February 2011/03
Issues paper

This report is for information

This analysis aimed to evaluate what the effect would be of using citation scores in the Research Excellence Framework (REF) for staff with particular attributes, such as the protected characteristics and early career researchers. It drew on the data collected for the pilot exercise to develop bibliometric indicators for the REF.

Analysis of data from the pilot exercise to develop bibliometric indicators for the REF

The effect of using normalised citation scores for particular staff characteristics

HIGHER EDUCATION FUNDING COUNCIL FOR ENGLAND

Contents

Analysis of data from the pilot exercise to develop bibliometric indicators for the REF

The effect of using normalised citation scores for particular staff characteristics

To	Heads of HEFCE-funded higher education institutions Heads of universities in Northern Ireland
Of interest to those responsible for	Equality and diversity management, Human resources management, Institutional strategic planning, Research management
Reference	2011/**03**
Publication date	February 2011
Enquiries about data, analysis or technical issues to	Hannah White tel 0117 931 7063 e-mail h.white@hefce.ac.uk
Enquiries about REF policy or equalities and diversity within the REF to	REF team tel 0117 931 7445 e-mail info@ref.ac.uk

Executive summary

Purpose

1. This analysis aimed to evaluate what the effect would be of using citation scores in the Research Excellence Framework (REF) for staff with particular attributes, such as the protected characteristics and early career researchers. It drew on the data collected for the pilot exercise to develop bibliometric indicators for the REF.

2. This analysis follows the publication of two HEFCE documents in 2009: 'Second consultation on the assessment and funding of research' (HEFCE 2009/38) and 'Report on the pilot exercise to develop bibliometric indicators for the Research Excellence Framework' (HEFCE 2009/39). It aims to supplement the findings, informing the development and interpretation of bibliometric indicators with respect to particular characteristics of staff.

Key points

Methodology

3. The data used in this analysis were collected as part of the pilot exercise to develop bibliometric indicators for the Research Excellence Framework. The population was a subset of those staff put forward for the RAE2008.

4. The methodology of this analysis is similar to that used in 'Selection of staff for inclusion in RAE2008' (HEFCE 2009/34). Using the dataset from the REF bibliometrics pilot exercise, we considered the proportions of staff who achieved a normalised citation score[1] of greater than or equal to (≥) 2 or ≥ 4 by seven staff characteristics. We then used statistical models to compare the proportion of staff in each characteristic group that achieve these two citation score thresholds on a like-for-like basis.

5. A direct comparison between the two citation databases reviewed showed that Web of Science (WoS) was found to have less coverage for staff included in the pilot than Scopus. WoS covered 90 per cent of the records and 94 per cent of the staff members that Scopus did[2].

6. Seven staff characteristics were considered; each is outlined below. The report focuses on staff achieving the ≥ 2 citation threshold from the Scopus database except where these results differed significantly from either those observed from the WoS database or with the ≥ 4 threshold.

Early career researchers

7. As might be expected, evidence suggested that staff in the early part of their academic careers (referred to here as early career researchers or ECRs) were less likely to be highly cited than those with longer careers. According to the Scopus database, 56 per cent of non-ECR records achieved a citation score of ≥ 2 compared to 51 per cent of ECR records. This suggests that using citation scores does not level out the advantage enjoyed by researchers with more years of experience. At the ≥ 2 citation score threshold this result was statistically significant for both citation databases, but not at the ≥ 4 threshold.

Age and sex

8. Age and sex were both significant factors in the modelling of this data however age effects were dependent on sex, so we considered the factors both separately and together.

9. Data from both citation databases indicated that those staff aged 50 or over were more likely to be highly cited than younger staff. The Scopus data showed that in the 50 to 54 age group 58 per cent of records achieved citation scores ≥ 2 compared to 43 per cent of records in the under 30 age group.

10. Men were consistently more likely to be highly cited than women. The Scopus data showed that 56 per cent of male records achieved citation scores ≥ 2 compared to 49 per cent of female records. However, this summary does not account for additional factors included in the models, such as age of staff member or subject area under which they were grouped.

11. The data showed that the proportion of men achieving a citation score of ≥ 2 was larger than women for many age groups, but that this was not always true for the age groups under 30

[1] The normalised citation score was calculated as part of HEFCE 2009/39 and adjusted the citation score to account for field of research, type of publication and year of publication. For further details see 'Report on the pilot exercise to develop bibliometric indicators for the Research Excellence Framework' (HEFCE 2009/39), paragraphs 54-56 (www.hefce.ac.uk/pubs/hefce/2009/09_39/).

[2] Percentages are calculated as a proportion of the whole population. The WoS coverage was not a subset of the Scopus coverage.

and 50 to 54. After other staff attributes were taken into account, the difference between men and women was found to be statistically significant in the age range 32 to 63.

Disability

12. Staff with a disability[3] were less likely to achieve the ≥ 2 citation score threshold. According to the Scopus database, non-disabled staff had 54 per cent of records achieving citation scores ≥ 2 compared to 46 per cent of disabled staff records. However, this difference was explained in all cases by other staff attributes included in the models, such as their institution and subject area.

Ethnicity

13. The reported results, for ≥ 2 and ≥ 4 thresholds and WoS and Scopus citation databases, were mixed and did not agree on any statistically significant effects of using citation scores by ethnic group. This is thought to be due to there being only small numbers of staff within each ethnic minority group. However, there was some indication that staff from a Black ethnic background were less likely to achieve the ≥ 2 citation score threshold than other ethnic groups. In the Scopus database, 36 per cent of records from the Black ethnic group achieved a citation score of ≥ 2 compared to 55 per cent and 59 per cent of records from the White and Mixed ethnic groups respectively.

Nationality

14. The proportion of staff with UK nationality achieving the ≥ 2 citation score threshold was not significantly different from the proportion of staff with non-UK nationality. The Scopus data showed that 55 per cent of records from UK nationality staff achieved citation scores ≥ 2 compared to 52 per cent of records from non-UK nationality staff.

Mode of employment

15. There was some evidence to suggest that part-time staff were more likely to achieve the ≥ 2 citation score threshold than full-time, however this was only statistically significant using the Scopus citation database.

Discussion

16. The population was a subset of those staff put forward for RAE2008, and we found that the trends in citation score achievement often reflected trends previously noted in the HEFCE publications ‘Selection of staff for inclusion in RAE2008’ (HEFCE 2009/34) and ‘Selection of staff for inclusion in RAE2001’ (HEFCE 2006/32).

17. We take the differences observed in citation scores seriously and are considering ways to address the inequalities that they imply. However, the potential role of citation information is still undecided. Panels, once constituted, will be asked for their view on the use of citation data within the assessment process, and standardised data will be provided if there is sufficient interest.

18. If citation data are used then the four UK higher education funding bodies will need to ensure that institutions planning to make submissions to the REF are aware of the results of this analysis so that they can take them into account when selecting staff for inclusion. Further,

[3] Disability is recorded on the basis of the staff member's own self-assessment; evidence suggests that this method of collection leads to an element of under-disclosure.

panels will also need to account for the differences found and will require guidance as part of their equality briefing.

19. The four UK higher education funding bodies have set up the REF Equality and Diversity Advisory Group to advise on promoting and supporting equality in the REF process. The advisory group felt that this report should serve as a health warning to the sector when using citation information in their business processes; indeed there are particular circumstances where individuals have low publication rates for good reasons.

Introduction

20. This analysis follows the publication of two HEFCE documents in 2009: 'Second consultation on the assessment and funding of research' (HEFCE 2009/38) and 'Report on the pilot exercise to develop bibliometric indicators for the Research Excellence Framework' (HEFCE 2009/39). It aims to supplement the findings, informing the development and interpretation of bibliometric indicators with respect to particular characteristics of staff.

21. The focus of the analysis was the attainment of early career researchers (ECRs) using the normalised citation score developed by the Research Excellence Framework (REF) team, and to evaluate whether they are more or less likely than non-ECR staff to be highly cited. We also considered the protected characteristics sex, age, disability, ethnicity and nationality, as well as mode of employment and which REF main panel staff would be submitted to, where staff numbers were large enough to do so.

Scope of the data

22. The data used in this analysis were collected as part of the pilot exercise to develop bibliometric indicators for the Research Excellence Framework. The population was a subset of those staff put forward for the RAE2008 and the data comprised information on 22 institutions and covered 35 RAE2008 units of assessment (UOAs). Each UOA within an institution, referred to as a department in the RAE, supplied to us details of all staff submitted to the RAE2008 and all published papers associated with that staff member during the publication period 1 January 2001 to 31 December 2006. As a result of the REF bibliometrics pilot exercise, we were also supplied with normalised citation scores[4] which were calculated using two citation databases: Scopus and Web of Science (WoS).

23. The dataset contained a row of data for each published paper and staff member supplied. Hence, each staff member was duplicated in the dataset depending on how many papers they were associated with, and each paper was duplicated depending on how many staff members were associated with it. In the analysis below, each row of data, or staff member by published paper entry, is referred to as a 'record', further details on how a record fits into the statistical models' structure can be found in Figure A1 of Annex A.

24. It is expected that as part of the REF institutions will be asked to select the research staff and papers to be submitted for assessment (see HEFCE 2009/38, paragraph 36). We are unable to replicate the selection behaviour of individual institutions or UOAs within institutions, so instead, we considered the six papers with the highest normalised citation score for each submitted staff member. If the staff member had fewer than six papers the analysis used all available papers. This approach replicated that taken in the REF bibliometrics pilot exercise (see HEFCE 2009/39).

25. The REF dataset was matched to the 2007/08 Higher Education Statistics Agency (HESA) staff person and contract tables. Matching was successful for 84 per cent of the 11,950 staff

[4] The normalised citation score was calculated as part of HEFCE 2009/39 and adjusted the citation score to account for field of research, type of publication and year of publication. For further details see 'Report on the pilot exercise to develop bibliometric indicators for the Research Excellence Framework' (HEFCE 2009/39), paragraphs 54-56 (www.hefce.ac.uk/pubs/hefce/2009/09_39/).

included in the data, and allowed us to analyse the additional characteristics of sex, age, disability, ethnicity, nationality and mode of employment that were not originally collected in the REF bibliometrics pilot exercise data return.

Methodology

26. The methodology used for this analysis was similar to that used in the publication 'Selection of staff for inclusion in RAE2008' (HEFCE 2009/34)[5]. Here, however, we used the dataset from the REF bibliometrics pilot exercise. We considered the proportions of staff who achieved a normalised citation score of greater than or equal to (≥) 2 or ≥ 4[6] by seven staff characteristics.

27. Using statistical models, we modelled the proportion of staff achieving the ≥ 2 and ≥ 4 citation score thresholds for the WoS and Scopus citation databases. The models simultaneously took into account a series of attributes (see paragraph 28), and their outputs enabled comparisons of different staff characteristics to be made on a like-for-like basis.

28. The attributes, or factors, taken into account in the statistical models were:

- age; sex; ethnicity; nationality; disability; ECR status
- mode of employment (part-time or full-time); subject area; clinical status; contract status (permanent, fixed-term or atypical); employment function (research and/or teaching); senior position holder; grade (researcher or above researcher); member of a department which employs ECRs
- published paper; institution; unit of assessment; staff member.

Further details on the statistical models are at Annex A. Further information about the data definitions and groupings are at Annex B.

Data comparison

29. Table 1 compares the overall proportion of records achieving the two citation score thresholds from Web of Science and Scopus. The proportion of records shown with a citation score ≥ 2 is 7 per cent higher for Scopus than for the WoS database and 6 per cent higher at the ≥ 4 threshold.

Table 1: Comparison of citation databases

Citation database	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Scopus	11,785	62,220	54%	27%
Web of Science	11,125	56,260	47%	21%
Difference	**660**	**5,960**	**7%**	**6%**

[5] This document can be viewed at www.hefce.ac.uk/pubs/hefce/2009/09_34/.

[6] A normalised citation score ≥ 2 equates to a citation score more than twice the world average for that classification of: field of research, type of publication and year of publication. The world average is calculated as the average of all the publications in that classification: this includes those papers with little or no citation counts.

30. For conciseness, we present only the results from the Scopus citation database at the ≥ 2 citation score threshold, unless the results are significantly different either from WoS or at the ≥ 4 threshold. A complete set of tables and graphs for both citation databases is in Annex C.

Early career researchers

31. For the purposes of the pilot exercise to develop bibliometric indicators for the REF, early career researchers were defined as an individual of any age who first entered the academic profession on employment terms that qualified them for submission to RAE2008 as Category A staff on or after 1 August 2003[7]. Institutions then flagged these staff as an ECR in the data return for the pilot exercise.

32. Table 2 shows that the proportion of records achieving a citation score of ≥ 2 was lower for records associated with ECRs than for non-ECR[8] associated records.

Table 2: Initial summary of staff by early career researcher status

ECR status	Number of staff	Number of records	% of records achieving citation score ≥ 2
Non-ECR	8,100	43,960	56%
ECR	1,555	7,510	51%
Unknown	2,135	10,745	48%
Total	**11,785**	**62,220**	**54%**

Notes: All data tables have had entries rounded to the nearest 5; this may cause discrepancies between the reported total and the sum of its parts. 95 staff were found to be recorded twice (according to HESA staff ID) at different institutions. These staff have been included twice in our study as they could have two contracts at the different institutions and it is not possible to accurately distinguish them from those staff who have left one institution and started at another during the academic year.

33. In order to evaluate whether the difference between ECR and non-ECR staff observed in Table 2 was statistically significant we used statistical models to account for additional attributes of the staff in each group (see paragraph 28 for the list of attributes accounted for in the models). Throughout the report, the results from the statistical models are most conveniently presented as a citation index, referred to as a 'model citation index'. In order to compare the results from the models to the proportion of records achieving a citation score threshold we calculate a comparable 'observed citation index' in Table 3.

34. The model and observed citation indices are calculated relative to a reference group, which can be any of the groups within the characteristic being considered. The reference group

[7] For further details see Annex A of 'Report on the pilot exercise to develop bibliometric indicators for the Research Excellence Framework', HEFCE 2009/39 (www.hefce.ac.uk/pubs/hefce/2009/09_39/).

