May 2022

Overview report by Main Panel A and Sub-panels 1 to 6

REF 2021 Research Excellence Framework

Contents

Main Panel A: Medicine, health and life sciences

Executive summary

1. The purpose of this report is to provide the higher education sector and other key stakeholders with an overview of health and life sciences research in the UK, as submitted in the REF 2021 units of assessment (UOAs) which constitute Main Panel A, and to provide key data on submissions and feedback on the process of assessment. As well as overarching comments from Main Panel A, the report consists of statements from each UOA directed at their disciplines and commentary on the process and results by international members of the Main panel.
2. Over the period of the REF assessment research environments, outputs and impact arising from research for the medical, health, biological, agricultural, food and veterinary sciences sectors has been assessed. Main Panel A confirms that the assessment process had been conducted fairly and in line with the published 'Panel criteria and working methods'.
3. The overall quality profile incorporating all three elements of the assessment (research outputs, impact and environment) for the six UOAs covered by Main Panel A indicated that the field is internationally exceptionally strong with a large proportion (45%, FTE-weighted) of submitted material judged to be world-leading. This was a greater proportion than for the previous assessment (REF 2014), however such comparisons are caveated by the fact that the submission rules differed between these exercises.
4. Nevertheless, the strong four star and three star profile in outputs across Main Panel A and seen in each of the UOAs, reflects the strength of the UK's health and life sciences sector – an observation reinforced by the international reviewers who concluded: The results of the exercise demonstrate the very high overall quality, breadth, and impact of research in the health and life sciences carried out in UK HEIs. Notable features of the submissions were the growing extent of multidisciplinarity and the very high level of collaboration between different UK HEIs, other UK research institutes and internationally.
5. The Covid-19 pandemic and accompanying lockdowns from March 2020 significantly affected planning for REF 2021 (as will be evident from the timetable and other contingency measures). However, sub-panels quickly adapted, and the sub-panel chairs effectively ensured full participation, and rich and robust discussion, using online systems. The sub-panels were also able to capitalise on the benefits of virtual meetings - such as reduced travel times, and ease of adding additional shorter meetings (especially for sub-panel executive teams, and sub-panel score reconciliations) which aided governance and planning. Therefore, while timings and modes of communication and engagement changed, these did not affect the overall robustness of assessment.
6. The sub-panels were guided in issues relating to equality, diversity and inclusion by the Equality and Diversity Advisory Panel (EDAP), which provided guidance on a number of issues. In addition, the sub-panels developed a Fairness in REF Intention plan which was used as a basis to regularly engage and remind panel members of the high importance to be placed on fairness in REF assessment.

7. International members of Main Panel A considered REF 2021 to have been an equitable and impartial process, especially in relation to challenging Covid-19 circumstances during the assessment phase. Specifically, the international panel members noted that the UK research ecosystem was well advanced in comparison to competitors in fostering the formation of networks, collaboration and interdisciplinarity. The international members expressed concern that if the UK's international position in health and life sciences was to be maintained, there would need to be continued investment in high quality research.
8. Whilst noting the strong four star and three star profile in outputs across Main Panel A, the panel also recognised the importance of two star outputs for underpinning impacts from research and as a reflection of research development.
9. Main Panel A welcomed examples of the continuing growth of major collaborative and interdisciplinary work where author contribution was clearly justified. UOAs across Main Panel A received a number of large interdisciplinary studies with authors in excess of 50 drawn from multiple institutions.
10. Main Panel A was extremely impressed by the diversity of impact described. The panel continues to hold the view 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.
11. There was clear evidence of the Main Panel A contribution to the work on Covid-19 and the UOAs received a number of such case studies. Main Panel A considers that the speed and quality of the UK health and life sciences communities' response to the pandemic attests to the essential value and importance of the UK continuing to invest in this scientific domain.
12. Members of Main Panel A were pleased to note that that for 90% of the submissions (FTE-weighted), the environments described were judged as conducive to producing research of world-leading or internationally excellent quality and enabling outstanding or very considerable impact. It was noted that these environments were the result of sustained investment by HEIs and funders including: UKRI (notably MRC and BBSRC), NIHR, CSO, Wellcome, CRUK, BHF and other charities and endowments.
13. Main Panel A recognises significant efforts within the HE sector to improve staff diversity and that continued effort will be required. Main Panel A welcomes the work of funders with HEIs on further improving the research culture.
14. In summary the results of this REF exercise demonstrate the very high overall quality, breadth, and impact of research in the health and life sciences carried out in UK HEIs. Notable features of the submissions were the growing extent of multidisciplinarity and the very high level of collaboration between different UK HEIs, other UK research institutes and overseas.

Summary of submissions

15. In total, 312 submissions were made to the six units of assessment (UOAs) within Main Panel A, of which four were joint submissions, with one institution making multiple submissions in the same UOA. There were 21,401 staff submitted by headcount. Despite a significant increase in headcount of submitted staff from REF 2014, fewer outputs (48,872) and impact case studies (1,460) were submitted, with the same number of environment templates (312). The size of submissions varied greatly between higher education institutions (HEIs), ranging from four to 499 staff, with the median submission comprising 27 staff.

Table 1: Summary of staff submissions to UOAs in Main Panel A

Name	Number of submissions	Total FTE	Total head-count	Staff submission range (FTE)		
				Smallest	Largest	Average
UOA 1 (Clinical Medicine)	31	4,878.50	5,208	19.2	498.02	157.4
UOA 2 (Public Health, Health Services and Primary Care)	33	2,031.52	2,278	7.1	381.74	61.6
UOA 3 (Allied Health Professions, Dentistry, Nursing and Pharmacy)	89	4,769.73	5,139	3.78	224.61	52.4
UOA 4 (Psychology, Psychiatry and Neuroscience)	93	4,039.77	4,279	4.9	379.49	43.4
UOA 5 (Biological Sciences)	42	2,866.69	3,001	9.0	308.94	65.15
UOA 6 (Agriculture, Food and Veterinary Sciences)	24	1,397.99	1,496	6.6	256.83	55.92
Main Panel A	312	19,984.20	21,401	3.78	498.02	63.04

Variation of staff submission across UOAs

16. UOA 1 (Clinical Medicine) included the largest HEI submissions across Main Panel A in terms of submitted staff numbers, with UOA 3 (Allied Health Professions, Dentistry, Nursing and Pharmacy) having the smallest submission. It was noted that UOA 3 was an outlier in terms of the percentage of eligible staff submitted, with significantly lower levels submitted than in other UOAs in Main Panel A.

Overview of Main Panel A results

17. The overall quality profile incorporating all three elements of the assessment (research outputs, impact and environment) for the six UOAs covered by Main Panel A indicated that the field is internationally exceptionally strong with 45% of submitted material judged to be world leading and an additional 41% internationally excellent. Within this overall positive REF profile there were characteristics specific to each UOA 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)

Panel name	Average percentage of activity meeting the standard for: 4*	3*	2*	1*	Unclassified
Main Panel A	45	41	12	2	0
UOA 1 (Clinical Medicine)	50	41	9	0	0
UOA 2 (Public Health, Health Services and Primary Care)	55	37	7	1	0
UOA 3 (Allied Health Professions, Dentistry, Nursing and Pharmacy)	37	47	14	2	0
UOA 4 (Psychology, Psychiatry and Neuroscience)	43	36	17	3	1
UOA 5 (Biological Sciences)	48	41	10	1	0
UOA 6 (Agriculture, Food and Veterinary Sciences)	40	46	12	1	1

18. Table 2 shows the average overall quality profile for each UOA, and for all submissions made in Main Panel A 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 4, 6 and 7 below).

Multiple and joint submissions

19. In line with the 'Panel criteria and working methods' specified for Main Panel A, which set out that the panel did not consider there was a case for multiple submissions in their UOAs, based on the nature of the disciplines covered, only one multiple submission was made to UOA 3 (two institutions). In addition, four joint submissions were made across Main Panel A, involving nine institutions.

Table 3: Summary of joint submission to Main Panel A

Panel name	Number of joint submissions	Number of institutions included
UOA 1 (Clinical Medicine)	0	0
UOA 2 (Public Health, Health Services and Primary Care)	0	0
UOA 3 (Allied Health Professions, Dentistry, Nursing and Pharmacy)	2	4
UOA 4 (Psychology, Psychiatry and Neuroscience)	0	0
UOA 5 (Biological Sciences)	1	3
UOA 6 (Agriculture, Food and Veterinary Sciences)	1	2

Number of cross-referrals

20. In total there were 1,749 outputs cross-referred for assessment into Main Panel A sub-panels and 1,178 outputs referred out to other sub-panels. Of these referrals into Main Panel A sub-panels, 753 referrals were from sub-panels within Main Panel A. The other main sub-panels cross-referring outputs into Main Panel A were: UOA 17 (Business and Management Studies), UOA 14 (Geography and Environment Science), and UOA 12 (Engineering). The sub-panels receiving most cross-referrals from Main Panel A were UOA 8 (Chemistry) and UOA 7(Earth Systems and Environment Science).

Panel working methods

21. Across all elements of the assessment, both the main panel and the sub-panels adhered to the published 'Panel 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 cases and environment. Individual sub-panel members and assessors did not take any part in the assessment of submissions from institutions in which they declared a major conflict of interest. Main Panel A confirms that the assessment process had been conducted fairly and in line with the published 'Panel criteria and working methods'.

Calibration exercises

22. For each element of assessment (outputs, impact and environment), Main Panel A undertook a calibration exercise to mock-assess and discuss a representative sample of material. Outputs were calibrated using material that was not eligible to be submitted to REF 2021 (outputs published by staff not employed at a UK university), whilst impact and environment calibrations used materials submitted to REF 2021, selected to avoid major conflicts of interest. These calibrations sought to ensure that there was a common understanding of the starred quality level definitions and approaches to assessment criteria across all the sub-panels. Further calibration was undertaken for outputs, impact case studies and environment statements across all four main panels to ensure consistency of interpretation of starred quality levels.

23. Sub-panel members and assessors also undertook calibration exercises, using Main Panel A calibration material that was not submitted to their own UOA, to ensure consistency of approach and understanding, before assessment of the three elements of the assessment began. These exercises were supplemented by further sub-panel discussions about individual submitted items and general issues as they arose.

Roles of international and user members

24. International and user members of Main Panel A played a major role in bringing external perspectives to the assessment process and in ensuring consistency between sub-panels. Whilst they were not asked to score any of the submissions themselves, they took part in the calibration exercises and attended both main panel and sub-panel meetings. International members were invited to attend sub-panel meetings to support the calibration of assessment. These members 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. The international members have compiled a report in which they describe their views of the assessment and its implications for the UK health and life sciences sector (see Annex 1).

Role of secretariat and the executive team

25. The secretariat supporting Main Panel A were knowledgeable and highly effective; characteristics commented on by the international members who were also highly appreciative of the support provided. Structurally, the secretariat served not only Main Panel A, but also the sub-panels as panel advisers. The secretariat and the Chair of Main Panel A (who together comprised the executive team of Main Panel A) met weekly via zoom during the active assessment period. The importance of the expert advice and support given by the secretariat during the generation of the 'Panel criteria and working methods' and the 'Guidance on submissions' documents, and particularly during the assessment period is difficult to overstate. Through the meeting structure described, the support of the secretariat proved an essential component of the evaluation phase and played a central role in the uniform application of the assessment criteria.

26. The REF director attended all of the Main Panel A meetings. The REF director and other members of staff from the central REF team also attended relevant sub-panel meetings, where they contributed to critical discussions on uniform interpretation of assessment criteria across the sub-panels, and the main panels.

27. Panel work in the assessment phase was assisted by a bespoke IT system and a REF panel members' website, alongside a dedicated email system. All of these systems were secure. Panel members were regularly reminded of the need for confidentially and of the processes for ensuring data was held securely.

Reviewing and approving assessment outcomes

28. During the assessment period, Main Panel A met regularly and reviewed the emerging quality profiles for the UOAs and identified variance within and between UOAs. Ongoing feedback was provided to sub-panel chairs and when appropriate was used to inform and trigger recalibration. Sub-profiles for individual institutional submissions were not examined until compiled after scoring was completed. Main Panel A thoroughly reviewed the pattern of outcomes across each of the individual UOAs and across the UOAs 1-6 as a whole. Main panel A was assured that the assessment had been carried out fairly, rigorously and equitably across all six UOAs. This assessment was supported by the international members. In consequence Main Panel A approved the results.

Implementation of panel criteria and working methods

29. The sub-panels followed the working methods as specified in the 'Panel criteria and working methods'. The UOA descriptors for the six UOAs were largely unchanged from REF 2014 and as noted above there were fewer outputs and impact cases submitted for assessment and slightly more environment templates. The sub-panel chairs were able to allocate the workload according to expertise of the panel members. Calibration exercises were undertaken by sub-panels before each element of the assessment started. Whilst sub-panel members were confident to assess a wide range of disciplines, where an output fell outside the expertise of sub-panel members, it was cross-referred to another appropriate sub-panel for review.

Adapting to Covid-19 requirements

30. The meetings in which Main Panel A and its constituent sub-panels developed and wrote the 'Guidance on submissions', and 'Panel criteria and working methods', took place in person. However, the arrival of the Covid-19 pandemic and accompanying lockdowns from March 2020 necessitated a significant change in working pattern and format for the assessment phase. The main panel (and sub-panels) rapidly changed their mode

of working from March 2020. Sub-panel members quickly adapted, and the sub-panel chairs effectively ensured full participation and rich and robust discussion using online systems. The sub-panels were also able to capitalise on the benefits of virtual meetings - such as reduced travel times and ease of adding additional shorter meetings (especially for sub-panel executive teams, and sub-panel score reconciliations) which aided governance and planning.

31. As a consequence of the changes necessitated by Covid-19, the assessment timetable was restructured, and panel meetings were convened virtually on Zoom. Meetings were carefully chaired to ensure that all participants contributed, and the use of breakout rooms was developed for small group discussions. In general, whilst panel chairs and members would have preferred to meet in person, Main Panel A and its constituent sub-panels rapidly adapted to this new format and found it an effective means of delivering the exercise without compromising standards. Welcome advice was received from those involved in the Hong Kong research assessment exercise (2020), which had been undertaken in a wholly virtual manner. However, most panel members noted that whilst assessing outputs virtually was relatively straight forward, assessing impact and environment has proved more complex and required greater administrative organisation. This did not affect the overall quality of assessment but was more time consuming.

32. Despite the comparatively short overlap of the REF 2021 period with the Covid-19 pandemic, Main Panel A received a number of high scoring impact case studies on Covid-19 and the scientific communities' response, including those related to public health advice and measures, and vaccine development. Main Panel A considered that these impact cases reinforced evidence for the strength and vigour of the health and life sciences sector in the UK. Furthermore, they demonstrated the agility of the sector to flex to address an unexpected major international crisis. In turn, the sector's ability to respond was facilitated by the long-term investments in underpinning science, including provision of facilities, training and recruitment of talent internationally. Main Panel A cited significant investments by (UKRI) MRC, (UKRI) BBSRC; NIHR, Wellcome Trust and other health and life science charities as particularly important in this regard. Main Panel A considers that the speed and quality of the UK health and life sciences communities' response to the pandemic attests to the essential value and importance of the UK continuing to invest in this scientific domain. Of note, the international members have highlighted potential threats to this important sector given uncertainty over the future of European funding arrangements and the pandemic challenges to the charitable sector.

33. It was noted that there were challenges for a number of sub-panel members due to their on-going involvement in the frontline management of the national Covid-19 response and the response of individual institutions. Where possible, adjustments in panel-based workload were made when required or requested by individuals. It was also noted that institutions were also impacted in their REF 2021 submission preparations and that a number of mitigations were put in place, such as the optional delay in the submission of corroborating evidence for impact cases and the submission of Covid-19 statements.

Equality, diversity and inclusion

34. The sub-panels were guided in issues relating to equality, diversity and inclusion by the Equality and Diversity Advisory Panel (EDAP), which provided guidance on a number of issues, most notably the assessment of the people section of the unit environment templates for each UOA.

Oversight and governance of sub-panel operations

Fairness in REF Assessment

35. Before undertaking the assessment process all panel members undertook training to understand unconscious biases and explore what they may look like in a REF context. Main Panel A developed an intention plan which was used by all of its sub-panels as a basis to regularly engage and remind panel members of the high importance to be placed on Fairness in REF Assessment. The intention plan was discussed at the beginning of all the sub-panel assessment meetings. The plan was consistent with the exemplar which will be published in the EDAP report.

Benchmarking and calibration

36. At each stage of the assessment process, a detailed calibration exercise was undertaken where, in sequence, representative outputs, impact cases and environment templates were assessed, scored and discussed by Main Panel A members in plenary. Sub-panels then reviewed a selection of these materials in plenary, and then a sample of these materials was discussed at a meeting of the four main panel chairs with the secretariat and the REF director.

