate of the MPA. It is our further opinion that there is recognition and appreciation for the quality of UK scientific excellence across the world.

Impact

12. The impact of research on some aspect of societal function is accepted worldwide as a factor of importance to evaluate, but has not been broadly studied to date in any organised or meaningful way. The current REF exercise is, to our knowledge, the first systematic and extensive evaluation of research impact on a national level. We applaud this initiative by which impact, with its various elements, has received considerable emphasis. This includes some technology transfer activities with spin-off companies that showed tangible impact of research on the economy and society. We appreciate the narrative aspect of this exercise and caution against attempts to 'metricise' the evaluation of the many superb and well-told narrations of the evolution of basic discovery to societal impact. It is our judgment that future exercises should be characterised by initiatives to provide more accurate quantification of the extent and reach of the impact, for most of which data are expected to be available. In addition, the proportionality of an individual contribution to 'impact' was often not sufficiently clear, and in some cases, rendered evaluation difficult, but did not appear to affect the final evaluation.

13. We conclude that there were major differences in the quality and content of the impact cases. The quality of writing varied widely, even between cases from the same institution and in any one submission. This appears to be due to the strategy employed by a number of universities of using professional writers to develop and present their strategy and impact statements, while others relied entirely or in part on academic staff. In our opinion neither strategy was uniformly successful, and, indeed, the most successful impacts told the story themselves.

Environment

Evaluation of the environment, as outlined in the REF guide, was less measurable, in an evidence-based manner, than output or impact for many of the institutions. We believe that the purpose, function and evaluation criteria for the environment category should be revised in future exercises, with the goal of providing sufficient clarity. Guidelines regarding environment, conducive for future research, not current impact, could be further developed. Criteria for future consideration could be: vision and strategy for the next five year period, the degree of focus on the most productive areas and plans to disinvest from less productive areas and lastly, the level of infra-structural support to be provided by the institution.

14. We suggest that as a future evaluation of the environment in the institutions, that there be a question along the lines of: 'What has changed in the institutional environment over the past funding cycle (since 2014) to affect the outcome of future research?' This criterion should be a stimulus for beneficial change to enhance research productivity and translation of research findings into societal impact.

Calibration exercises

Calibration exercises were the backbone of this evaluation process and we found the calibrations to be very useful. The strategy to involve all main and sub-panel members and assessors in the calibration exercises allowed for identification of and consequent amelioration of substantial differences in evaluation across disciplines. We found that panel members' comments from different disciplines indicated that they were able to discern research quality regardless of discipline (i.e. good quality, as judged by evaluator in one discipline, was also judged as good by evaluator in other disciplines). In the end, we strongly believe that the evaluations have been, in major part, consistent across the sub-panels.

Issues

The size of an institution as an effect on evaluation

Submissions from larger universities were generally found to be of a higher quality, in particular when they had justifiable data to warrant 4* rating. The excellent evaluations are justified when infrastructure and administration of these institutions have provided their faculty and scientific personnel with incentives and support to advance their research agenda with consequent high quality outcome. Nonetheless, we found that some smaller institutions have made clever and well-considered investments and have succeeded in emphasising research strengths in spite of their size. In this case, specialisation was to their advantage.

Translation of research to impact

15. The 2014 REF illustrates, in particular by way of the submitted impact cases, the increasing power of the contribution that multidisciplinary teams make to translational research and innovation. The process of bringing new insights and innovations to market requires an understanding of complex problems as well as a team composition with a breadth of competencies beyond the boundaries of each of the four REF main panel areas. Successful translation to impact requires, for example, the integration of Medicine and Biology, or Engineering, Physics and Mathematics to conceive new, more sophisticated medical devices and treatment regimes. Similarly, novel routes to lifestyle interventions to prevent disease would require a combination of Medicine, Nursing and Midwifery, Allied Health Sciences, the Humanities and perhaps Architecture.

16. An example of an infrastructure to achieve this more holistic perspective to wealth creation, improvements in wellbeing, as well as job creation, can be found in the European Union (EU)'s Knowledge and Innovation Communities (KIC) program. There are three of these communities in place, at €700 million each, with the express goal of fostering the process of innovation to market implementation to meet Europe's big societal challenges. The KIC mechanism includes not only the support of multidisciplinary research, but also the training of scientists to the wider appreciation of the breadth of the innovation process from scientific insights to market implementation including the understanding of market opportunities as well as the required entrepreneurial concepts and skills. This more holistic approach should perhaps be more vigorously pursued within the UK to more effectively bring multiple, high impact scientific insights effectively to market.

The potential for manipulation of the system exists in some contexts

17. One example that we observed was the 'parachuting in' of an accomplished expert for the purposes of having their output available for REF evaluation, or the claiming of a foreign (full time) faculty member at 0.2 FTE in the UK. Given the current rules and constraints, it is apparent that such gaming is impossible to manage and should be discouraged in future evaluation exercises. A second example is the practice of some departments to declare only a fraction of their staff, those that are very productive, whereas others declare their entire membership, providing the former group with an advantage that may contribute to the outcome of their quality profile. We believe it essential in future evaluation exercises that there be consideration of the total 'research power' of an institution. Evaluation applied to the total number of FTE will provide a closer and more accurate evaluation of the well performing 'Research Centres of Excellence' found in all sectors of research endeavour.

Support for 'big science'

18. We were impressed with the extent and comprehensiveness of the funding consortia that have been established between government, funding agencies, charities and industry in recent years. These endeavours have resulted in a shift of resources, from the broadly distributed healthcare sector, to consortia with more targeted translational initiatives. The major benefit has been creation of the possibility for undertaking of large projects with clearly translational goals and realisation of benefits that this approach yields. We applaud the evidence of the political will to change the status quo funding system and expand it to the benefit of research. Clearly, this is a productive national direction, as evidenced by the excellence of the outputs generated. It is essential that this initiative to fund and maintain key capabilities in '-ologies' or '-omics' be continued to pursue 'big science' and 'big data' projects. We applaud the UK in the boldness and cohesiveness of this effort.

19. In this regard, the collaborative environment encouraged by an approach to big science cannot result in anything but a plethora of multi-authored and valuable outputs and MPA spent a lot of time developing the criteria for multi-authored outputs. In practice, there were additional efforts required to ensure proper author contribution to multi-authored outputs; and for the next REF these issues will need to be examined carefully and modified to promote large-scale collaborative research (which is likely to increase).

Feedback to institutions

All MPA and sub-panel members took part in discussions with examples of the recommendations for feedback statements. The procedure was to look at the profile graphs and to formulate text. The statements were meant to be positive, without making specific comparisons and not to be bland. This is a tall order, and as a result, the feedback is somewhat formulaic. It is not clear, given these constraints, that the feedback will be very useful to the institutions.

Overall conclusions

20. The REF is an impartial and highly significant evaluation of the investment made in research in the UK over the past 10 years and the impact of these advances on society and the UK economy. It is the boldest, largest and most comprehensive exercise of its kind of any country's assessment of its science. We would hope that this unique and enormous REF exercise can be evaluated (i.e. to establish what this process adds beyond metrics such as counting impact factors and first authorships) and this evaluation made publicly available such that other countries, such as our own, may consider undertaking a similar evaluation process.

21. The exercise that concluded in 2014 has presented incontrovertible evidence of the will within the UK to lead science across the world. The methods to evaluate research performance were comprehensive, impartial and the product of careful consideration. We believe that UK science is succeeding to produce high quality research, well in excess of the expectation based on funding information alone. The UK is leading in many areas of fundamental, applied and clinical research. We note that the results of the exercise for institutions were, in some cases, either above or below prior expectations. We believe that the results will stimulate institutions to engage with the new process in future in order to demonstrate, as clearly as possible, the strength of their scientific faculty and the environment that they provide to ensure scientific quality and productivity.

22. The evaluation approach chosen by the REF process is cutting edge and should stimulate administrators at the university faculty and departmental levels as well as scientists, to consider the importance of societal impact of the research conducted within their institutions. It is critically

important to demonstrate, unequivocally, the return of the research investment to the taxpayer. It is our view that the REF process has had a major effect with respect to changes of behaviour in the science community across all sectors of institutions and that this approach will be highly effective in stimulating the generation of increased successful translational research activities.

23. It is obvious to us that the funds administered by the higher education funding bodies of the UK are critical to the success and credibility of the UK research enterprise. These central funds support the fundamental essence of the research that underlies the excellence of UK research endeavour.

24. We hope that our home countries recognise the highly positive consequences of directly funding research at the universities and that they would choose to emulate this process as broadly and as effectively as we have seen done in the UK. We believe the funding scheme in the UK not only supports research but also showcases the valuable concept that research is a productive and impactful element, essential for the progress of society.