[8] The term non-ECR is used to describe those staff who were eligible to be entered to RAE2008 as Category A prior to 1 August 2003. It is expected that staff in this group will include more experienced researchers with established careers.

always has an index of 1 and if the comparison group has an index higher (or lower) than 1 then the comparison group has higher (or lower) citation scores than the reference group.

Table 3: Derivation of the observed citation index (≥ 2) by early career researcher status

	Non-ECR (ref)	ECR	Unknown
% of records achieving citation score ≥ 2	56.5%	50.6%	47.6%
% of records achieving citation score < 2	43.5%	49.4%	52.4%
Citation score ≥ 2/citation score < 2 (odds ratio)	1.300	1.024	0.908
Odds ratio relative to odds ratio of reference group (observed citation index)	1.300/1.300 = 1.00	1.024/1.300 = 0.79	0.908/1.300 = 0.70

35. Table 3 shows that the reference group (non-ECR) had a observed citation index of 1 and the ECR group had a observed citation index of 0.79. The ECR index was lower than the reference group index, so the observed citation scores observed for ECR records were lower than those seen for the reference group, as observed in Table 2. However, this index does not account for additional staff attributes, so we also considered the model citation index.

36. Table 4 shows that the reference group (non-ECR) had a model citation index of 1 and the comparison group (ECR) had a model citation index of 0.88 at the ≥ 2 threshold. The model result was tested at the 1% level and found to be significant. This means that, after accounting for additional staff attributes (see paragraph 28), the proportion of ECRs achieving a citation score ≥ 2 was significantly lower than the proportion of non-ECRs.

Table 4: Citation indices at the ≥ 2 threshold by ECR status

ECR status	Observed citation index	Model citation index (accounts for other factors)
Non-ECR	(ref) 1.00	(ref) 1.00
ECR	0.79	0.88*
Unknown	0.70	0.73

Note: * indicates that the result is significantly different from 1.00 at the 1% level.

37. The findings from the WoS database supported those observed for the Scopus database, in paragraphs 32-36, in that the citation scores achieved by ECR records are lower than those achieved by non-ECR records. At the ≥ 2 threshold, the citation databases consistently showed that this result was significant, but significance was not consistent at the ≥ 4 threshold.

38. In addition to the analysis conducted on citation scores and citation indexes, Annex D presents analysis of the mean and median number of papers per staff member matched to the Scopus and Web of Science databases. This identifies groups of staff where either match rates to the databases were low or where there were less papers available to match to the database. As expected, this analysis found that ECRs had a consistently lower average number of papers

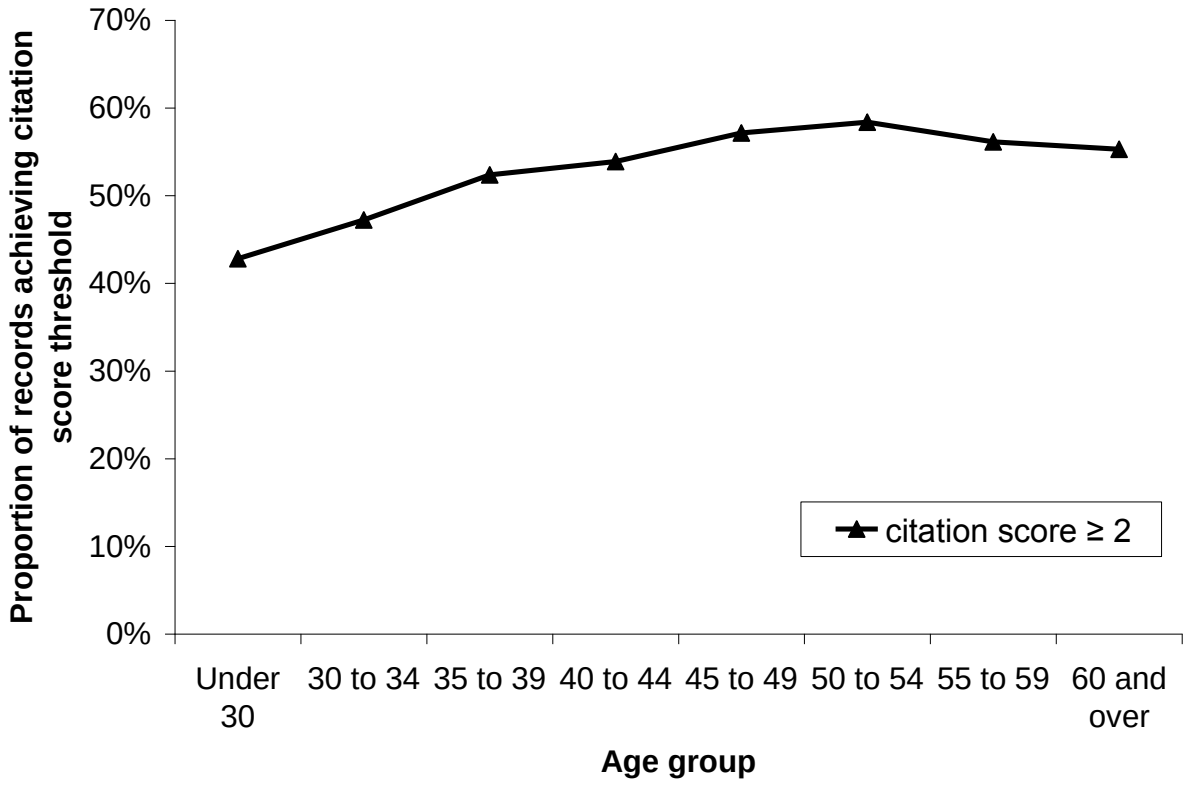
per person than non-ECRs, which may go some way to explaining the differences found in the citation analysis; see Table D1 of Annex D for more information.

Age group

39. Age and sex are both significant factors in the modelling of this data but, as we show in paragraph 46, the age effects are dependent on sex. In the following sections on age group and sex, paragraphs 40-45, we do not consider observed or model citation indices because the model output details the significance of the interaction between age and sex and cannot be used to comment on age or sex alone.

40. Figure 1 shows the age group that achieved the highest proportion of records with a citation score ≥ 2 was 50 to 54, and the group that achieved the lowest proportion was under 30.

Figure 1: Initial summary of staff by age group



41. The WoS database concurred with these findings at the ≥ 2 threshold, but the findings at the ≥ 4 threshold for both databases suggested that the highest proportion was in either the 55 to 59 or the 60 and over age group.

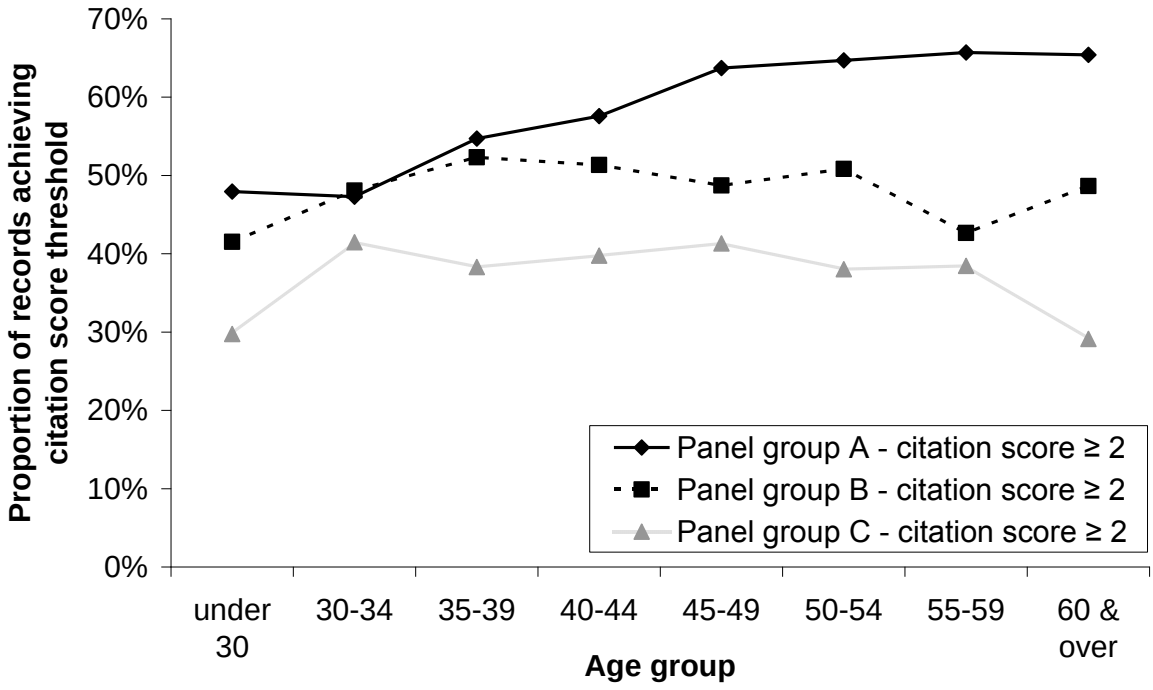
42. Analysis of the average number of papers per staff member showed that, in general, the number of papers increased with age, see Table D2 of Annex D.

43. Further to the seven characteristics discussed in this report, the effect of main panels[9] has also been considered. In most cases there is little difference to the findings when split by main panel. However, Figure 2 shows that for Main Panel A there is an increase in the proportion of

[9] The mapping of main panel to REF unit of assessment is in Table B3 of Annex B.

records achieving the ≥ 2 citation threshold by age group that is not observed for the other two main panels that were used in the pilot bibliometrics exercise. This suggests that the overall observed increase in attainment by age could be due to the subject profile of the sample population; see Annex C for the complete set of figures.

Figure 2: Initial summary of staff by age group and REF main panel



Sex

44. Table 5 shows that the proportion of records achieving a citation score of ≥ 2 was lower for records associated with women than that seen for men. This was supported by the results from the WoS database and at the citation score ≥ 4 threshold.

Table 5: Initial summary of staff by sex

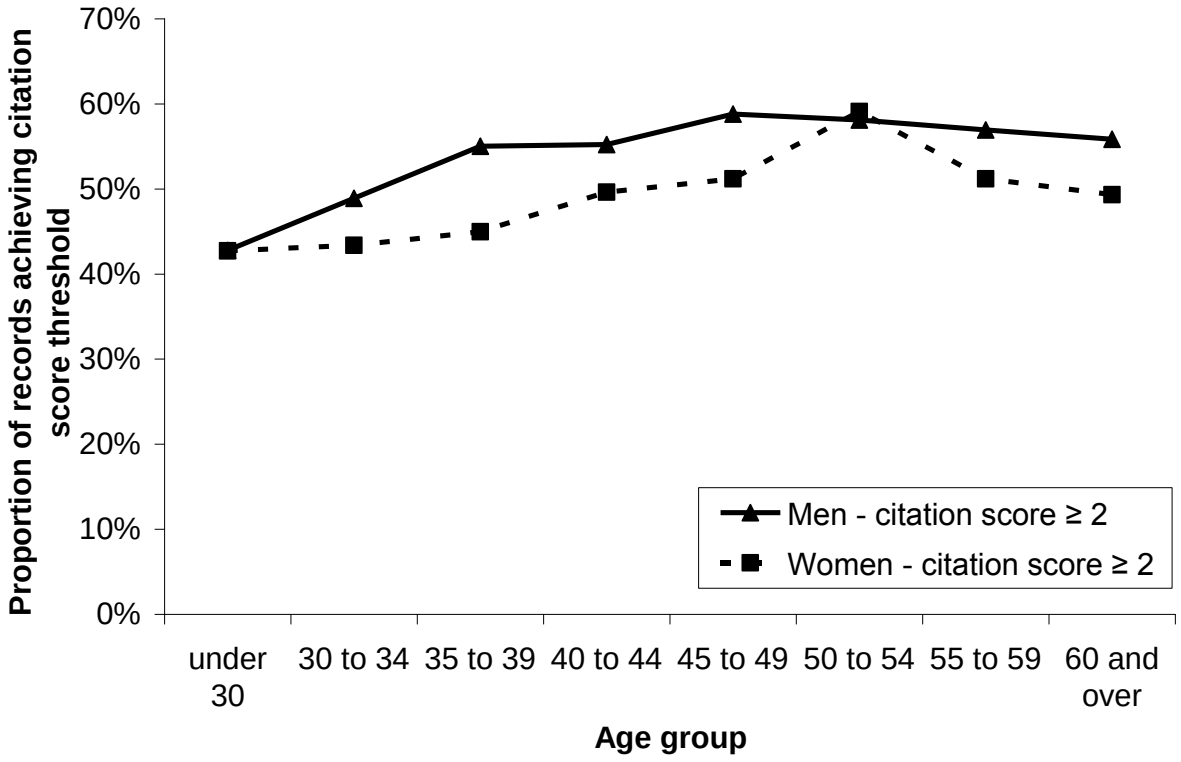
Sex	Number of staff	Number of records	% of records achieving citation score ≥ 2
Women	2,325	11,920	49%
Men	7,605	41,085	56%
HESA no match	1,855	9,215	53%
Total	**11,785**	**62,220**	**54%**

45. Further, the average number of papers per staff member for women was lower than that observed for men, see Table D3 of Annex D.

Age and sex

46. Figure 3 shows that the difference by sex in proportion of staff achieving citation scores ≥ 2 varies by age. The proportion of males achieving a citation score ≥ 2 was higher than the proportion of females for many age groups, but not for the under 30 group and 50 to 54 group.

Figure 3: Initial summary of proportion of records achieving citation score ≥ 2 by sex and age group using Scopus



47. The data for the citation score ≥ 4 thresholds and the WoS database showed similar trends to that seen in Figure 3. However there were some differences, Figure 4 shows the trend observed for the citation score ≥ 2 using the WoS database. The under 30 age group shows a larger proportion of women achieving the ≥ 2 threshold than the proportion of men.

48. The interaction between sex and age was considered in the statistical models; Figure 5 shows the outcome of this. The area where the error bars are completely above or below the dotted line at 1 indicates a statistically significant difference between men and women. So, Figure 5 shows that men achieved a significantly higher number of records with a citation score ≥ 2 than women until age 63.