Methods of allocation and approach to assessing outputs

37. 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 allocating the outputs based on journal category and output titles mapped to panellist expertise. Each output was assessed by at least two panellists, at least one of whom had expertise in that particular discipline. The sub-panels regularly reviewed both progress and individual scoring behaviour in order to ensure consistency across the UOA.

38. In developing the output sub-profiles, initial assessment in the UOAs used either a 13-point scale (sub-panels 2, 3 and 6) or the 5-point scales (sub-panels 1, 4 and 5) and individual scores were blinded up to this point. Following this assessment, each output grade was reconciled as four star, three star, two star, one star or 'unclassified', in line with the published output quality level definitions based on quality in terms of originality, significance and rigour.

39. There were very few requests for double-weighted outputs within Main Panel A UOAs. Where they occurred, each request was judged on its own merit as to whether it met the criteria for double weighting, based on the panel guidance.

Methods of allocation and approach to assessing impact

40. In addition to academic sub-panel members, sub-panel membership included impact assessors representing relevant research user experience in industry, clinical services, research commissioning and policy making. Each impact case 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 Main Panel A attended sub-panel impact assessment meetings, to promote common operating procedures, best practice and calibration. Allocation of impact cases was done according to the expertise of the panellists.

41. The great majority of scores were agreed through discussion by the allocated panellists and agreed with the wider panel in plenary. For the relatively small number of case studies for which no immediate resolution could be found, an additional panellist was allocated. Sub-panel plenary sessions were used to check for consistency and to further

discuss unresolved impact 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. In developing the impact sub-profiles, the sub-panels had use of a 9-point scale for the assessment based on the starred level definitions. Case studies that were judged to be on the borderline between two of the starred quality levels were assigned a midpoint grade (3.5, 2.5, 1.5 or 0.5). Where this occurred, half of the grade was assigned to each of the two starred quality levels that the midpoint grade fell between.

Methods of allocation and approach to assessing environment

42. Each environment template was allocated to and scored by at least three sub-panel members. Templates were assessed by individual assessors and final scores were agreed through discussion, either in scoring groups or in full sub-panel plenary sessions, with plenary sessions used to check for consistency and to discuss unresolved templates. Sub-panels used standard REF supplied research income figures and numbers of research doctoral degrees awarded, to provide an evidential context to sit alongside the narrative of the environment statement. Due to changes in university accounting practices, it was not possible to look at the trajectory on research income data across the REF 2021 period for a submitted unit.

43. In developing the environment sub-profiles, all the sub-panels used the same method of assigning starred quality levels to the submitted templates. The four sections of the environment template, which were equally weighted for Main Panel A, were graded using a nine-point scale, based on the starred level definitions. A section of the environment template that was judged to be on the midpoint between two of the starred levels was assigned a grade (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 quality levels that the midpoint grade fell between.

Future exercises

44. The sub-panels and Main Panel A noted that the allocation of outputs to panellists and the analysis of performance of sub disciplines would have been facilitated by providing a common coding structure for outputs and asking institutions to assign these codes to outputs before submission. This is an approach that other sub-panels beyond Main Panel A have taken. This would allow a deeper analysis of patterns of strength, growth, challenge and shrinkage in areas and professional groups, not only in sub-panels, but across main panels also.

Outputs

45. Table 4 gives the overall FTE-weighted output sub-profiles for Main Panel A and each of its UOAs. For an explanation of FTE weighting please see the 'Summary report across the four main panels', paragraph 6. Across Main Panel A, 48,872 outputs were received. Over 99% were journal articles.

46. Sub-panels and the main panel considered carefully the increase in world-leading quality of the submitted outputs from REF 2014, and undertook modelling to identify the degree that the increase reflected the change in REF 2021 submission criteria.

Using this work and regular calibration of outputs, Main Panel A was reassured that the output profile reflected both the change in the criteria, but also provided evidence of a thriving research base. Main Panel A noted that 84% of outputs submitted to the UOAs were judged to be of world-leading or internationally excellent quality, emphasising the strength of health and life sciences research in the UK.

Table 4: Output quality sub-profiles (FTE-weighted averages)

Panel name	Average percentage of activity meeting the standard for: 4*	3*	2*	1*	Unclassified
Main Panel A	37.0	46.8	14.6	1.0	0.6
UOA 1 (Clinical Medicine)	39.0	48.1	12.0	0.5	0.4
UOA 2 (Public Health, Health Services and Primary Care)	44.1	46.3	8.7	0.3	0.6
UOA 3 (Allied Health Professions, Dentistry, Nursing and Pharmacy)	31.9	51.1	15.2	1.0	0.8
UOA 4 (Psychology, Psychiatry and Neuroscience)	33.7	42.4	20.8	2.2	0.9
UOA 5 (Biological Sciences)	45.1	41.7	12.3	0.5	0.4
UOA 6 (Agriculture, Food and Veterinary Sciences)	29.5	52.4	16.0	1.4	0.7

Disciplinary boundaries

47. Where individual UOAs received groups of outputs which clearly satisfied the disciplinary descriptors of another UOA, through cross referral and joint assessment, sub-panels were able to appropriately benchmark and maximise consistency of output assessment across Main Panel A.

48. The flexibility of the REF exercise allows submission of outputs on a strategic basis to UOAs to take account of structural groupings that HEIs have developed to enhance research environments. This means that hard conclusions over the relative strengths in individual disciplines based solely on UOA results are necessarily limited. However, some sub-panels did identify patterns that are highlighted in their reports. By capture of the data from the six UOAs across this main panel, the overall strength and vigour of the health and life sciences in the UK is effectively summarised in these Main Panel A results.

Outputs sub-profile

49. Whereas in previous REF exercises, a direct comparison of the current output sub-profile with the previous one has been possible with some degree of legitimacy. In the case of REF 2021, the changes in the output submission (from four outputs per submitted staff member in 2014, to an average of 2.5 per submitted staff FTE, with a range of 1 to 5 outputs per submitted staff member) makes such a comparison not viable for REF 2021. Nevertheless, the strong four star and three star profile in outputs across Main Panel A and seen in each of the UOA, reflects the strength of the UK's health and life sciences sector. Main Panel A also recognised the importance of two star outputs for underpinning impacts from research and as a reflection of research development.

Multi/inter disciplinarity

50. Sub-panels received and assessed multiple examples of interdisciplinary work in the submitted outputs. However, it was noted that the use of the interdisciplinary flag by institutions was inconsistent; on this basis, Main Panel A concluded that it was unreasonable to use this flag to represent the proportion of outputs that should be classified as interdisciplinary. Through the interdisciplinary adviser network and cross-referral mechanism, sub-panels reported that they felt able to assess interdisciplinary work straightforwardly and effectively. Indeed, the assessment of interdisciplinary work across the full range of Main Panel A was considered as 'business as usual'.

51. Main Panel A welcomed examples of the continuing growth of major collaborative and interdisciplinary work. Sub-panels across Main Panel A received a number of large interdisciplinary studies with authors in excess of 50 drawn from multiple institutions. Analysis of such submissions to UOA 2 revealed that nearly 30% of submitted outputs had more than 15 co-authors.

52. Members of sub-panels and Main Panel A expressed a concern that if in future exercises, multi-author/-institution studies formed a greater proportion of output returns and were submitted in greater numbers both within and across UOAs, then the value of the exercise as an accurate analysis of the UK research base might be distorted. Sub-panels noted that the attribution statements in journals did not consistently provide evidence of an author's substantial contribution in a form that was useable in the assessment.

Unclassified outputs

53. Very few outputs assessed by Main Panel A received an unclassified score. The most common reasons for being unclassified were either that the output submission did not include sufficient evidence to satisfy the criteria for demonstrating a substantial contribution to the output by the attributed author, as detailed in the 'Panel criteria and working methods'; or the output did not meet the REF definition of research stated in the 'Guidance on submissions'.

Double-weighted outputs

54. Main Panel A received only 18 requests for double-weighted outputs (16 to UOA 3, and one each to UOAs 2 and 4). Of those submitted eight were accepted.

Output types

55. Over 99% of outputs submitted to Main Panel A were journal articles, see Table 5. In arriving at individual scores for journal articles it was the quality of the content of the output that was assessed, taking no account of the journal publication vehicle or the impact factor of that journal. The provision of citation data from Clarivate 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. Citation data were only used where these provided a positive indicator of academic significance.

Table 5: Types of output submitted to UOAs across Main Panel A

Output type	Number submitted	Share of total
Journal article	48,722	99.69%
Research report for external body	61	0.12%
Authored book	23	0.05%
Working paper	23	0.05%
Chapter in book	14	0.03%
Conference contribution	14	0.03%
Patent/ published patent application	8	0.02%
Research data sets and databases	2	~0%
Other	2	~0%
Edited book	1	~0%
Website content	1	~0%
Confidential report for external body	1	~0%

Impact

56. Table 6 gives the overall FTE-weighted impact sub-profiles for the main panel and each of its sub-panels. All sub-panels received examples of outstanding impact from a wide range of HEIs. Sub-panels welcomed the wide range of types of impact case studies received and were impressed by both the exceptional reach and significance of many of the impacts described.

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

Panel name	Average percentage of activity meeting the standard for: 4*	3*	2*	1*	Unclassified
Main Panel A	56.5	34.2	7.8	1.4	0.1
UOA 1 (Clinical Medicine)	67.7	30.3	2.0	0.0	0.0
UOA 2 (Public Health, Health Services and Primary Care)	71.8	23.9	3.8	0.5	0.0
UOA 3 (Allied Health Professions, Dentistry, Nursing and Pharmacy)	41.8	42.9	13.8	1.4	0.1
UOA 4 (Psychology, Psychiatry and Neuroscience)	57.1	28.4	10.0	4.2	0.3
UOA 5 (Biological Sciences)	50.0	42.6	7.0	0.4	0.0
UOA 6 (Agriculture, Food and Veterinary Sciences)	56.6	33.4	7.8	1.6	0.6

57. Types of impact 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 response to the Covid-19 pandemic, the UK economy and culture.

58. The calibration exercises and real-time interchanges between sub-panels via Main Panel A members (as described in the working methods above) proved invaluable for ensuring consistent assessment of impact. The four star category contained some truly exceptional impacts in terms of their reach and significance, whereas others still worthy of four star, were less exceptional but nevertheless outstanding.

59. There was clear evidence of the Main Panel A contribution to the work on Covid-19 and the sub-panels received a number of such case studies. It was also noted that a number of case studies had also been affected in the later part of the assessment period, by an inability to complete certain planned activities. The sub-panels took into account submitted Covid-19 mitigations, in accordance with the 'Guidance on revisions to REF 2021'. It is also noted that there is likely to be ongoing impacts of Covid-19 and that these may need to be considered in any future exercises.

Outcomes

60. The most highly graded impact case studies in Main Panel A 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 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.

61. Most low-scoring impact case studies were characterised by a lack of objective evidence of the reach and significance of the impacts 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 in the current REF period also attracted lower scores.

62. Encouragingly, very few of the 1,460 impact case studies submitted to Main Panel A UOAs were scored as unclassified. In most instances 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.

63. The sub-panels were able to assess all of the impact case studies submitted to them and did not need to seek advice from other sub-panels. The sub-panels welcomed the accessibility of the underpinning evidence sources, available to provide corroboration as required of the case studies.

64. The involvement of research users both on the sub-panels and main panel was agreed to be extremely helpful to the exercise; their insights into best practice in translating research into practice and understanding of the challenges of maximising impact was welcomed.

Reflections

65. Disruptions due to the Covid-19 pandemic affecting the final year of the assessment were reported in some of the case studies. The sub-panel took account of these circumstances in assessing the impact cases. However, it was recognised that Covid-19 disruption could have a negative ongoing effect on case studies submitted to future REF exercises.

Research environment

66. Members of Main Panel A were pleased to note that in total 90% of the environments described were judged as conducive to producing research of world-leading or internationally excellent quality and enabling outstanding or very considerable impact. It was noted that these environments were the result of sustained investment by HEIs and funders including: UKRI (notably MRC and BBSRC), NIHR, CSO, Wellcome, CRUK, BHF and other charities and endowments. However, the percentage of environments assessed at these quality levels has not changed significantly since REF 2014. The international, members of MPA expressed concern that if the UK's international position in health and life sciences was to be maintained, there would need to be continued investment in high quality research environments.

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

Panel name	Average percentage of activity meeting the standard for: 4*	3*	2*	1*	Unclassified
Main Panel A	57.5	32.4	8.6	1.4	0.1
UOA 1 (Clinical Medicine)	63.1	34.5	2.4	0.0	0.0
UOA 2 (Public Health, Health Services and Primary Care)	67.7	27.8	3.6	0.9	0.0
UOA 3 (Allied Health Professions, Dentistry, Nursing and Pharmacy)	49.2	35.3	13.9	1.5	0.1
UOA 4 (Psychology, Psychiatry and Neuroscience)	55.1	24.7	15.8	4.1	0.3
UOA 5 (Biological Sciences)	58.2	34.9	5.8	1.1	0.0
UOA 6 (Agriculture, Food and Veterinary Sciences)	56.2	39.1	4.4	0.3	0.0

67. Main Panel A were pleased to see environment submissions which included exceptional qualities of staff support, such as a broad perspective on equality, diversity and inclusion that extended to a range of protected characteristics and mentoring programmes extending across all staff groups and levels of seniority, accompanied by examples of how the policies benefitted staff in practice. Main Panel A welcomes the work of funders with HEIs on further improving the research culture.

Outcomes

68. Overall, Main Panel A noted the vitality and sustainability of the environments submitted, with strong evidence of dynamic cultures and of growing infrastructure in many submitted units. International panel members noted that continued strategic investment will be required to at least maintain the UK's research infrastructure and ensure capacity building across disciplines. In addition, the main panel recognised that infrastructure for population cohorts and biobanks, as well as investments in data and in people encompassing epidemiology, statistics, computational biology, data and implementation science, and health economics, all contributed to environmental and scientific excellence in this assessment. These crucial infrastructure components

will need sustained support to continue to leverage their research potential and if the opportunities in key areas such as Big Data and artificial intelligence in medicine, health and life sciences are to be fully realised.

69. The international members have compiled a report in which they describe their views of the assessment and its implications for the UK, see Annex 1. The international members noted that the results of the exercise demonstrate the very high overall quality, breadth, and impact of research in the health and life sciences carried out in UK HEIs. Notable features of the submissions were the growing extent of multidisciplinarity and the very high level of collaboration between different UK HEIs, other UK research institutes, and internationally.

Research income

Table 8: External research income across Main Panel A by funder source

Main Panel A: Research income source	Research income (£ million)	Proportion of total income
UK-based charities (open competitive process)	6,515	28.9%
BEIS Research Councils, The Royal Society, British Academy and The Royal Society of Edinburgh	5,242	23.2%
UK central government bodies/ local authorities, health and hospital authorities	2,453	10.9%
Health research funding bodies	2,025	9.0%
EU government bodies	1,647	7.3%
UK industry, commerce and public corporations	925	4.1%
Non-EU other	702	3.1%
Non-EU-based charities (open competitive process)	688	3.1%
Non-EU industry commerce and public corporations	679	3.0%
UK-based charities (other)	611	2.7%
EU industry, commerce and public corporations	376	1.7%
UK central government tax credits for research and development expenditure	339	1.5%
UK other sources	199	0.9%
EU (excluding UK) other	99	0.4%
EU-based charities (open competitive process)	50	0.2%

70. The financial support from charities was noted by Main Panel A as particularly important for health and life sciences research. While NIHR funding has continued to support the highest quality applied science, Main Panel A noted that not all of the NIHR funding schemes are available to researchers in the devolved administrations.

Early career researchers, training and capacity building

71. Main Panel A were pleased to note the increase in doctoral degrees awarded across its sub-panels during the assessment period, from 6,040 (2013-14) to over 7,000 (2019-20) per year. However, the main panel noted that the early career researchers (ECRs) participating in REF 2021 represented 16% of the staff headcount submitted, whereas the figure for REF 2014 had been 19%. Main Panel A is particularly concerned because, the Covid-19 pandemic has had an adverse effect on the careers of many ECRs with personal challenges and childcare and caring responsibilities. Clinically facing and laboratory based ECRs submitted to Main Panel A also spent significant periods of time contributing to the national clinical response. Main Panel A identified a focus on ensuring that the career pipeline for all ECRs should remain an area of importance for funders and HEIs.

72. Across Main Panel A the percentage return of eligible staff was very high in all UOAs except for UOA 3. In this UOA, which spans a range of medical and allied health professionals, the percentage return was far lower (47%), and was as low as 5% for a submitted unit. Main Panel A expressed the concern that these data might suggest that the opportunity to undertake research was not available as widely to practice-based academics; particularly those from underrepresented professions vital to the UK's research endeavour, and workforce development.

Further analysis of output scores

73. Under the auspices of the Future Research Assessment Programme, the four Higher Education Funding Bodies have commissioned further analysis of the submission and scoring of outputs. The work includes an assessment at sub disciplinary level across the health-related sub-panels, as well as a deep dive on ageing and gerontology across the whole exercise.