UOA 1: Clinical Medicine

Average quality profiles for the UOA

	% 4*	% 3*	% 2*	% 1*	% UC
Overall quality	39	44	15	1	1
Outputs	23.1	53.5	21.3	1.1	1.0
Impact	76.4	19.6	3.3	0.3	0.4
Environment	59.4	36.1	4.5	0.0	0.0

Key messages

1. Over the past six years, UK universities have made an outstanding contribution to clinical medicine and to the world-leading position of the UK in biomedical science and clinical/translational research. Not only this, but they have also demonstrated that the sustained investment in medical research over the last 20 years has yielded substantial impacts for human health, the economy and society both in the UK and globally. The strong research environments across the UK suggest that, with maintained investment in all aspects of the translational research spectrum, from discovery to adoption and diffusion, UK clinical medicine will continue to yield significant benefits in the future.
2. The headline statistics are:
 - A headcount of nearly 4,000 staff have been responsible for over 10,000 peer reviewed research outputs rated at the internationally excellent level or above, with over 3,000 outputs scored as world-leading research.
 - 30 submissions were received from UK universities and their research income over the period was nearly £6 billion.
 - 383 impact case studies were submitted alongside the 30 impact templates, and 76 per cent of impacts were considered to be outstanding, with 96 per cent rated as either outstanding or very considerable in terms of reach and significance.
 - 18 per cent of Category A staff submitted were early career researchers, demonstrating a healthy commitment to training and nurturing the next generation of researchers.
 - All submissions, regardless of their size, contributed to the high quality of the outputs and impact case studies.
3. A very wide range of clinical specialties was represented in the submissions, including the full range of medical and surgical specialties, neonatology and general paediatrics, anaesthesia and intensive care; and radiology/medical imaging. There were substantial submissions from laboratory based scientific disciplines allied to medicine, in particular genetics and cell biology, including stem cell and cancer cell biology.
4. Much of this work was underpinned by the vast charitable investment made in clinical medicine in the UK, with over a third of the income (over £2 billion) over the period derived from UK-based charities. The increasing investment made by the NIHR since 2006 has also had an enormous beneficial effect on the ability of universities to translate their research into patient benefit. Nearly £1 billion of research income from the NIHR was submitted to this sub-panel

which, together with a similar level of investment by the Research Councils, undoubtedly made a major contribution to the overall increase in quality of the UOA compared to submissions to the cognate panels in RAE2008. The sub-panel noted repeatedly the beneficial effects of the increasingly close working relationship between UK academia and the NHS, almost certainly enhanced by the NIHR funding awarded to the NHS partners. From identifying research problems and producing high quality research, to ensuring that this research is translated into bedside care, the unique partnership working between academia and the NHS in the UK clearly underpins a significant proportion of the excellence the sub-panel found in the submissions.

5. However, there remains considerable scope for development, particularly of capacity building and the support of early career clinical and basic science researchers. Additionally, whilst pockets of high quality expertise were identified (particularly in the cancer field), the sub-panel was concerned that further capacity building in the fields of pathology and informatics is required to maintain the current vigour of UK medical science. Moreover, there was a perception that, whilst outputs from basic science-led teams were well represented at the highest level, fewer were received from the scientifically trained investigator clinician. The sub-panel identified that fostering and maintaining a cadre of such individuals equipped to deliver experimental medicine studies in their clinical disciplines was important for the future UK biomedical vitality.

Outputs

6. Just over 13,400 research outputs were assessed by the sub-panel, which noted the generally very high standard of research returned. Thus, fewer than 300 outputs (2 per cent) were rated as only nationally recognised or unclassified, the majority of the latter being due to issues of eligibility, rather than quality. By contrast, nearly 77 per cent of the return represented research scored at internationally excellent or better, with 23 per cent of the outputs scored as world-leading. This level of performance is most impressive and underpins the UK's leading position in international analyses of clinical medical research. World-leading excellence was found across all submissions, regardless of size and in almost all disciplines.

7. The following areas were noted as particularly outstanding: cancer, cardiovascular medicine, genetics, infection, inflammation/immunology and regenerative medicine. These areas highlighted the UK's expertise in multidisciplinary or 'team' science.

Impact

8. The sub-panel received a total of 383 impact case studies in this UOA. The sub-panel noted how impressive the impacts were in terms of their reach and significance. Indeed, the range and quality of impacts returned to this UOA underscored the global importance of UK biomedical research and its huge contribution to the health and wealth of the nation.

9. Judged in terms of their reach and significance, 96 per cent of the impacts were considered by the sub-panel to be outstanding or very considerable, with 76 per cent outstanding. Underpinning these excellent impacts, the sub-panel noted that 50 per cent of submitting institutions were able to describe an approach to impact that was conducive to supporting and enabling impacts of outstanding reach and significance. Almost all of the impacts described led to significant improvements in health and wellbeing, either directly or indirectly. The underpinning research encompassed the whole translational spectrum, from impacts resulting from basic discovery science to classical public health research. The reach of impacts ranged from cures for small numbers of patients with rare genetic diseases through to influences on health policies across the globe. Examples of outstanding impacts included the establishment of small and medium sized enterprises (some leading to multi-million pound biotech companies), the development of new treatments and treatment paradigms (many resulting in significant mortality

reductions and/or considerable cost savings for the NHS), clinical guideline development and novel diagnostic approaches. These examples are applicable to a wide range of settings, from primary, secondary and community care, through changes in government public health policies to increased public engagement with medical science. The sub-panel noted that impacts on wealth generation were, as a group, less well developed than those describing clinical benefits. Additionally, panellists noted that HEIs need to continue to work with the NHS and other healthcare providers to enable and encourage the adoption and spread of innovations with the potential to enhance health and wellbeing.

10. At least three panellists assessed each impact item, with a 'user' assessor always involved. The calibration exercise undertaken at the start of the process established common views and a further calibration exercise took place before impact scoring was finalised. These discussions, together with in-depth discussions between panellists on each item, meant that the sub-panel found it straightforward to assess the impact elements of the submission, and were confident in the robustness of their conclusions. The involvement of the user assessors was extremely valuable in providing a different perspective on the reach and significance of the impacts. A small minority of cases focused too heavily on the academic impact of the research rather than on its impact outside academia.

11. The score given for the impact template correlated with the average scores given for case studies in a submitting unit. A number of HEIs appeared to have employed specialist writers for their case studies and templates, and whilst clarity is welcomed, on occasion the lack of academic language and emphasis hindered the ability of the sub-panel to judge against the criteria.

Environment

12. Almost 60 per cent of the environment reviewed by the sub-panel was considered to be conducive to producing research of world-leading quality, in terms of its vitality and sustainability and providing excellent training of scientists and the full range of healthcare professionals.

13. The development and support for early career researchers was particularly strong. The sub-panel was encouraged by the number of submitting units which had already achieved bronze or silver Athena SWAN awards and heartened that the others had clear plans to do so, reflecting an increased focus on achieving equality and diversity. On the negative side, the sub-panel was disappointed to note the decreased numbers of Category C staff returned when compared to RAE2008. This may reflect a true decline in the numbers of NHS staff involved in high quality research or be related to the rules of REF2014 which restricted their submission. Furthermore, the sub-panel was concerned that the lack of any allowed reduction in required outputs based on the proportion of time spent on clinical duties may have reduced the volume of clinical academics returned.

14. The sub-panel was impressed that a total of almost £6 billion of research income was reported over the 2008-2013 period, with around £900 million derived from UK Research Councils and a further £950 million from NIHR. Income from UK-based charities was over £2 billion, reinforcing the critical nature of their contribution to UK clinical medicine. A further £400 million of research income came from industry. The sub-panel was particularly pleased to see the substantial success in obtaining research funds from EU government sources, with income totalling £220 million during the REF assessment period.

15. There was evidence of widespread international and national collaboration, both within and between disciplines, and the extent of industrial collaboration, including with small and medium-sized enterprises, was a positive feature of many submissions.

UOA 2: Public Health, Health Services and Primary Care

Average quality profiles for the UOA

	% 4*	% 3*	% 2*	% 1*	% UC
Overall quality	39	41	17	3	0
Outputs	22.6	48.6	25.0	3.1	0.7
Impact	68.3	26.5	5.2	0.0	0.0
Environment	70.7	25.8	2.2	1.3	0.0

Key messages

1. The sub-panel judged that the UK is a world leader in the inter-linked and complementary disciplines of public health, health services and primary care research submitted to UOA 2. Observations from the international members of MPA supported this view. The sub-panel was particularly impressed with the reach and significance of the impact case studies from across the submissions, and with the strength and vitality of the research environments.
2. The headline statistics are:
 - UOA 2 received 31 submissions, of which one was a joint submission.
 - Almost 5,000 outputs, 194 impact case studies and templates and 31 environment statements were assessed.
 - The submissions included over 1,350 FTE staff, an increase of 13 per cent since RAE2008.
 - Almost 20 per cent of the staff submitted were early career researchers.
 - Submissions ranged in size from 10 to 296 staff, and from two to 27 impact case studies.
 - Two institutions accounted for almost 30 per cent of the submitted material.
 - During the REF assessment period approximately £1.5 billion was invested in research in this field, and this increased by over 30 per cent over the five year period
 - 1,678 doctoral degrees were awarded in the period 2008-2013.
3. A striking and pleasing feature of the work submitted to this sub-panel was the large proportion of work which involved multi-disciplinary teams working in collaboration. The disciplines submitted to the sub-panel are inter-linked and complementary, and the underpinning methodologies are common across the disciplines, so that the sub-panel was unified in a common understanding of the research submitted. This led to a cohesive panel able to judge the submissions as a whole, without the need to sub-divide the panel to assess different submissions.
4. HEIs have clearly made substantial investments in applied health research, supported by a strong and growing research funding environment. During the REF assessment period from 2008-2013, roughly £1.5 billion was invested in research in our field, and this increased by over 30 per cent over the five year period in which funding was reported, with no evidence that this trajectory was slowing down. Much, but by no means all, of this growth has been supported by the NIHR which came into being in 2006 and reached full funding by 2009. The effect of this combined investment has been the evolution of a research environment which is judged to be

outstanding and in which public health, health services and primary care research in the UK is flourishing.

5. The sub-panel also considers that the inclusion of impact assessment in the REF has contributed to a shift in the perceptions of HEIs about the value of applied research, which is the focus of the research submitted to UOA 2. This shift has also contributed to the notable improvement in the research environment for public health, health services and primary care research.

6. A substantial body of exceptionally high quality research and impact cases focused on public health problems overseas was also submitted to the sub-panel, often supported by UK Research Councils and charities. The sub-panel was impressed and delighted with this demonstrable and impressive contribution made by the UK to improving global public health.