49. The data for the citation score ≥ 4 thresholds and the WoS database showed a similar pattern to that shown in Figure 5. The model output was consistently greater than 1 and the error bars increased in size at the extremes of the age range, which is likely to be due to the lower numbers of staff in these categories and hence less certainty over the estimate of the citation index. However, the age range where there was a significant difference between men and women varied when using the different citation databases and citation score thresholds, see Figures C7 to C12 of Annex C for more information. Overall, the difference was significant between the ages 32 and 63 for ≥ 2 and ≥ 4 thresholds and both citation databases.

Figure 4: Initial summary of proportion of records achieving citation score ≥ 2 by sex and age group using WoS

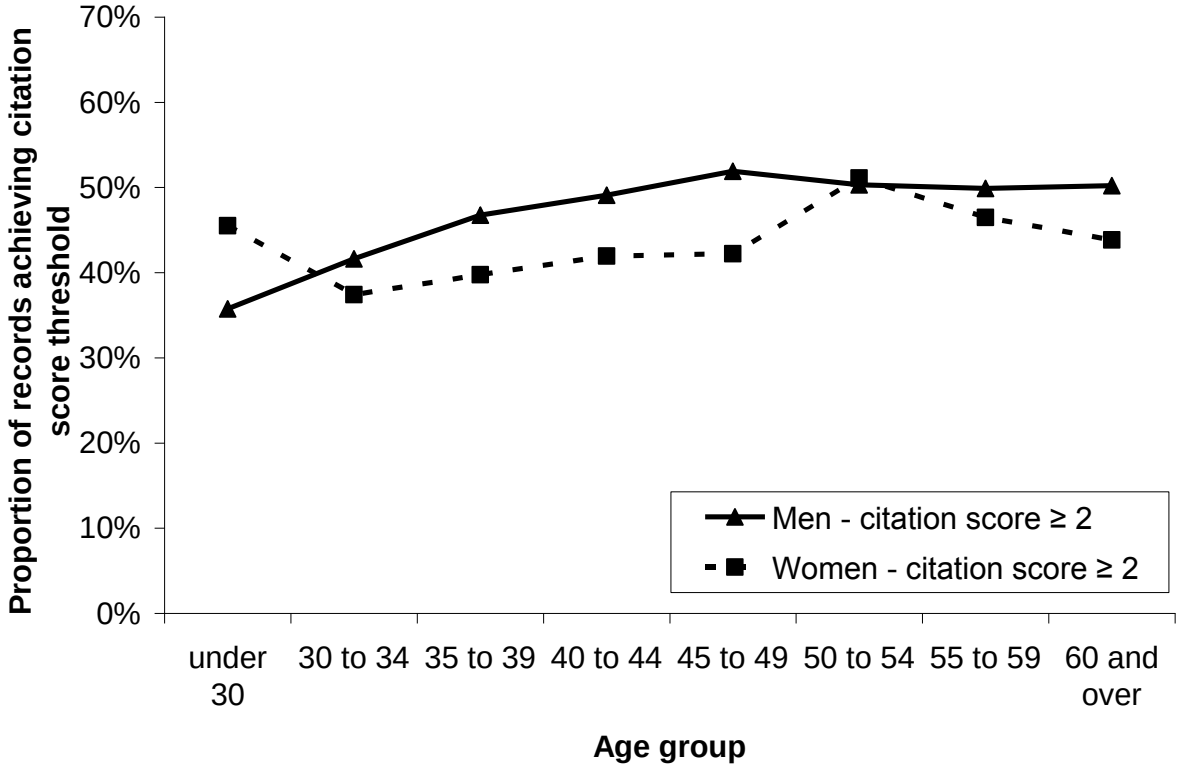
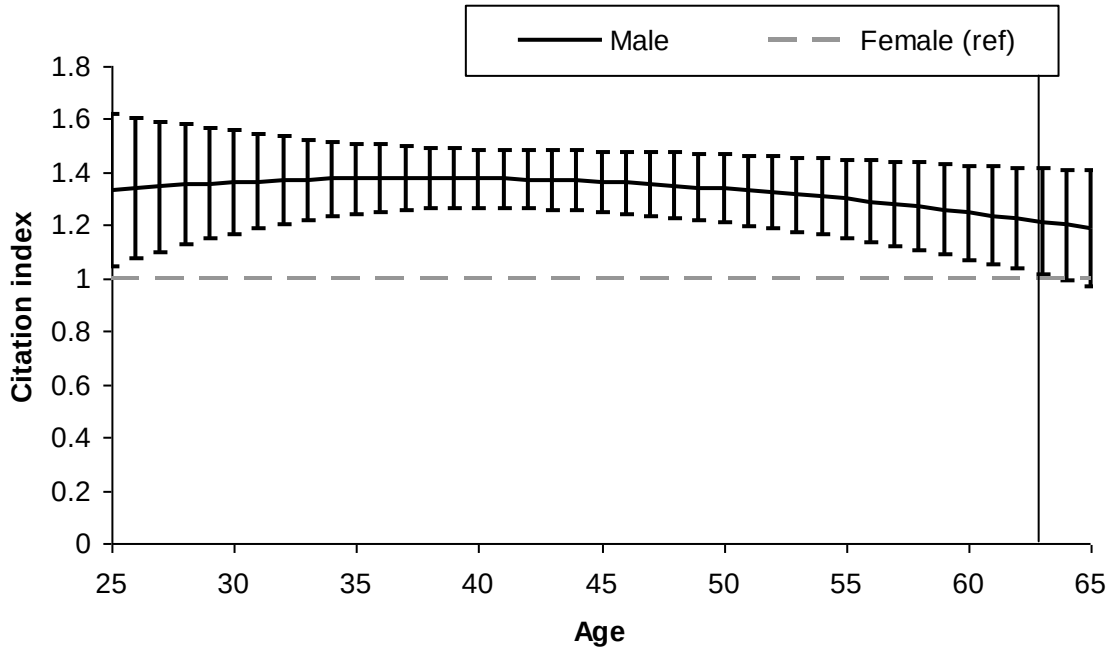


Figure 5: Model citation index (accounts for other factors) where citation score ≥ 2 for sex by age



Notes: Error bars are calculated at the 1% level.

50. The average number of research papers per staff member was higher for men than women over all age groups, and the difference between averages tended to get bigger as age increased. However, there was evidence to suggest that the difference decreased around age range 50-59; see Figures D1 and D2 of Annex D for more information.

Disability

51. Table 6 shows that disabled staff had a lower proportion of records achieving citation scores ≥ 2 when compared to non-disabled staff.

Table 6: Initial summary for staff by disability status

Disability status	Number of staff	Number of records	% of records achieving citation score ≥ 2
Non-disabled	9,365	50,030	54%
Disabled	170	895	46%
HESA no match/unknown	2,250	11,295	54%
Total	**11,785**	**62,220**	**54%**

52. The statistical model output is presented in Table 7. This shows that the differences in the proportion of records achieving citation scores ≥ 2 by disability status were not significant when other factors (see paragraph 28) were taken into account. No significant differences were found at the ≥ 4 threshold or when using the WoS database.

Table 7: Citation indices at the ≥ 2 threshold by disability status

Disability status	Observed citation index	Model citation index (accounts for other factors)
Non-disabled	(ref) 1.00	(ref) 1.00
Disabled	0.71	0.84

Notes: Staff in the 'HESA no match/unknown category' were grouped with the non-disabled staff during modelling as they had comparable citation scores.

53. The average number of papers per person was lower for disabled staff; however the citation analysis has shown that this did not significantly impact the proportion of records achieving high citation scores; see Table D4 of Annex D.

Ethnicity

54. The data on the ethnicity of staff are reported from both citation databases and both citation thresholds, because there were mixed results. The Scopus database indicates that the Black ethnic group[10] had the lowest proportion of records achieving citation scores ≥ 2 or ≥4 (see Table 8).

[10] Grouped from HESA staff data and includes staff who describe their ethnicity as 'Black or Black British – Caribbean', 'Black or Black British – African' or 'Other Black background'. See Annex B for further details.

Table 8: Initial summary for staff by ethnicity using Scopus

Ethnicity	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
White	8,235	44,220	55%	27%
Black	45	200	36%	17%
Asian	640	3,340	54%	29%
Mixed	95	490	59%	25%
Other	100	535	50%	24%
HESA no match/ unknown/refused	2,670	13,435	54%	27%
Total	**11,785**	**62,220**	**54%**	**27%**

55. Table 9 displays the statistical modelling output of these data. This reveals that the differences observed for the proportion of records achieving a citation score ≥ 2 and ≥ 4 were explained by other model factors (see paragraph 28).

Table 9: Scopus citation indices comparing staff by ethnic group

Ethnicity	Citation index (≥ 2)		Citation index (≥ 4)	
	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
White	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Black	0.47	0.93	0.54	0.40
Asian	0.96	0.91	1.12	0.99
Mixed	1.17	1.07	0.93	0.85
Other	0.84	0.85	0.84	0.76
Refused	0.87	0.98	0.87	1.02

Notes: There were no results significantly different from 1.00 at the 1% level.

56. Table 10 presents the same data as Table 8 but using the WoS data. As with Scopus, it shows that the ethnicity group with the lowest proportion of records achieving citation scores of ≥ 2 or ≥ 4 were those from a Black ethnic background. The highest proportion was observed for records associated with a White ethnic background at the citation score ≥ 2 threshold, and for records associated with an Asian or Mixed ethnic background at the citation score ≥ 4 threshold.

57. Table 11 presents the same data as Table 9 but using the WoS data. However, unlike the Scopus data it shows that the difference in the proportion of records associated with Black ethnic staff achieving a citation score ≥ 2 was significantly lower than the proportion observed for staff from a White ethnic background, after taking into account other factors such as unit of assessment and subject area. At the citation score ≥ 4 threshold the difference between Black

and White ethnic staff was not significant; however, staff from an Asian ethnic background had significantly greater citation scores than those observed for staff from a White ethnic background.

Table 10: Initial summary of staff by ethnicity using WoS

Ethnicity	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
White	7,805	40,000	48%	21%
Black	40	165	27%	13%
Asian	575	2,845	47%	23%
Mixed	80	400	47%	23%
Other	95	495	41%	19%
HESA no match/ unknown/refused	2,530	12,355	47%	21%
Total	**11,125**	**56,260**	**47%**	**21%**

Table 11: WoS citation indices comparing staff by ethnic group

	Citation index (≥ 2)		Citation index (≥ 4)	
Ethnicity	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
White	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Black	0.42	0.48*	0.57	0.76
Asian	0.99	0.99	1.17	1.2*
Mixed	0.98	0.93	1.12	1.00
Other	0.78	0.70	0.93	1.02
Refused	0.95	1.03	0.88	0.99

Notes: * indicates that the result is significantly different from 1.00 at the 1% level.

58. To explore why the results for the two databases differ, we considered the population coverage of each (see Table 12). It shows that the Web of Science database contained information on fewer staff and fewer records than the Scopus database over all ethnic groups. This suggests that even small changes in data coverage affect whether a result is significant. This may have arisen from there being only low numbers of black and minority ethnic (BME) staff submitted to the REF bibliometrics pilot study.

59. For the population considered in the REF bibliometrics pilot study, the average number of papers per person was lower for Black staff than all other ethnic groups. Averages for White, Asian, Mixed and Other staff depended on the type of average and which citation database was used; see Table D5 of Annex D for more information.

Table 12: Record coverage of Web of Science database compared to Scopus database

	Scopus		Web of Science		% coverage of WoS	
Ethnicity	**Number of staff**	**Number of records**	**Number of staff**	**Number of records**	**Number of staff**	**Number of records**
White	8,235	44,220	7,805	40,000	95%	90%
Black	45	200	40	165	89%	83%
Asian	640	3,340	575	2,845	90%	85%
Mixed	95	490	80	400	84%	82%
Other	100	535	95	495	95%	93%
HESA no match/ unknown/refused	2,670	13,435	2,530	12,355	95%	92%
Total	**11,785**	**62,220**	**11,125**	**56,260**	**94%**	**90%**

Nationality

60. Table 13 shows that staff with UK nationality had the highest proportion of records achieving citation scores ≥ 2.

Table 13: Initial summary of staff by nationality

Nationality	**Number of staff**	**Number of records**	**% of records achieving citation score ≥ 2**
UK	7,365	39,915	55%
Non-UK	2,440	12,455	52%
HESA no match/unknown	1,980	9,850	53%
Total	**11,785**	**62,220**	**54%**

61. Table 14 shows the output from the statistical model. While the observed citation indices suggest that the proportion of records achieving a citation score of ≥ 2 were lower for those of non-UK nationality than for those of UK nationality, when other factors were accounted for this finding was not statistically significant.

Table 14: Citation indices comparing staff by nationality

Nationality	**Observed citation index**	**Model citation index (accounts for other factors)**
UK	(ref) 1.00	(ref) 1.00
Non-UK	0.90	1.03
Unknown	0.94	0.97

Notes: There were no results significantly different from 1.00 at the 1% level.

62. There were differences between Scopus and WoS in the proportion of records achieving the ≥ 2 or ≥ 4 thresholds. However, once other factors were accounted for the differences were not significant and therefore could be due to random variation.

63. Staff with UK nationality consistently had a higher average number of papers per staff member than those with Non-UK or unknown nationality. However, the citation analysis shows that this did not significantly affect the proportion of records achieving high citation scores; see Table D6 of Annex D.

Mode of employment

64. Table 15 shows that there was little variation in the proportion of records achieving citation scores ≥ 2 or ≥ 4 by mode of employment.

Table 15: Initial summary of staff by mode of employment

Mode of employment	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Full-time	9,070	48,470	54%	27%
Part-time	860	4,535	55%	29%
HESA no match/unknown	1,855	9,215	53%	27%
Total	**11,785**	**62,220**	**54%**	**27%**

65. Table 16 shows the output from the statistical models at the ≥ 2 and ≥ 4 thresholds. The difference observed at the ≥ 2 threshold was found to be significant while the difference observed at the ≥ 4 threshold was explained by other factors. Using the WoS database showed no significance at either threshold.

