Australian Government

National Health and Medical Research Council

2019 Survey of research culture in Australian NHMRC-funded institutions

Survey findings report

February 2020

MELBOURNE CANBERRA SYDNEY BRISBANE
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ORIMA RESEARCH

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This project has been undertaken in accordance with the International Standard AS ISO 20252, and in accordance with the Australian Privacy Principles contained in the Privacy Act 1988. ORIMA Research also adheres to the Privacy (Market and Social Research) Code 2014.

I. Executive summary

The National Health and Medical Research Council (NHMRC) is committed to ensuring that NHMRC-funded research is of the highest quality. In May 2019, the NHMRC commissioned ORIMA Research to conduct a survey on its behalf in relation to the research culture in Australian NHMRC-funded institutions.

The survey aimed to better understand:

- the **relevance** of globally identified drivers, enablers and barriers to excellence in research quality in NHMRC-funded institutions;
- the **views and experiences** of individuals who are responsible for research conduct and quality in NHMRC-funded institutions;
- major **pressures and environmental issues** around research quality in NHMRC-funded institutions; and
- opportunities for **change and innovation** in the industry.

The target groups for the survey were research students; senior, mid-career and junior researchers; institutional representatives; and ethics committee members (Human Research Ethics Committees and Animal Ethics Committees).

What are the experiences to date of individuals involved with the conduct of research in Australian NHMRC-funded institutions?

Understanding of research quality

The NHMRC expects NHMRC-funded research to be conducted responsibly, ethically and with integrity, and regards high-quality research to be rigorous, transparent and reproducible.[1] In order to understand the current perceptions that exist within the Australian NHMRC-funded community, all participants were asked which elements they believe are the most important for high-quality research.

73% of all participants believed that **rigour** was the most important aspect of high-quality research. This was followed by reports that high-quality research reflects research that is **ethical** (69%), **beneficial to society** (57%), and **accurate** (53%).

Furthermore, 41% nominated **transparency,** which is regarded by the NHMRC as a key aspect of high-quality research (along with rigour and reproducibility).

[1] https://www.nhmrc.gov.au/about-us/publications/nhmrcs-research-quality-strategy

Use of research resources

58% of research students / researchers reported that the conduct of unnecessary research that might have been avoided if all **negative or neutral studies were routinely published** was the main factor that substantially contributed to inefficient use of research resources.

Research students were *more likely* than other participant groups to feel that a range of factors greatly contributed to inefficient use of research resources.

Environmental features encouraging the production of high-quality research

76% of research students / researchers felt that **codes of conduct** had the greatest **positive effect** on the production of high-quality research. Ethical review processes and data sharing policies were also seen as highly positive influences (73% each).

In contrast, the features which participants felt had the most **negative effect,** and hence discouraged the production of high-quality research were: how funding for specific projects and programmes is awarded (52%); emphasis on publishing in top-tier journals (44%); and how researchers are assessed for promotion during their careers (44%).

Researchers (particularly senior researchers) were generally more critical of the effect that environmental features have in terms of encouraging researchers to produce high-quality research, while research students and ethics committee members (particularly AEC members) were generally more optimistic in their ratings.

Reproducibility of results

93% of all participants believed that **reproducibility was important** to research, and 73% had heard of the term **'crisis of reproducibility'**.

Senior researchers and AEC members were *most likely* to indicate that they felt that reproducibility was important to research (96% each), while research students and HREC members were *least likely* to view reproducibility as important to research (though were still high at 89% and 86% respectively).

56% of all participants felt that there is currently a **significant** 'crisis of reproducibility', while 40% believed that there is a **slight** 'crisis of reproducibility'.

AEC members and junior researchers were *most likely* to indicate that there is a significant crisis of reproducibility (66% and 60% respectively), while HREC members were *least likely* to share this sentiment (41%).

Research students / researchers and institutional representatives were asked to indicate the extent to which a variety of factors were felt to contribute to a failure to reproduce results. Overall, the top three factors which they believed contributed **'considerably'** or **'to a great extent'** were: selective reporting of results (71%); pressure to publish for career advancement (62%); and original findings obtained with low statistical power / poor statistical analysis (52%).

In contrast, the three factors which participants felt contributed only **'slightly'** or **'not at all'** were: bad luck (75%); fraud (62%); and insufficient peer review of grant applications (60%).