7. The sub-panel was also impressed with the volume and quality of the research and impact cases assessing the effectiveness and cost-effectiveness of treatments and services, an area in which the UK is undoubtedly the world leader. New developments in other areas, such as in epidemiological studies of gene-disease associations, the use of 'big' e-health data to inform and understand the impact of healthcare practice and policy, and the integration of qualitative and quantitative research methods to improve the richness and value of the research, are evident.

8. One area in which new approaches were less evident was in the involvement of patients and the public (PPI) in health research. With a few notable exceptions, PPI in REF2014 was not as visible as expected. This may partially reflect the REF guidance and a time lag factor, and the sub-panel might expect to see more substantive PPI in the future. Careful guidance is required to enable PPI to be more visible in future REF exercises.

9. The inter-linked and complementary disciplines submitted to the sub-panel, with their common methodologies, meant that the approach of the sub-panel to assessing the quality of the submissions was for the whole sub-panel to be involved in the assessment of all elements of the submission of every HEI. As a rule, all panellists assessed some outputs from every HEI. The whole panel was involved in scoring every impact case study, every impact template, and every environment statement in plenary sessions. The sub-panel is confident that this approach has led to a fair and unbiased assessment for each HEI.

Outputs

10. Nearly 5,000 outputs were received from across the spectrum of public health, health services and primary care research. Almost 23 per cent of the outputs were judged to be of world-leading quality (4*) and a further 49 per cent to be internationally excellent (3*). Direct comparisons with RAE2008 are difficult to make, but the sub-panel, many of whom had sat on panels in RAE2008, judged that there was a notable improvement in the quality of the research outputs submitted. One reason for this was the excellent and improving research environment underpinned by growing research funding.

11. Almost all of the outputs were multi-authored, reflecting multi-disciplinary teams often from a number of collaborating institutions. Some outputs were submitted more than once by different authors from different HEIs. Excluding duplicates submitted to UOA 2, nearly 20 per cent of the unique outputs were judged to be of world-leading quality.

12. Particular strengths were noted in global public health research, health technology assessment, trials in primary care and other clinical areas submitted to the sub-panel, and the use of routine NHS data for research.

13. The sub-panel was also impressed with the rigour of the research methods being used across all areas, and also by how these methods continue to be developed, with new ideas and approaches evident in the submissions. The importance of different methodologies, such as qualitative research methods, medical statistics, and health economics, were equally valued.

14. In addition to the sub-panel members, three output assessors joined the sub-panel in 2013 to ensure there was sufficient expertise to assess the material submitted. Material was allocated to panel members and assessors at random to ensure that the outputs of each HEI were assessed in an unbiased way by the whole panel and that the sub-panel as a whole had a shared understanding of the quality of each submission. The allocated panel members and assessors were encouraged to seek advice when necessary from topic experts on the panel or from other UOAs through cross-referral. However, cross-referral of outputs to other UOAs was minimal.

Impact

15. The sub-panel received 163 impact case studies to assess, and 60 per cent of these were judged to be outstanding (4*). The sub-panel was impressed with the very important contribution that public health, health services and primary care research has made to health and welfare worldwide. Many of the impact case studies that were submitted were the culmination of many years of research and impact, resulting in many examples with outstanding reach and significance.

16. Outstanding examples included cases focused on national screening programmes for the detection and early diagnosis of conditions, UK wide and international studies leading to changes to clinical practice which have improved outcomes and saved many lives, and contributions related to changes in national policy and legislation.

17. The range of case studies submitted was extensive. The majority were related to impacts on policy and practice. These included case studies which described changes to Department of Health or NHS guidelines and guidance. Importantly, these included demonstration of policies being maintained, changed and removed as well as new policies being introduced. There were also case studies concerning the management of illnesses in general practice and other settings, and improving treatment delivery. Some case studies illustrated informed public debate, for example on issues such as breast-feeding, obesity, alcohol consumption and smoking. Impact case studies on resource management and training of healthcare professionals were also received.

18. The global reach of the impacts stood out and included cases that described the introduction of vaccine programmes, improving access to healthcare in developing countries, and contributions to changes in international prescribing practices.

19. The outstanding reach and significance of the impact case studies underlines the importance of research in public health, health services, and primary care to the health, wealth, and well-being of the UK and elsewhere. The impact case studies were generally regarded more positively than the impact templates with many HEIs seen to still be developing a strategic approach to impact.

20. In 2013 three impact assessors joined the sub-panel specifically to advise on impact, and their input, as well as the advice of international members of MPA, was particularly valuable.

21. At least three people were randomly assigned to each impact item and provided initial scores on each one, with a user assessor always involved. All impact case studies and templates were discussed by the whole sub-panel to agree scores.

Research environment

22. The sub-panel was particularly impressed with the vitality and sustainability of the research environments. There was strong evidence of dynamic, growing research environments supported by HEIs, and underpinned by the size and vitality of the funding environment in this area. Since 2008-09 research income has increased by over 30 per cent and this is reflected in the growing infrastructure present in many units.

23. There was strong evidence of collaborations underpinning research in this discipline. Almost all outputs reflected institutional, national, or international collaborations. The environment statements made clear how important these collaborations, especially with the NHS, are to the development of important high quality research in this area.

24. Evidence of support for equality and diversity was present in nearly all of submitted units, in particular the sub-panel noted many Athena SWAN successes with almost all units holding bronze or silver awards.

25. All environments were initially scored by three members of the sub-panel randomly allocated and then reviewed and scored by the whole panel. The standard analyses provided of research income or doctoral degrees awarded per FTE submitted were not used in the assessment because of the likely differential selectivity of the submissions. However, the sub-panel did take note of the trajectory of these indicators.

UOA 3: Allied Health Professions, Dentistry, Nursing and Pharmacy

Average quality profiles for the UOA

	% 4*	% 3*	% 2*	% 1*	% UC
Overall	31	50	17	1	1
Output	21.4	55.7	20.1	1.9	0.9
Impact	47.2	40.8	10.4	0.6	1.0
Environment	50.1	35.5	13.4	1.0	0.0

Key messages

1. In RAE2008, 'Nursing and Midwifery', 'Allied Health Professions', 'Dentistry' and 'Pharmacy' had separate units of assessment (UOA 10, 11, 12 and 13). In REF2014, these disciplines were combined (UOA 3). With 91 submissions across different disciplines, this was one of the largest and most diverse UOAs in REF2014 covering disciplines from different epistemological backgrounds. While reducing the ability to distinguish between what in the past may have been seen as clearly distinct subject areas, it led to greatly enhanced positive interactions between disciplines and professional groups with sub-panel members working extremely well together. Interaction was further helped by the strategic matching of panellists in reviewing pairs and groups and by the careful allocation of work across the sub-panel. It was also helped by the use of calibration exercises to strengthen the assessment of outputs, impact and environment. The presence of international members from MPA also ensured a fair and rigorous reviewing process. In addition, the sub-panel members had extensive experience of working in multidisciplinary research teams and employing a variety of research methodologies. This had many advantages in terms of interdisciplinary understanding of methods, subjects and research priorities.
2. Submissions to this UOA included research from the disciplines of allied health professions, biomedical sciences, dentistry, nursing, midwifery, and pharmacy. Its boundaries include research in underpinning science, laboratory-based work, applied clinical research and both empirical and theoretical research into public health, social care and health promotion; there are many areas of overlap with other UOAs.
3. The headline statistics are:
 - 91 submissions were received from UK HEIs – including those with large, established departments covering the full range of the field (largest submission size 121 FTE staff) through to small less well established departments (smallest submission size three FTE staff).
 - There were three joint submissions (involving six HEIs) and 21 multiple submissions (involving 10 HEIs).
 - 3,016 staff (2,984 FTE) have been responsible for 10,358 research outputs, with over 77 per cent of them rated as internationally excellent or world-leading.
 - Research income by spend reported over the period was £918 million, 19 per cent being from UK Research Councils, 21 per cent from charities, 34 per cent from UK central

government bodies, local authorities, health and hospital authorities, 8 per cent from industry and 9 per cent from the EU.

- 351 impact case studies were submitted alongside the 91 impact templates, and 88 per cent of these were rated as having outstanding or very considerable impact.
- 509 early career researchers were submitted, representing 17 per cent of the total staff returned. This demonstrates a healthy commitment to training and nurturing the next generation of researchers and enabling productivity in their early posts.
- There was strong evidence of research training, with 4,959 doctoral degrees awarded during the REF period.

4. In interpreting this overview report, it is important to remember that some HEIs will have been more selective than others in their submissions, but in the absence of staff denominators, it is not possible to specify to what extent. Furthermore, it is probable that not all eligible academic departments have submitted to this UOA. This overview should be interpreted in this light: it is a statement only on the evidence submitted, not necessarily on the state of all the research relevant to this UOA in the UK. In addition, some of the submissions were unidisciplinary whereas others incorporated multiple disciplines. While direct comparisons between the results of RAE2008 and those of REF2014 are, therefore, challenging, it is possible to note some trends. It is also important to remember that for research environment the RAE2008 covered a six-and-a-half year period while the REF2014 covered a five year period, while for outputs the corresponding time periods covered were seven and six years respectively.

5. Over the REF period, UK HEIs have made an outstanding contribution to the knowledge base in this UOA. This enhances their international standing and shows that UK researchers continue to publish some of the most influential work in the world. Results also show that the sustained investment in research in this UOA over the last 20 years has yielded outstanding impacts for quality of life, health, the economy and society nationally and internationally. The strong research environments across the UK showed good evidence of this investment by both HEIs and external research funders. This suggests that, with maintained or enhanced investment, these disciplines will continue to yield significant benefits in the future.