Table 16: Citation indices comparing staff by mode of employment

Mode of employment	Citation index (≥ 2)		Citation index (≥ 4)	
	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
Full-time	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Part-time	1.05	1.13*	1.12	1.20

Notes: * indicates that the result is significantly different from 1.00 at the 1% level.

66. The average number of papers for staff on part-time contracts was similar to the average for those on full-time contracts; see Table D7 of Annex D. The citation analysis gave mixed results, which suggests that mode of employment could affect the proportion of records achieving high citation scores.

Discussion

67. The population was a subset of those staff put forward for RAE2008, and we found that the trends in citation score achievement often reflected trends previously noted in the HEFCE

publications 'Selection of staff for inclusion in RAE2008' (HEFCE 2009/34) and 'Selection of staff for inclusion in RAE2001' (HEFCE 2006/32).

68. The results of the analysis showed there was an increased likelihood of achieving a normalised citation score ≥ 2 or ≥ 4 for staff who fell into the older, male category. Additionally, the results suggested a reduced likelihood of being highly cited for staff from a Black ethnic background[11].

69. There are two elements in the REF process where reliance on citation information could lead to disadvantages to some equality groups:

a. Inadvertent discrimination by institutions in selecting both staff and outputs for assessment in the REF.

b. The assumption that citation information is unbiased and can be fully relied on by REF panels in the assessment phase.

70. We take the differences observed in citation scores seriously and are considering ways to address the inequalities that they imply. However, the potential role of citation information is still undecided. Panels, once constituted, will be asked for their view on the use of citation data within the assessment process, and standardised data will be provided if there is sufficient interest[12]. If the data are used, the four UK funding bodies will need to consider the issues described in the following paragraphs.

71. We will consider how to ensure that institutions planning to make submissions to the REF are aware of the results of this analysis and how they should take them into account. This is particularly important for those UOAs where citation information may be used in the assessment process. In addition, we should give HEIs guidance on incorporating these issues into their codes of practice on preparing submissions and selecting staff, whether or not citation information is used.

72. We also need to consider how best to ensure that panels take this aspect of citation information into account if using the data to inform their assessments of quality. As a minimum, this report could be made available to panel members during the criteria setting phase during which the panels will decide whether to use citation information.

73. We will also consider how best to give further guidance to panels as part of their equality briefing. It could be possible to tailor any data given to panels to reflect protected characteristics, for example by separating citations to work authored by early career researchers from those by more established researchers. The UK funding bodies will work with the ECU and HEFCE's Analytical Services Group to develop the best options for taking this forward.

74. This work raises further questions about citation use within the higher education sector; however, it is not the final word on bibliometrics and citation scores. The assumptions used when conducting the pilot exercise and resulting analysis are different to the way the final REF structure is developing, so we see this as a work in progress and will wait for the final proposals to be agreed before considering if further analysis is required.

---

[11] Note that analysis of ethnic background often involves small numbers of staff, which makes interpretation of these results difficult.

[12] For further information on the use of bibliometrics in the REF go to www.hefce.ac.uk/research/ref/biblio/.

75. The four UK funding bodies have set up a REF Equality and Diversity Advisory Group to advise on promoting and supporting equality in the REF process. A draft of this report was shared with the group, and following their input the final version includes analysis split by main panel and reflects their comments.

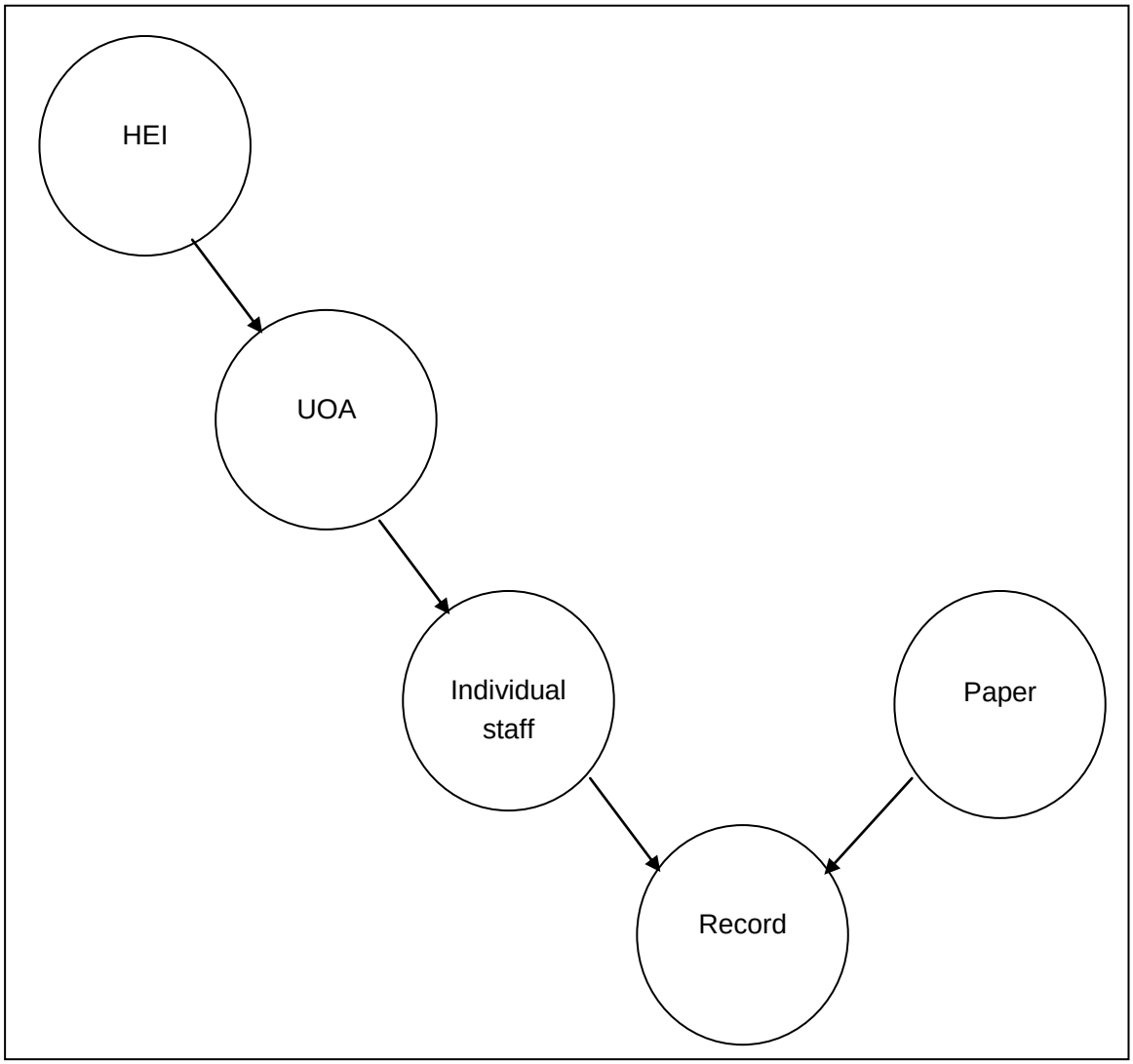
76. The advisory group will provide advice to the sector on developing codes of practice, including the use of citation information in the staff selection process. It will also provide guidance to the REF expert panels via the REF team. The advisory group felt that this report should serve as a health warning to the sector when using citation information in their business processes; indeed there are particular circumstances where individuals have low publication rates for good reasons.

Annex A

Statistical models

1. The statistical models used in this study model the proportion of records with citation score thresholds ≥ 2 and ≥ 4 and have a cross-classified multi-level structure, as illustrated in Figure A1.

Figure A1: Schematic of the statistical model



2. Figure A1 shows that records are a cross-classification of staff members and papers; further, staff members are assumed to be nested within a UOA, and UOAs nested within HEIs.

3. The statistical form of the model is given in Figure A2.

Figure A2: Statistical model form

$$\text{citationscore\_2}_{ijklm} \sim \text{Binomial}(\text{const}_{ijklm}, \pi_{ijklm})$$

$$\begin{aligned}\text{probit}(\pi_{ijklm}) = {} & \beta_{0jklm}\text{const} + \beta_1\text{ECR}_m + \beta_2\text{age}_{jklm} + \beta_3\text{male}_m + \beta_4\text{parttime}_m + \beta_5\text{pf2}_m + \\ & \beta_6\text{t1}_m + \beta_7\text{t2}_m + \beta_8\text{t3}_m + \beta_9\text{black}_m + \beta_{10}\text{asian}_m + \beta_{11}\text{mixed}_m + \beta_{12}\text{other}_m + \\ & \beta_{13}\text{refused}_m + \beta_{14}\text{disabled}_m + \beta_{15}\text{clinical}_m + \beta_{16}\text{senior}_m + \beta_{17}\text{ug1}_m + \\ & \beta_{18}\text{ug2}_m + \beta_{19}\text{ug3}_m + \beta_{20}\text{NonUK}_m + \beta_{21}\text{NatUnk}_m + \beta_{22}\text{no\_ecr}_m + \\ & \beta_{23}\text{grade4}_m + \beta_{24}\text{age.male}_{jklm} + \beta_{25}\text{age.age.male}_{jklm}\end{aligned}$$

$$\beta_{0jklm} = \beta_0 + g_{0m} + f_{0lm} + v_{0klm} + u_{0jklm}$$

$$\begin{bmatrix} g_{0m} \end{bmatrix} \sim \text{N}(0,\ \Omega_g)\ :\ \Omega_g = \begin{bmatrix} \sigma^2_{g0} \end{bmatrix}$$

$$\begin{bmatrix} f_{0lm} \end{bmatrix} \sim \text{N}(0,\ \Omega_f)\ :\ \Omega_f = \begin{bmatrix} \sigma^2_{f0} \end{bmatrix}$$

$$\begin{bmatrix} v_{0klm} \end{bmatrix} \sim \text{N}(0,\ \Omega_v)\ :\ \Omega_v = \begin{bmatrix} \sigma^2_{v0} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jklm} \end{bmatrix} \sim \text{N}(0,\ \Omega_u)\ :\ \Omega_u = \begin{bmatrix} \sigma^2_{u0} \end{bmatrix}$$

$$\text{var}(\text{citationscore\_2}_{ijklm} | \pi_{ijklm}) = \pi_{ijklm}(1 - \pi_{ijklm})/\text{const}_{ijklm}$$

$$\textit{Deviance(MCMC)} = 49466.820(62220 \text{ of } 62220 \text{ cases in use})$$

where *i* represents the record, *j* represents the individual, *k* represents the unit of assessment, *l* represents the higher education institution and *m* represents the paper. The variables in the model are defined in Table A1.

4. The statistical model form was used to model the data for both databases and at both the ≥ 2 and ≥ 4 citation score thresholds, except that the Scopus data at threshold ≥ 4 was unable to include the paper cross-classification.

5. Table A1 gives the details of all the variables used in the models.

6. **Table A1: Variables used for the statistical models**

Type	Model variable name	Variable description	Categories
Continuous	Age	Individual's age (in years)	
	T	Terms of employment	Permanent(1); Fixed term(2); Atypical(3); [Unknown(REF)]
	Black, Asian, Mixed, Other, Refused	Ethnicity of individual	Black; Asian; Mixed; Other; Refused; [White(REF)]
	Ug	Group of UOAs	Arts & vocational (1); Clinical (2); Humanities, social sciences & languages (3); [Engineering & sciences(REF)]
Categorical	NonUK, NatUnk	Nationality	Non-UK national; Nationality unknown; [UK national(REF)]
	ECR	Early career researcher status	ECR; [not an ECR(REF)]
	Male	Sex	Male; [Female(REF)]
	Parttime	Mode of employment	On a part-time contract; [full-time contract(REF)]
	Pf2	Primary employment function	Research only; [not research only (REF)]
	Disabled	Disability status	With disability [without disability (REF)]
	Clinical	Clinical status	Staff on clinical contract [Not on clinical contract(REF)]
	Senior	Senior management post holder status	A smph [Not a smph(REF)]
	No_ecr	ECR department	ECRs present within the department [no ECRs present in the department(REF)]
Binary	Grade4	Grade	Researcher grade [above researcher grade(REF)]
	const	Constant	Set to 1 for all individuals
	G	Random effect relating to the paper	
	F	Random effect relating to a particular HEI	
	V	Random effect relating to the unit of assessment	
Structural	U	Random effect relating to individual	

Notes: Those categories marked with '(REF)' are the reference categories for each categorical or dummy variable.

Annex B

Data definitions and groupings

Ethnicity groupings

1. This analysis used six ethnicity groupings; the groupings were derived from the more detailed classification used on the HESA staff record[13] using the mapping given in Table B1.

Table B1: Mapping to ethnicity groups

Ethnicity group	Ethnicity fields
White	White – British
	White – Irish
	White Scottish
	Irish Traveller
	Other White background
Black	Black or Black British – Caribbean
	Black or Black British – African
	Other Black background
Asian	Asian or Asian British – Indian
	Asian or Asian British – Pakistani
	Asian or Asian British – Bangladeshi
	Chinese
	Other Asian background
Mixed	Mixed – White and Black Caribbean
	Mixed – White and Black African
	Mixed – White and Asian
Other	Other Mixed background
	Other Ethnic background
Refused	Not known
	Information refused

Other groupings

2. Two modes of employment were used in the models: full-time and part-time staff. Table B2 maps the HESA staff record[14] mode of employment to the two modes used in this report.

[13] See www.hesa.ac.uk/index.php?option=com_collns&task=show_manuals&Itemid=233&r=07025&f=007 for further details.

[14] See www.hesa.ac.uk/index.php?option=com_collns&task=show_manuals&Itemid=233&r=07026&f=007 for further details.

Table B2: Grouping mode of employment

Mode	Mode of employment
Full-time	Full-time Full-time, term-time only
Part-time	Part-time Part-time, term-time only Atypical

3. All staff who were not declared as having a disability were treated as non-disabled.

4. Staff with an 'unknown' equalities status or unmatched to the HESA data were grouped with the reference group for each of the model variables, see Table A1 of Annex A.