What environmental factors are identified and / or experienced as barriers and enablers to high-quality research?

General perceptions – immediate environment

90% of research students / researchers agreed that research practices in their department / research group **follow established institutional policies** regarding research; whilst

55% of research students / researchers agreed that researchers in their immediate research environment are **committed to open access publishing** when publishing research results (17% disagreed).

Furthermore, 16% of all participants *disagreed* that junior researchers are effectively mentored about responsible research practices.[2]

Barriers to implementing procedures to improve reproducibility of results

19% of research students / researchers reported that they / their research group had **experienced barriers** when trying to implement procedures to improve reproducibility, primarily cost and time-related barriers.

Barriers were reportedly more common amongst senior researchers; however junior researchers and research students were also more likely to report that they have never tried to implement procedures to improve reproducibility of results.

Attempts to reproduce results

50% of research students / researchers reported that they were able to **fully reproduce a finding from their own published paper**, whilst 30% were able to fully reproduce a finding from another researcher's published paper.

Furthermore, participants were considerably more likely to have been *unable* to fully reproduce a finding from another researcher's published paper, compared to their own published paper (44% versus 8%).

Pressures

Results suggested that pressures were more often observed in other researchers than personally experienced by researchers.

54% of all participants were **aware of researchers** feeling tempted or under pressure to compromise on research quality.

Junior researchers were *most likely* to be aware of such instances, while ethics committee members (particularly AEC members) were *least likely*.

[2] Responsible research practices are defined as those that ensure research is rigorous, transparent and reproducible.

27% of research students / researchers indicated that they had **personally** felt tempted or under pressure to compromise on research quality.

Research students and junior researchers were *most likely* to have felt such pressure, while senior researchers were *least likely*.

Funding, publishing and competition

Research students / researchers demonstrated some concerns regarding funding and publishing pressures.

46% of research students / researchers agreed that their department's / research group's expectations of researchers for obtaining external **funding** were reasonable (versus 66% agreeing that expectations with respect to **publishing** were reasonable).

53% of research students / researchers agreed that pressure to obtain external **funding** has a negative effect on the quality of research in their department / research group (versus 33% who felt this way in relation to **publishing**).

Junior researchers were *most likely* to be impacted by these pressures, compared to mid-career and senior researchers.

70% of all participants felt that **competition** was having a **negative effect** on the production of high-quality research, while 25% believed that competition was having a positive effect.

Research students and junior researchers were *least likely* to indicate that competition had a *positive* effect on the production of high-quality research, while senior researchers and ethics committee members were *most likely*.

What behaviours that may affect research quality are occurring in Australian NHMRC-funded institutions?

Overall behaviours

Research students / researchers were generally more likely to report that they had **witnessed others** undertaking undesirable behaviours throughout the research process, than they were to report that they had **personally undertaken** such behaviours themselves.

43% of research students / researchers reported that they had **witnessed others propose a research question which was easy to answer rather than needed**.

Other commonly witnessed behaviours included choosing an inadequate research design because it minimised costs (40%); and using an unsuitable measurement method because it was readily available (35%).

25% of research students / researchers admitted to **personally not attempting to publish a valid 'negative' or 'neutral' study**.

Other common behaviours personally undertaken included choosing an inadequate research design as it minimised costs (16%), and proposing a research question that was easy to answer rather than needed (15%).

Research students were generally *less likely* to report having witnessed or undertaken the listed behaviours, compared to their senior colleagues. This was likely driven by the fact that they would have had less opportunity to do or see such behaviours due to a relatively shorter length of engagement in their role.

What are the opportunities for change and innovation to improve research quality in Australian NHMRC-funded institutions?

Current practices: Researchers

97% of research students / researchers reported that they / their research group had **established procedures in place to ensure reproducibility** in their work.

88% of research students / researchers employed **transparent reporting of study design and methods** to ensure reproducibility.

The establishment of procedures to ensure reproducibility generally increased with seniority.

Overall, 61% of research students / researchers felt that the quality of their research had *improved* as a result of the introduction of such procedures. Compared to their junior colleagues, senior researchers were *more likely* to indicate that the quality of their research remained unchanged after these procedures were introduced. Given that 96% of research students / researchers overall felt that there was currently a 'crisis of reproducibility', there may be scope to improve the effectiveness of such procedures.