6. It is clear from the results of the exercise that there is internationally-excellent or world-leading research in each of the disciplines/groups submitted to this UOA. However, compared to the number of submissions from corresponding UOAs in RAE2008 (n=133), fewer submissions were made to this UOA in REF2014 (n=91) and with 8 per cent (n=270) fewer staff. Nonetheless, the overall quality profile has improved compared to the combined corresponding UOAs in RAE2008.

7. A broad range of robust research methodologies was noted and there was evidence of more national and international collaborations compared to the last exercise. The interdisciplinary nature of research was believed to be a key factor in this approach, enabling and facilitating collaboration among researchers across different disciplines and countries. This trend reflects a move away from a more uniprofessional approach more evident in RAE2008.

8. This UOA undoubtedly benefitted from developments in research funding during the REF period, notably through the NIHR. This reflected a move to further integrate academic researchers with the NHS towards more translational research that underpinned many of the impact case studies. This has also had a very positive effect on the ability of HEIs to translate their research into patient benefit. From identifying research questions and producing high quality research, to ensuring that this research is translated into healthcare services, the working partnership between

academia and the NHS in the UK clearly contributed a significant proportion of the excellence the sub-panel found in the submissions. Although not directly comparable here, there was also some evidence that the level of funding from major charities, the EU, and Research Councils had increased since RAE2008.

9. The sub-panel noted that the number of researchers returned in dentistry had reduced by about 25 per cent (to only 281 FTE) compared with RAE2008. This was in contrast to other areas of research that the sub-panel reviewed and raised questions about the sustainability of oral and dental research. However, there was still evidence of considerable vigour with a large proportion of the outputs and impacts submitted in this area rated as world-leading or internationally excellent.

10. There remains considerable scope for development in this UOA, particularly in capacity and capability building and the support of early career researchers. The sub-panel identified that fostering a collaborative cadre of research active individuals with such expertise, equipped and resourced to deliver multicentre studies, was important for the future vitality and sustainability of these disciplines.

Outputs

11. One specialist and one more generalist reviewer scored each output. Occasionally, a third reviewer was involved where the initial scoring pair could not readily concur, or where another reviewer was felt to have expertise that was more relevant. The robust and helpful output calibration exercise undertaken at the start of the process used contemporary outputs that were from outside the UK and that represented a wide range of quality. Where outputs were found to lie outside the expertise of the sub-panel, advice was sought from other sub-panels. The sub-panel also provided advice on a number of cross-referred outputs that had been submitted to other sub-panels.

12. The sub-panel assessed 10,358 research outputs from across all areas within the disciplines submitted to this UOA. Compared to the corresponding UOAs in RAE2008, there were 17.6 per cent (n=2208) fewer outputs submitted to this UOA in REF2014. Similarly, the outputs submitted per person declined from 3.82 in the corresponding UOAs in RAE2008 to 3.42 in this exercise, probably due to the introduction of enhanced equality and diversity guidelines. It is important to stress that world-leading outputs were found across all submissions regardless of size and in almost all disciplines. In essence, 77 per cent of the research outputs submitted to this UOA were judged internationally excellent or better.

13. In the allied health professions, research into ageing and conditions associated with old age was seen to be increasing in amount and quality. Implementation research was emerging and the use of the MRC framework for complex interventions was demonstrable. The level of theoretically well-grounded qualitative research submitted has increased and the sub-panel welcomed this. Research into stroke rehabilitation, exercise prescription, patients and user expectations and experiences of care and of specific conditions, occupational science, low back pain, cardiac rehabilitation, falls and fall prevention, biomechanics of joints and pain management produced world-leading and internationally excellent outputs.

A large proportion of the research in biomedical and nutritional sciences delivered outstanding outputs, with research covering the breadth of the biomedical sciences, from molecules and cells through to clinical genetics. This demonstrates the success of this multidisciplinary science in being translated to human studies that investigates both healthy ageing and disease treatment. Across the spectrum, world-leading research outputs were evident in both specialist single discipline journals and leading multidisciplinary journals.

14. Overall, the standard of outputs in pharmacy and pharmaceutical sciences indicated a vibrant research discipline with a strong commitment to interdisciplinary and translational research. Traditional research fields of pharmaceuticals, pharmacology, pharmacy practice/clinical pharmacy and medicinal chemistry continue to produce internationally excellent and world-leading outputs. The sub-panel was encouraged by new areas of strengths in areas such as nanotechnology, molecular biology and regenerative medicine. The quality of outputs in these new areas demonstrated the enthusiasm of HEIs to contribute to pharmacy innovation and future medicines.

15. A high proportion of the world-leading outputs from dentistry resulted from multidisciplinary research encompassing a range of biological, physical and chemical sciences with clinical disciplines using collaborative teams, often with several groups across institutions. Research excellence in dental related outputs was observed in many areas such as: epidemiology; understanding fundamental mechanisms of disease; dental caries; periodontal diseases; cancer related stem cell biology and regenerative medicine.

16. In terms of nursing-related research outputs, many of those in cancer, palliative and related supportive care were widely held to have been internationally excellent or world-leading as were those in the field of self-care management and the support of people with long term conditions. Sub-panellists felt that there were particular strengths in the mental health field, notably in the areas of prevention of self-harm and suicide. Midwifery contained many areas of strength including breastfeeding and place and manner of birth, with evidence of strong multidisciplinary. Important work was also noted in the general area of quality and safety of care in acute and community settings (e.g. prevention of infections, falls, pressure sores, wound care and leg ulcers, urgent and emergency care, access to care outside of hospital). There were excellent examples of world-leading work on staffing levels and quality of care. The application of new technologies to patient care and managing chronic illness was also worthy of praise. Public perspectives on research and pedagogic research were areas that were less well represented. Similarly, it was noted that research into the care and support of people with learning difficulties, though evident, was not as prominent as expected. Laboratory-based research was also not as evident in nursing, although increased collaboration with biomedical science and pharmacy has produced some very good examples.

17. There were a large number of systematic reviews and meta-analyses conducted using established methodologies, and the quality of these was generally excellent. However, the submission of a small number of descriptive reviews offering no new insights was noted. The sub-panel also wishes to acknowledge the submission of research based books, which at their best, were rated highly.

18. Work in public health and epidemiology submitted to this UOA was considerably stronger than in RAE2008, and, in this as in other areas of work (e.g. palliative care, paediatrics, mental health), there was a much better inter-disciplinary focus, which often had a strong theoretical grounding. This approach was particularly exemplified by the increasing use of large and rigorously mined big datasets for secondary analysis producing important new insights in disease causation, care and treatment effects and policy and practice guidance.

19. The information provided on citations was used positively, but played a relatively minor role in the assessment of outputs. Journal Impact Factors were not taken into account.

Impact

20. The UOA received a total of 351 case studies covering a wide range of impacts. The sub-panel was impressed with the great diversity and breadth of the impact achieved across the UOA.

21. At least three panellists assessed each impact item, with a user assessor always involved. The rigorous calibration exercise undertaken at the start of the process initiated robust discussion that was highly productive in establishing common views and a further calibration occurred before scoring was finalised. The involvement of user assessors, including those who represented health or care service user organisations, was valuable in providing exceedingly helpful perspectives and insights. These deliberations, alongside in-depth discussions between assessors on each item, meant that the sub-panel found it straightforward to assess the impact elements of the submission, and were confident in their conclusions.

22. Most submissions presented strong and well-evidenced accounts of their best impact. They demonstrated the translational and applied nature of research undertaken within this UOA, and its effects on service users, policy, and practice at local, national and international levels. Positive impacts on economic development and commercial sectors were also noted. There were also excellent examples of research impact emanating from close working relationships with other sectors such as the NHS, government and policy makers, industry and the voluntary sector.

23. The quality of the case studies was very high, with no fewer than 45 per cent deemed to be outstanding (4*) and a further 42 per cent very considerable (3*) in terms of their reach and significance. Only a small minority (1 per cent) were assessed as having had less than considerable impact. Panellists rated highly those case studies that provided robust and verifiable evidence. It was noteworthy that strong impact case studies were not confined to the larger submissions and many cases with outstanding impact were put forward by some of the smaller submissions and across all four countries in the UK.

24. A minority of cases focused too heavily on the strength of the academic work rather than the resulting impact. Cases that were highly rated were (i) those that had a clear linkage between the original research and the subsequent impact, (ii) those where there was clear evidence and verification of the impact produced and (iii) those that had outstanding and highly significant reach and significance.

25. There were outstanding cases representing the full breadth of the research submitted to UOA 3. Many cases evidencing influencing policy, guidelines and professional practice were evaluated as outstanding. Submitted cases demonstrated diverse outstanding impacts on for example, drug development, diabetes, arthritis, ageing and care of older people, infection control, maternity care; nutrition, wound care, palliative care and rehabilitation physiotherapy. Outstanding impacts were apparent in the areas of commercialisation and improving the quality of healthcare and its delivery. The sub-panel also noted that there were examples of impacts applicable to a wide range of healthcare settings, including those in the developing world. The case studies often reflected key national and international priorities, and many were linked to important public health issues.

26. The impact cases included examples of outstanding impact in drug development from research through to clinical trials, to economic benefits and improved therapeutic outcomes (such as chemotherapy and antiviral therapies). In addition, there were outstanding cases related to commercial spin-outs of novel drug delivery technologies, for example, in the area of development of inhaled pharmaceutical products. There were several outstanding examples of impact on improving care, quality of life and support for cancer patients. In terms of dentistry-related cases there was an excellent group of cases focused on translation of research into dental practice and on dental epidemiology.