Sub-panel reports

74. Whilst Main Panel A had common approaches and noted many common issues, each UOA has specific characteristics. In the reports by each sub-panel, the key messages from REF 2021 are presented for HEIs, research groups, research funders, and service users in respect of moving forward to further increase research quality and impact.

UOA 1 Clinical Medicine

Average quality profiles (FTE-weighted) for the UOA

Profile type	% 4*	% 3*	% 2*	% 1*	% Unclassified
Overall quality	50	41	9	0	0
Outputs	39.0	48.1	12.0	0.5	0.4
Impact	67.7	30.3	2.0	0.0	0.0
Environment	63.1	34.5	2.4	0.0	0.0

Working methods

1. The sub-panel adhered to published working methods and guidance. Due to unexpected circumstances, the sub-panel deputy chair took over as acting chair for the 2022 sub-panel meetings. All evaluation meetings were held as virtual meetings except the impact case study and environment evaluation meeting, which was a hybrid meeting with the sub-panel executive meeting in person to facilitate the assessment process.

Summary of Submissions

2. The unit of assessment (UOA) received 31 submissions from separate institutions. There were no multiple submission requests (in line with the published criteria) and no joint submissions were made. The 31 submissions were comprised of 30 institutions which submitted to this sub-panel in REF 2014 and one institution that made its first submission to REF in this assessment. Submissions were received from English (25), Welsh (1) and Scottish (5) institutions.
3. Submissions ranged in size from 19 to 499 FTE staff, with the median submission size of 138.6 FTE. This indicates an increase in the number of individuals returned from REF 2014, when the median submission size was 84.5 FTE. This was in line with expectations given the changes in rules for eligibility and inclusion between the two assessment exercises.
4. Submissions spanned the whole spectrum of clinical specialties. A substantial amount of submitted work also came from laboratory based scientific disciplines allied to medicine including genetics, cancer and cell biology.

Outputs

5. 11,991 outputs were received by the UOA. The general standard of submitted outputs was extremely high, with 87% being rated as world-leading or internationally excellent (FTE-weighted figures). The sub-panel was pleased to note the increase in world-leading outputs to 39%, up from 23% in REF 2014, emphasising the continuing strength of research outputs from the disciplines included in submissions to the sub-panel. The world-leading outputs spanned a wide spectrum of clinical medicine, and provided evidence of excellence from underpinning discovery science, through to real-world research in patients and populations. Newer approaches such as data science and evidence synthesis were well represented. Many of the strongest outputs brought together complimentary research strengths, for example to corroborate laboratory findings in humans and to deliver world changing clinical trials, and the sub-panel noted that the extent of this had increased since REF 2014. The sub-panel noted a number of early outputs describing world-leading research on Covid-19 emphasising the UK's key role in delivering transformative research during the pandemic.

Cross-referrals

6. The sub-panel found that, in practice, there was little difference between cross-referral and joint assessment requests and so considered these together. A very small proportion of outputs submitted to Sub-panel 1 were cross-referred (<0.5%). Over half of these went to physical sciences, engineering and mathematics sub-panels, especially Sub-panel 8 (Chemistry) and Sub-panel 12 (Engineering). About a quarter of cross-referred outputs were sent to other medicine, health and life sciences panels. Reflecting the encouraging breadth of disciplines being deployed to address challenges in Clinical Medicine, the sub-panel received 384 requests for cross-referral from other sub-panels.

Interdisciplinary research

7. The sub-panel recognised a high level of collaboration amongst clinical and non-clinical disciplines that contributed to excellence across all elements within the return. Collaborations were apparent amongst diverse disciplines represented within UOA 1 as well as within Main Panel A and across other main panels. Institutions flagged 13% of outputs as inter-disciplinary, but the sub-panel found this to be somewhat inconsistent and to underestimate involvement of other disciplines within Main Panel A. A review of a random sample of ~1000 outputs indicated that more than half involved disciplines from other UOAs, with 14% involving disciplines outside Main Panel A.

Impact

8. The UOA received 255 impact case studies to assess, of which 98% were judged to be outstanding or very considerable in reach and significance (FTE-weighted figures). The sub-panel included impact assessors from a range of backgrounds in industry, health care and knowledge exchange to facilitate a broad perspective on impact assessment. Overall, it was considered that the range and quality of the impact case studies received underlined the global importance of UK biomedicine and the huge contribution the discipline area makes to the health and wealth of the UK and beyond. The underpinning research spanned the translational continuum from laboratory-based research to public health research. Impact case studies were received across the broad range of discipline areas covered by the UOA, with the majority focusing on health gains. Encouragingly, the majority of impact case studies received by the UOA were new rather than continuing

from REF 2014 submissions, emphasising the breadth and depth of impact achieved in Clinical Medicine. Many of the submitted case studies were considered to be 'beyond outstanding' in reach and significance by the sub-panel, since they had led to transformative changes in management of health and disease in the UK and beyond. These included early impact case studies defining treatment approaches for Covid-19 which had been adopted across the world.

Research environment

9. 63% of the research environments were judged to be conducive to support research of world-leading quality (FTE-weighted figures), a small increase from 2014, reflecting the continued strength and investment in the underpinning research environments in UK medical schools. In all, 98% of the environment was considered to be conducive to producing research of internationally excellent or world-leading quality and enabling outstanding or very considerable impact. The sub-panel were impressed by the increased attention being paid to support trainees and early career researchers evidenced in environment statements. Encouragingly, a marked increase in attention compared with REF 2014 is also being paid to issues of equality, diversity and inclusion, with particular evidence of progress made on gender balance. Trainee numbers remain high, indicating that the research environment within UK biomedicine is supporting the development of the next generation of research leaders in this discipline area.
10. Total research income reported to UOA 1 during the period 2013-2020 averaged £1,574 million per annum, with substantial support from Research Councils, industry and charities. NIHR continues to make a major contribution to clinical research within England, although the sub-panel noted that investments made by devolved administrations were in general more limited. The sub-panel noted that over this period EU government funding was >£86 million per annum across UOA 1 and the loss of this would potentially impact research in the future.

Table 9: UOA 1 External research income by funder source (page 22).

Table 9: UOA 1 External research income by funder source

UOA 1: Research income source	Research income (£ million)	Proportion of total income
UK-based charities (open competitive process)	3,608	36.5%
BEIS Research Councils, The Royal Society, British Academy and The Royal Society of Edinburgh	1,756	17.8%
UK central government bodies/ local authorities, health and hospital authorities	986	10.0%
Health research funding bodies	669	6.8%
EU government bodies	604	6.1%
UK industry, commerce and public corporations	491	5.0%
UK-based charities (other)	362	3.7%
Non-EU-based charities (open competitive process)	348	3.5%
Non-EU industry commerce and public corporations	336	3.4%
Non-EU other	251	2.5%
EU industry, commerce and public corporations	185	1.9%
UK central government tax credits for research and development expenditure	163	1.7%
UK other sources	65	0.7%
EU (excluding UK) other	34	0.3%
EU-based charities (open competitive process)	25	0.3%
Total	**9,884**	

11. All of the environment statements submitted to the sub panel emphasised the value of strong local and regional collaborations with the NHS. The submissions also evidenced strengthening of commercialisation of research and collaboration with commercial partners since REF 2014. Many also highlighted major global collaborations which emphasise the continued importance of UK medical schools to global health research.

UOA 2 Public Health, Health Services and Primary Care

Average quality profiles (FTE-weighted) for the UOA

Profile type	% 4*	% 3*	% 2*	% 1*	% Unclassified
Overall quality	55	37	7	1	0
Outputs	44.1	46.3	8.7	0.3	0.6
Impact	71.8	23.9	3.8	0.5	0.0
Environment	67.7	27.8	3.6	0.9	0.0

Summary of Submissions

1. The sub-panel was impressed by the world-leading quality of many of the outputs and the outstanding nature of the majority of the impacts generated from the Public Health, Health Services and Primary Care UOA. The sub-panel commended the strength, vitality and sustainability of the research environments that support the disciplines represented in this UOA.
2. The sub-panel noted that virtually all of the submissions were based on interdisciplinary research (IDR), irrespective of whether outputs were flagged as IDR by institutions, reflecting the great strengths of interdisciplinarity within this UOA. The sub-panel was aware that some world-leading research in the disciplines represented in this UOA, was submitted to other units of assessment, further testifying to the strength, breadth and depth of UK population health science.
3. The headline statistics include:
   - UOA 2 received 33 submissions.
   - 4941 outputs, 151 impact case studies and 33 environment statements were assessed.
   - The submissions included over 2,000 full time equivalent (FTE) staff, an increase of 50% since REF 2014.
   - 17% of the staff submitted were early career researchers.
4. Submissions ranged in size from 7.1 to 381.7 FTE staff, and from two to 14 impact case studies, and included five HEIs submitting to this UOA for the first time.
5. The sub-panel recognised world-leading strengths across a broad swathe of the underpinning quantitative and qualitative sciences, and across disciplines represented in the UOA. These include epidemiology, public and global health, primary care, data science and informatics, statistics, disease modelling, clinical and public health trials, genomics, evidence synthesis, health economics, health services research, management and policy, and health social sciences. The sub-panel was impressed by the extensive scope of the research base, both nationally and internationally, notably including in low- and middle-income countries.

6. The sub-panel noted that the UK's world-leading research strengths in depth represented in this UOA were pivotal to the UK's response to the Covid-19 pandemic. These strengths were impactful because they were combined with enhanced access during the pandemic to extensive National Health Service (NHS) data covering whole populations, including both primary and secondary care, as well as data on vaccinations and infections. Record linkage was also greatly improved during this period, which significantly added to UK population science's ability to respond rapidly to the evolving challenges faced by public health policy makers. Likewise, the availability of large population-based and disease cohorts across the life-course proved to be essential infrastructure to underpin the response. The success of the Covid-19 scientific response clearly demonstrates the vital role of this infrastructure in responding to public health challenges. The sub-panel recognised that continued investments in the infrastructure, data and resources has clear potential to build on these gains post-pandemic. Priorities include agile approaches to data collection, streamlined data access and governance, enhanced record linkage and analysis, support for world-leading cohorts and trials infrastructure, with improved availability and coverage of data from the NHS and other sources to inform the wider determinants of health.
7. The sub-panel was impressed with the advances made since REF 2014 in the use of genomic and other -omic technologies in discovery science, and the growing use and evaluation of artificial intelligence (AI) and Machine Learning applied to -omic science, environmental, administrative and other complex health datasets. These advances should lead to significant impacts in the future on understanding the causes of disease, the development of new preventive strategies and treatments, and the delivery of cost-effective health care -- and help ensure on-going agility to address and support the research priorities and needs of stakeholders including government departments, the industrial base and society.
8. The sub-panel was pleased to see continuing strengths in the development and application of robust methodologies across the various disciplines represented in the UOA. These included innovative methodological developments in epidemiology, statistics, computational biology, health economics and evidence synthesis, with a strong emphasis on interdisciplinarity. Advances include the development of agile public health evaluations and clinical trial designs which will lead to the delivery of more efficient and timely prevention programmes, treatments and improvements in health care and public health. The sub-panel was also impressed with advances made in the REF 2021 period regarding the development, delivery and evaluation of complex health interventions. In the view of the sub-panel, continued investment in the development of underpinning methodologies is essential to ensure the UK remains at the forefront of advances in these areas.
9. Over the REF 2021 period, £3.2 billion was invested in UOA 2 research across the submitting HEIs. The high proportion of world-leading quality research noted by the sub-panel reflects a significant return on investment that has led to outstanding impacts at national and international levels. In this regard, the sub-panel noted that NIHR and UKRI funding has been critical for the delivery of the highest quality science and its impact.
10. While the majority of this research investment has been in the UK, it was clear that increased amounts were invested in global health, particularly in the early part of this REF period. This has already paid significant dividends in terms of outputs and impacts. The sub-panel considered that sustaining this funding trajectory has the potential to drive significant progress on Sustainable Development Goals (SDGs) being led or co-led by the UK science base.

Outputs

11. The core membership of the UOA 2 sub-panel was supplemented by two output assessors. As noted above, while a very high proportion of the outputs were interdisciplinary, the sub-panel members had expertise covering a wide range of inter-linked and complementary disciplines, and were therefore able to make informed assessments of interdisciplinary outputs without the need for many cross-referrals (22 instances). By comparison we received a much greater volume of cross-referred outputs (253 instances) from 15 other sub-panels.
12. Each of the outputs submitted to the UOA was initially assessed by two panellists, one subject specialist and another randomly assigned, subject to conflicts of interest. The grading was moderated by a third panellist when necessary, to ensure that the assessment of all outputs was fair and consistent. Panel members undertook a rigorous output calibration exercise to ensure that the sub-panel members as a whole had a shared understanding of the quality criteria. In general, outputs of each submitting institution were assessed by all non-conflicted panellists, ensuring a fair and balanced assessment of the outputs from the submitted units.
13. The international advisors to the sub-panel endorsed the sub-panel's judgment of the sustained and world-leading excellence of the research outputs submitted to this UOA. Overall, 44% of the outputs (FTE-weighted) were judged to be of world-leading quality (four star) and a further 46% to be internationally excellent (three star). Direct comparisons with results from REF 2014 are not possible to make because of the changes in the criteria and working methods post-Stern.
14. Most of the outputs submitted to UOA 2 were multi-authored, with nearly 30% having more than 15 co-authors, reflecting multi-disciplinary teams, often from a number of collaborating institutions, showcasing the predominance and value of team science within the UOA. In some instances, clarification of the contribution of attributed authors was sought through the audit process. The numbers of outputs in emerging fields, such as multi-modal -omics and "Big Data" using linked Electronic Health Records and Machine Learning, have grown considerably since 2014, with many examples of world-leading or internationally excellent quality. Likewise, the proportion of world-leading or internationally excellent outputs was high in all the various disciplines represented in this UOA, reflecting strength in depth over a wide range of research activities.

Impact

15. The core membership of the sub-panel was joined by six impact assessors, from a range of research user bodies, specifically to advise on impact; their input, as well as the advice of national and international members of Main Panel A, was particularly valuable. At least three panellists were randomly assigned to each impact case study, subject to conflict of interests, and they provided an initial assessment on each case study, with an impact assessor always involved. Further input was sought from additional sub-panel members where needed. Disruptions due to the Covid-19 pandemic affecting the final year of the REF 2021 period were reported for two of the 151 case studies. The sub-panel took account of these circumstances in assessing the impact cases.
16. The sub-panel assessed 151 impact case studies, and 54% (non FTE-weighted) of the impact was judged to be outstanding (four star). The sub-panel was impressed with the outstanding contribution that public health, health services and primary care research has made to health and welfare worldwide, including the Covid-19 pandemic response.

17. The strongest impacts were those for which the submitted units were able to demonstrate compelling evidence for the reach and significance of the impacts being claimed. While there was extensive evidence of strength in depth for many of the case studies submitted, the sub-panel noted that the maximum REF research period eligibility (20 years) between the underpinning research and the realisation of impacts, was relatively short for some impacts in public health. For example, it took over 50 years before the evidence on smoking was enacted in legislation in the UK and worldwide.
18. Outstanding reach and significance, often on a global scale, was evident in case studies across a broad range of areas, with direct benefits on health, as well as impacts on both health and non-health policies. These spanned impacts on Global Health and Sustainable Development Goals, health care quality improvement, medicines development and regulation, screening programmes, national and international practice guidelines, as well as economic, industrial and societal benefits.

Research environment

19. All environment statements were initially assessed by three randomly allocated members of the sub-panel, and then reviewed and scored by the whole sub-panel, subject to conflicts of interest. Overall, the sub-panel was highly impressed by the vitality and sustainability of the research environments submitted. There was strong evidence of dynamic research environments with evidence of growing infrastructure in many submitting HEIs. However, the sub-panel considered that continued and increasing investment is needed to maintain and enhance the research infrastructure and capacity building across the whole range of disciplines represented by the UOA. In addition, the sub-panel recognised that infrastructure for population cohorts and biobanks, as well as investments in data and in people encompassing epidemiology, statistics, computational biology, data and implementation science, and health economics, will need sustained support if the opportunities for Big Data and AI in health are to be fully realised.
20. Evidence of support for equality and diversity was present in all the submitted units and a clear strength in many, with a variety of mechanisms evident across the sector to support all grades of staff in the submitting HEIs. The sub-panel noted that a major strength of the research environment across submitting HEIs was the improving support offered to early and mid-career researchers and the promotion of a more inclusive research culture. The sub-panel was particularly impressed with the submitted units that had robust policies to support staff across all protected characteristics and which gave quantitative evidence of implementation of these policies. The sub-panel noted many successes in supporting staff, early career researchers and students, including adoption of a variety of equality, diversity and inclusion accreditation schemes. The sub-panel noted the vitality of the postgraduate research student environment in most submitting HEIs across the sector, reflecting the progress on training the next generation of applied health researchers and population scientists. The sub-panel also noted the strength of the international profile across the UOA, including a strong UK presence in large EU and other international consortia during the period of the assessment. The sub-panel was anxious to see that the UK contribution to the European and wider international scientific effort is sustained so that the UK science base remains at the leading edge of the areas covered by the UOA.