Education and training

Overall, the majority of participants had offered or received education and training about responsible research practices, primarily through mandatory institutional training (62%) and training by supervisors / mentors (55%). Just 1% reported that their institution does not offer such training, and 5% indicated that they had never received such training – ethics committee members were most likely to report that they had never received training (11%-15%, compared to 2%-6% of research students / researchers). [3]

All participants were also asked about their *perceptions* of training on responsible research practices. Overall, most agreed that appropriately educating and training researchers about responsible research practices will improve research quality (87%), and that education and training about responsible research practices is beneficial for their work / role (85%). However, despite this positive sentiment toward training, participants were *less likely* to agree that the education and training opportunities available at their institution were effective (53%). This suggests that there is opportunity to improve the training offered through institutions to meet the needs of the research community.

[3] Institutional representatives were not shown this response option.

Suggested actions and opportunities for improvement

Overall, the results suggested that researchers themselves were perceived to have the greatest potential to enact change. By participant group, however, both ethics committee members and institutional representatives strongly acknowledged that they too could have a strong impact on research quality.

When asked about the actions that participants felt researchers, academic / research institutions, and funders could take in order to improve research quality, a key take-out was that 84% of all participants felt that **academic / research institutions** could make an impact by shifting industry norms within the research community, by **promoting an environment where high-quality research and reproducible research is considered the required norm**.

In addition to this, it was felt that:

- **researchers** could have the most impact by specifying critical research design elements (71%) and obtaining statistical advice and developing a plan early (69%); and
- provision or ensuring of (by institutions / funders) or attendance at (by researchers) appropriate training or mentoring programs was an action that **all** could take (60-72%).

Other key areas of opportunity identified through the research are as follows (but are not limited to the following):

- Focusing on training / mentorship (especially of junior researchers) about responsible research practice, and the effectiveness of such education and training;
- Addressing the perceived crisis of reproducibility, through factors that are seen to be contributing most to a failure to reproduce results (such as selective reporting of results or pressure to publish for career advancement);
- Promoting positive initiatives / processes rather than competition where possible;
- Encouraging open access publishing (due to perceptions that this is not happening as frequently as other measures that contribute to high-quality research), whilst considering the barrier of cost;
- Considering the impact of funding pressures / funding expectations on researchers, and the potential to explore other funding models; and
- Encouraging more rigorous reproducibility procedures (as procedures such as in-house replication before publication are not currently being undertaken frequently).

II. Survey background and methods

Background

The National Health and Medical Research Council (NHMRC) is Australia's leading funding agency for health and medical research. Ensuring the highest quality of NHMRC-funded research is a priority for the agency and aligns with NHMRC's strategy for health and medical research.[4] High-quality research that is rigorous, transparent and reproducible maximises the opportunity for benefits to be gained.[5]

Research quality has been a topic of increasing attention globally, with international reports identifying the drivers, enablers and barriers to excellence in research quality. However, there is limited documented information about the research culture in Australia, and the relevance of these factors in the Australian context.

In May 2019, the NHMRC commissioned ORIMA Research to conduct a survey on its behalf in relation to the research culture in Australian NHMRC-funded institutions.

Research objectives

The primary objective of the survey was to collect information and identify issues related to research quality in Australian NHMRC-funded institutions, through a survey of individuals who make up the NHMRC-funded research community.

More specifically, the survey aimed to better understand:

- the **relevance** of globally identified drivers, enablers and barriers to excellence in research quality in NHMRC-funded institutions;
- the **views and experiences** of individuals who are responsible for research conduct and quality in NHMRC-funded institutions;
- major **pressures and environmental issues** around research quality in NHMRC-funded institutions; and
- opportunities for **change and innovation** in the industry.

The survey results will be used to inform other activities being undertaken by NHMRC as part of its Research Quality Strategy to ensure the highest quality of NHMRC-funded research by providing guidance and supporting good practices throughout the research cycle. The survey will also provide control data for comparison with future iterations of the survey to determine whether actions taken by NHMRC and within institutions and research groups lead to improvements in research practices, and ultimately the quality of NHMRC-funded research.

[4] https://www.nhmrc.gov.au/about-us/publications/nhmrcs-research-quality-strategy
[5] https://www.nhmrc.gov.au/research-policy/research-quality

The target groups for the survey were research students; senior, mid-career and junior researchers; institutional representatives; and ethics committee members (Human Research Ethics Committees and Animal Ethics Committees).