5. The REF units of assessment have been grouped into four main panels, Table B3 gives the mapping details. The pilot exercise analysed data from units of assessment where there was sufficient coverage[15] of papers in either the Scopus or Web of Science databases, this did not include any units of assessment from Main Panel D.

Table B3: Grouping REF units of assessment to main panels

Main panel	REF unit of assessment
A	Clinical Medicine Public Health, Health Services and Primary Care Allied Health Professions, Dentistry, Nursing, and Pharmacy Psychology, Psychiatry and Neuroscience Biological Sciences Agriculture, Veterinary and Food Science
B	Earth Systems and Environmental Sciences Chemistry Physics Mathematical Sciences Computer Science and Informatics Aeronautical, Mechanical, Chemical and Manufacturing Engineering Electrical and Electronic Engineering, Metallurgy and Materials Civil and Construction Engineering General Engineering
C	Architecture, Built Environment and Planning Geography, Environmental Studies and Archaeology Economics and Econometrics Business and Management Studies Law
	Politics and International Studies Social Work and Social Policy Sociology Anthropology and Development Studies

[15] For further details see page 5 of 'Report on the pilot exercise to develop bibliometric indicators for the Research Excellence Framework', HEFCE 2009/39 (www.hefce.ac.uk/pubs/hefce/2009/09_39/).

	Education Sports-Related Studies
D	Area Studies Modern Languages English Language and Literature History Classics Philosophy Theology and Religious Studies Art and Design: History, Theory and Practice Music, Drama, Dance and Performing Arts Communication, Cultural and Media Studies, Library and Information Management

Annex C

Complete set of data tables and figures

1. The following tables and figures provide a comprehensive summary of the analysis carried out. The order follows that seen in the main report and includes tables from the main report to allow comparisons to be made.

Table C1: Initial summary of staff by early career researcher status using Scopus citation database

ECR status	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Non-ECR	8,100	43,960	56%	29%
ECR	1,555	7,510	51%	24%
Unknown	2,135	10,745	48%	21%
Total	**11,785**	**62,220**	**54%**	**27%**

Table C2: Citation indices by ECR status using Scopus citation database

	Citation index (≥ 2)		Citation index (≥ 4)	
ECR status	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
Non-ECR	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
ECR	0.79	0.88*	0.81	0.90
Unknown	0.70	0.73	0.68	0.73*

Notes: * indicates that the result is significantly different from 1.00 at the 1% level.

Table C3: Initial summary of staff by early career researcher status using WoS citation database

ECR status	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Non-ECR	7,715	40,900	50%	22%
ECR	1,280	5,360	42%	18%
Unknown	2,130	9,995	40%	15%
Total	**11,125**	**56,260**	**47%**	**21%**

Table C4: Citation indices by ECR status using WoS citation database

ECR status	Citation index (≥ 2)		Citation index (≥ 4)	
	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
Non-ECR	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
ECR	0.73	0.71*	0.78	0.83*
Unknown	0.65	0.66*	0.63	0.78

Notes: * indicates that the result is significantly different from 1.00 at the 1% level.

Figure C1: Initial summary of staff by age group using Scopus citation database

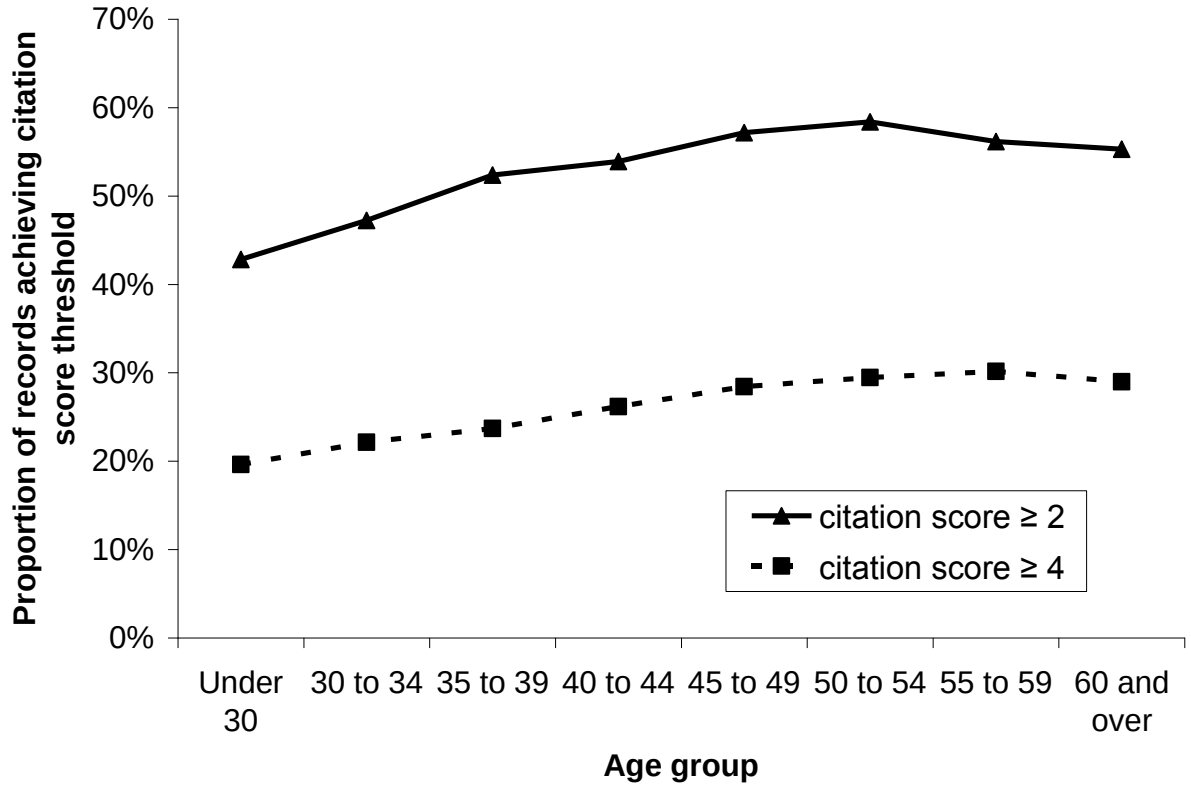


Figure C2: Initial summary of staff by age group using WoS citation database

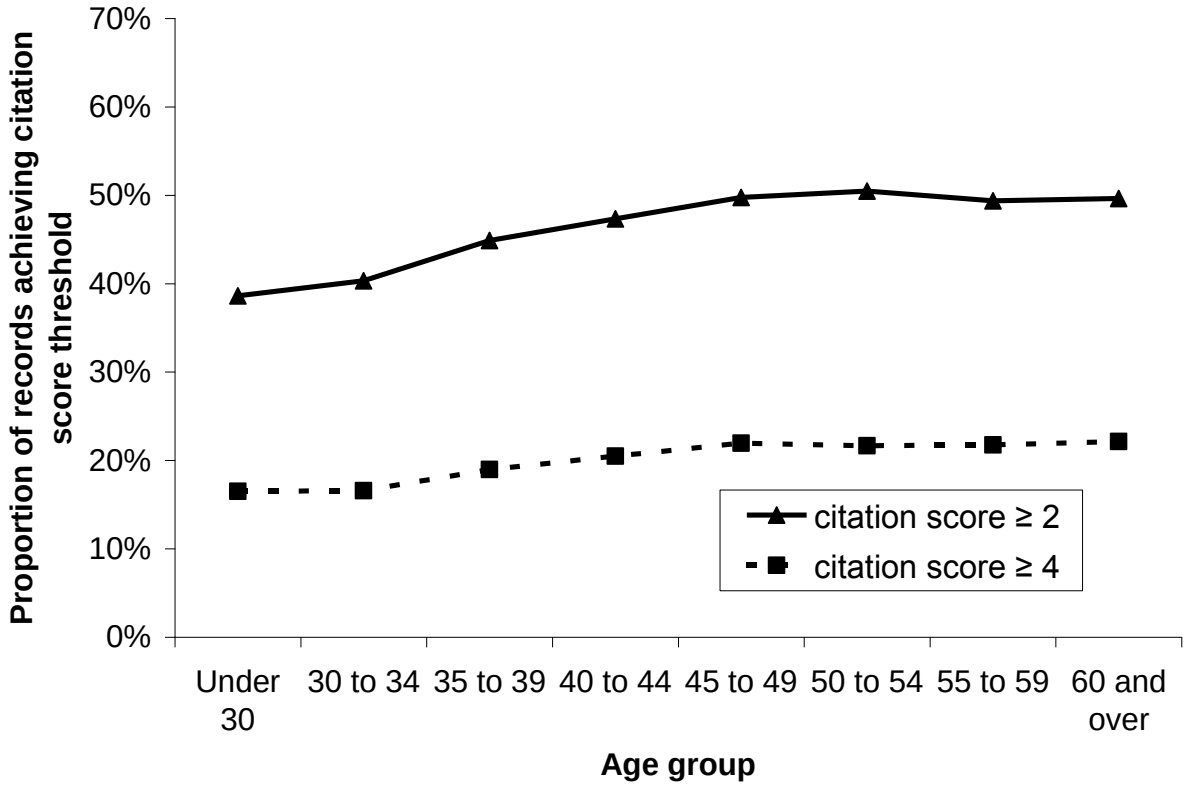


Figure C3: Initial summary of staff where citation score ≥ 2 by age group and main panel using Scopus citation database

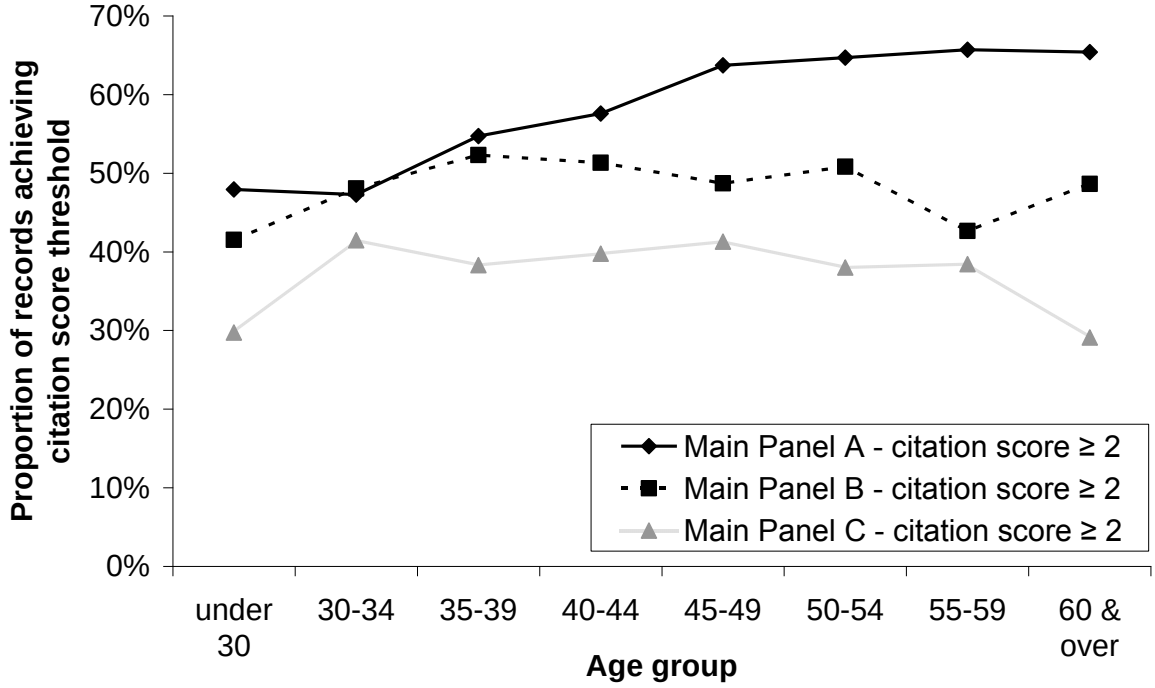


Figure C4: Initial summary of staff where citation score ≥ 4 by age group and main panel using Scopus citation database

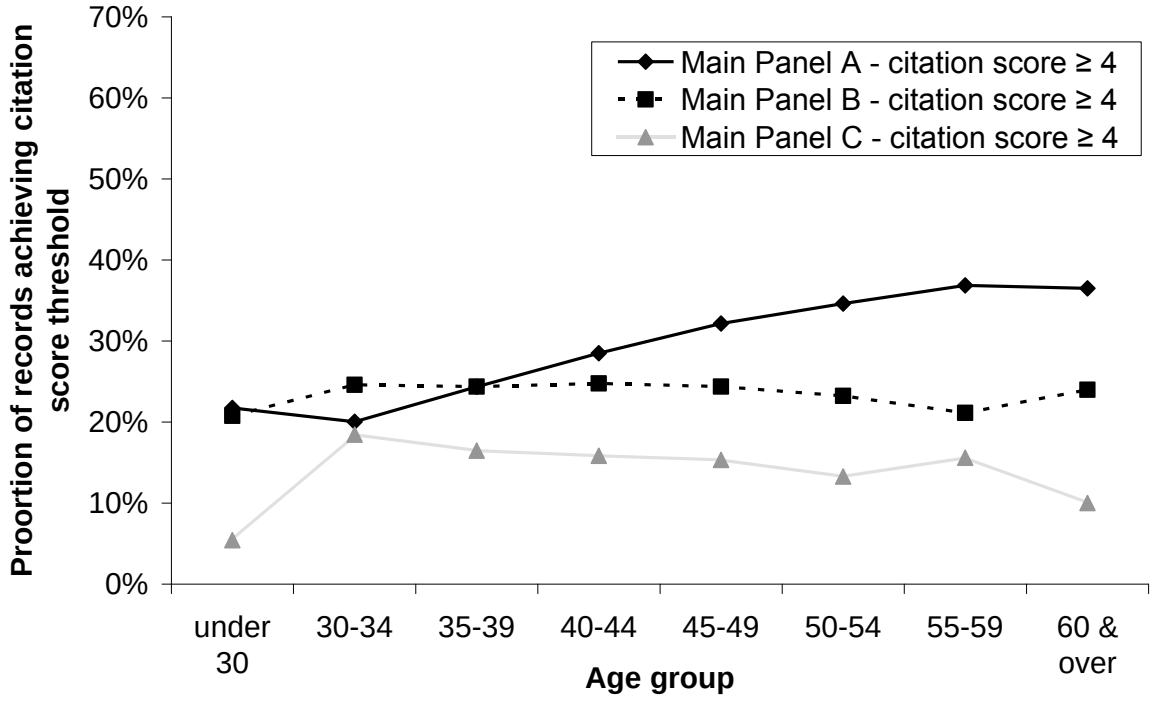


Figure C5: Initial summary of staff where citation score ≥ 2 by age group and main panel using WoS citation database