21. A more visible and welcome aspect of the research base in the UOA, compared with REF 2014, was the involvement and engagement of patients and the public (PPIE). This is supported by the increased emphasis of the major funders on PPIE throughout all stages of the research process. In parallel, the sub-panel was pleased to see extensive progress across the research communities in promoting an open research culture, the sharing of data and research tools, and attention to the reproducibility of research.
22. Over the REF 2021 period, £3.2 billion was invested in UOA 2 research across the submitting HEIs. The major funders were health research funding bodies (26%), research councils (17%), UK central bodies/local authorities, health and hospital authorities (17%), UK charities (13%), and the EU (4%). While NIHR funding has continued to support the highest quality applied science, the sub-panel noted that not all of the NIHR funding schemes are available to scientists from all of the devolved administrations. The sub-panel recognised that in order to keep pace with NIHR funding, sufficient devolved administration funding will be required. Nonetheless, the sub-panel was impressed with the extent of world-leading quality research and outstanding impacts submitted by HEIs in each of the home nations.

Table 10: UOA 2 External research income by funder source (page 28).

Table 10: UOA 2 External research income by funder source

UOA 2: Research income source	Research income (£ million)	Proportion of total income
UK-based charities (open competitive process)	842	26.0%
BEIS Research Councils, The Royal Society, British Academy and The Royal Society of Edinburgh	539	16.7%
UK central government bodies/ local authorities, health and hospital authorities	537	16.6%
Health research funding bodies	404	12.5%
EU government bodies	202	6.3%
UK industry, commerce and public corporations	159	4.9%
UK-based charities (other)	127	3.9%
Non-EU-based charities (open competitive process)	122	3.8%
Non-EU industry commerce and public corporations	81	2.5%
Non-EU other	81	2.5%
EU industry, commerce and public corporations	57	1.8%
UK central government tax credits for research and development expenditure	33	1.0%
UK other sources	25	0.8%
EU (excluding UK) other	18	0.6%
EU-based charities (open competitive process)	4	0.1%
Total	**3,232**	

23. There was strong evidence of extensive collaborations underpinning research in and across the sub-panel's disciplines, and the environment statements made clear how important these collaborations, extending globally, are to the development of impactful high-quality research in this area.

UOA 3 Allied Health Professions, Dentistry, Nursing and Pharmacy

Summary of Submissions

Average quality profiles (FTE-weighted) for the UOA

Profile type	% 4*	% 3*	% 2*	% 1*	% Unclassified
Overall quality	37	47	14	2	0
Outputs	31.9	51.1	15.2	1	0.8
Impact	41.8	42.9	13.8	1.4	0.1
Environment	49.2	35.3	13.9	1.5	0.1

Key messages

1. With 89 submissions, this was one of the largest and most diverse units of assessment (UOAs) in REF 2021, covering disciplines from different philosophical backgrounds. As in REF 2014, the sub-panel members from different disciplinary groups worked extremely well together. Interaction was further enhanced by the strategic matching of panellists into reviewing pairs and groups and by the careful allocation of work across the sub-panel. It was also helped by employing calibration exercises to benchmark the assessment of outputs, impact and environment. All the sub-panel members had extensive experience of working in interdisciplinary research teams and employing a variety of research designs and methodologies. This reflected 'team science' and had many advantages in terms of understanding the methods, topics and research priorities of diverse disciplines.
2. Over the REF period, UK HEIs and external funding bodies have made an outstanding contribution to the research environments in UOA 3. This enhances the disciplines' international standing and shows that UK researchers continue to undertake some of the most significant and influential work in the world. Results also show that the sustained investment in research in this UOA over the last 30 years has yielded highly cited world-leading outputs and outstanding impacts for quality of life, health, the economy, and society regionally, nationally and internationally.
3. UOA 3 includes research into all aspects of the disciplines of allied health professions, dentistry, nursing, midwifery, and pharmacy. Its boundaries include research in underpinning science, laboratory-based work, applied clinical research, healthcare technologies, and research into public health, social care and health promotion. Research into psychosocial, philosophical and ethical aspects of healthcare, as well as education, policy and methodology relevant to these disciplines, is also included. As anticipated, such work used qualitative, quantitative and mixed methods, as well as philosophical and theoretical approaches.

4. The headline statistics are:
   - 89 submissions were received from 90 UK Higher Education institutes (HEIs) – including those with large, established departments covering the full range of the field (largest submission size 225 FTE staff) through to small less well-established departments (smallest submission size 3.8 FTE staff).
   - There was one joint submission (involving two HEIs).
   - 4,769 FTE staff were responsible for 11,627 research outputs, mainly journal papers, with over 83% of them rated as internationally excellent or world-leading (FTE-weighted).
   - Research income by spend reported over the period was £1,695 million, 17% being from UK Research Councils, 20% from charities, 37% from UK central government bodies, local authorities, health and hospital authorities, 11% from industry and 8% from the EU.
   - 400 impact case studies were submitted, and 85% of these were rated as having outstanding or very considerable impact (FTE-weighted).
   - 738 early career researchers (ECR) were submitted, representing 14% of the total staff returned, revealing a reduction by 3% compared to the REF 2014 return.
   - There was strong evidence of research training, with 9,251 doctoral degrees awarded during the REF period, representing 1.94 per FTE staff member returned.
5. It is probable that not all eligible academic departments were submitted to this UOA. One of several examples is nutrition research. In addition to UOA 3, nutrition research has been returned in UOA 6, UOA 1 and UOA 2. Such fragmentation of submissions makes it difficult to get a coherent grasp of the state of research in the discipline. In addition, a minority of the submissions were unidisciplinary, whereas others incorporated multiple disciplines. Therefore, this overview should be interpreted in this light: it is a statement only on the evidence submitted and assessed through REF 2021, not necessarily on the state of all the UK research relevant to this UOA.
6. Direct comparisons between the results of REF 2014 and those of REF 2021 are challenging. This is because of changes to the REF rules because of the Stern recommendations. Among other variations, support for research impact moved from the impact to the environment template. In addition, and as alluded to above, the REF 2014 submission covered a six-year period while the REF 2021 encapsulated a seven-year interval.
7. It is clear from the results of the exercise that there is evidence of internationally excellent or world-leading research in all the submissions returned to this UOA. Furthermore, the number of submissions from corresponding UOAs in REF 2014 (n=91), was very similar to that made to this UOA in REF 2021 (n=89).
8. Because of the Stern recommendations, it was expected that the number of staff returned to UOA 3 in REF 2021 would increase significantly. This proved to be the case with 2,021 FTE more staff submitted. As anticipated, this growth was reflected in an increased number of outputs submitted, 11,627 compared to 10,358 in REF 2014. The number of impact case studies also increased from 355 to 400, covering a wide range of impacts. Almost all were new impact case studies rather than continued case studies, demonstrating that novel impact has continued to be generated since REF 2014.

9. Welcome trends were noted, such as the demonstration of a greater theoretical grounding for empirical research, a greater sophistication in use of methods and a good mix of non-clinical and clinical investigations. There was also evidence of more national and international collaborations. The interdisciplinary nature of research is possibly a key factor in this trend, enabling and facilitating collaboration among researchers across different disciplines and countries. Panellists also noted larger scale, more complex and ambitious research with far reaching implications for health, wellbeing and society.
10. This UOA undoubtedly benefitted from developments in research funding during the REF 2021 period, notably through the National Institute for Health Research (NIHR). This reflected a move to further integrate academic researchers with the NHS, leading to more translational research, which underpinned a majority of the impact case studies. From identifying research questions and producing high-quality research, to ensuring that this research is translated into healthcare benefits, the working partnership between academia and the NHS in the UK clearly contributed a significant proportion of the excellence the sub-panel members found in the submissions. There was also evidence of a seamless transfer of ideas from the research lab to the marketplace, showing that research can lead to innovation and that innovation drives growth and productivity. The panellists also noted substantial grant capture from major charities, the EU, and the Research Councils.
11. 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 international multicentre studies, was important for the future vitality and sustainability of these disciplines.

Outputs

12. Considering conflicts of interest and subject-matter expertise, all research outputs were allocated to and assessed by at least two panellists; one specialist and one more generalist reviewer. A third reviewer was involved where the initial scoring pair could not readily concur, or where another reviewer was considered to have relevant expertise.
13. The in-depth discussions between assessors meant that the sub-panel members found it straightforward to assess the outputs in the submission and were confident in their conclusions. Where outputs were found to lie outside the expertise of the sub-panel, advice was sought from other sub-panels (6% of outputs were cross referred). Panellists also provided advice on several incoming cross-referred outputs that had been submitted to other sub-panels.
14. Panellists were surprised that some institutions returned a considerable number of outputs that did not fall within the remit of its UOA descriptor and which would have been more helpfully submitted elsewhere (see 'Panel criteria and working methods'). As stipulated in the last paragraph of the descriptor, these were cross-referred to other sub-panels.
15. The sub-panel members assessed 11,627 research outputs from across all areas within the disciplines submitted to this UOA. As alluded to above, compared to the corresponding sub-panel in REF 2014, there were 1,269 more outputs submitted to

this UOA in REF 2021. Furthermore, panel members noted world-leading research that employed quantitative, qualitative and mixed-methods approaches.

16. In the allied health professions, outputs contained a significant volume of research that is central to current and future work by the UK's 14 Allied Health Professions (AHPs) and included a wide range of research topics and diversity in the paradigms and methods employed. Research addressing areas of AHP practice and underpinning theories were varied in nature and scale and were highly interdisciplinary. There is evidence of AHP research areas thriving. For example, optometry (and more broadly vision science) was well represented, with world-leading activity ranging from the global prevalence of eye disease through to hypothesis-rich psychophysical investigations of visual function. AHP research tended to be strongest in cases where specific interventions were tested.
17. In returns from the dental specialties, panel members observed very significant breadth in terms of the research themes. This covered the span from fundamental research into biological mechanisms through cell biology, cancer, materials science, clinical dentistry and public health. It was notable that there were world leading outputs from large, complex, multi-centre clinical RCTs, often delivered in dental primary care and supporting the delivery of clinical dental care. There were also multi-centre RCTs addressing complex health issues in primary care settings. Panel members also noted world-leading outputs in dental public health and prevention, a majority with strong international components.
18. Some of the strongest nursing outputs reflected a focus on topics of major relevance to people's quality of life and health outcomes. Examples included: investigations of interventions designed to support older people and those with enduring health challenges, symptom management, and support for self-management, as well as attention to endemic challenges such as pain, continence, and skin integrity. In scientific focus and methodology, compared to REF 2014, there was a growing emphasis on evaluating new approaches to care delivery and new/advanced roles. Some of the strongest outputs submitted included complex studies in the form of NIHR HTA reports, and these evidenced very strong research team leadership by nurses.
19. Strong midwifery research was demonstrated, reflecting solid evidence of world-leading and internationally excellent research. The panel members were impressed by the volume and quality of midwifery outputs. Submissions demonstrated a breadth of methodological expertise, informed by important clinical, social, psychological, and educational issues. Research outputs were grounded in real-life practice, with potential for underpinning outstanding or very considerable research impact.
20. In biomedical science, a majority of the research outputs were of world-leading quality, covering the breadth and depth of biomedical sciences, from molecules and cells through to clinical genetics. Most of the outputs, especially the high-scoring ones, came from scientific teams and commonly included *in vitro, in vivo*, and sometimes clinical data. This interdisciplinarity was welcomed by the sub panel and fits with a strong focus on major global challenges such as cancer, diabetes and infection, all of which are multi-factorial in nature and require an interdisciplinary approach.
21. Overall, the standard of outputs in pharmacy, pharmacology and pharmaceutical sciences indicated a vibrant research discipline with a strong commitment to interdisciplinary and translational research. There was a range of world-leading outputs encompassing underpinning science, cutting-edge translational studies, and patient-focused investigations, increasingly informed by patient and public involvement and engagement. A key observation was the inclusion of interdisciplinary research, demonstrating that the discipline has adopted a holistic approach, which crosses the

traditional boundaries of discipline-specific research focus.

22. Public perspectives on research and pedagogic research were areas that were less well represented in UOA 3, than might have been expected. It was noted that research into the care and support of people with learning difficulties, though evident, was not prominent particularly given the clinical and educational challenge. Laboratory-based research was also not as evident in nursing, midwifery and some of the allied health disciplines.
23. There were many systematic reviews and meta-analyses conducted using established methodologies, and the quality of these was generally high. However, several submissions showed a disappointing reliance on iterative systematic reviews that added little to the extant knowledge base. While there was evidence of rigour in many of these, originality and significance are critical to meet the REF definition of research. Panellists wondered whether the emphasis on systematic reviews reflected a tendency for some grant awarding bodies to fund the review of previous research rather than the overall development of new knowledge.
24. HEIs were invited to flag outputs that they classified as interdisciplinary research (IDR) in their submissions. The sub-panel assessors found that the approach to this had been variable, with a small number of institutions identifying IDR outputs through the flagging system. A significant number of outputs that were not classed as IDR by the HEI were, on assessment, identified as such by sub-panel members. However, panellists did not undertake a systematic exercise to identify all potential IDR outputs. Many involved collaborative science between biological, chemical, pharmaceutical, clinical and health scientists, both within and between HEIs.
25. Panellists welcomed the number of multi authored outputs returned to UOA 3. This was expected and is in line with the greater emphasis on 'team science' and interdisciplinary research that crosses all fields in the UOA.
26. In this exercise UOA 3 received 16 outputs where double-weighting was requested by the submitted institution. This was where the outputs were derived from substantial academic endeavour by the member of staff against whom the output is listed. The majority of these were in the form of large NIHR HTA reports. Where the case for double-weighting was not accepted by the panel, the reserve output was reviewed.
27. Analytics on citations was used positively, but as in REF 2014, played a relatively minor role in the assessment of outputs. Journal impact factors were not considered.

Impact

28. Considering conflicts of interest and subject-matter expertise, impact case studies were randomly allocated and assessed by at least three panellists, including a user assessor. Panellists scored using a nine-point scale (1.0, 2.0, 2.5. etc.). The rigorous calibration exercise undertaken at the start of the process initiated robust discussion that was highly productive in establishing common views on quality; a further calibration occurred before scoring was finalised. The involvement of user assessors, including those who represented healthcare user organisations, was invaluable in providing exceedingly helpful perspectives and insights. These deliberations, alongside in-depth discussions between assessors on each case study, meant that the panellists found it straightforward to assess the impact elements of the submission, and were confident in their conclusions.

29. Most submissions presented well-evidenced impact case studies. 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, policy makers, industry, and the voluntary sector.

30. The quality of the case studies was very high, with 41.8% deemed to be outstanding (four star) and a further 42.9% very considerable (three star) in terms of their reach and significance (FTE-weighted figures). Only a small minority (1.5%) were assessed as having had less than considerable impact. Panellists highly rated 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 a majority of cases with outstanding impact were submitted by smaller submissions and across all four countries in the UK.

31. Cases that were highly rated were (i) those that had a clear linkage between the internationally recognised 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 very considerable reach and significance.

32. Panellists noted outstanding impacts representing the full breadth of the research submitted to UOA 3. A majority evidenced changes in policy, new guidelines, and innovative professional practice. Panellists noted the importance of not just effecting change in terms of practice or policy, but in providing evidence of the positive effect of implementing such a change. Outstanding impacts were also apparent in the areas of commercialisation and improving quality of life. The sub-panel members 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 were linked to important public health issues, including Covid-19.

33. The overall quality of 'dental' impact case studies was either outstanding or very considerable, with widespread impact in terms of clinical care. There were notable impacts on national and international health policy and on guideline development. There was also an excellent group of case studies focused on translation of research into dental practice and on dental epidemiology.

34. In pharmacy, pharmaceutical science and pharmacology, the impact case studies demonstrated that new impact has continued to be generated since REF 2014. The diversity of impacts spanned multiple domains such as society, policy, practice and economy. Collectively, research from pharmacy has led to new products, services and significant changes to policy, all of which have delivered improved healthcare, and commercial and societal benefits. Impact cases included examples of outstanding advances 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 case studies related to commercial spin-outs of novel drug delivery technologies; for example, in the area of development of inhaled pharmaceutical products.

35. The biomedical science impact case studies demonstrated a majority of outstanding or very considerable examples of innovation and impact. These ranged from basic research to implementing the benefits through new devices and processes, or modifications to treatment guidelines and management.