27. Through reviewing the impact templates the sub-panel judged that 77 per cent of HEIs were able to describe an approach to impact that was conducive to supporting and enabling

impacts of outstanding or very considerable reach and significance. It is clear that the research impact is being taken seriously and most HEIs have put in place well-developed strategic approaches that should position them to deliver future impacts of outstanding reach and significance.

28. There was often a strong correlation between the impact template and the case studies, although it was not unusual for outstanding case studies to be linked to a template outlining a weaker strategy for delivering such impact in the future. The sub-panel noted that in some instances submissions to this UOA had not scored highly on outputs but had achieved outstanding impact. It was also evident that although some new departments had been constrained in their selection of impact case studies, they had an effective strategy for achieving impact of substantial reach and significance in the future.

29. The impact case studies submitted to this UOA illustrate that a very substantial amount of research in these disciplines, spread across the four UK countries and HEIs, has delivered real benefits outside the academic community both nationally and internationally.

Research environment

30. As with assessment of impacts, at least three panellists assessed each environment template. The rigorous calibration exercise undertaken at the start of the process initiated robust discussion that was highly productive in establishing common views.

31. The sub-panel was impressed that 86 per cent of the environments reviewed by the sub-panel were considered to be conducive to producing research of world-leading or internationally excellent quality, in terms of its vitality and sustainability. There appeared to be a trend in many HEIs in bringing together strengths from different disciplines, often involving imaginative and fruitful collaborations between apparently disparate areas of work. The sub-panel also noted that since RAE2008 many HEIs had undertaken strategic reorganisations to establish, and invest in, cross-disciplinary research centres.

32. There was evidence of widespread national and international collaboration, both within and between disciplines, though in some instances the sub-panel would have welcomed a fuller explanation on the nature and outcome of these collaborations. The extent of industrial collaboration, including that with small and medium-sized enterprises, was a positive feature of many submissions. Evidence of funded research with international partners was noted and viewed positively by the sub-panel. Furthermore, several UK HEIs were playing leading roles in large-scale international research collaborations. It is clear from this review of research environments that an international collaborative research network is vital for world-leading and internationally excellent activity. A small but important number of submissions had been made jointly with other universities, bringing together strengths in the research environment and the sharing of expensive facilities and equipment.

33. The sub-panel found strong evidence of a robust environment and supportive culture in which research students could flourish, facilitated by training awards, the establishment of graduate schools, and great diligence in managing the research student trajectory. Although not directly comparable, there is evidence of an increase (12 per cent) in the number of doctoral awards submitted to UOA 3 in REF2014 (n=4,961), compared to RAE2008 (n=4,347). The increase in the number of doctoral awards across the REF assessment period in many submissions was regarded as an important indicator of research strength. However in general, postdoctoral researchers were less well supported than were postgraduate research students. Despite this, there was good evidence of support for early career researchers, with 509 (17 per cent of total staff submitted) being returned from across both small and large submissions.

34. Generally, there was evidence of greater and more positive engagement with issues of equality and diversity. The sub-panel felt that the Athena SWAN and the Concordat highlighted in many submissions were important quality benchmarks. The improved REF policies on staff circumstances had allowed a more inclusive strategy for many researchers, especially ECRs. The sub-panel was also pleased that structures and processes were set up in many departments to incorporate a service user perspective within the research environment.

35. The sub-panel was impressed that a total of nearly £1 billion of research income for this UOA was reported over the 2008-2013 period. This is a considerable increase from the £739.8 million returned from the corresponding UOAs in RAE2008. While it was recognised that large-scale support is not required for all disciplines in this UOA, the level and growth of external funding provided a reflection on the quality of the work being carried out. The sub-panel noted evidence of marked upward funding trajectories over the REF period in a number of strong submissions. Funding was obtained across the full range of relevant peer reviewed sources, including UK Research Councils, NIHR, government bodies, industry, the EU and major charities. In many instances, it was evident that substantial funding awards had allowed ambitious large-scale research to be carried out, leading to robust and important findings and outputs. Many of the leading HEIs had been supported during the review period by infrastructure funding in larger-scale facilities and equipment. This has helped enhance the profile of UK research in these disciplines on an international stage. The maintenance of this funding base is crucial to the future growth of quality research and impact in these disciplines.

36. The sub-panel considered the diversity of the field and the spread of excellence across so many HEIs to be a great strength. If research funding is maintained or increased, the future of these disciplines in the UK is very bright and the impact on the care and treatment of patients, families and communities will continue to be enhanced nationally and globally. It was clear from the international members of MPA who had joined the sub-panel meetings that they held UK research in this UOA to compare well with the best in the world.

UOA 4: Psychology, Neuroscience and Psychiatry

Average quality profiles for the UOA

	% 4*	% 3*	% 2*	% 1*	% UC
Overall quality	38	40	19	2	1
Outputs	25.9	45.8	24.6	3.0	0.7
Impact	60.9	29.1	8.1	1.6	0.3
Environment	58.3	28.7	10.6	2.4	0.1

Key messages

1. REF2014 has demonstrated that a substantial proportion of psychology, neuroscience and psychiatry research in the UK is internationally excellent, with world-leading basic and translational work being undertaken across both large and small institutions. The sub-panel viewed the leading UK institutions as being at the very top of the international field and during the REF assessment period UK researchers published some of the most widely read scientific reports in their fields with over 350 submitted papers receiving citations of over 100. This was reflected in the very high proportion of 4* grades given to outputs (25.8 per cent). The excellent outputs are supported by strong research environments with good evidence of substantial investment by both HEIs and external grant funders. There was also impressive evidence for the reach and significance of impact covering health, social and educational policy, wealth creation and public dissemination. New investment, particularly supporting translational developments through the NIHR and the research councils, in conjunction with the new REF procedures for recognising impact, have led to substantial improvements in gradings (supported by our international panel members) relative to RAE2008. With appropriate and sustained investment, the sector should continue to generate the kinds of significant benefits to the UK that REF2014 has identified.

2. There were 82 submissions, which varied greatly in size. The submissions included institutions with large, established departments covering the full range of the field (largest submission size 301 FTE staff) through to small, newly established departments typically with a psychology focus (smallest submission size three FTE staff). Over 50 per cent of the submissions had fewer than 20 FTE staff. The sub-panel reflected the broad spread of topic areas and discipline approaches but was able to judge each area on its own merits and recognising the very best within each field.

3. Headline statistics are:

- 2,709 staff (headcount) were submitted, of which 2,672 were Category A and 37 (1.37 per cent) were Category C. Overall 3 per cent more staff were submitted than in RAE2008.
- 22 per cent of the staff submitted were ECRs (n=593, of which four were Category C), with well-articulated processes in play for training and staff development, providing evidence for sustained excellence.
- Out of 9,126 outputs submitted by the sector, 25.9 per cent were rated as world-leading and 45.8 per cent rated as internationally excellent.
- 324 impact case studies were submitted. 60.9 per cent of the submitted impacts were rated as outstanding. Impact was found in an impressive range of areas. Outstanding impact cases included: the development, evaluation and roll-out of clinical and

psychological interventions in mental health, applications of cognitive psychology to address challenges posed by a range of stakeholders from industry to the police, the generation of evidence-based changes to public policy, epidemiological evidence for drug and lifestyle interventions on health and improving public engagement with science.

- There was strong evidence of continued research training with 5,641 doctoral degrees awarded during the assessment period.
- Research income (£1.3 billion by spend 2008-13) was increased relative to RAE2008. Funding came from a wide range of sources reflecting the breadth of research, from basic to applied. Funders included the Royal Society, the British Academy, UK and international charities, and the EU in addition to government, NIHR, the UK Research Councils and industry. There were excellent examples of government and Research Council funding helping to leverage further research support from industry and international sources.

4. A wide range of research approaches were reported in the submissions, from work dependent on the co-ordinated action of large research groups (e.g. in brain imaging or genomics) through to work arising from individual researchers. Both quantitative and qualitative research was represented and reviewed on its own merits. Much of the work in this field continues to be driven forward by the development of new techniques, for example in brain imaging and in the various ‘-omics’. In many cases, these new techniques were pioneered in the UK. There was world-leading research across this full range of activity – from Nobel Prize-winning work on the coding of space in the brain through to developments in reading and mathematical education. There continues to be an important underpinning of basic research (e.g. using animal models) that supports human research and more applied developments.

5. Work in the sector notably benefitted from new mechanisms for research funding during the REF assessment period, notably through the NIHR, which has helped to integrate academic researchers with the NHS, giving access to patients and populations, and to support work that led to many of the examples of impact cited in the case studies submitted. Many of the leading institutions had also been supported during the review period by infrastructure funding for larger-scale facilities. This has been important for ensuring that UK researchers in psychology, systems neuroscience and psychiatry are able to work at the forefront of their fields. Continued renewal of the science infrastructure will be needed for this to be sustained.

6. Many of the important translational developments came through the work of clinician-scientists and the sub-panel recognised the need to nurture scientifically trained investigator-clinicians across all areas of the field (psychology, neurology, neurosurgery and psychiatry) to ensure that translational work with the greatest potential for international leadership and impact is to continue. There is a concern about the training of future world-leaders particularly in clinically-related disciplines.

Outputs

7. Just under 9,130 research outputs were assessed by the sub-panel. The quality of the work was very high, with over 70 per cent of the outputs scored as internationally excellent or better (over 25 per cent world-leading). World-leading excellence was found across the majority of submissions and in all of research areas addressed by submissions to the sub-panel.