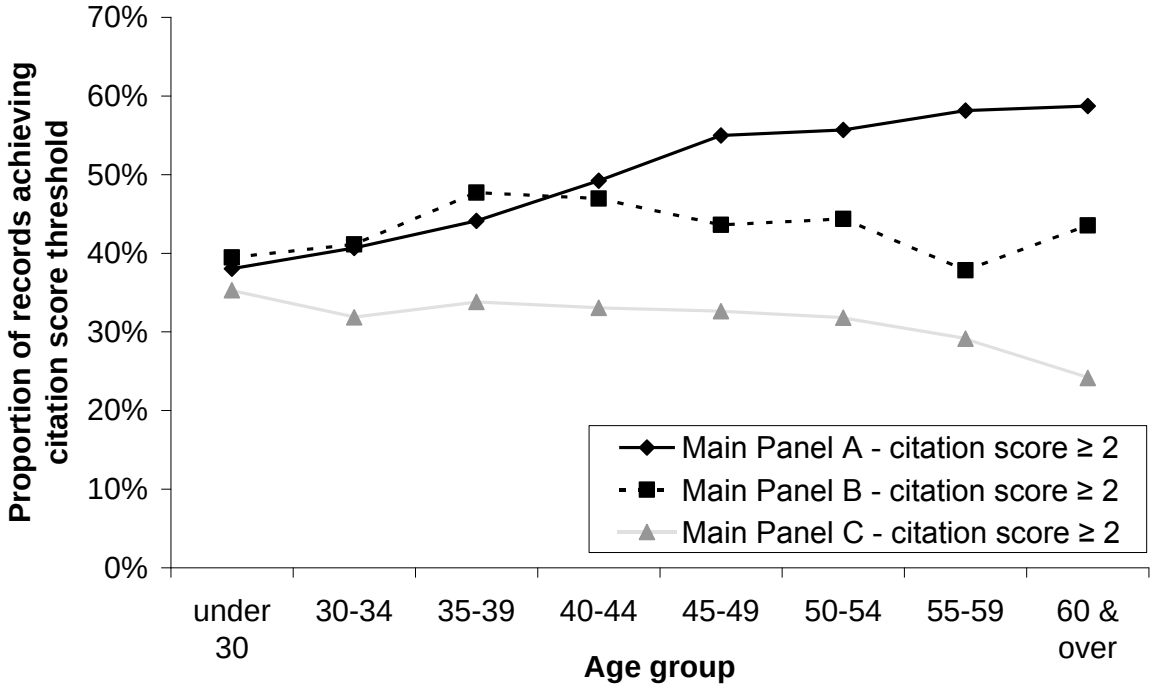


Figure C6: Initial summary of staff where citation score ≥ 4 by age group and main panel using WoS citation database

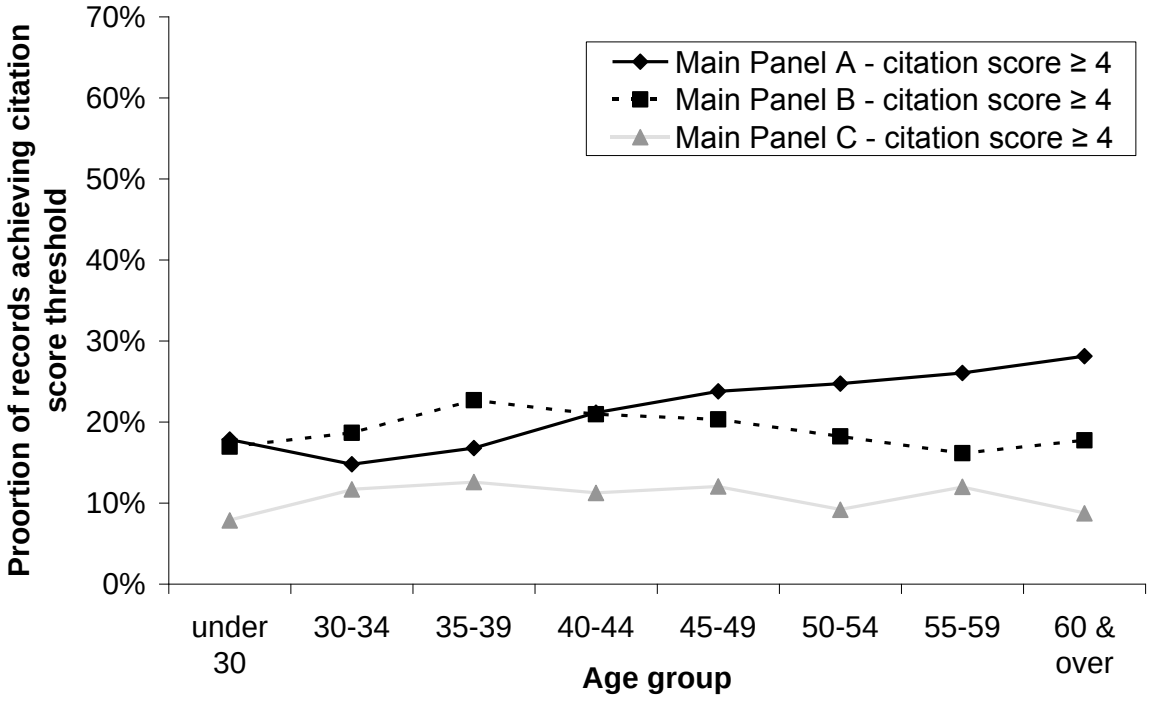


Table C5: Initial summary of staff by sex using Scopus citation database

Sex	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Women	2,325	11,920	49%	22%
Men	7,605	41,085	56%	28%
HESA no match	1,855	9,215	53%	27%
Total	**11,785**	**62,220**	**54%**	**27%**

Table C6: Initial summary of staff by sex using WoS citation database

Sex	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Women	2,150	10,350	43%	17%
Men	7,195	37,310	49%	22%
HESA no match	1,780	8,605	46%	21%
Total	**11,125**	**56,260**	**47%**	**21%**

Figure C7: Initial summary of proportion of records achieving citation score ≥ 2 or ≥ 4 by sex and age group using Scopus citation database

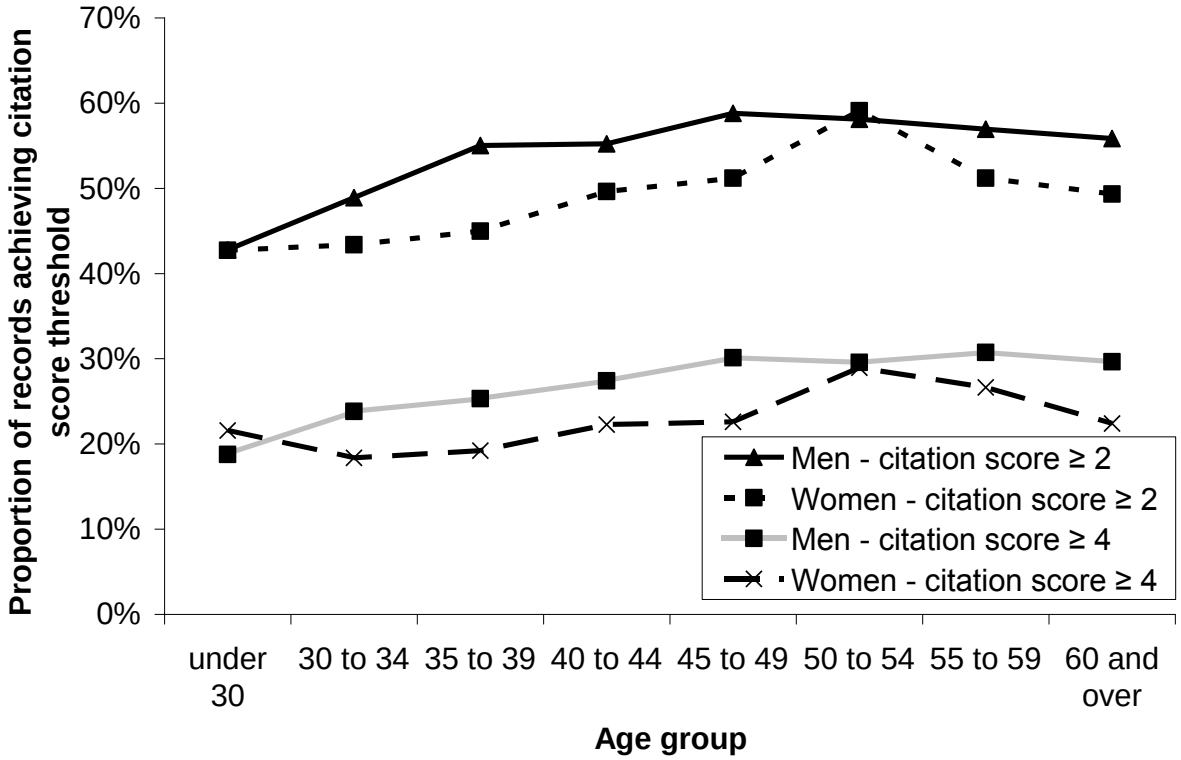


Figure C8: Model citation index (accounts for other factors) where citation score ≥ 2 for sex by age using Scopus citation database

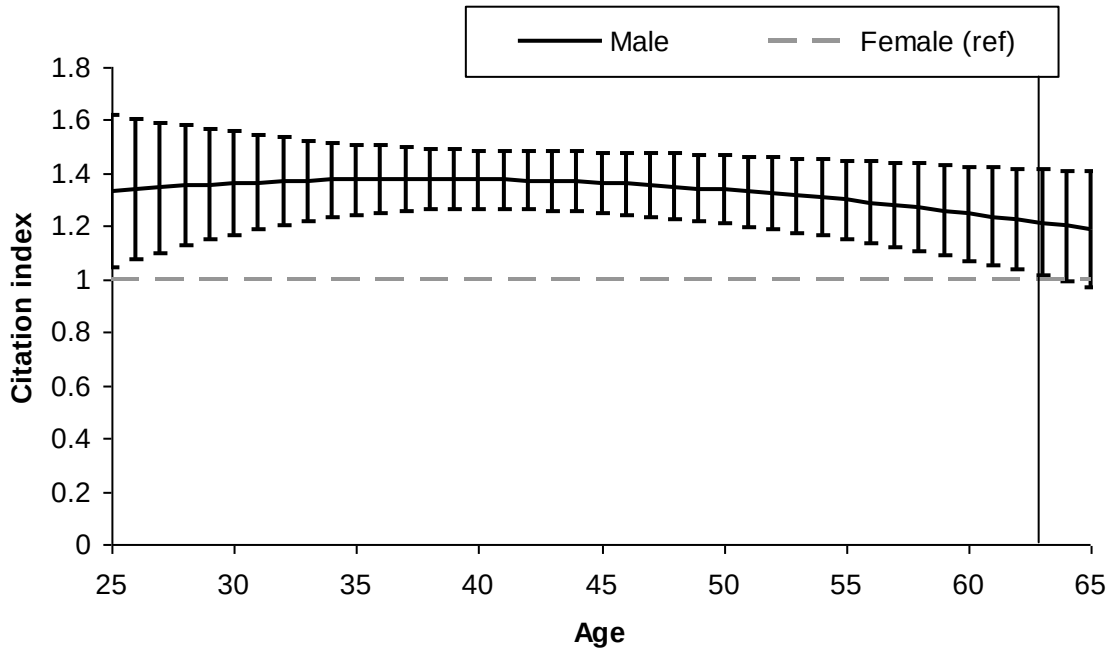


Figure C9: Model citation index (accounts for other factors) where citation score ≥ 4 for sex by age using Scopus citation database

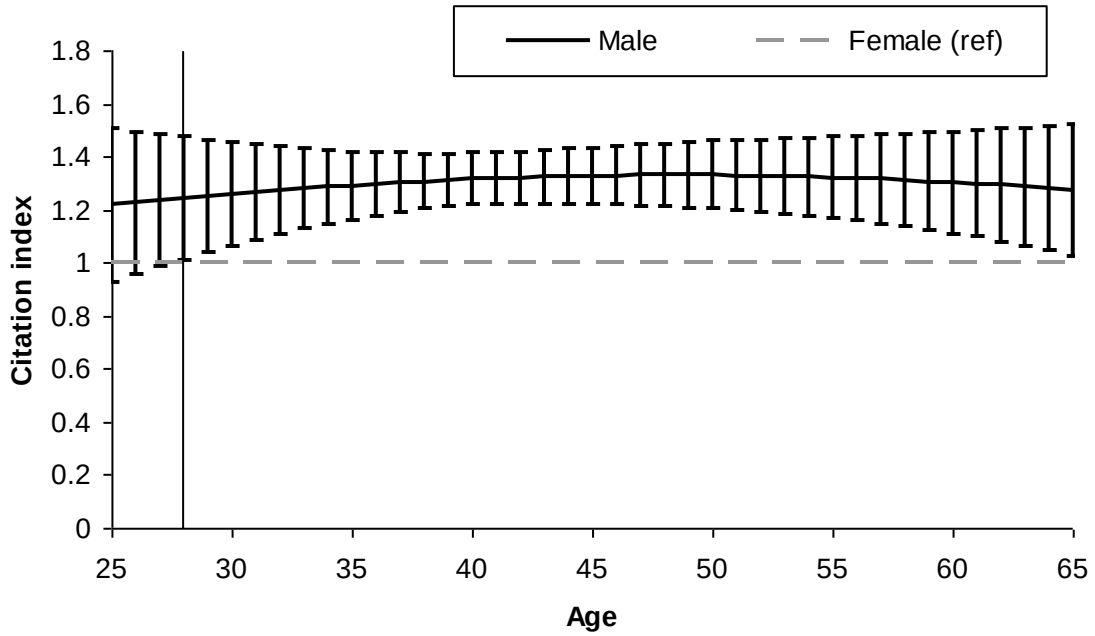


Figure C10: Initial summary of proportion of records achieving citation score ≥ 2 or ≥ 4 by sex and age group using WoS citation database