36. The impact case studies that were initiated by nursing research focused on issues such as mental health, ageing, dementia, enduring health challenges and self-management. The diversity of impact spanned multiple domains such as society, policy, practice and economy and demonstrated improvements in healthcare and outcomes for patients. The stronger impact case studies revealed clear links to the underpinning research, evidence of impact, and outstanding reach and significance. Panellists judged that research from nursing has led to new services, changes to policy and has shaped public perceptions of health matters.
37. Midwifery impact case studies provided further evidence of the strong links to clinical practice, contributing to improved care and outcomes for women and their families. The majority of the impact case studies demonstrated outstanding and very considerable reach and significance. The impact included health care and societal benefits, and significant changes to policy and practice.
38. Feedback from the user assessors articulated both the pleasure they derived from reviewing the impact case studies, and the way in which those studies demonstrated how academic research helped and supported improved policies and practices in health care and enhanced quality of life and quality of care. They also noted how research has led to economic growth, especially in small and medium-sized enterprises, through providing innovative solutions to problems. They identified as a strength of the REF system the collaborative nature of the process and the ability of the panellists to discuss and reach consensus on scoring. The research users also noted that impact case studies demonstrated consistently the importance of interdisciplinary studies in bringing applied research through to impact at the outstanding level of quality.

Research environment

39. As with assessment of impacts, at least three panellists assessed each environment template. Conflicts of interest were considered when environment templates were randomly allocated. Panellists scored using a nine-point scale (1.0,1.5, 2.0 etc.). The rigorous calibration exercise undertaken at the start of the process initiated robust discussion that was highly productive in establishing common views.
40. The panellists were impressed that 85% of the environments reviewed were conducive to producing research of world-leading or internationally excellent quality, in terms of its vitality and sustainability (FTE weighted figure). There appeared to be a trend in many HEIs of bringing together strengths from different disciplines, often involving imaginative and fruitful collaborations between apparent disparate areas of work. The sub-panel members also noted that since REF 2014, a majority of HEIs had undertaken strategic reorganisations to establish, and invest in, interdisciplinary research spaces, institutes and centres.
41. The panel did not consider in its assessments the percentage of eligible staff returned by an institution. However, it should be noted that across the submissions there was significant variation in the number of eligible staff returned in this UOA, compared to other UOAs in Main Panel A, and compared to their institutional return rates. It was not clear why this had occurred. Panellists expressed significant concern that staff within this UOA who are technically eligible for submission to the REF are not being given time to undertake research and to develop research careers. Hence, they are not classed as having significant responsibility for research and this has an impact on the health and vitality of the disciplines more widely. This is not to suggest that institutions did not

follow their Codes of Practice, but that these disciplines need to be supported to bring the submission rates of eligible staff for this UOA up to institutional norms. This would ensure that all staff members aiming for, and capable of undertaking research, are supported in the same way as others at the same institution. In this respect UOA 3 was a clear outlier in comparison to all other sub-panels across Main Panel A.

42. There was evidence of widespread national and international collaboration, both within and between disciplines, though in some instances the panellists would have welcomed a fuller explanation of the nature and outcome of these collaborations. Evidence of funded research with international partners in many countries was noted and viewed positively by the sub-panel members. Furthermore, several UK HEIs were playing leading roles in large-scale international research collaborations.

43. Panellists 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/doctoral colleges, and great diligence in managing the research student trajectory. Although not directly comparable, there is evidence of growth in the number of doctoral awards submitted to UOA 3 in REF 2021 (n=9,251) over 7 years, compared to REF 2014 (n=4,961) over 5 years. The increase in the number of doctoral awards across the REF assessment period was regarded as an important indicator of research strength and vitality for the UOA.

44. In general, evidence of support for postdoctoral researchers was less well described than were postgraduate research students. Despite this, there was good evidence of support for early career researchers and good progress was evident regarding staff on fixed term contracts. 14% of the FTE return were early career researchers This represents a reduction by 3% compared to the REF 2014. Panellists noted that coupled with the low return of eligible staff in some institutions, there is a question as to how future research capacity in key healthcare disciplines is being supported.

45. Generally, there was evidence of greater and more positive engagement with issues of equality, diversity, and inclusion than in REF 2014. The sub-panel members judged that the HR Excellence Award and the Concordat benchmarks highlighted in submissions were important quality benchmarks. The improved REF policies on staff circumstances had allowed a more inclusive strategy for researchers. Panellists were also pleased that structures and processes were set up in a majority of departments to incorporate a service user co-production perspective within the research environment.

46. In the best submissions, commitment to equality , diversity and inclusion (EDI) was evident in the both the richness of data and narrative provided, and in the full range of protected characteristics considered. There was very little focus on support for disability in any of the submissions, and only a minority referred to LGBTQ+.

47. The sub-panel members noted that a total of over £1,695 million of research income by spend for this UOA was reported over the 2014–2020 assessment period. While it was recognised that large-scale support is not required for all disciplines in this UOA, the level and growth of external funding reflects the quality of the work being carried out. Panellists noted evidence of marked upward funding trajectories over the REF period in several 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 outputs and impacts.

Table 11: UOA 3 External research income by funder source

UOA 3: Research income source	Research income (£ million)	Proportion of total income
UK central government bodies/local authorities, health and hospital authorities	360	21.2%
BEIS Research Councils, The Royal Society, British Academy and The Royal Society of Edinburgh	295	17.4%
UK-based charities (open competitive process)	286	16.9%
Health research funding bodies	264	15.6%
EU government bodies	140	8.3%
UK industry, commerce and public corporations	113	6.7%
Non-EU other	48	2.8%
Non-EU industry commerce and public corporations	41	2.4%
UK-based charities (other)	39	2.3%
UK other sources	30	1.8%
EU industry, commerce and public corporations	30	1.7%
UK central government tax credits for research and development expenditure	18	1.1%
Non-EU-based charities (open competitive process)	15	0.9%
EU (excluding UK) other	10	0.6%
EU-based charities (open competitive process)	5	0.3%
Total	**1,695**	

48. A majority of HEIs had been supported during the review period by infrastructure funding of 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. The extent of industrial collaboration, including that with small and medium-sized enterprises, was a positive feature of several submissions. This reflected very significant developments, often linked to substantial investment by HEIs and local government (City deals, Technology hubs, etc).

49. The sub-panel members judged that 77% of HEIs were able to describe an approach that was conducive to supporting and enabling impacts of outstanding or very considerable reach and significance. It was clear to panellists that 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.

50. There was often a strong correlation between the impact strategy in the environment template and the case studies. Nonetheless, a minority of outstanding case studies were linked to a relatively weak strategy for delivering such impact. The panel noted that institutions new to REF usually had established an effective strategy for achieving impact of reach and significance in the future.

51. The AHP landscape included a wide range of research disciplines and diversity in the research paradigms and methods employed. There is evidence of several AHP research areas thriving, with world-leading activity. Research in areas of health and social care relevant to AHP practice was explicit in environment statements. However, whether and to what extent AHPs were part of the research environment in the HEIs was not always specifically described. In a number of environment statements the specific intentions regarding the strategic importance of AHP research capacity and capability, and research leadership, were implicit rather than explicit.

52. The environments in which pharmacy research was being conducted were largely considered to be conducive to producing research of world-leading or internationally excellent quality, in terms of vitality and sustainability. There was a clear commitment to interdisciplinary research and investments in initiatives that would encourage, support, and enhance such research. In several submissions, exemplary practice was demonstrated in supporting doctoral students and early career researchers. There were outstanding examples of collaborations and contributions to the discipline.

53. Panel members noted that the environments in those HEIs submitting dental research support the development and delivery of research at world-leading or internationally excellent levels of quality. There was evidence of careful strategic planning, clear recognition of human resource issues, including the application of equality and diversity policies. Sustained efforts to address gender balance, prolonged research funding and widespread esteem at both national and international levels was noted in the majority of dental submissions.

54. The research environment for biomedical science varied significantly as UOA 3 had submissions from across the breadth of UK academic institutions; some with over a century of research history to others being submitted to this sub-panel for the first time. However, the sub-panel judged that in all areas of the discipline there was a majority of world-leading or internationally excellent research environments. The strong evidence of interdisciplinarity shows that working in this way is now considered the norm for biomedical science research. In other words, departments are configured to bring the relevant skill sets together to address global problems.

55. Regarding midwifery, the panel was impressed with submissions where HEIs had managed to create joint posts (particularly at senior levels), which integrated research across the NHS and academia. This dismantled barriers, built capacity, and ensured that research had outstanding and very considerable impact. Increased support for interdisciplinary research, and strong national and international collaborations were noted. Institutions that had invested in supporting midwifery research, and had a critical mass of midwifery researchers, did particularly well. However, it was evident that there needs to be greater external investment to support capacity building through pathways such as the NIHR ICA awards, where midwifery underperforms compared to other disciplines.

56. In the strongest nursing submissions, there was evidence of highly developed research environments where there was world leading vitality and sustainability. These also demonstrated a strategic commitment to furthering nursing research, methodological innovations, strong partnerships with non-academic partners and explicit attention to EDI. Whether starting out on the journey of developing research in nursing or sustaining a long tradition, the commitment and strategic priority made by the majority of submitting institutions was exemplary. There was evidence of nurses leading large multimillion pound interdisciplinary research centres. This underlines the potential there is for building further on this to develop a critical mass of nurse researchers commensurate with the size of the nursing workforce. As with other disciplines in UOA 3, there were high doctoral completions. However, a very small number of ECRs were submitted (and none in a minority of submissions), emphasising the need to attend to capacity and capability building. Furthermore, it highlights the critical need for funding bodies to give priority to building research careers.
57. Panellists noted issues of equity in support for different disciplines. This was related to a dearth of funding programmes that build research careers and centres of excellence with critical mass. This was particularly evident for disciplines such as nursing and midwifery and some AHPs. The reason for this may be linked to the relative priority given to these subjects by some funding bodies and HEIs. The issue is likely to be further compounded by workforce shortages, if not actively addressed.
58. The sub-panel members considered the professional diversity of the field and the spread of excellence across HEIs to be a great strength. If research funding is 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. It was clear from the international members of Main Panel A who had joined the sub-panel meetings that UK research in UOA 3 compares well with the very best in the world. This suggests that, with investment, these disciplines will yield even more world leading research with outstanding benefits to the UK.

UOA 4 Psychology, Psychiatry and Neuroscience

Average quality profiles (FTE-weighted) for the UOA

Profile type	% 4*	% 3*	% 2*	% 1*	% Unclassified
Overall quality	43	36	17	3	1
Outputs	33.7	42.4	20.8	2.2	0.9
Impact	57.1	28.4	10.0	4.2	0.3
Environment	55.1	24.7	15.8	4.1	0.3

Summary of submissions

1. The UK continues to be a world leader in psychology, neuroscience and psychiatry. REF 2021 has demonstrated that researchers are generating novel insights into fundamental mechanisms that place the UK at the forefront of these disciplines. Its discoveries are reducing mortality, improving quality of life and creating wealth through impacts on policy, professional practice, legislation, physical and psychological health, education, industry and business, and public engagement. The submissions demonstrated benefits across local, national, international and global communities that reflect i) the exceptional calibre of the UK researchers who are driving new theory and methods, ii) the excellent research environments supported by institutions, ii) the support of funders sustaining research of outstanding quality, iv) the translational impetus that is extending across all fields, and v) the deeply embedded collaborations with stakeholders and international collaborators. A particular highlight was the mutually beneficial relationship with the NHS and with other health services extending across the full breadth of the submission. There was clear evidence of a further strengthening of the UK's world-leading position in developing and applying new research methods, techniques and analytics, leading to fundamental advances in molecular genetics, data-intensive fields including neuroimaging and neurophysiology, and population science.

2. There were 93 submissions to this unit of assessment (UOA), an increase of 11 from REF 2014. The submitted staff FTE (full-time equivalent) ranged from five to 380. Average FTE was 28 for the 75 units primarily focused on psychology and 169 for the nine with outputs spanning psychology, neuroscience and psychiatry. The large majority of overall research activity was assessed as either world-leading or internationally excellent. A third of the outputs were judged as world-leading and over half of the research environments as world-leading. Almost all of the impact case studies were considered to be of outstanding or very considerable reach and significance.

3. The headline statistics are:
   - UOA 4 received 93 submissions, 17 of which did not submit in REF 2014.
   - 9,774 outputs, 336 impact case studies, and 93 environment statements were assessed.
   - Submissions included 4,040 submitted staff (FTE), an increase of 60% from REF 2014.
   - 17% of staff submitted were early career researchers.
   - £2.7 billion of external funding was secured by submitted units.
4. The large majority of outputs were judged to be of predominantly world-leading and internationally excellent quality, with 34% rated four star and 42% rated three star (FTE-weighted values). Rigorous theory-led experimental research employing diverse and sophisticated quantitative and qualitative methodologies was seen to be flourishing across the UOA, with evidence in many fields that the UK is a world leader. The sub-panel welcomed the large numbers of outputs in fields directly addressing pressing societal needs: in clinical, developmental, forensic, health, social and occupational psychology, neuropsychology, psychiatry, and preclinical and clinical neuroscience. At the core of the submitted research is experimental research applying specialised methods to advance, refine and drive breakthroughs in understanding basic mechanisms, using cell and animal models as well as human participants. Individual differences approaches were widely applied in developmental, educational and organisational psychology, and qualitative approaches generated novel insights in diverse contexts from health settings and public spaces through to education and national security. Research with clinical populations was strongly represented across the UOA, and world-leading research was evident across psychiatry and clinical neurosciences in areas spanning from genetics and molecular sciences to population health and clinical trials. The sub-panel noted major advances in genetic and neuroimaging research that capitalised on UK Biobank and other population cohorts supported by UKRI and other funders.
5. Team science moved from strength to strength in this REF period through the creation and curation of larger and more representative datasets, national and international consortia, and the pooling of data from multiple sources. 11% of submitted outputs had 15 or more authors, with the majority judged to be world-leading. The sub-panel commended the exceptional UK strengths in the application of informatics to large datasets in order to identify new solutions to fundamental and translational issues at scale. Outstanding and often global benefits include the unravelling of nervous system function achieved by ground-breaking methodologies, generating discoveries of biomarkers for both rare and common diseases. These have in turn led to clinical trial readiness for interventions for common neurological disorders and evidence-based phenotyping and treatments of psychological and psychiatric disorders. Much of the submitted research combined multiple methodologies from both within and across the three core disciplines of the UOA. While this was often made possible by interdisciplinary groups working across institutions, the integration of multiple methodologies in many areas has now become the norm in many research groups. For example, bioinformatics, data science and computational techniques are now core parts of many sub-fields of neuroscience and psychiatry. Many outputs also arose from both continuing and new interdisciplinary collaborations with the physical sciences, social sciences and humanities.

6. The quality of the research infrastructure was noted as a critical element of much of the world-leading and internationally excellent research in this UOA. For the larger submitted units, a large proportion of outstanding research was made possible by leading-edge physical infrastructure and advanced methodological expertise. Key elements of the national infrastructure includes laboratory facilities supporting fundamental studies of experimental medicine and the study of human and animal behaviour; single cells and behaviourally-relevant circuitry; imaging of human brain function through a range of imaging technologies including MRI, MEG/ EEG, PET, mobile imaging technologies including fNIRs, and non-invasive rain stimulation; circuit modulation through optogenetics and chemogenetics in animal models; stem cell neuroscience; globally competitive strengths in neurogenetics and epigenetics. Significant elements of this work were supported by a network of excellent clinical trial centres benefitting from close interaction with the NHS Advanced expertise in computational modelling and machine learning now underpins research in many submissions, with particular strengths in the usage of large-scale health data. World-leading outputs were produced by submitted units of all sizes applying the methods and insights gained from research in psychology, psychiatry and neuroscience to benefit physical and mental health, and of practice and policy in legal, forensic, educational, leisure, workplace, environmental, and industrial contexts.
7. The total external funding for research for the UOA over the REF 2021 period was £2.7 billion. Major funders included UKRI, charities, the EU, and health research funding bodies. Income varied from project-level support to multi-million investment in multi-disciplinary collaborations addressing complex priority areas, typically in physical health and mental health and well-being. Of particular note were ground-breaking advances in the basic neuroscience of neurodegeneration made possible by large-scale investment by the Medical Research Council, the Alzheimer's Society and Alzheimer's Research UK in a multi-centre platform for dementia research. The sub-panel noted the very significant support for excellent researchers at all stages of their careers provided by the EU funding streams, and the need to ensure that the current level of world-leading research in this sector can be sustained in the event of reduced access to these schemes.
8. Research of the highest quality was common in units with coherent and realistic strategic visions supported by processes to achieve them – in recruitment strategies, support for people at all stages of their careers, in investment in necessary infrastructure, and in proactive approaches to delivering impact. Progress in achieving equality, diversity and inclusion (EDI) and excellent support for people at all stages of their careers was observed. In the most impressive environments, commitment to this agenda extended beyond gender to other protected characteristics and was demonstrated in the clarity of the narrative and setting of explicit targets and the monitoring of outcomes of strategic initiatives.
9. Outstanding impacts were demonstrated across diverse contexts including drug discovery and gene-based therapies, legislation, national and local government policies in multiple contexts including education, health and the criminal justice systems. A large proportion of impacts demonstrated international and in many instances global reach. The most successful case studies typically built on close partnerships between researchers and stakeholders extending from inception to impact. There was extensive evidence of mutually beneficial relationships with the NHS and health services, policy-makers in government departments and local authorities, practitioners within the health, education

and justice sectors, charities, and industry. The sub-panel commended the quality and diversity of impacts, ranging from initiatives addressing climate change and improving animal welfare through to digital aids designed to improve public understanding of psychological and psychiatric conditions. Impacts of exceptional therapeutic significance and international reach included new drug treatments and psychological therapies for psychological, psychiatric and neurological conditions, improved patient stratification at diagnosis, advances in treatment and management of stroke, gene therapy for eye disease, and successful clinical trials for genetic disorders.