8. Much of the internationally leading research represented multidisciplinary approaches that cut across traditionally separate research areas. There was also excellent research in the application of basic systems level neuroscience and genomics to relevant clinical populations, along with increasing evidence for the creation of large, well designed and rigorously maintained

datasets through collaborative efforts across multiple research groups that will provide unique resources for future science and impact. Contributions coming from such large data collection efforts (coupled with advanced data analysis techniques) already are world-leading in many instances. However, it was also noted that there was international excellence across the sector, from small research groups (e.g. in forensic psychology, in applied cognitive psychology) through to larger groups (e.g. in brain imaging or genomics). There were some areas however (e.g. in neurosurgery, in organisational and occupational psychology) where there were low levels of submissions despite recognised needs. This raises contrasting questions – for example, whether there is sufficient critical mass for major research-led developments and whether fragmentation of disciplines is limiting the potential for gains from cross-area fertilisation of ideas.

Impact

9. At least three panellists assessed each impact item and user assessors were involved for all. The calibration exercise undertaken at the start of the process established common approaches and a further calibration across panellists was undertaken before scoring was finalised. With these broader panel discussions, building on in-depth discussions between assessors for each item, the sub-panel did not have difficulty in achieving consensus for assessments of the impact elements of the submission, and was confident in its conclusions. User assessors were drawn from industry, government, the NHS and the charity sector and their involvement ensured that a range of different perspectives contributed to the assessments.

10. Cases that were highly rated were those that had (i) a clear linkage between the original underpinning research and the subsequent impact, and (ii) clear verification of the impact produced. A small minority of cases focused too heavily on the strength of the underpinning academic work rather than the impact.

11. The sub-panel received over 400 case studies and impact templates. The submissions were impressive in terms of their reach and significance as well as the spread of topics that were covered. There were outstanding case studies across the field, with impact internationally as well as nationally. Examples include: the development of screening measures for a wide variety of neurological, neuropsychiatric and neuropsychological disorders and their application to both adult and child populations; drug development for neurological and neuropsychiatric problems; the application of psychological therapies to a range of mental disorders and the changing of treatment guidelines through large-scale randomised control trials; the development and evaluation of health guidance; the influencing of political decisions in relation to schooling and conflict; the application of psychological principles to food design and marketing; the development of better procedures for policing and for improving eye witness testimony; evidence based procedures for rehabilitation in prisons; the application of psychological principles in designing computer games and training; the demonstration of improved teaching methods; health improvements to reduce the risk of stroke; the dissemination of science to the public. Funding for impact came from a large variety of sources, including Research Council and charity research along with industry. There was a wide range of beneficiaries including the NHS, government and policy makers and industry, as well as impact on health and wellbeing.

12. Over 90 per cent of impacts submitted to the sub-panel were judged to be of outstanding or very considerable impact in terms of reach and significance. These judgements were endorsed by both our sub-panel users and also MPA international panel members. Some of the cases were noted to have had transformational impact on the world stage (e.g. some of those concerning health interventions). It was noteworthy that outstanding impact case studies were not confined to the larger submissions. This reflected the creation of a strong impact niche and agenda within

some smaller institutions with a highly focused research agenda. This conclusion was supported by the ratings of the impact templates which frequently provided evidence of important strategic developments to support and enable impacts of outstanding reach and development. There were also excellent examples of researchers working closely with users and with other sectors (the NHS, government and policy makers and industry) in order to support impact based on verifiable evidence.

Research environment

13. Nearly 87 per cent of the environments reviewed by the sub-panel were judged to be conducive to producing research of internationally excellent quality, in terms of its vitality and sustainability, with over 58 per cent viewed as world-leading. Submissions that scored highly tended to be those providing evidence of high levels of institutional support and which demonstrated structures and processes that went beyond those that might be regarded as standard in any HEI. There was also good evidence of a strategic vision for nurturing the specific attributes of small as well as large submissions, and for responding to the demands of the external stakeholders in terms of research planning.

14. Across the sector there was strong development and support for early career researchers. The sub-panel was encouraged by the commitment to diversity indicated by the large number of submitting units which have already achieved bronze or silver Athena SWAN awards (and heartened that the others had clear plans in order to do so). There was a proportionally larger number of early career researchers in some of the smaller and newer departments. Plans need to be developed further for sustained support in such cases.

15. The sub-panel was gratified that a total of nearly £1.3 billion of research income was reported over the 2008-2013 period despite what is perceived to be have been a generally difficult climate for research funding. While it was recognised that large-scale support is not required for all sectors of the field, the level and growth of external funding provides a reflection on the quality of the work being carried out, particularly in the context of limited or no growth in available support from some major funders. The sub-panel noted that there was substantial success in obtaining research funds from EU government sources, covering not only large multidisciplinary research programmes, but also support from the European Research Council for the research of individual principal investigators. The growing investment of EU funding in doctoral training was also recognised as a positive development. In general, there was evidence of a supportive environment and culture for research students and the attempts to develop cross-institutional structures to support doctoral training in smaller departments were regarded positively.

16. There was evidence of widespread international and national collaboration, both within and between disciplines, with several UK institutions playing lead roles in large-scale international collaborations. Much of the work is also sustained by researchers attracted by the quality of UK research in the field and procedures need to be maintained to ensure that the UK continues to gain from the best international researchers coming to work in our HEIs.

UOA 5: Biological Sciences

Average quality profiles for the UOA

	% 4*	% 3*	% 2*	% 1*	% UC
Overall quality	37	46	15	1	1
Output	29.3	48.9	19.1	1.3	1.4
Impact	47.8	41.1	9.5	0.6	1.0
Environment	57.9	36.1	4.5	1.5	0.0

Key messages

1. The work submitted to the Biological Sciences sub-panel shows that this area of research is in extremely good health in the UK, with world-leading quality research found across all discipline areas and in nearly every submission. The sub-panel assessed research from across the spectrum of biological sciences, from basic science to applied, and the full range of disciplines including biochemistry, biomedical science, cell and molecular biology, conservation science, developmental biology, ecology, evolution, environmental biology, genetics, immunology and infection, microbiology, neuroscience, plant science, pharmacology, physiology, structural biology, systems biology and zoology.

2. Headline statistics are:

- There were 43 submissions, one of which was a joint submission, so 44 HEIs were involved in the submissions assessed.
- In total 2,492 staff were submitted (2,373 FTE staff) and a significant proportion (22 per cent) of staff submitted were early career researchers.
- The submissions ranged widely in size, from 226 staff to eight, and from 23 impact cases to only two.
- There were five submissions which had more than 100 FTE staff each and these five submissions accounted for 36 per cent of the total FTE staff.
- 272 impact case studies were submitted, and overall nearly 90 per cent of impact was judged to be either outstanding or very considerable in terms of its reach and significance.
- In total there were 6,539 doctoral degrees awarded during the REF period and the research income over the same period was nearly £2.4 billion.

3. In RAE2008, UOAs 14 (Biological Sciences) and 15 (Pre-Clinical and Human Biological Sciences) together received submissions from 52 HEIs (65 submissions in total). The number of FTE staff submitted was 2,934 so the reduction of staff submitted this time to the Biological Sciences sub-panel (incorporating the Pre-Clinical and Human Biological Sciences) to 2,373 FTE staff amounts to a decrease of 20 per cent. However, it is important to note that this reduction in quantity was associated with an improvement in the overall quality of the work submitted to REF2014 as compared to RAE2008. Some of the biological sciences research was submitted to other UOAs in REF2014 and many cross-referrals were received from other sub-panels, with the majority from UOA 6 (Agriculture, Veterinary and Food Science), UOA 7 (Earth Systems and Environmental Sciences), UOA 9 (Physics), and UOA 17 (Geography, Environmental Studies and

Archaeology). This underscores the point that biological sciences research impacts significantly on many other fields.

Outputs

4. The submissions included 8,608 outputs, all of which were read and assessed as described in the published criteria. Where outputs were found to lie outside the expertise of the sub-panel, advice was sought from other sub-panels. Each output was assessed by two panellists, selected because of their relevant expertise and in this way every submission was assessed by a number of different pairs of panellists. The information provided on citations was used positively, but played a relatively minor role in the assessment. Journal impact factors were not taken into account.

5. The quality of the outputs submitted to the sub-panel was extremely high, with 29 per cent being assessed as world-leading and 49 per cent internationally excellent. In RAE2008 only 13 per cent of the outputs submitted to the Biological Sciences sub-panel and 15 per cent of the outputs submitted to the Pre-clinical and Human Biological Sciences sub-panel were assessed as world-leading. In REF2014, as compared to RAE2008, the component of outputs deemed to fall below the level of 'recognised internationally' had almost vanished (less than 3 per cent in 2014 as compared to 15 per cent in 2008). It is therefore evident that the overall quality of UK research in the biological sciences submitted to REF2014 was very significantly better than what was submitted to RAE2008. Inevitably, there were significant differences between submissions with regard to the percentage of world-leading and internationally excellent outputs, but it is nevertheless remarkable that there were internationally excellent outputs in every single submission and that a vast majority (95 per cent) of the submissions contained world-leading outputs. This testifies to the increasingly high level of professionalism in UK biological sciences, including the very good judgement of quality by the biological sciences community in the HEIs who submitted to this sub-panel. Furthermore, it is important to stress that world-leading research outputs were found in all areas of biology. The sub-panel considered that the diversity of the field and the spread of excellence across so many HEIs are great strengths. The future of the biological sciences in the UK is very bright, if adequate funding is provided (see 'Environment').