This report presents the findings of the survey, with comparisons between the seven aforementioned groups of participants (referred to as "participant groups" throughout the report) where relevant.

Research methodology

Questionnaire development

The survey questionnaire (see Appendix A) was developed in consultation with the NHMRC project team and NHMRC's Research Quality Steering Committee (RQSC), with content informed by the following international surveys:

- **Haven, T. L., Tijdink, J. K., Martinson, B. C., & Bouter, L. M.** (2019). Perceptions of research integrity climate differ between academic ranks and disciplinary fields: Results from a survey among academic researchers in Amsterdam. *PLoS ONE*, *14*(1). https://doi.org/10.1371/journal.pone.0210599

  Participants – academic researchers.

- **Boulbes, D. R., Costello, T., Baggerly, K., Fan, F., Wang, R., Bhattacharya, R., Ye, X., & Ellis, L. M.** (2018). A Survey on Data Reproducibility and the Effect of Publication Process on the Ethical Reporting of Laboratory Research. *Clinical Cancer Research, 24*(14), 3447-3455. https://doi.org/10.1158/1078-0432.CCR-18-0227

  Participants – graduate students and postdoctoral fellows performing bench science.

- **QUEST Center for Transforming Biomedical Research.** (2018). *Assessing the organizational climate for translational research with a new survey tool*. Retrieved from https://www.bihealth.org/en/research/quest-center/projects/survey-on-the-research-climate

  Participants – researchers and doctoral students.

- **Nature.** (2018). Checklists work to improve science [Editorial]. *Nature, 556,* 273-274. https://doi.org/10.6084/m9.figshare.6139937

  Participants – researchers who had published in a Nature journal between July 2016 and March 2017.

- **Baker, M.** (2016). Is there a reproducibility crisis? *Nature, 533*(7604), 452-454. doi:10.1038/533452a Retrieved from https://www.nature.com/news/1-500-scientists-lift-the-lid-on-reproducibility-1.19970

  Participants – researchers.

- **Nuffield Council on Bioethics.** (2014). *The findings of a series of engagement activities exploring the culture of scientific research in the UK*. Retrieved from https://www.nuffieldbioethics.org/publications/the-culture-of-scientific-research

  Participants – scientists.

- **Martinson, B. C., Thrush, C. R., & Crain, A. L.** (2013). Development and validation of the Survey of Organizational Research Climate (SORC). *Science and Engineering Ethics, 19*(3), 813-834. https://doi.org/10.1007/s11948-012-9410-7

  Participants – biomedical and social science faculty and postdoctoral fellows.

- **Mobley, A., Linder, S. K., Braeuer, R., Ellis, L. M., & Zwelling, L.** (2013). A Survey on Data Reproducibility in Cancer Research Provides Insights into Our Limited Ability to Translate Findings from the Laboratory to the Clinic. *PLoS ONE*, *8*(5). https://doi.org/10.1371/journal.pone.0063221

  Participants – faculty and trainees.

- **John, L. K., Loewenstein, G., & Prelec, D.** (2012). Measuring the Prevalence of Questionable Research Practices With Incentives for Truth Telling. *Psychological Science, 23*(5), 524-532. https://doi.org/10.1177/0956797611430953

  Participants – academic psychologists.

Publicly available results from these international surveys are referenced throughout this report where relevant. If no benchmarking information is included in a Figure, there were no relevant benchmark results publicly available. Please note that comparisons against benchmark results should be treated with caution, as there may be differences in question / statement wording, response options / scale (including showing or hiding of 'don't know' / 'unsure' results), and participant types (see above) – these caveats are noted throughout the report where benchmark results are presented.

Human Research Ethics Application

Ethics approval was granted for this project by the ORIMA Research Human Research Ethics Committee on Tuesday 25 June 2019 (Approval Number: 0102019). An amendment was subsequently approved by the committee on Tuesday 15 October 2019 to account for a series of revisions to the questionnaire (post-pilot – see below for further information) and other supporting documents.