Outputs

10. The 9,774 submitted outputs were assessed by the core sub-panel members and 12 output assessors selected to match the profile of research fields across the submission. Each output was scored independently by two assessors with relevant expertise, with final scores agreed through discussion. Consistency of scoring using the REF quality criteria was achieved by an initial calibration exercise and benchmarking across panel members across the assessment period. The fields with the highest numbers of submitted outputs were neuroscience (most notably, molecular and genetic neuroscience, neurology and neurophysiology); clinical, cognitive, developmental and social psychology; cognitive neuroscience; and psychiatry. Cross-referred outputs were assigned to one member each of the home and the advising sub-panel.
11. Research of world-leading excellence was found in all fields and the majority of submitted units. The overall quality of submitted outputs was very high, with over 75% (FTE-weighted) judged to be either world-leading or internationally excellent. Multi-method interdisciplinary work was the norm for many submitted units and a rich network of collaborations was evident across psychology, psychiatry and neuroscience. The integration of multiple methodologies within and across behavioural, qualitative, computational, clinical, genetic and neuroscientific approaches yielded much of the research judged to be world-leading. For example, computational neuroscience working in tandem with in vivo work to interrogate large data sets generated by neuroimaging and multi-array electrophysiology has transformed understanding of neural networks and generated novel insights into the effects of genetic variants on phenotypes from cognition and brain structure to hearing. Research of internationally excellent and world-leading quality was recognised in those review outputs (including meta-analyses and systematic reviews) that presented novel, testable theoretical models or made outstanding practical or methodological contributions to the literature.
12. The sub-panel commended the growth in research on under-researched groups, conditions and disorders in the submission, including populations at risk as a consequence of deprivation or marginalisation. It is hoped that this trend will continue in the coming period through increased representation and more culturally and geographically diverse researched groups, enhanced access to hard-to-reach groups, and greater prioritisation of research addressing inequalities relating to early life adversity, socio-economic status, ethnicity, and race.
13. Interdisciplinary research methods extending beyond the boundaries of this UOA were evident in collaborations with disciplines including electronic engineering, materials science, physics, linguistics, sociology and archaeology. For example, recent advances

in informatics have supported the use of machine learning to improve understanding and diagnoses of neurodevelopmental conditions and the application of bioinformatic approaches to large-scale genomic and epigenetic datasets coupled with health record data. Interdisciplinary approaches have been recruited to address challenges presented by technological change, such as understanding human cooperation when acting through autonomous machines by pooling insights from psychology, economics, and robotics.

14. Researchers from this UOA demonstrated international leadership in the development and widespread application of open science practices including data sharing, pre-registration and registered protocols alongside randomised control trial designs. Increased access to open data facilitated outputs testing the replicability of key findings, secondary data analysis, and meta-analyses pooling existing findings. The sub-panel welcomed the increasing use of Bayesian analyses for quantifying the quality of evidence and rigorous large-scale studies in which multiple labs collaborated to replicate key findings with high levels of statistical power and more diverse samples. While the quality of these outputs varied in their significance, the sub-panel was encouraged by the extent to which a range of open science practices were becoming standard in many areas. Transparent reporting practices such as ARRIVE for animal research and EQUATOR for psychology and health research were being increasingly adopted as markers of methodological rigour.
15. The UOA received a significant number of cross-referrals from other UOAs (405). These were mainly from UOA 17 (Business and Management Studies: 126), and UOA 3 (Allied Health Professionals, Dentistry, Nursing and Pharmacy: 123). There was a moderate number of outputs submitted to this UOA in areas falling outside of its scope leading to 160 cross-referrals from SP4 to other UOAs, predominantly to UOA 5(Biological Sciences: 62) and UOA 1 (Clinical Medicine: 46). The increased volume of cross-referrals may reflect reconfigurations of research groupings influencing the selection of UOAs by submitted units. The number of joint submissions was very small (2).

Impact

16. In total 336 case studies were assessed by groups of three panellists: two full panel members and one research user. User assessors were selected to cover the diverse range of expertise relevant to the impacts generated by this UOA, with backgrounds in industry, health and public sectors, animal welfare bodies and charitable organisations. A calibration exercise was undertaken prior to assessment to foster common approaches and classification criteria across assessors, with further benchmarking and moderation by the sub-panel executive following initial scoring to ensure consistency across multiple assessor groups. Panel-wide discussions were undertaken to ensure parity in scoring.
17. Impact cases that were most highly rated i) described specific links between the underpinning research and resulting impact, distinguishing the impact of the submitted unit from other teams where relevant; ii) supported clearly-stated impact claims with verifiable evidence, and iii) presented impact with impressive reach and significance. The sub-panel considered that case studies judged to have weaker levels of impact would often have benefitted from a more robust evidence base to support claims of significance and a clearer narrative structure.

18. Case studies described impacts that spanned the breadth of the UOA. The large majority of cases demonstrated impact considered to be either outstanding (57%) or very considerable (28%) in its reach and significance (FTE-weighted values). Substantial proportions of outstanding impacts were noted across submitting units of all sizes. Across many areas, qualitative research played a key role in guiding understanding of core issues that formed the basis for well-evidenced impacts. The sub-panel welcomed the ingenuity of many of the translations of research into practice, the international reach of the beneficiaries, the extent to which stakeholder engagement extended through all stages of the projects through to the evaluation of impact, the degree of co-production between academics, service providers and service users, and the value of interdisciplinary collaboration and team-based working present in most of the outstanding impact cases. Stakeholder partners included policy-makers in NHS, government departments or local authorities, practitioners within the health, education and justice sectors, charities and a wide range of other third-sector organisations, and in business and industry including HEI spin-out companies. The sub-panel was impressed by proportion and diversity of impact cases studies that demonstrated benefits on an international and sometimes global scale.

19. Impact highlights included interventions in a range of clinical conditions and at-risk populations across the UOA. A diverse range of new interventions were built on outstanding underpinning research and robust clinical trials to improve quality of life and to reduce symptoms and mortality. World-leading impact cases have transformed the clinical management of stroke achieving significant reductions both in mortality and in secondary prevention in areas such as thrombectomy for large vessel stroke. Advances of global significance have also been made in clinical support for motor neurone disease, migraine, multiple sclerosis, epilepsy and a range of single-gene disorders. The UK is also now a world leader in the development of gene- and cell-based therapy for eye disease. Enhanced treatments and support were established for individuals with common neurodevelopmental conditions including ADHD and autism. Improved mental health and well-being resulted from psychological therapies including modified forms of cognitive behavioural therapy and mindfulness training to address a wide range of conditions such as multiple forms of depression, anxiety, psychosis, eating disorders, and fire-setting behavior, and for individuals with cystic fibrosis, tinnitus, and those experiencing menopause. Tailored psychological approaches improved mental health for different groups including carers living in challenging circumstances. Major advances were evident in preventing suicide in vulnerable populations. Outstanding impacts were seen in improving healthcare services and treatments for mental health problems and addictions. Of particular note were interventions and support for groups at high-risk of mental health problems and work improving physical healthcare for individuals with mental health conditions and learning disabilities.

20. Impacts generated substantial economic benefits for UK, international and global markets. Health economic analyses indicate current and ongoing savings of many billions of pounds in the areas of physical health, mental health and well-being to the NHS and other health providers. Notable examples are new treatment approaches for neurological conditions including stroke, hypoxia, migraine and multiple sclerosis, development of early screening tools for dementia, and the roll out of modified psychological therapies at scales that can address population needs. Impact cases contributed to the very substantial market values of pharmaceutical and other industries of manufacturing, and generated commercial wealth through its wide-ranging contributions to product design and advertising.

21. The sub-panel commended the breadth of impacts on policy and legislation. Highlights include NICE and practitioner guidelines for a wide range of psychological, psychiatric and neurological conditions, and in education through policies and new approaches to improve literacy, social mobility and children's learning and well-being. Impact cases were shown to benefit environmental conservation and improve animal welfare. Research on human performance and perception led to practical advances in areas that include the security of currency, identification at border control, the management of visual stress through environment modification, and driver safety. Methods from social psychology changed behavior in multiple contexts.
22. Much of the funding support for larger-scale impact studies was provided by UKRI, research charities, the health sector, and industry. The sub-panel also noted that many successful cases were primarily resourced by institutional support for research staff through protected time and small-scale funding, or from research partners who were beneficiaries of the impact.
23. Disruptions due to the Covid-19 pandemic in the final year of the REF 2021 period were reported for 12% of the case studies. These most commonly arose from delays in the collection of data to demonstrate impact, the rollout of impact-based policies, interventions and training activities, and anticipated legislative changes arising from the case study. The pandemic also limited the capacity of stakeholders to engage in impact activities, and reduced engagement of participants in person and online training sessions. The sub-panel took account of these circumstances in assessing the impact cases.

Research environment

24. Each submitted environment template was assessed by groups of three full panel members with balanced expertise within the UOA. A calibration exercise and moderation of scores by the sub-panel executive was undertaken to ensure consistency across assessment groups and adherence to REF quality criteria.
25. The sub-panel observed exceptional strengths in the research environments of the submitted units, with a large proportion of the submitted units judged to be conducive to producing research of world-leading quality in terms of its vitality and sustainability. There was evidence for international excellence in individual elements of the research environments of 75% of units. High-scoring submissions presented clear narratives describing ambitious but realistic research visions, the strategies and specific plans for achieving them, and coherent, sustainable research groupings. The sub-panel noted that in many areas of the UOA, high-cost equipment required the technical support that underpins internationally excellent research. The co-investment by HEIs was considered to be a key pillar of high-quality UK research in resource-demanding fields of research particularly, although by no means exclusively, in neuroscience. The sub-panel found evidence for high levels of research excellence in units of all sizes with coherent and compelling research strategies alongside enabling leadership, processes and cultures.
26. Very considerable progress in supporting people and promoting equality, diversity and inclusion in this REF period was evident. The strongest submissions outlined processes and initiatives to support people that were reinforced by data and outcome monitoring. Demonstrations of good practice included evidence for positive outcomes such as a reduced gender pay gap, engagement with barriers faced by individuals

with other protected characteristics including race and disability and engagement with LGBTQ+ issues, the integration of annual appraisal and access to mentoring schemes for postgraduate research students and mid-career staff in addition to early career researchers, and increased transparency of promotion procedures and criteria. Highlights across submissions included workshops and mentoring to prepare staff from diverse backgrounds for promotion, specialist agency support for recruitment of more Black, Asian and Minority Ethic (BAME) staff, a mentoring scheme to guide BAME staff in progression to professorships, workshops on trans awareness, a policy for supporting the impacts of menopause, and a support group for mid-career staff. The sub-panel hopes in the future to see wider involvement of submitted units in a broad range of initiatives to improve inclusivity supported by the use of data to monitor outcomes.

27. The sub-panel welcomed the introduction and development of open science practices in many submitting units across this REF period, a process that is expected to continue over the coming period in the light of initiatives by UKRI and other research funders for its support. Researchers in this UOA are encouraged to embed open science practices within their research strategies and to quantify and demonstrate the engagement and success of these activities. Coupled with rigorous review, these endeavours will improve the quality of the evidence base on which its fields are built, increase public confidence in psychology, psychiatry and neuroscience, and propel impacts to policy and practice arising from robust research findings. Submitted units have a key leadership role to play in promoting open research cultures in terms of leadership and incorporating incentives into career rewards and progression.

28. Over 10,000 research doctoral degrees were awarded across the REF period, with consistent levels of postgraduate recruitment maintained. Access to funded studentships varied widely across the UOA, with greater numbers of nationally and internationally-funded studentships in laboratory sciences. Smaller submitted units often had greater proportions of part-time and self-funded students. Postgraduate training provision and more general support for students through mentoring and other support mechanisms was generally seen to be of a high quality. Smaller units without the infrastructure for highly-specialist training were observed to benefit from cross-institutional collaboration, engagement in consortia, or regional training networks. The sub-panel noted that annual student satisfaction data provided a valuable source of evidence for the effectiveness of postgraduate support but were reported in only a minority of submissions.

29. Total external research income in REF 2021 was £2.7 billion, which shows a 48% increase in annual funding from REF 2014 (the increase quoted does not include any adjustment for inflation or differing assessment period). The major funders were UKRI research councils including MRC, ESRC and EPSRC (28%), UK charities including Wellcome (26%), the EU (10%), UK government bodies/ local authorities health and hospital authorities (10%) and health research funding bodies including the NIHR and the devolved administrations in Scotland, Wales and Northern Ireland (9%). In the strongest submissions, targeted investment by home institutions was aligned to research strategy at both the unit and institutional level. The sub-panel noted that a hallmark of world-leading research excellence in the medium- and larger- sized units was success in securing programme-level funding for substantial research groups. Institutional investment aligned with strategic priorities contributed very significantly to the vitality and sustainability of research of the highest quality. The sub-panel highlighted the value

of national investment in the cutting-edge infrastructure such as UK Biobank and the UK Dementia Research Institute, which have already generated world-leading research in genetics and neurodegeneration. The sub-panel noted that as it will take many years yet before the full translational potential of funding for these common, complex conditions will be realised, continued investment will be needed to sustain UK's premier research position across the coming period. The need for investment in cohorts with representative, hard-to reach populations such as those with severe mental disorders was also noted.

Table 12: UOA 4 External research income by funder source

UOA 4: Research income source	Research income (£ million)	Proportion of total income
UK-based charities (open competitive process)	757	28.3%
BEIS Research Councils, The Royal Society, British Academy and The Royal Society of Edinburgh	694	25.9%
UK central government bodies/ local authorities, health and hospital authorities	280	10.4%
Health research funding bodies	278	10.4%
EU government bodies	231	8.6%
UK industry, commerce and public corporations	77	2.9%
UK-based charities (other)	75	2.8%
Non-EU-based charities (open competitive process)	64	2.4%
Non-EU industry commerce and public corporations	55	2.0%
Non-EU other	53	2.0%
EU industry, commerce and public corporations	31	1.1%
UK central government tax credits for research and development expenditure	31	1.1%
UK other sources	30	1.1%
EU (excluding UK) other	14	0.5%
EU-based charities (open competitive process)	8	0.3%
Total	**2,678**	

30. National and international academic collaborations were evident in the majority of submissions, with key leadership roles in international organisations and consortia a common feature of the strongest units. The sub-panel welcomed the networks of links with local and national partners in sectors including health, education and the justice system and the roles they played in enabling research and its impact in many submissions.

UOA 5 Biological Sciences

Summary of submissions

Average quality profiles (FTE-weighted) for the UOA

Profile type	% 4*	% 3*	% 2*	% 1*	% Unclassified
Overall quality	48	41	10	1	0
Outputs	45.1	41.7	12.3	0.5	0.4
Impact	50.0	42.6	7.0	0.4	0
Environment	58.2	34.9	5.8	1.1	0

1. The unit of assessment (UOA) received 42 submissions from English (38), Scottish (5) and Welsh (1) institutions. There were no multiple submissions requested (in line with the Panel criteria and working methods) and one submission jointly made by three institutions. This means that in total, 44 institutions were involved in submissions to UOA 5. This includes 39 institutions which submitted to UOA 5 in REF 2014 and five institutions that made their first submission to this UOA in REF 2021 (one as part of the joint submission). The size of staff submissions ranged from 9.00 to 308.94 FTE, with the mean submission size of 68.26. These figures indicate an increase in comparison to REF 2014, where the average staff submission size was 40.9 FTE. The total FTE submitted to REF 2021 was 2,866.69 compared to 2,373.33 submitted to REF 2014. However, due to the changes to criteria for eligibility between the two assessment exercises, this data cannot be conclusively interpreted as indicating any change to in staff FTE working in biological sciences within the sector.

Outputs

2. The submissions to the UOA included 7,108 outputs, all of which were assessed according to the published criteria. Each output was assessed by two panellists, selected on the basis of their relevant expertise. Each HEI submission was assessed by several different pairs of panellists. The primary aim in allocation of outputs was to ensure expert review, but also to ensure that a single HEI submission was not exposed to unconscious bias by being the focus of a narrow sub-group of panellists. As a result of this allocation, the average proportion of a submission's output that was assessed by any sub-panel member was 10% (median 9%). The highest proportion was 25%; only in cases where combinations of submission size, research specialism and/or conflicts prevented a wider allocation of outputs. Information provided on citations informed the assessment process and was always used positively and in line with the published criteria; citation rates were always compared to standard discipline data provided to the sub-panel. There was no consideration given to journal impact factors and the authors' contributions were assessed in accordance with the REF 2021 guidelines.