Impact

6. The sub-panel evaluated 272 case studies covering a wide range of impacts derived from high quality research, as well as the 43 impact templates outlining the submitting units' approaches and strategies for realising impact. The breadth of research in biology leading to outstanding impact was amazing with impacts coming from the whole spectrum of the biological sciences, including, for example, molecular and cellular biology (both animals and plants), integrative neuroscience, animal behaviour as well as biodiversity and ecology. The impacts delivered also ranged widely, many of them relating to health and welfare (for both humans and animals), economy and commerce as well as international development and the environment. There were many examples of basic molecular research resulting in the establishment of successful spin-out companies dealing with drug discovery, which in addition to health benefits also had significant economic benefits. Many devices, which had been developed on the basis of biological research were also described in the case studies, for example diagnostic tools for human disease or environmental monitoring. Improved processes, technologies or practices assisting particular industries such as agriculture were common, with many case studies involving industry collaboration. There were a number of outstanding examples of how biological sciences research informed conservation policy to protect endangered species or ecosystems, both in the UK and around the world.

7. The vast majority of impact cases were based on basic biological science research, but a significant minority was based on technical/physics/chemistry research of a non-biological nature (including, for example, development of new diagnostic devices). The most frequent type of impact was medical (including health/human welfare), followed closely by economic impact. These two groups accounted for the vast majority of the impacts, but there was also a significant number of environmental impacts, including those dealing with food security. A smaller number of impacts were in the fields of animal welfare, public engagement with science and influencing legislation.

8. At least three panellists evaluated each impact item and each trio conducted in depth discussions. A user assessor was always involved. The assessment was informed by a calibration exercise at the start and another before scoring was finalised. The quality of the impact items was very high, with no less than 48 per cent of impact deemed to be outstanding and a further 41 per cent very considerable in terms of its reach and significance. The scores given for impact templates correlated with the average scores given for case studies in a submitting unit. Only a small minority (11 per cent) of the impact was assessed as less than very considerable. There was a strong positive correlation between the assessed performance of HEIs with regard to outputs and impact cases but, as with outputs, very considerable impact cases were found in virtually all HEIs and the vast majority of the submissions contained outstanding impact cases. This shows that a very substantial amount of research in the biological sciences, spread across a large number of HEIs, has delivered real benefits outside the academic community both nationally and internationally.

Research environment

9. As for outputs and impact, the environment described in the submissions was assessed very positively. Overall, 58 per cent was assessed as world-leading and a further 36 per cent as internationally excellent, leaving only 6 per cent below this level. Almost all (91 per cent) of the HEIs had at least parts of their environment assessed as internationally excellent. The quality of the environment is of course crucially dependent on the funding level. The standard data analysis for UOA 5 showed that external grant income for this part of the sector has remained essentially flat throughout the assessment period, representing a fall in real value. Current excellent outputs will have been underpinned by relatively good levels of funding in the past, but there must be concerns about the long term sustainability of this level of attainment in the face of intense and rapidly increasing competition, particularly from South East Asia, fuelled by the very marked increase in funding opportunities in these countries. The UK Research Councils and the UK-based charities are by far the most important providers of research grants for the biological sciences, together accounting for 74 per cent of the funding, but there is a significant amount of funding from the EU.

10. The submitting HEIs had awarded a total of 6,538 doctoral degrees in the REF assessment period which is fewer than the total reported to cognate sub-panels in RAE2008, and there was only a small rise in yearly figures during the REF2014 period.

11. Intense international collaboration is an all-pervasive feature of virtually all the environments assessed by the sub-panel and very many outputs have been produced in close collaboration with researchers in institutions in continental Europe, the US and countries in South East Asia. An international collaboration network is therefore now a vital part of an effective research environment. The very strong performance of UK biological sciences is, therefore, to a considerable extent dependent on having an environment that is attractive to the best scientists worldwide. The continuation of the UK's remarkably strong research performance in the biological

sciences will be dependent on future research grant funding opportunities in the UK, on government policies that allow the best scientists from any country to settle in the UK and on the continued ability to conduct experiments on animals within an efficiently run regulatory framework. It is important that governments at UK and EU levels take rigorous science advice with respect to regulation: crop improvement with genetic modification has no pathway to impact for some excellent research here and in previous RAEs.

12. Overall, the evidence submitted to the sub-panel indicates that the biological sciences sector has the intellectual power and capacity to generate very significant benefits for the UK and the world in coming years. In particular, the many promising ECRs bode well for the future.

UOA 6: Agriculture, Veterinary and Food Science

Average quality profiles for the UOA

	% 4*	% 3*	% 2*	% 1*	% UC
Overall quality	35	41	20	3	1
Output	18.2	50.7	27.7	2.6	0.8
Impact	64.3	20.9	10.3	2.8	1.7
Environment	68.9	22.4	6.0	2.1	0.6

Key messages

1. Many of the post-war advances in food, agriculture and veterinary practice that were required to support the rapidly growing and increasingly sophisticated demands for high quality, safe and nutritious foods, were led by scientists working in a number of world-leading UK institutions. During the latter part of this REF assessment period the UK has again played a leading role in stimulating the renewed debate around global food insecurity, a debate which has powerfully articulated the combined adverse consequences on the world food supply chain, of a burgeoning global population and damaging effects of climate change. The outcomes from REF2014 provide confidence that, between 2008-13, the UK has continued to make a very significant contribution to advances in the basic and translational sciences which underpin food, agriculture and veterinary policy and practice. This was evident in all aspects of the assessment.
2. **Headline statistics are:**
 - 27 submissions were made to UOA 6, including two joint submissions.
 - There were 1,042 FTE staff submitted, of which 17 per cent were early career researchers.
 - Submissions varied greatly in size from 8.8 FTE staff to 179.99 FTE staff.
 - Units submitted to UOA had a total research income of £670 million over the REF assessment period and 1,765 doctoral degrees awarded.
3. The quality and range of the 128 impact case studies submitted to the sub-panel was particularly impressive, with 85 per cent rated as outstanding or very considerable in terms of their reach and significance. The UK clearly has the potential to play an important part in the global response to food insecurity, with positive benefit for the UK economy and human health and well-being. The investments made by a number of individual institutions in staff and infrastructure, despite a relatively flat external funding environment, were particularly striking. The strong, forward looking strategies that read in a number of the environment statements, demonstrate significant vision and leadership in UK agriculture, food and veterinary sciences.
4. However, the submissions also demonstrate some areas of concern if the UK is to sustain a leadership position in this area in the future.
5. The quality profile for this UOA demonstrated a significantly lower proportion of 3* and 4* rated outputs than for the other UOAs in MPA, questioning the ability of this research community to maintain its world-leading position.

6. UOA 6 was the smallest of the six units within MPA with no significant growth in this part of the research sector since RAE2008. One large submission showed an increased head count of 81 compared with 2008, due to merger with a co-located research institute, and by making a joint submission with another newly-eligible institution. Another joint submission of two HEIs also included a recently merged Research Council funded plant science institute. Without the submission of these previously non-REF eligible institutions there would have been contraction of 19 per cent overall in the submitted volume, with a third of previously submitted institutions returning fewer staff than in 2008.

7. Research income was higher in 2014 (£670 million) than in 2008 (£468 million). However the mergers and alliances described above accounted for £175 million (88 per cent) of the increased income into the unit since 2008, with the many institutions showing no growth, or a fall in income, since 2008. In real terms income fell by 1.7 per cent over the REF period.

8. There was a smaller increase in doctoral degrees awarded during the REF period in UOA 6 than in the majority of other UOAs in MPA. This is a matter of concern given recent findings which show veterinary and agriculture and related subjects to have the lowest and third lowest number of PhD graduates, respectively, of all UK disciplines.

9. The sub-panel considered the modest additional investments made during the latter part of the REF period have been insufficient to assure a future world-leading position in agriculture, food and veterinary sciences for the UK. The ability of individual institutions to maintain their current levels of investment in staffing and infrastructure, as well as in training research leaders of the future, is threatened by this significant funding gap. The sub-panel considered the development of new strategically-driven funding streams is urgently required and should be underpinned by a coherent UK-wide food and agriculture policy jointly owned by the various government agencies and departments currently responsible for this sector.

Outputs

10. Outputs from each institution were allocated to as wide a range of sub-panel members and output assessors as possible, to minimise the chance of any bias in scoring. Typically each output was scored by one specialist and one more generalist reviewer. On rare occasions a third reviewer was involved where scores could not be agreed by the initial scoring pair, or where another reviewer was felt to have more relevant expertise. The first half of outputs from each institution was reviewed at the end of this scoring period, with scoring recalibrated before the second half of scores were allocated; this was to avoid any unintentional drift in scoring levels as the exercise proceeded.

11. In agriculture, outputs in molecular plant and animal sciences were of notable quality, reflecting the generally more buoyant external funding environment, as well as strategic investments in infrastructure and people in a number of the larger institutions. The sub-panel considered research in sustainable agricultural systems to be a growing strength, with an emerging cadre of high quality research on mitigating greenhouse gas emissions from agriculture in a small number of institutions. Outputs in the area of food economics represented another strong niche with a large proportion of the submitted outputs achieving the highest assessment ratings. However the sub-panel also noted the decline in the number of institutions with capability in this area and in the broader social sciences relating to agriculture and food. The sub-panel noted fewer outputs in areas such as plant breeding, horticulture and animal and crop production systems, with these outputs also less likely to achieve the highest assessment ratings.

12. Outputs from the veterinary science community scored highly in a number of areas including infectious disease, musculoskeletal biology and animal welfare. However, the

REF definition of veterinary science embraces the 'one health' concept and many of the submissions in the fields of basic, comparative translational or experimental animal research were directed towards problems in human rather than animal health. As a result the veterinary research base in HEIs primarily directed towards the important areas of animal production and animal disease is smaller than would appear from the size of the veterinary submission to REF. This small size should be a matter of concern in relation to the importance of this sector and the reduction nationally in the veterinary research base in research institutes and government service.