Pilot survey

The survey was administered using an online self-completion methodology. As part of the questionnaire finalisation process, a pilot was conducted between Wednesday 10 July 2019 and Friday 26 July 2019, to assess the suitability of survey design and content, and to test the online system. Ethics approval was not obtained for the pilot survey as it did not involve the submission of real responses, and the pilot data was not included in the final reported results.

Pilot participants were volunteers recruited by the NHMRC project team and included members of the RQSC. A total of n=23 individuals participated in the pilot survey, from a pilot contact list of N=33.

Overall, the pilot was assessed as being successful as there were no substantial criticisms or feedback provided in relation to any aspect or question of the survey, and no critical survey issues were uncovered.

A Pilot Testing Report was provided to NHMRC on Monday 29 July 2019, which detailed suggestions for improvement primarily in relation to:

- improving the clarity of some survey questions and key terms;
- reducing the length of the questionnaire by evaluating the redundancy of some questions (either whole or in part); and
- including additional questions related to education and training in order to collect sufficient data to answer all research questions.

Following the pilot survey, the questionnaire was revised to incorporate pilot feedback, and was finalised in consultation with the NHMRC project team in preparation for the main fieldwork phase. This included a substantial reduction in the number of questions asked to reduce participant burden. The final revised online survey underwent comprehensive internal testing by the ORIMA project team, as well as User Acceptance Testing by the NHMRC project team and the RQSC, prior to launch.

Main survey

The main survey was conducted between Monday 28 October 2019 and Monday 25 November 2019. Participation in the survey was voluntary, and responses to the survey were private and confidential, and de-identified at the data processing stage.

Contact list preparation

Following an opt-out process facilitated by NHMRC, contact details (names and email addresses) for individuals from the following target groups (who did not opt-out) were provided to ORIMA Research:

- Researchers and students currently receiving NHMRC funding; and
- Institutional representatives (senior executives, support staff and administrators).

These individuals were sent a survey invitation from ORIMA Research containing a **personalised** survey link, which is a link that is unique to an individual. The survey to which this link is attached can only be completed once and not shared with other potential participants. This type of link allows for monitoring of response numbers and sending of targeted reminder emails to boost response rates.

NHMRC does not hold contact details for individual members of Human Research Ethics Committees (HRECs) and Animal Ethics Committees (AECs). In order to capture the views from members of these committees, staff of the institutional research offices / ethics committee secretaries were requested to forward a **generic** survey link onto these members. This request was included in their personalised survey invitation.

In order to further boost response numbers, all individuals who received a personalised survey invitation were also provided with the generic survey link, which they could forward to other relevant people who may wish to participate (e.g. PhD students who may not be named on the research grant).

Response rate

Overall, a total of 1,768 responses were received for the survey, representing an approximate response rate of 14% (see Table 1 and Table 2 for a detailed response rate breakdown).

Table 1: Response rate breakdown (based on population estimates)

Participant group	Population size (approximate)	Number of responses	Response rate
Research students	8,526[6]	149	10%
Junior researchers		284	
Mid-career researchers		397	
Senior researchers	2,349	658	28%
Past or current HREC members	672	126	19%
Past or current AEC members	420	48	11%
Representatives from an institution	401	106	26%
TOTAL	**12,368**	**1,768**	**14%**

Table 2: Response rate breakdown (based on personalised survey invitations)

Participant group	Number of invitations sent	Number of responses	Response rate
Research students	6,801[7]	149	22%
Junior researchers		284	
Mid-career researchers		397	
Senior researchers		658	
Institutional representatives *Includes heads of institutions, Research Administration Offices (RAOs) and Research Integrity Officers (RIOs)*	291	106	36%
TOTAL	**7,092**	**1,594**	**22%**

[6] Population estimates were only available for this group as a whole (research students and junior / mid-career researchers). As such, the 'population size' and 'response rate' cannot be disaggregated by participant group.
[7] Contact details were only provided for this group as a whole (research students and junior / mid-career / senior researchers). As such, the 'number of invitations sent' and 'response rate' cannot be disaggregated by participant group.

Statistical precision

As this survey was an attempted census of those responsible for research conduct and quality in Australian NHMRC-funded institutions (i.e. all those in scope for the survey were assumed to have been invited to participate, via either a personalised or generic survey link), the survey results are not subject to sampling error.

However, the survey is subject to potential non-sampling error, including coverage error and non-response error. Unlike sampling error, non-sampling error is generally not mathematically measurable. ORIMA Research uses several strategies to address sources of non-sampling error to the extent possible, including careful questionnaire construction and data processing quality control.