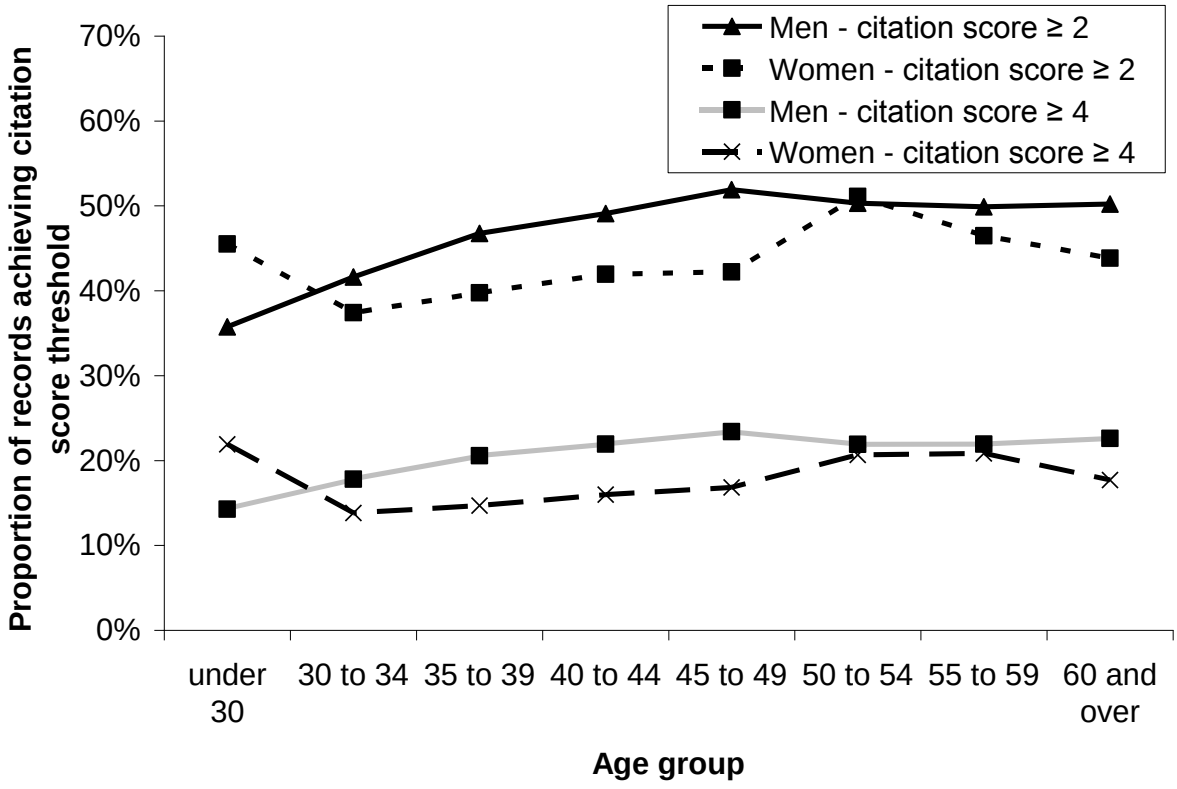


Figure C11: Model citation index (accounts for other factors) where citation score ≥ 2 for sex by age using WoS citation database

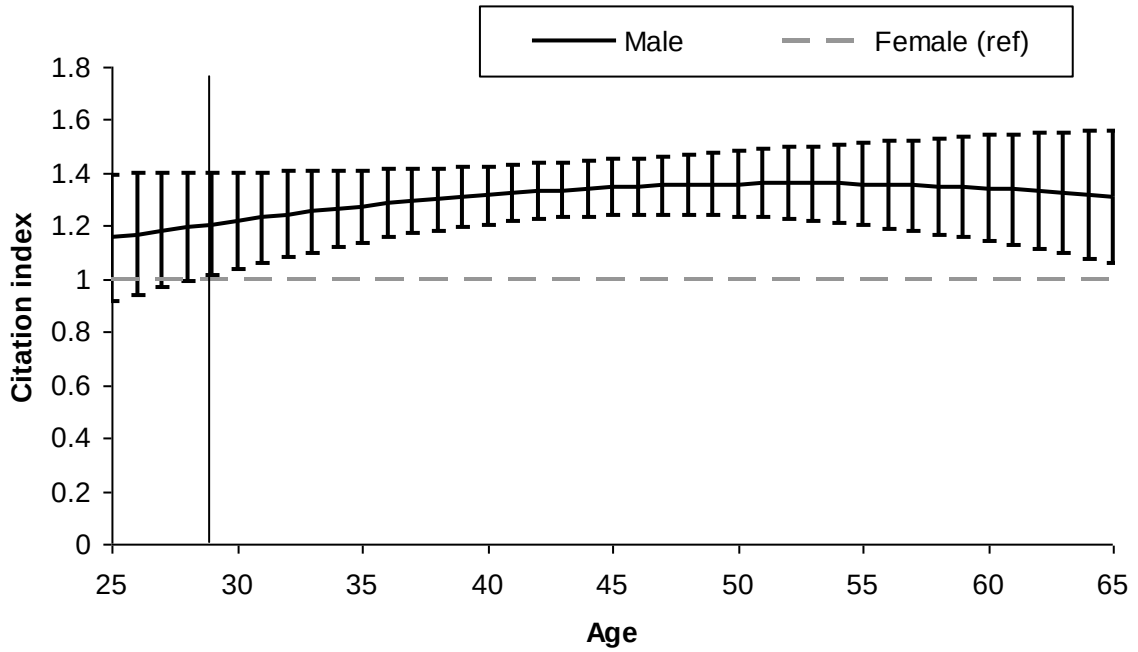


Figure C12: Model citation index (accounts for other factors) where citation score ≥ 4 for sex by age using WoS citation database

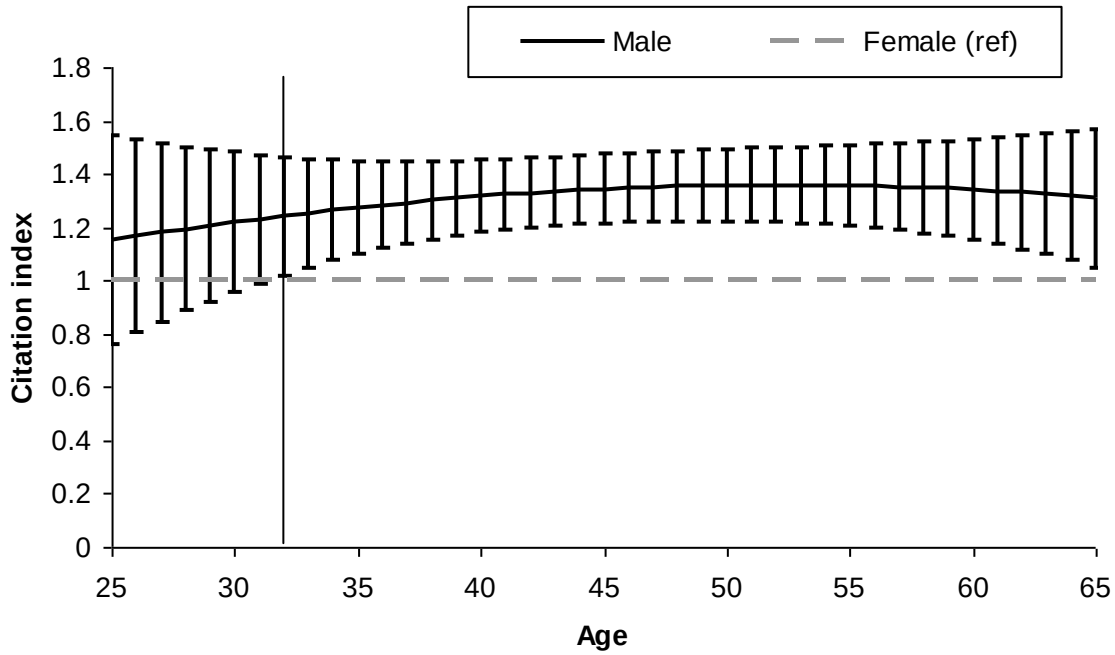


Table C7: Initial summary for staff by disability status using Scopus citation database

Disability	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Non-disabled	9,365	50,030	54%	27%
Disabled	170	895	46%	21%
HESA no match/unknown	2,250	11,295	54%	27%
Total	**11,785**	**62,220**	**54%**	**27%**

Table C8: Citation indices by disability status using Scopus citation database

	Citation index (≥ 2)		Citation index (≥ 4)	
Disability status	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
Non-disabled	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Disabled	0.71	0.84	0.71	0.79

Table C9: Initial summary for staff by disability status using WoS citation database

Disability	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Non-disabled	8,830	45,060	48%	21%
Disabled	165	840	42%	16%
HESA no match/unknown	2,130	10,360	47%	21%
Total	**11,125**	**56,260**	**47%**	**21%**

Table C10: Citation indices by disability status using WoS citation database

	Citation index (≥ 2)		Citation index (≥ 4)	
Disability status	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
Non-disabled	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Disabled	0.81	1.04	0.74	1.01

Table C11: Initial summary for staff by ethnicity using Scopus citation database

Ethnicity	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
White	8,235	44,220	55%	27%
Black	45	200	36%	17%
Asian	640	3,340	54%	29%
Mixed	95	490	59%	25%
Other	100	535	50%	24%
HESA no match/ unknown/refused	2,670	13,435	54%	27%
Total	**11,785**	**62,220**	**54%**	**27%**

Table C12: Scopus citation indices comparing staff by ethnic group

	Citation index (≥ 2)		Citation index (≥ 4)	
Ethnicity	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
White	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Black	0.47	0.93	0.54	0.40
Asian	0.96	0.91	1.12	0.99
Mixed	1.17	1.07	0.93	0.85
Other	0.84	0.85	0.84	0.76
Refused	0.87	0.98	0.87	1.02

Notes: There were no results significantly different from 1.00 at the 1% level.

Table C13: Initial summary of staff by ethnicity using WoS citation database

Ethnicity	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
White	7,805	40,000	48%	21%
Black	40	165	27%	13%
Asian	575	2,845	47%	23%
Mixed	80	400	47%	23%
Other	95	495	41%	19%
HESA no match/ unknown/refused	2,530	12,355	47%	21%
Total	**11,125**	**56,260**	**47%**	**21%**

Table C14: WoS citation indices comparing staff by ethnic group

Ethnicity	Citation index (≥ 2)		Citation index (≥ 4)	
	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
White	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Black	0.42	0.48*	0.57	0.76
Asian	0.99	0.99	1.17	1.2*
Mixed	0.98	0.93	1.12	1.00
Other	0.78	0.70	0.93	1.02
Refused	0.95	1.03	0.88	0.99

Notes: * indicates that the result is significantly different from 1.00 at the 1% level.

Table C15: Initial summary of staff by nationality using Scopus citation database

Nationality	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
UK	7,365	39,915	55%	27%
Non-UK	2,440	12,455	52%	25%
HESA no match/unknown	1,980	9,850	53%	27%
Total	**11,785**	**62,220**	**54%**	**27%**

Table C16: Citation indices comparing staff by nationality using Scopus citation database

Nationality	Citation index (≥ 2)		Citation index (≥ 4)	
	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
UK	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Non-UK	0.90	1.03	0.92	0.99
Unknown	0.94	0.97	1.08	1.19

Table C17: Initial summary of staff by nationality using WoS citation database

Nationality	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
UK	7,150	37,385	48%	20%
Non-UK	2,090	9,790	47%	21%
HESA no match/unknown	1,885	9,080	46%	21%
Total	**11,125**	**56,260**	**47%**	**21%**

Table C18: Citation indices comparing staff by nationality using WoS citation database

Nationality	Citation index (≥ 2)		Citation index (≥ 4)	
	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
UK	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Non UK	0.95	0.96	1.05	1.07
Unknown	0.93	1.22	1.03	1.22

Table C19: Initial summary of staff by mode of employment using Scopus citation database

Mode of employment	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Full time	9,070	48,470	54%	27%
Part time	860	4,535	55%	29%
HESA no match/unknown	1,855	9,215	53%	27%
Total	**11,785**	**62,220**	**54%**	**27%**

Table C20: Citation indices comparing staff by mode of employment using Scopus citation database

Mode of employment	Citation index (≥ 2)		Citation index (≥ 4)	
	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
Full time	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Part time	1.05	1.13*	1.12	1.20

Table C21: Initial summary of staff by mode of employment using WoS citation database

Mode of employment	Number of staff	Number of records	% of records achieving citation score ≥ 2	% of records achieving citation score ≥ 4
Full time	8,520	43,535	48%	21%
Part time	825	4,125	46%	19%
HESA no match/unknown	1,780	8,605	46%	21%
Total	**11,125**	**56,260**	**47%**	**21%**

Table C22: Citation indices comparing staff by mode of employment using WoS citation database

Mode of employment	Citation index (≥ 2)		Citation index (≥ 4)	
	Observed citation index	Model citation index (accounts for other factors)	Observed citation index	Model citation index (accounts for other factors)
Full time	(ref) 1.00	(ref) 1.00	(ref) 1.00	(ref) 1.00
Part time	0.96	1.04	0.92	1.00

Annex D

Average number of papers per person by characteristics

1. The following tables provide information on the average number of papers matched in the Scopus and Web of Science databases split by the seven characteristics discussed in the main report. The order follows that in the main report and Annex C.

2. There were a number of possible approaches to calculating the average number of matched papers; presented here are those which most clearly displayed the differences between the particular groups of staff. Namely we have calculated:

a. Mean: calculated using all the papers returned on the REF bibliometrics pilot exercise dataset.

b. Mean (top 6): calculated after the selection of the top 6 papers for each staff member (so the maximum number of papers a staff member could have would be 6).

c. Median: calculated using all the papers returned on the REF bibliometrics pilot exercise dataset.