13. The bulk of the submissions in veterinary science were from the seven UK veterinary schools all of which combine research activity with involvement in clinical veterinary practice. However, their submissions showed little evidence of substantial involvement in rigorous quantitative analysis of their companion animal caseload or that of the commercial veterinary practices with which they work. As in human medicine such analysis should provide the evidential basis for clinical veterinary practice. Provided controlled trials are of adequate power and suitable design they are not only valuable clinically but can achieve the highest ratings in the REF exercise.

14. Outputs in the area of food science and food integrity covered a broad range, with evidence of high scoring outputs in food analysis and microbiology in a small number of institutions. A number of institutions showed growth in the area of diet and health, with evidence of high scoring outputs across the breadth of epidemiology, controlled human intervention studies and molecular nutrition. Outputs of world-leading quality in the biophysical and engineering sciences underpinning food processing were less evident than in previous assessment exercises. However, there was evidence of investment in food processing and sensory analysis for food quality and health which was leading to new strategic approaches to the science. Attention may need to be placed on achieving greater integration of the physical and engineering sciences within food biosciences if future demand for novel, healthy food products is to be fulfilled. The sub-panel commented upon a notable decline in the number of outputs in meat science and lack of submissions in the area of food spoilage; the latter is of concern in relation to targets for reductions in food waste.

15. The sub-panel considered many future advances in policy and practice in each of the three areas above would be dependent upon high quality integrative research. Generally, where such research was submitted to this sub-panel, the research questions were considered to be more complex and the outputs of greater variability in terms of quality scores, than in those outputs which took a more reductionist approach.

16. The majority of the submissions included some interdisciplinary outputs and the sub-panel noted that many institutions had undertaken strategic reorganisation to establish and invest in cross-disciplinary centres since RAE2008. However the full potential of recent investments is yet to be realised in terms of world-leading interdisciplinary outputs. These developments largely represented the response of individual institutions to the developing food security agenda and were positively reviewed by the sub-panel. The sub-panel considered the work of this unit to be extremely diverse with potential for significant overlap with UOAs 1, 3 and 5 in Main Panel A as well as with UOA 7 in Main Panel B.

Impact

17. The assessment of the impact case studies and templates sections of the submissions formed a major part of the work of this sub-panel with significant preparatory work and full sub-panel involvement in the assessment of final scores. Each case study and template was

independently scored by three panellists with at least one user assessor leading discussion on the scoring. The final score was agreed following full discussion of the strengths and weaknesses of each individual case study. The rigour of the assessment of this part of the submission was greatly strengthened by having a number of users as full sub-panel members, with a further 6 user assessors appointed specifically to assist with impact assessment. All sub-panel members and assessors took part in a calibration exercise prior to the assessment phase and with regular review of scores throughout the assessment meetings.

18. The sub-panel was impressed by the outstanding range, reach and significance of the impacts to user communities across clinical veterinary medicine and the farming, environment and food sectors. Whilst many end-user applications were focused on the UK and western industrialised countries, a number of the case studies with the most impressive reach and significance were those which responded to the fundamental need for adequate, safe and nutritious food within the developing world. The contribution of a number of the case studies to the development of UK and global food and agriculture policy was rated as outstanding in many areas, which is reflected in the high proportion of impact case studies scoring the highest assessment rating. Examples include research that has contributed to new approaches to sustainable intensification including: reducing the climate impact of agriculture, the development of new plant varieties, and animals and animal products (including aquaculture,) with greater productivity and nutritional value. In veterinary science the sub-panel was impressed with a number of case studies concerned with the development of new vaccines, and in food science, with novel chemistry to understand the pathways through which potentially harmful by-products of food processing were generated and thereby ameliorated.

19. The sub-panel wishes to highlight the evidence of the substantial value that applied research has brought in policy making and in delivering substantial environmental and commercial benefits. Much of this impact has arisen from government commissioned research or by schemes which are co-funded by government and industry. Many of these programmes support work which industry is unable or unwilling to fully fund; however most of these schemes have been discontinued or shown a downward trajectory in recent years, with danger of such impact being lost if this continues in the future.

Research environment

20. The sub-panel was impressed by the quality of the environment statements which demonstrated investment in the strategic development of science underpinning agriculture, veterinary and food science by a number of the submitting institutions over the period 2008-2013. However, this investment was not uniform and much of it took place during the latter part of the REF period. The incorporation of two Research Council funded institutions into two of the 27 submitting units provided an expansion in head count of 91, without which the UOA would have contracted in volume by 19 per cent since RAE2008. These mergers or alignments also accounted for £175 million (88 per cent) of the increased income into the UOA since 2008. The sub-panel recognised that some of the contraction in head count may reflect greater selectivity in some submissions and/or be due to staff submitted into other UOAs, reflecting the increasingly interdisciplinary nature of research in agriculture, veterinary and food research.

21. The smaller increase in doctoral degrees awarded since RAE2008 compared with other UOAs and the minimal year-on year increase across the REF assessment period (table 9) may in part reflect decisions made by Research Councils and some other funders to award four year rather than three year doctoral scholarships, resulting in fewer but longer awards. The sub-panel recognised these changes to be directed towards achieving a higher quality training experience,

including emphasis on the development of a wider range of skills, than had been possible with the previous three year scholarships. The sub-panel was aware of the constraints under which many of the funding agencies were operating, but noted fluctuations in PhD funding to have an adverse effect on the ability of HEIs to plan their own investments, especially with the emphasis on co-funded schemes. To sustain the significant infrastructure required to support this area of research, many institutions are recruiting government- and self-funded PhD students from overseas whose project topics tend to be focused on non-UK priorities. The return of many of these UK trained postdoctoral researchers to their own countries is likely to be of benefit to global food security challenges, but does not help to grow UK capacity.

22. The smaller increase in doctoral degrees awarded during the REF period in UOA 6 than in the majority of the other UOAs in MPA is a matter of concern given that the number of PhD graduates in these disciplines currently lies in the lowest quintile for all UK PhD awards. These data suggest the UK's ability to achieve the critical mass of high quality future research leaders that will be required to respond to the multi-faceted challenges of food insecurity is under significant threat.

23. The sub-panel was pleased to note that the great majority of the submitting institutions had been awarded at least a bronze Athena SWAN award; however, there were few awards at departmental level. Attempts to assess progress towards a more equal and diverse research community in submitting HEIs for this UOA is limited by the lack of evidence for progress at cognate disciplinary level.

24. The UK once held a position of international pre-eminence in food and agriculture research in the last century. However, the funding environment for this discipline has been very challenging over the past 10-20 years. This is reflected in the present analysis which indicates that, when compared to the health-related sciences, the volume of UK science in this area has remained static since 2008 and with less expansion in PhD awards than in other related disciplines in the UK. This reduction in capacity and capability within the HEI sector is of concern given the nature and extent of the challenge facing global food supply. In the past, UK plant, animal and food science has ranked very highly internationally e.g. typically top one or two based on citations. The sub-panel was concerned at the disparity in output quality between this UOA and other submitting units within MPA, which may reflect the static funding environment that has operated since the late 1990s. There have been welcome signs over the last few years of a commitment to reverse this funding trend, including via funding streams for agricultural research which is industry-led, as well as a renewed focus on agriculture research by two of the Research Councils. However, the sub-panel considered these developments to be too modest and too recent to have had any impact in this REF exercise. In making these comments the sub-panel is aware that a number of BBSRC institutes, which are not eligible for submission to this exercise, receive significant amounts of funding via both BBSRC response mode and strategic funding routes. The work funded via these institutes, particularly in plant sciences, is of world-leading quality and contributes to the UK's strong reputation in basic plant science research.

25. The sub-panel was concerned that lack of investment could seriously impair the competitiveness of the UK food industry. At £24 billion, the Gross Value Added of the UK food industry is nearly two and half times as great as the automotive sector while there are nearly three times as many businesses employing over 3.7 million people. Food exports are now as valuable as the aerospace sector and the sector employs over four times as many people. Total consumer expenditure in the UK on food, drink and catering in 2013 was estimated by the Department for Environment, Food and Rural Affairs to be worth £196 billion. In comparison the total research

spend on veterinary and agri-food within the submitting units during the REF assessment period amounted to only £670 million.

Given the enormity of the challenges of tackling global food insecurity, global climate change, the threats to natural capital and the contribution of the sector to UK economic prosperity, it is vital that there is renewed investment in the disciplines represented in this unit. A significant increase in research funding will be required to fill the gap that currently exists. The sub-panel considered the lack of a coherent UK food and agriculture policy is a significant barrier to the development of a strategic approach to funding, and a threat to UK pre-eminence in the underpinning science for a sector which makes a very major contribution to the UK economy. There is now a window of opportunity during which the UK could demonstrate the leadership and commitment required to reduce such a threat; this should be tackled with some urgency.

Glossary of terms

BBSRC

Biotechnology and Biological Sciences Research Council

ECR

Early career researcher, defined in the REF as members or staff who meet the criteria to be selected as Category A or Category C staff on the census date, and who started their careers as independent researchers on or after 1 August 2009.

EDAP

The Equality and Diversity Advisory Panel established to advise the funding bodies, the REF team and the REF panels on the implementation of equality measures in the REF.

FTE

Full-time equivalent. Used as an alternative to headcount to indicate the actual volume of activity.

HEI

Higher education institution

KIC

Knowledge and Innovation Communities program

MPA

Main Panel A

MRC

Medical Research Council

NIHR

National Institute for Health Research

OSCHR

Office for Strategic Coordination of Health Research

PPI

Public and patient involvement

RAE

Research Assessment Exercise

REF

Research Excellence Framework

SP

Sub-panel

UOA

Unit of assessment