Response bias

When interpreting results throughout this report, it should be noted that due to the nature of the research topic, participants may have exhibited a degree of social desirability bias when answering the survey questions. Social desirability bias is the tendency of participants to provide answers that they believe are more acceptable or favourable.

Assurances were provided throughout the questionnaire to mitigate this type of response bias as much as possible, particularly in the survey introduction and the 'Current and past behaviours' section. These included:

- A clear explanation of the focus of the survey (research quality, not research misconduct) and the value of honest responses;
- Reassurance that responses are private and confidential, and there would be no repercussions for individuals or institutions based on the responses provided; and
- Provision of an 'I prefer not to answer this question' option in the *Current and past behaviours* section of the survey to allow participants to actively opt-out (per question) as desired.

When reading this report, it should also be noted that the nature and content of the survey (particularly the concept of reproducibility) generally lends itself more to experimental and empirical research. Furthermore, the international surveys referenced in the development of the questionnaire (see page 11) were primarily focused on quantitative research. As such, participants who specialise in other types of research, particularly qualitative research, may have found it challenging to answer some questions throughout the survey.

Presentation of results

Percentages in this report are based on the total number of valid responses made to the particular question being reported on. In most cases, results reflect those participants who expressed a view and for whom the questions were applicable. 'Don't know / can't say' and 'prefer not to answer' responses are included only where they aid in the interpretation of results. Full results including such responses may be viewed in Appendix B and C if required. Results presented as percentages throughout the report may not add up to 100% (particularly where displayed in chart form) due to rounding, or where participants were able to select more than one response.

III. Profile of participants

ROLE (n=1,768)

8%	16%	22%	37%	6%	7%	3%
Research student	Junior researcher	Mid-career researcher	Senior researcher	Institutional representative	HREC member	AEC member

TOP THREE CURRENT (PRIMARY) ROLE / JOB TITLES

Institutional representatives

1. Research Administration Officer (37%)
2. Director (14%)
3. Research Integrity Officer (13%)

(n=105)

HREC members

1. Person with knowledge of / current experience in the areas of research regularly considered by the HREC (31%)
2. Layperson (25%)
3. Person with knowledge / experience in the professional care of people (14%)

(n=126)

AEC members

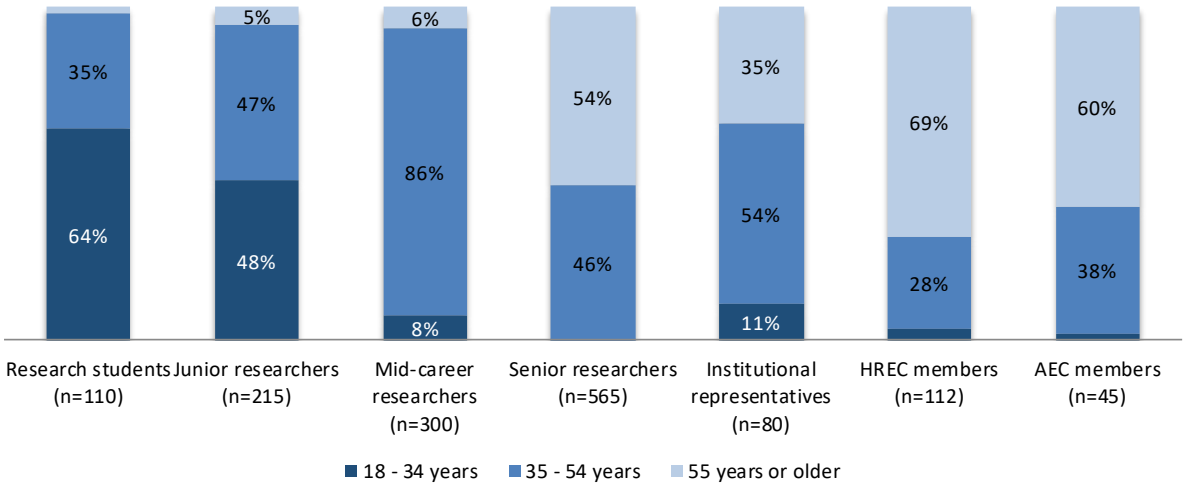
1. Category D member (25%)
2. Category C member (19%)
3. Category A or Chair (17%)