Table D1: Average number of matched papers for REF pilot study staff by early career researcher status

	Scopus			Web of Science		
ECR status	**Mean**	**Mean (top 6)**	**Median**	**Mean**	**Mean (top 6)**	**Median**
Non-ECR	17.8	5.4	12	17.0	5.2	11
ECR	10.2	4.9	7	7.7	4.2	5
Unknown	14.4	5.0	9	13.4	4.8	8
Total	**16.3**	**5.3**	**10**	**15.4**	**5.1**	**10**

Table D2: Average number of matched papers for REF pilot study staff by age group

	Scopus			Web of Science		
Age group	**Mean**	**Mean (top 6)**	**Median**	**Mean**	**Mean (top 6)**	**Median**
Under 30	5.2	4.0	4	4.9	3.7	4
30 to 34	8.7	4.8	6	7.7	4.3	5
35 to 39	12.2	5.2	9	10.9	4.8	7
40 to 44	16.0	5.4	11	15.1	5.2	10
45 to 49	19.4	5.5	14	18.0	5.3	12
50 to 54	21.0	5.5	14	19.5	5.4	13
55 to 59	21.4	5.5	14	19.8	5.4	14
60 and over	21.9	5.5	14	21.7	5.4	14
HESA no match	14.4	5.0	9	13.4	4.8	8
Total	**16.3**	**5.3**	**10**	**15.4**	**5.1**	**10**

Table D3: Average number of matched papers for REF pilot study staff by sex

	Scopus			Web of Science		
Sex	**Mean**	**Mean (top 6)**	**Median**	**Mean**	**Mean (top 6)**	**Median**
Women	12.6	5.1	8	11.6	4.8	8
Men	17.9	5.4	12	17.0	5.2	11
HESA no match	14.4	5.0	9	13.4	4.8	8
Total	**16.3**	**5.3**	**10**	**15.4**	**5.1**	**10**

Figure D1: Average number of matched papers to Scopus for REF pilot study staff by age group and sex

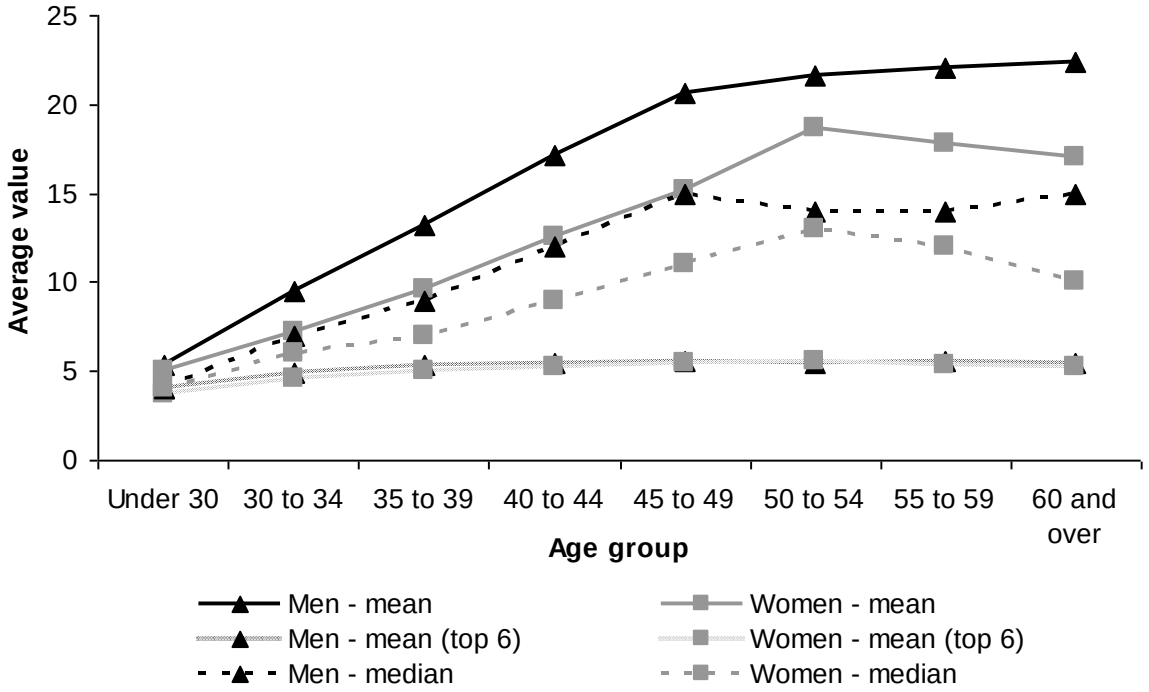


Figure D2: Average number of matched papers to Web of Science for REF pilot study staff by age group and gender

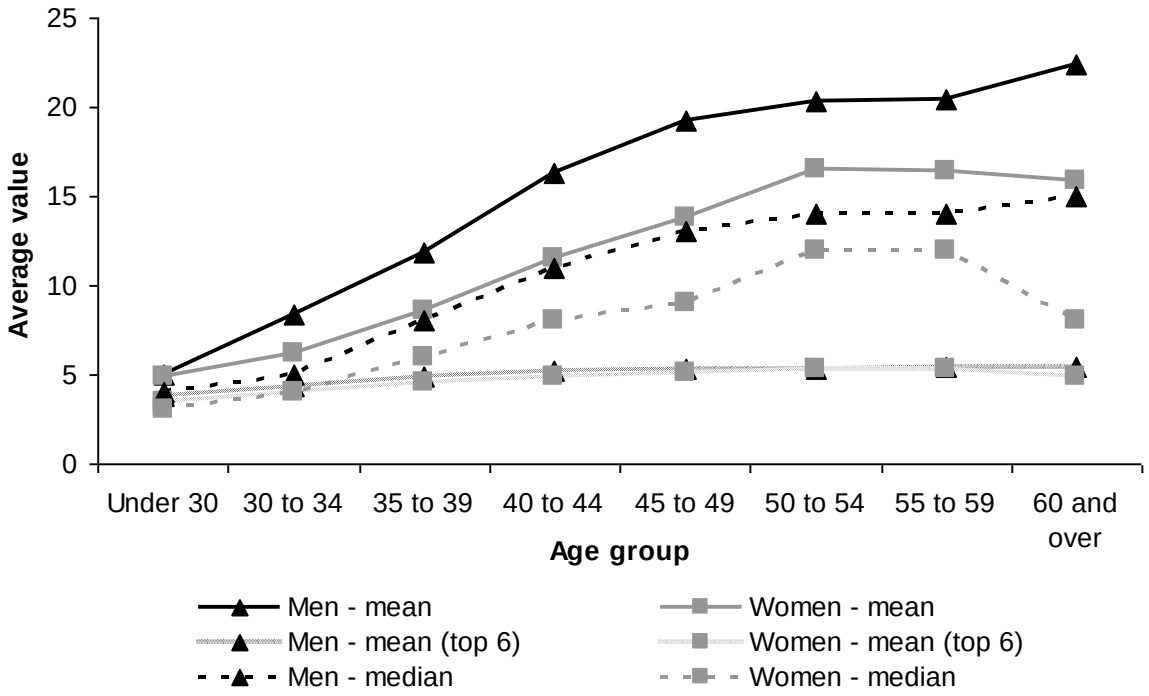


Table D4: Average number of matched papers for REF pilot study staff by disability status

	Scopus			Web of Science		
Disability	**Mean**	**Mean (top 6)**	**Median**	**Mean**	**Mean (top 6)**	**Median**
Not known to be disabled	16.8	5.3	11	15.9	5.1	10
Declared disabled	13.0	5.2	10	12.6	5.1	10
HESA no match /unknown	14.5	5.0	9	13.6	4.9	8
Total	**16.3**	**5.3**	**10**	**15.4**	**5.1**	**10**

Table D5: Average number of matched papers for REF pilot study staff by ethnic group

	Scopus			Web of Science		
Ethnicity	**Mean**	**Mean (top 6)**	**Median**	**Mean**	**Mean (top 6)**	**Median**
White	16.9	5.4	11	15.9	5.1	10
Black	13.6	4.7	6	11.5	4.3	5
Asian	15.7	5.2	9	15.0	4.9	9
Mixed	14.9	5.2	10	12.5	5.1	8
Other	16.7	5.3	9	16.5	5.2	9
HESA no match/ unknown/refused	14.7	5.0	9	14.1	4.9	9
Total	**16.3**	**5.3**	**10**	**15.4**	**5.1**	**10**

Table D6: Average number of matched papers for REF pilot study staff by nationality

	Scopus			Web of Science		
Nationality	**Mean**	**Mean (top 6)**	**Median**	**Mean**	**Mean (top 6)**	**Median**
UK	17.8	5.4	12	16.8	5.2	11
Non-UK	13.6	5.1	8	12.5	4.7	7
HESA no match /unknown	14.3	5.0	9	13.3	4.8	8
Total	**16.3**	**5.3**	**10**	**15.4**	**5.1**	**10**

Table D7: Average number of matched papers for REF pilot study staff by mode of employment

	Scopus			Web of Science		
Mode of employment	**Mean**	**Mean (top 6)**	**Median**	**Mean**	**Mean (top 6)**	**Median**
Full time	16.7	5.3	11	15.8	5.1	10
Part time	16.9	5.3	10	15.4	5.0	9
HESA no match /unknown	14.4	5.0	9	13.4	4.8	8
Total	**16.3**	**5.3**	**10**	**15.4**	**5.1**	**10**

Annex E

Glossary and abbreviations

Glossary

Bibliometrics	A range of methods for studying or measuring publications and the relationships between them (including the analysis of **citations**).
Category A staff	Academic staff in post and on the payroll of the submitting **institution** on the RAE 2008 census date. Eligible staff must be employed under a contract of employment which lists research and/or teaching as their primary function.
Citation	The reference in an academic work to another academic work.
Citation database	A database containing academic works and research which are linked using **citation** data.
Citation score	Used interchangeably with **normalised citation score**.
Citation score threshold	Refers to the value at which the **citation score** associated with a **record** is classed as **highly cited**. In this analysis we use two citation score thresholds of ≥2 and ≥4.
Citation information	Data about the extent to which research has been cited by subsequent research publications, within a given time period.
Citation index	When using simple summary statistics, this is a ratio of odds ratios based on the proportion of **records** achieving a **citation score** ≥ the **citation score threshold** of one **comparison group** of staff and a **reference group** of staff. C_j x (100 – C_r) / C_r x (100 – C_j) Where C_j = proportion of **records** achieving a **citation score** ≥ **citation score threshold** of j^{th} staff group C_r = proportion of **records** achieving a **citation score** ≥ **citation score threshold** of reference staff group When based on a model, the citation index is the exponential of the coefficient identifying the staff group.
Comparison group	Group of staff defined by a characteristic, they are compared to the **reference group** to evaluate if there are differences in **citation information**.

Funding bodies	The four UK HE funding bodies: **DELNI**, **HEFCE**, **HEFCW** and **SFC**.
Highly cited	If the **normalised citation score** for a **record** is greater than or equal to the **citation score threshold** then it is classed as highly cited.
Institution	Used interchangeably with **HEI**.
Main panel	Panels of experts that will be responsible for assessing **institutions**' **submissions** to the **REF**. The main panels will decide the outcomes and will be responsible for coordinating the work of **sub-panels** to achieve an appropriate level of consistency between them.
Model citation index	The **citation index** resulting from the statistical models; this **citation index** value accounts for attributes included in the models.
Normalised citation score	The number of **citations** linked to a **record** adjusted to account for field of research, type of publication and year of publication.
Observed citation index	The **citation index** resulting from the observed proportion of **records** achieving the **citation score** ≥ the **citation score threshold**.
Quality of research	The quality of research outputs will be assessed in terms of their rigour, originality and significance.
Record	The dataset contains unique paper by staff member entries, which are called records, as there may be duplicate entries for any single paper or staff member.
REF bibliometrics pilot exercise	In order to investigate the extent to which **citation information** could be used to inform the **REF** a **bibliometrics** pilot exercise was conducted using a subset of staff previously selected for **RAE2008**. For further information see the **HEFCE** publication 'Report on the pilot exercise to develop bibliometric indicators' (HEFCE 2009/39).
REF Equality and Diversity Advisory Group	A group convened on behalf of the four **funding bodies**, by the **REF** team, to advise on the development and promotion of equalities and diversity in the **REF**. The group includes representatives from the **ECU**, the Universities and College Union, **SFC** and a range of universities.

Reference group	Group of staff defined by a characteristic; they are compared to all the **comparison groups** to evaluate if there are differences in **citation information**.
Submitted staff	Staff selected and put forward by the **institution** for **submission** to the **REF**.
Scopus	A **citation database** used in the **REF bibliometrics pilot exercise**.
Submission	A portfolio of evidence compiled by an **institution** and presented in a standard format, to be assessed by a **sub-panel** in a specific **unit of assessment**.
Sub-panel	Panels of experts that will be responsible for assessing **institutions**' **submissions**. The **REF** proposes a two-tier structure involving 30 sub-panels (one for each **unit of assessment**) working under the guidance of four **main panels**. The sub-panels will assess **institutions**' **submissions** and recommend the outcomes to the **main panels**.
Unit of assessment	One of 35 discipline areas which institutions made submissions to in the RAE2008. The REF is proposing 30 discipline areas be used.
Web of Science	A **citation database** used in the **REF bibliometrics pilot exercise**.

Abbreviations

BME	Black and minority ethnic
DELNI	Department for Employment and Learning in Northern Ireland
ECR	Early career researcher
ECU	Equality Challenge Unit
HE	Higher education
HEFCE	Higher Education Funding Council for England
HEFCW	Higher Education Funding Council for Wales
HEI	Higher education institution
HESA	Higher Education Statistics Agency

RAE	Research Assessment Exercise
RAE2001	Research Assessment Exercise that took place in 2001
RAE2008	Research Assessment Exercise that took place in 2008
REF	Research Excellence Framework
SFC	Scottish Further & Higher Education Funding Council
UOA	RAE unit of assessment
WoS	Web of Science