3. The sub-panel had appropriate expertise to assess the vast majority of the outputs. However, there were a small proportion of outputs (2.5%) where expert advice was sought from other sub-panels through cross-referral. A proportion were cross-referred to Social sciences panels, particularly sub-panel 14 - Geography and Environmental Studies, with the remainder were equally split between Physical sciences, engineering and mathematics panels and other Medicine, health and life sciences panels (especially Chemistry and Clinical Medicine). No outputs were cross-referred to Arts and humanities sub-panels. Of the outputs where cross-referral was requested by the submitting institution, this was undertaken except in a very small number of cases, where either it was determined that the sub-panel had the relevant expertise to be able to make an assessment without cross-referral, or a more appropriate sub-panel was selected. The sub-panel also received a substantial number (552) of cross referrals from an equally wide range of sub-panels, suggesting that much mainstream biology was submitted elsewhere. This indicates the extent to which biological sciences skills and technology and discovery science underpins work in many other disciplines.
4. There was a very high quality of outputs with 45% being assessed as world-leading and 41% internationally excellent (FTE-weighted figures). Less than 1% of outputs were assessed to fall below the quality level of 'recognised internationally'. This reflects that the overall quality of UK research in the biological sciences submitted to REF 2021 is very high. There were significant differences between submissions with regard to the percentage of world-leading and internationally excellent outputs; but it is nevertheless remarkable that every submission contained internationally excellent outputs and the majority had world-leading outputs. Significantly, world-leading research outputs were found in all areas of biology including biochemistry, biomedical science, cell and molecular biology, conservation science, developmental biology, ecology, evolution, environmental biology, genetics, immunology and infection, microbiology, neuroscience, plant biology, pharmacology, physiology, structural biology, systems biology and zoology. Importantly, the review of outputs indicated that interdisciplinary research is firmly embedded across the full spectrum of the biological sciences and this was reflected in the many examples of team science seen in the outputs. The sub-panel noted positively that many outputs used multiple approaches from across biology and beyond.

Impacts

5. The sub-panel evaluated 210 impact case studies covering a wide range of impacts from across the whole spectrum of the biological sciences, including, for example, biochemical and molecular studies of both animals and plant systems, immunology, animal behaviour as well as biodiversity and ecology. At least three panellists reviewed each case study, with each trio conducting in-depth discussions as part of the evaluation process. The assessment was informed by calibration exercises and constant discussion to sustain effective calibration. Panellists agreed a single score for each impact case study and those that were judged to be on the borderline between two of the starred quality levels were assigned a midpoint grade (3.5, 2.5, 1.5 or 0.5). Where this occurred, half of the grade was assigned to each of the two starred quality levels that the midpoint grade fell between.
6. The quality of the impacts was very high, 50% of impacts were judged to be outstanding and a further 42% as very considerable in terms of reach and significance (FTE-weighted figures). As with outputs, impacts of very considerable reach and significance were found

in virtually all HEIs and the majority of the submissions contained outstanding impact case studies. This demonstrates that a very substantial amount of research in the biological sciences, spread across a large number of institutions, has delivered tangible real-world benefits outside academia, both nationally and internationally.

6. The impacts delivered were diverse, many of them relating to improving human, animal and plant health, international development and the environment. There were many examples of basic biochemical and molecular research resulting in the establishment of successful spin-out companies dealing with drug discovery. There were also examples of the development of diagnostic tools for human or animal disease and good examples of impacts from plant science. There were many case studies of drug discovery involving industry collaboration and these provide exemplars of how the high quality of biological science in the UK is a mechanism to attract industrial investment in the UK. Many of the impacts demonstrated clear economic benefits to local communities as well as further reach to national and international industries and communities. The sub-panel recognised the value of these local impacts, particularly around job creation in relatively deprived areas. There were a number of outstanding examples of how biological sciences research has informed conservation policy to protect endangered species or ecosystems, both in the UK and around the world. The sub-panel were impressed with the clear evidence that pathways of translation of basic discovery science for impact are now embedded in UK HEIs. The data show unequivocally how investments in high quality discovery science and science infrastructure ensures the delivery of economic and societal impacts.

Research environment

7. The submissions to the UOA gave a very positive view of the overall research environment in UK higher education institutions. Overall, 58% of research environments were assessed as world-leading, with a further 35% judged to be internationally excellent (FTE- weighted figures). Each element of individual environment statements was scored separately, with the majority of institutions having at least elements of their environment assessed as internationally excellent. The sub-panel viewed positively the number of Biological Sciences early career researchers (ECRs) involved in submissions and also noted the health of doctoral training programs. The sub-panel noted the importance of independent research fellowship schemes, both externally funded or funded by HEIs, to the career development of many ECRs. Collectively, submitting institutions awarded a total of 9,305 doctoral degrees during the REF 2021 assessment period.

8. The sub-panel were very encouraged that all submissions gave significant attention to issues of equality and diversity and research integrity, with the majority of institutions working with external accreditation organisations such as Athena Swan and the Race Equality Charter. However, the sub-panel also noted that the minimum accreditation levels provided by these charters alone are not distinguishing features of a high-quality research environment. Indeed, there was recognition in all submissions of the imperative to improve the diversity of staff in all aspects and evidence of work to reduce and remove institutional and cultural barriers that prevent the progression of individuals on the basis of gender, ethnicity and other protected characteristics. Many submitted units discussed examples of how to recognise and support staff at critical career transition points and how to support the professional development of individuals with primary carer responsibilities.

Table 13: UOA 5 External research income by funder source

UOA 5: Research income source	Research income (£ million)	Proportion of total income
UK-based charities (open competitive process)	1,447	36.8%
BEIS Research Councils, The Royal Society, British Academy and The Royal Society of Edinburgh	1,432	36.5%
UK central government bodies/ local authorities, health and hospital authorities	383	9.7%
Health research funding bodies	101	2.6%
EU government bodies	96	2.4%
UK industry, commerce and public corporations	92	2.3%
UK-based charities (other)	82	2.1%
Non-EU-based charities (open competitive process)	80	2.0%
Non-EU industry commerce and public corporations	68	1.7%
Non-EU other	66	1.7%
EU industry, commerce and public corporations	31	0.8%
UK central government tax credits for research and development expenditure	17	0.4%
UK other sources	15	0.4%
EU (excluding UK) other	12	0.3%
EU-based charities (open competitive process)	7	0.2%
Total	**3,928**	

9. The quality of the research environment is critically dependent on funding. The standard data analysis for the unit of assessment illustrated that external grant income for the discipline has marginally increased, but not at a level that maintains pace with inflation. In particular, funding from UK Research Councils, which accounts for approximately 40% of the research income has been flat during the REF period. UK- based charities were very important providers of research grants for the biological sciences sector, providing funding that was effectively equivalent in value to the funding from UK Research Councils. There was also a significant amount of funding for biological sciences provided by the EU. The changes to the political landscape (Brexit) and the economic impacts of the Covid-19 pandemic on charity funding raise concerns about the sustainability of funding for these research environments. The sub-panel noted that all submitted units indicated strong

international collaborative networks, an indicator that the ability to attract, and engage with, the best scientists worldwide is an important success factor in the UK's outstanding research performance in biological sciences. In order to sustain this, it is important that there are policies in place that ensure that there are no barriers to such international collaborations, with freedom of movement for all scientists critical. Institutions demonstrated a clear commitment to promoting interdisciplinary academic activities that aim to tackle the barriers between the physical, computational, biological and clinical sciences and embed a culture of innovation and translation among biological scientists. In order to sustain this, it is important that there are funding streams in place to support these initiatives and to support the infrastructure needs of biological sciences research more broadly.

10. In summary, the data and evidence presented to the sub-panel indicates that the biological sciences sector has produced outstanding world-leading science during the REF 2021 period, that has produced very significant benefits for the UK and global economy and society.

UOA 6: Agriculture, Food and Veterinary Sciences

Summary of Submissions

Average quality profiles (FTE-weighted) for the UOA

Profile type	% 4*	% 3*	% 2*	% 1*	% Unclassified
Overall quality	40	46	12	1	1
Outputs	29.5	52.4	16.0	1.4	0.7
Impact	56.6	33.4	7.8	1.6	0.6
Environment	56.2	39.1	4.4	0.3	0

Key messages

1. Research in unit of assessment (UOA) 6 is of immense national strategic importance in a wide variety of areas of societal need. It is imperative that the global food insecurity crisis is addressed in the face of the demands of a burgeoning world population, environmental change, biodiversity loss, the climate crisis and considerable geopolitical upheaval. The recent conflict in Eastern Europe highlights the vulnerability of global food systems.
2. There was evidence that many research outputs were combining disciplinary research to create new conceptual, theoretical, methodological, and translational innovations which focused on specific challenges or issues to promote both interdisciplinary and transdisciplinary working in areas directly relevant to UOA 6. These included improved food security and understanding of AgriFood systems. The recognition of the requirement for increased interdisciplinarity was addressed in a number of institutional research strategies and structures.
3. The strategies of a number of institutions encompassed system-level interdisciplinary approaches to address challenges to the sustainability of food systems. Advances need collaboration between natural, social, and economic sciences, as well as with the arts and humanities; to elucidate the interactions from the agri-environment, through to consumer behaviour, and human health and well-being. The required collaborations and strategies are being encouraged by recent funding initiatives, such that the UK is well placed to lead on impactful systems-level research. This current UKRI agenda has a strong focus on food systems and achieving net zero for agri-food, particularly in primary production, and we expect to see this reflected in the next REF with a strong focus on interdisciplinarity.
4. In the agricultural sciences there was strong evidence of the leading role that the UK holds in understanding the molecular and physiological bases of yield, quality and resilience in the farmed species and their close relatives. Highly regarded work linked genetic, biochemical, and cellular studies to the performance of whole organisms,

crops, and/or populations. In addition, the UK provided significant understanding of the underpinning ecology of agri-environments.

5. In the veterinary sciences, research contributes to the food security agenda, as well as contributing widely to the prevention and management of infectious diseases, animal welfare, advancing clinical care and management of all species including companion animals and animals used for sporting disciplines. As in REF 2014 a considerable number of the outputs returned were related to either 'one health' or 'underpinning biosciences for health' with an emphasis of the latter often related to human rather than animal health. These two strategic areas provided a key focus for a number of the larger and better performing submissions with many outputs returned in this area being frequently world leading in quality.
6. In the food sciences, the number of food-related outputs submitted was low in comparison to the submissions relating to agriculture and veterinary sciences, and may mark a decline in the number of academics working in the discipline. The strengths observed were around the challenges to the integrity of food supply chains in terms of contamination linked to climate change, and fraud in complex supply chains. The outputs submitted on food web contamination due to micro and nano plastics were also impressive and world leading. There were also a number of very strong outputs relating to clinical trials in human nutrition. It was surprising that with the growing trend towards less meat-based diets, the importance of ensuring healthy nutrition as well as a sustainable food system was not covered to any great extent.
7. The role of this UOA in advancing both human and planetary health is to be celebrated. In addition to above, a considerable volume of the submissions were related to the control of zoonoses, including Covid-19, and to the suppression of antimicrobial drug resistance, underpinning biosciences to improve human health, human nutrition, and the wider role of food systems to impact on issues such as the environment, ecosystems and global warming. There is a need to promote research and innovation to support the UK and global food system; food and drink is the biggest manufacturing sector in the country, accounting for 20% of total UK manufacturing (IGD, December 2020). 71% of UK land area was used for agricultural production, but the UK still imports 46% of the food it consumes (UK Food Security Report, Defra, 2021). Modelling by the Met Office indicates significant future risks to UK food production from heat stress to livestock, drought, pests and pathogens, and increased soil erosion risks, all of which should be directly addressed by research in UOA 6.

Headline statistics:

- 24 submissions were made to UOA 6 from 25 institutions and included 1 joint submission, compared to 29 institutions in REF 2014. There were no multiple submissions.
- There were 1,398 FTE staff submitted, of which 251 were ECRs (16.8%), who were responsible for 3,430 outputs, nearly all of which were journal articles. 86% of the outputs (FTE-weighted) were judged to be internationally excellent or world leading.
- Submissions varied in size from 6.6 FTE staff to 256.8 FTE staff
- Units submitted to UOA 6 had a total research income of £1,133 million over the REF assessment period, with an additional £4.3 million of income in-kind. For research

income 41% came from research councils (UKRI), 11.5% from charities, 19.1% from central government bodies, local authorities, health and hospital authorities, 10.5% EU government and 7.0% from UK industry

- 108 impact case studies were assessed with 90% judged to be outstanding or very considerable in terms of their reach and significance (FTE-weighted)
- 2,904 doctoral degrees were awarded, representing 2.08 per FTE staff member returned.

8. The quality and range of 108 impact case studies submitted to the sub-panel was impressive with 90% rated as outstanding or very considerable in terms of their reach and significance (FTE-weighted). There was evidence that the contribution of the UOA to developing novel approaches, changing policy and developing commercial products and companies was considerable. The sub-panel noted that studies where the impact was realised in low and middle income countries (LMIC) were particularly strong. There was substantial evidence within their environment statements of institutions investing in strategies to develop impact and foster a culture of translational research. There is significant vision and strategy within submitted units to further develop the impact agenda, particularly with regards to the food systems agenda where a wide inter and transdisciplinary approach is required.
9. There is much to celebrate with the outcomes of UOA 6:
    - There was an increase in research income over the REF period with the funding being £1,133 million in comparison to £670 million in 2014 and £468 million in 2008. This is a 21% increase in research income with the different lengths of assessment periods bring taken into account (the increase quoted does not include any adjustment for inflation)
    - There was a significant increase in postgraduate numbers from 1,765 in 2014, to 2,904 in 2021, a 17% increase when the different lengths of assessment periods are taken into account
    - The proportion of ECRs remained healthy with 16.8% of submitted staff returned being ECRs
10. Despite the number of positive areas are areas of concern that need to be highlighted:
    - The quality profile for UOA 6 demonstrated a lower proportion of four star outputs than other UOAs in Main Panel A. Similarly, the overall profile for four star in UOA 6 was significantly lower than clinically orientated sub-panels in Main Panel A. This raises issues about the continuing ability of researchers in this area to maintain their world leading position with respect to quality.
    - UOA 6 continues to be smallest of the six units returned within Main Panel A, both in terms of FTE and the number of institutions that submit to the sub-panel. The scale of research in this UOA is small compared to many other disciplines, although essential to support global food production and environmental sustainability.
    - hilst ECR numbers were healthy (16.8%) there was considerable disparity across unit of submissions; 7/24 institutions had <10% of their submitted staff return including ECRs. All the returns which contained a veterinary school had a higher percentage of ECRs returned than the mean for the UOA. This disparity in ECR numbers will reflect many factors, but raises issues around sustainability and vitality of some of the non-veterinary focussed research units returned in UOA 6.

Outputs

11. Considering conflicts of interest and subject-matter expertise, all research outputs were allocated to and assessed by at least two panellists; one specialist and one more generalist reviewer. An additional reviewer was involved where the initial scoring pair could not readily concur, or where another reviewer was considered to have relevant expertise. 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.
12. The in-depth discussions between assessors meant that the sub-panel members found it straightforward to assess the outputs in the submission and were confident in their conclusions. Where outputs were found to lie outside the expertise of the sub-panel, advice was sought from other sub-panels (2% of outputs were cross referred out). Panellists also provided advice on a significant number of incoming cross-referred outputs that had been submitted to other sub-panels.
13. The sub-panel members assessed 3,430 research outputs from across all areas within the disciplines submitted to this UOA with 81.9% of the research outputs submitted to this UOA being judged internationally excellent or world-leading (FTE-weighted).
14. HEIs were invited to flag outputs that they classified as interdisciplinary research (IDR) in their submissions. The sub-panel assessors found that the approach to this had been variable, with a small number (11/24) of institutions identifying IDR outputs through the flagging system. A large number of outputs that were not classed as IDR by the HEI were, on assessment, identified as such by sub-panel members. All outputs that were identified to be IDR through either HEI flagging, or through sub-panel assessment were treated identically and were subject to either cross referral or joint assessment if the sub-panel lacked expertise in any of the disciplines in the output.
15. Information provided on citations informed the assessment process and was always used positively and in line with the published criteria; citation rates were always compared to standard discipline data provided to the sub-panel. There was no consideration given to journal impact factors and the authors' contributions were assessed in accordance with the REF 2021 guidelines.
16. The sub-panel noted that a range of outputs on a broad range of subject areas were returned to the sub-panel including a significant number of outputs which were relevant to UOAs 1, 2 and 5 as well as panels contained within Main Panel B.
17. The sub-panel noted that a large proportion of four star outputs tended to be, but were not exclusively, linked to those research institutions which scored highly in environment. These institutions with world-leading research environments had excellent infrastructure, culture, ability to attract high class staff, and greater opportunities for interdisciplinary working.
18. An area of strength was 'biosciences underpinning health'. The sub-panel received many world-leading outputs in the fields of biochemistry and cell biology, as well as fundamental mechanistic biosciences. Many such papers were multidisciplinary and used multiple techniques including -omic approaches and model species. A number of these outputs had subject matters relating to problems of human health rather than animal or plant health.
19. A further area of strength was in the field of infectious diseases research. Whilst the sub-panel noted strength across this discipline, the use of mathematical modelling approaches relating to infectious disease research was particularly strong. The sub-

panel noted the world-leading rigour of a significant number of mathematical-modelling outputs, which often involved development of novel methodologies and their use on diseases of national and international importance affecting both humans and animals.