(n=48)

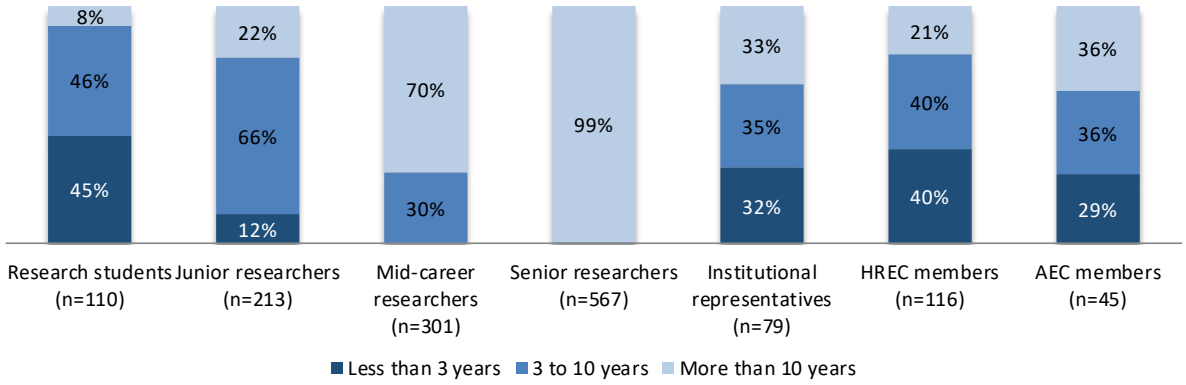
GENDER

	Research students	Junior researchers	Mid-career researchers	Senior researchers	Institutional representatives	HREC members	AEC members
Female	65%	73%	58%	42%	59%	50%	51%
Male	33%	27%	42%	58%	41%	50%	49%
	(n=108)	(n=212)	(n=299)	(n=562)	(n=80)	(n=113)	(n=45)

AGE



YEARS IN CURRENT ROLE

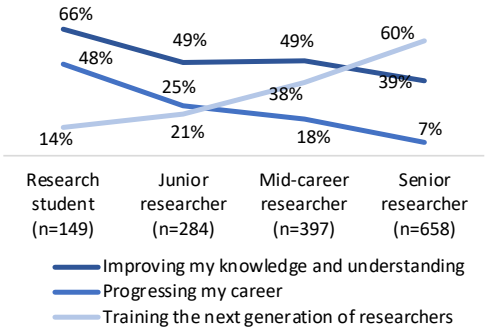


MOTIVATIONS AS A RESEARCHER (n=1,488)

OVERALL

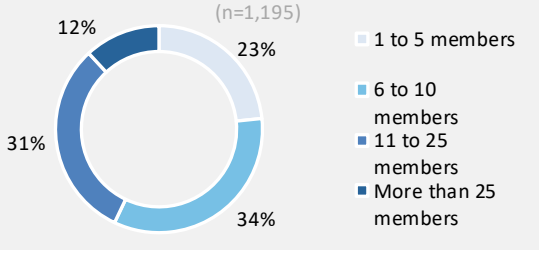
Making research discoveries for the benefit of society	83%
Improving my knowledge and understanding	46%
Training the next generation of researchers	42%
Satisfying my curiosity	32%
Working as part of a team	23%
Communicating research to others	19%
Progressing my career	18%
Earning a salary	16%
Gaining recognition from my peers	7%
Gaining recognition from the public	1%
None of the above	<1%
Don't know / can't say	<1%