20. In the veterinary research area there was evidence of a more systematic use of larger clinical caseloads to inform clinical research questions which is to be celebrated. There was evidence of world-leading or internationally excellent clinical veterinary research, but some outputs did not achieve the highest scores due to deficiencies in various aspects of rigour and study design. We would hope that in the next REF these positive developments in study design for veterinary clinical research studies will continue.
21. The sub-panel noted that a large number of outputs which were rated as world-leading in quality were returned by several different institutions and were often papers with a large numbers of authors.
22. Whilst many of the world leading outputs in the agricultural sciences related to molecular biology and genomics, as well as ecology there were fewer outputs relating to the multi-disciplinary enviro- agri-food system arenas. There are several potential explanations for this disparity:
    - It is acknowledged that research from recent funding initiatives in under-represented systems research requires more time to allow new understanding to be fully reflected in outputs.
    - Institutions may have prioritised submission of more genetic, molecular, and mechanistic science.
    - Many outputs relating to enviro-agri-food systems may have been returned to other sub-panels (for instance UOA 5, 7 and 16). For example, we received few outputs relating to agricultural and food economics, which was identified as an area of strength in REF 2014.
    - Overall, the sub-panel would have welcomed more submissions concerning the interplay of economic, social, and environmental sciences to improve the sustainability of food systems.

Impact

23. Considering conflicts of interest and subject-matter expertise, impact case studies were randomly allocated and assessed by at least three panellists, including a user assessor. Panellists scored using a nine-point scale (1.0, 1.5, 2.0, 2.5 etc.). The rigorous calibration exercise undertaken at the start of the process initiated robust discussion that was highly productive in establishing common views on quality; a further calibration occurred before scoring was finalised. The involvement of user assessors, was valuable in providing exceedingly helpful perspectives and insights. These deliberations, alongside in-depth discussions between assessors on each case study, meant that the panellists were able to assess the impact elements of the submission, and were confident in their conclusions.
24. Most submissions presented well-evidenced impact case studies. 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 governments, policy makers, industry, and the voluntary sector. The sub-panel also noted that there a large number of case studies where the impact was rated as outstanding in terms of reach and significance related to impact in LMIC

25. The quality of the case studies was very high, with 56.6% judged to be outstanding impacts (four star) and a further 33.4% very considerable impacts (three star) in terms of their reach and significance. Only a small minority (2.2%) were assessed as having had less than considerable impact.

26. The sub-panel noted that the underpinning research in some of the outstanding impact case studies was frequently either two star or three star in quality. The sub-panel commented that institutions should value research which can lead to outstanding impact where the underpinning outputs may not always be of the highest quality.

Research environment

27. Four panellists assessed each environment template. Conflicts of interest were considered when environment templates were randomly allocated. Panellists scored using a nine-point scale (1.0,1.5, 2.0 etc.). The rigorous calibration exercise undertaken at the start of the process initiated robust discussion that was highly productive in establishing common views.

28. The panellists were impressed that 95% (FTE-weighted) of the environments reviewed were conducive to producing research of world-leading or internationally excellent quality, in terms of its vitality and sustainability.

29. Panellists 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/doctoral colleges, and great diligence in managing the research student trajectory. The 2,904 doctoral awards recorded in the UOA 6 submission for REF 2021 compared favourably with the 1,765 recorded for REF 2014. This is a 17% increase once the differing time periods are taken into account.

30. There was strong evidence of involvement in multi-institutional doctoral training partnerships funded by either UKRI or biomedical research charities. These training partnerships tended to be held within the larger institutions and were often focussed onto problems around biomedical sciences or food systems. It was recognised that some of the smaller institutions were not involved in such training partnerships and there were areas, particularly around agriculture, where doctoral training appeared to be less well supported.

31. The sub-panel noted that some significant areas of research received considerable support from the European Union. It was noted that 11% of the research income within the submission was received from the EU, and that much of this was in the agricultural/ plant and food systems areas. The potential loss of such investment was seen as a key risk to this research area.

Table 14: UOA 6 External research income by funder source

UOA 6: Research income source	Research income (£ million)	Proportion of total income
UK-based charities (open competitive process)	464	40.9%
BEIS Research Councils, The Royal Society, British Academy and The Royal Society of Edinburgh	210	18.5%
UK central government bodies/ local authorities, health and hospital authorities	119	10.5%
Health research funding bodies	80	7.0%
EU government bodies	76	6.7%
UK industry, commerce and public corporations	43	3.8%
UK-based charities (other)	33	2.9%
Non-EU-based charities (open competitive process)	31	2.8%
Non-EU industry commerce and public corporations	22	1.9%
Non-EU other	18	1.6%
EU industry, commerce and public corporations	14	1.2%
UK central government tax credits for research and development expenditure	10	0.9%
UK other sources	7	0.6%
EU (excluding UK) other	6	0.5%
EU-based charities (open competitive process)	1	0.1%
Total	**1,133**	

32. Several well performing submissions had extensive programmes in LMIC, which were central to their strategies and had received significant funding from the Global Challenges Research Fund. The recent cuts to the ODA budget in 2021 was seen as a risk to this research area, specifically as the sub-panel noted that impact case studies relating to LMICs often performed well.

33. Several of the larger submissions which scored highly on all three aspects of the REF 2021 exercise had one health as a key strategic aim. A focus on both one health and comparative biomedical science (where often the aim is improving human rather than animal health) was a key feature of a number of the better performing institutions.

34. The sub-panel noted positive efforts in a number of the veterinary institutions in developing research career opportunities for veterinary clinicians.

35. It was noted that most environment statements in the people section demonstrated progress on the equality and diversity agenda, with some submitting institutions actively broadening inclusivity beyond gender and their Athena Swan accreditation. EDI issues linked to other protected characteristics, as well as broader dimensions of diversity, which potentially result in socio-economic disadvantages were, in some HEIs, addressed through structural institutional changes, with success being measured using appropriate KPIs.

Annex 1: Report of the international members of Main Panel A REF 2021

International members

Professor Garret FitzGerald, University of Pennsylvania, USA

Professor Jack Gauldie, McMaster University, Canada

Professor Anthony Hickey, RTI International, USA

Professor Dermot Kelleher, University of British Columbia, Canada

Professor Richard Oliver, Curtin University, Australia

Summary of findings

1. The international members of Main Panel A participated fully in the REF 2021 exercise despite the challenges brought about by distance and exacerbated by Covid-19. All international members attended most Main Panel A meetings and individual members also attended the sub-panel meetings.

2. The international members are unanimous in congratulating the REF secretariat, other Main Panel A members, and sub-panel members for the extraordinary diligence and rigour applied to the entire process. The exercise was thorough and fair.

3. The results of the exercise demonstrate the very high overall quality, breadth, and impact of research in the health and life sciences carried out in UK HEIs. Notable features of the submissions were the growing extent of multidisciplinarity and the very high level of collaboration between different UK HEIs, other UK research institutes and internationally.

Overview of the process

4. It is obvious that the Covid-19 pandemic had a major impact on the operation and timeframe of REF 2021. Despite the various restrictions and lockdowns, the exercise was completed successfully and represents a monumental achievement for all members of the review panels, for the activity of the Main Panel, A and for the outstanding work of the staff and UKRI representatives. Overall, it is seen as an excellent example of fair evaluation, with constant attention to bias and conflicts, and seeming to find the best and most important aspects of the many submissions.

5. On reflection, the early face-to-face meetings were vital in giving the members of the international group an important opportunity to meet the other members of Main Panel A, including the sub-panel chairs and the secretariat. This turned out to be an important first step as the future changed dramatically and virtual meetings became the norm. International members commend the response of all involved taking on the challenges presented and turning it into 'business as usual' and proceeding to carry out their tasks with professionalism and outstanding effort.

Secretariat and panels

6. The secretariat was exceptionally helpful and knowledgeable. They demonstrated an ease of adaptability and willingness to modify. We believe the term 'pivot' would correctly apply to the responses required by the changing conditions that forced re-arrangements of time and place. The chair was excellent and highly competent. He listened exceptionally well, helped to synthesise the position of all panel members and sought advice and consensus before moving on. We were constantly reminded of the requirement for fairness, lack of bias, and conflicts of interest.

7. Each of the sub-panel chairs were highly professional with specific expertise, as well as having real understanding and empathy for individuals and for institutions. The topics and content of each sub-panel were broad and covered an exceptionally wide spectrum of issues, yet we saw an even, fair and thorough approach across the sub-panels. The discussions between sub-panel chairs that were seen at Main Panel A meetings showed a willingness to listen and find consensus for providing a balanced evaluation of outputs, impact cases and environment templates, across the diverse areas covered in Main Panel A.

8. With the switch to virtual meetings there was an element of world timing that introduced difficulties in attendance. Meetings started at 10:00am UK time, making the start time on the East Coast of North America 5:00am, on the West Coast 2:00am, and 5.00pm in West Australia. This led to some of the international members not being able to attend all of the Main Panel A functions and also introduced difficulty for international members to attend a number of the sub-panel meetings. Future research evaluation exercises may need to consider temporal issues and geographic membership, if virtual approaches are contemplated.

Evaluations

9. The evaluation process was both meaningful and highly rigorous. There appeared to be more detail provided for the working methods employed and it was obvious that the REF 2021 had learned from the 2014 exercise. Notable differences included the removal of a minimum requirement for four outputs per person and a modified requirement for the number of impact case studies. These changes could be seen as benefiting larger HEIs, as compared to smaller and specialised research organisations. Overall, it would appear these changes had a beneficial impact on the completeness of the submissions and it was also clear that concerns that were brought forward from the 2014 exercise, such as institutions undertaking 'gaming of the conditions' or of high profile academic staff being poached, would appear to no longer be a concern. However, the extensive changes have made it futile to compare the results of REF 2021 to earlier exercises in a quantitative manner.

10. The international members were impressed with the commonality shown by the various sub-panels in the calibration exercises which provided a strong indication of an even evaluation process for outputs, impact, and environment. This was obviously influenced by the outstanding leadership of the chair and the sub-panel chairs.

11. In consideration of the environment, this was a more difficult aspect to evaluate. It would appear that if the submission was perceived as 'well written' it seemed to be more readily evaluated, (not necessarily highly scored). Those that were more difficult to discern because of the writing seemed to induce considerably more discussion at the sub-panel levels.

12. One of the most important issues that the members noted arose during the calibration exercises and evaluation of both output and impact aspects of REF 2021. This was obvious in the discussion and considerations around one or two particular submissions - suffice to say that Covid-19, and the response delivered to this pandemic over the past years, were central to some absolutely outstanding submissions, indeed the panel saw a range of impact statements related to Covid response including modelling and vaccine development. Panels discussed fully examples of excellence and worldwide impact. Discussion of such cases which significantly exceeded the definitions of four star impact also provided a vehicle for a reality check to be carried out on other excellent world-influencing outputs and impacts that satisfied the descriptor for four star and reinforced that sub-panel members were to rate impacts on an absolute and not on a relative scale. We were impressed that all of the sub-panels had the capacity to understand that some four star achievements were incredibly highly impactful and therefore should not be taken as the standard for four star, but rather should be seen for the outstanding individual contribution that they represent.
13. We note that the number of submissions and outputs were similar to those seen in REF 2014. While the discussions and meetings were mostly virtual and all at a distance, a consensus decision and evaluation was achieved. Perhaps inevitably there was concern and conversation about the role of journal standing or impact factor in sub-panel members decision making. However, all sub-panel members consistently discounted these attributes in favour of evaluation of the output. Further, as with the impacts, sub-panel members proved effective at discerning an output as clearly four star even when evaluated alongside outputs that significantly exceeded the four star criteria. Impact factors were not used in the evaluation.

Specific considerations

14. Translation of the discoveries of fundamental science into therapeutics, technologies and strategies that influence human health relies on the erosion of traditional barriers between academic disciplines. Such interdisciplinary research (IDR) and translational activity addresses an area of historical weakness in the UK, i.e the ability to capitalise, commercially and socially, from basic scientific discoveries. In the past, such downstream value has often been first realised elsewhere. Going forward, HEIs may be encouraged to specifically highlight examples of such IDR, recognising that the impact of basic research may be delayed until it is translated into clinical effect. In the impact evaluations there was discussion around how to evaluate impact case studies that represented a 'continued' nature as opposed to a new impact case study, but there did not appear to be many that failed to demonstrate novel impact and that therefore should and could count independently.
15. There was much discussion about multi-author and multi-centre research and although the issue was beginning to surface in REF 2014, it was much more obvious in the 2021 submissions. This led to good and robust discussions throughout the sub-panels, and the multi-authorship aspect appeared to be handled in an even-handed and fair manner. The prevalence of multi-author/centre papers reflects a continuing trend towards these types of research projects. The international members noted that UK HEIs are global leaders in this trend and that this reflects positively on the atmosphere of collegiality which is a feature of UK HEIs. Furthermore, the extent of interdisciplinarity amongst the outputs and impact case studies continues to rise. Across UK HEIs, multi-centre interdisciplinary research projects has become the norm. This is to be welcomed.

16. One issue of concern that was noted, was the choice of some institutions to influence and direct their submissions or elements of their submissions towards a particular sub-panel or away from a sub-panel whose descriptor the submission matched. It was not clear why this action was taken, but it did seem to be inconsistent given the nature of some of the institutions. Moreover, it had the potential to create an imbalance between the assessment elements, particularly between outputs and the environment.
17. In the examination of the environment submissions, for the international members, it was a bit more difficult to appreciate some of the nuances of description, but it was also clear that the sub-panels in their discussions took every effort to be fair and unbiased. They were able to recognise effort by the institutions to provide a feasible and productive environment for the research to succeed at their institutions over the previous and coming years. In this regard, it is noted that a number of institutions over the past few years have been heavily reliant on resources – both fiscal and personnel - from European sources. It is therefore unclear to us as to what effect Brexit will have on future European based funding for these institutions. It was not clear that all institutions were taking these aspects into consideration and this may well have a very significant effect on the environment and productivity of institutions that were previously highly involved in European co-supported research.
18. We also note that basic research returns submitted to UOA 5 (Biological Sciences), may underestimate the volume and quality of basic research underpinning human health in the UK, as many returns are submitted to other UOAs, especially Clinical Medicine. While this can be seen as enhancing the impact of basic science at a UK-wide level, finding a way to highlight interdisciplinary research might serve partly to address this misperception in relationship to basic science at the unit of assessment level.

Research supporting food production, agriculture, and environmental protection

19. Brexit is likely to affect food, agriculture and environment more substantially than any other areas of UK academic activity. The EU Common Agricultural Policy established a UK-wide subsidy platform and linked payments to EU policy. The four UK governments are now free to establish different policies. Independent UK biosecurity arrangements are also impacting policy and creating demand for skilled staff. These changes have substantially altered the policy framework underpinning food, agriculture, and the environment.
20. The REF exercises have not sought to classify research outputs or impact case studies at a finer scale than the UOA level. There have also been substantial changes in rules governing submissions between this REF exercise and the last. This means that it is not straightforward to assess the strength of individual life science disciplines or make reliable comparisons with the last REF exercise. It would be desirable to classify outputs and impact case studies by discipline. However, there can be no doubt about the outstanding strength of the sciences underpinning the various areas of health and life sciences.
21. We note the REF 2014 reports expressed concern about the scale of research in UK HEIs in the areas of agricultural and food. For the reason mentioned above it is not possible to make a definitive quantitative judgement on the strength of these areas based on the data presented, although individual outputs and impacts case studies were of the highest quality.

22. UOA 6 (Agriculture, Food and Veterinary Sciences) was the smallest unit of assessment in Main Panel A in 2014 and UOA 6 is once again the smallest for REF 2021. This applies to the number of submitting HEIs (24) as well as numbers of outputs and impact studies. UOA 5 (Biological Sciences) has the broadest remit and included many outputs and case studies related to agriculture, food and the environment and the non-health life sciences more generally. In the absence of the appropriate data, the international members remain concerned about the scale of research in HEIs in the areas of food, agriculture and environment.

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