MOTIVATIONS THAT SHIFTED MOST WITH SENIORITY

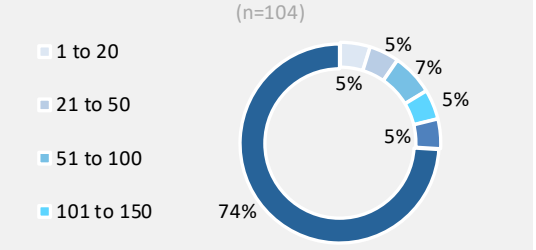


SIZE OF RESEARCH GROUP / INSTITUTION

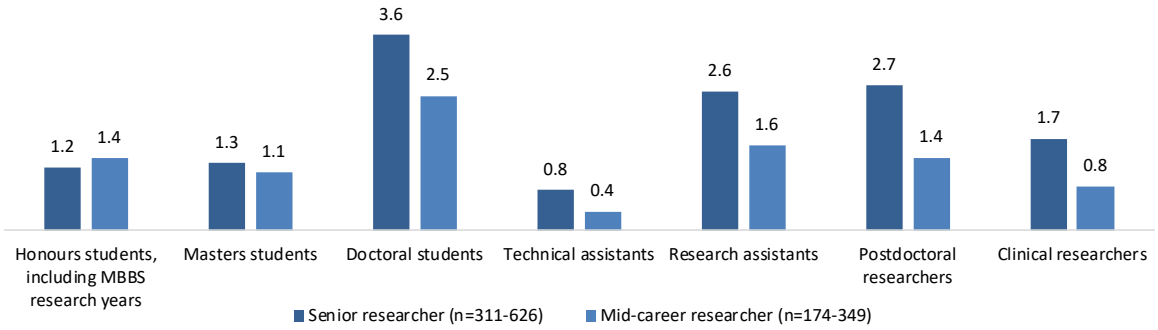
NUMBER OF MEMBERS: RESEARCH GROUP



NUMBER OF RESEARCHERS: INSTITUTION



PROVISION OF PRIMARY SUPERVISION BY SENIOR AND MID-CAREER RESEARCHERS: AVERAGE NUMBER BY STAFF / STUDENT TYPE



TOP 5 MAIN FIELDS OF RESEARCH

Research students	Junior researchers	Mid-career researchers	Senior researchers	Institutional representatives	HREC members	AEC members
45% Quantitative research	**51%** Quantitative research	**46%** Quantitative research	**51%** Discovery	**88%** Translational research	**87%** Qualitative research	**63%** Discovery
36% Public health	**39%** Translational research	**42%** Discovery	**46%** Translational research	**80%** Quantitative research	**80%** Quantitative research	**58%** Quantitative research
33% Qualitative research	**36%** Public health	**36%** Translational research	**40%** Quantitative research	**79%** Qualitative research	**73%** Health services	**48%** Qualitative research
29% Translational research	**31%** Discovery	**30%** Public health	**30%** Preclinical	**77%** Discovery	**63%** Hospital clinical	**38%** Translational research
27% Discovery (n=149)	**29%** Qualitative research (n=284)	**27%** Preclinical (n=397)	**29%** Public health (n=658)	**76%** Public health / Health services (n=106)	**62%** Public health (n=126)	**38%** Preclinical (n=48)
Type of Institution 1. University (71%) 2. Research institute (16%) 3. Hospital (9%) 4. Other (3%) 5. Company (<1%) (n=110)	**Type of Institution** 1. University (68%) 2. Research institute (28%) 3. Hospital (3%) 4. Other (<1%) 5. Company (0%) (n=216)	**Type of Institution** 1. University (65%) 2. Research institute (27%) 3. Hospital (7%) 4. Company (<1%) 5. Other (<1%) (n=302)	**Type of Institution** 1. University (64%) 2. Research institute (27%) 3. Hospital (7%) 4. Other (1%) 5. Company (<1%) (n=571)	**Type of Institution** 1. University (60%) 2. Research institute (27%) 3. Hospital (11%) 4. Other (1%) 5. Company (0%) (n=81)	**Type of Institution** 1. Hospital (42%) 2. University (39%) 3. Other (11%) 4. Research institute (6%) 5. Company (2%) (n=118)	**Type of Institution** 1. University (54%) 2. Research institute (17%) 3. Other (13%) 4. Hospital (9%) 5. Company (7%) (n=46)

IV. What are the experiences to date of individuals involved with the conduct of research in Australian NHMRC-funded institutions?

Knowledge, understanding and views about research quality

Participants were asked a number of questions regarding their experiences in undertaking their work to date. Areas addressed included their understanding of research quality, what matters most to validity of research, inefficient use of research resources, environmental features that encourage the production of high-quality research, the effect that ensuring research quality has on workload, and the importance of reproducibility in research. The findings are discussed in this chapter.

Understanding of research quality

The NHMRC expects NHMRC-funded research to be conducted responsibly, ethically and with integrity; and regards high-quality research to be rigorous, transparent and reproducible.[8] In order to understand the perceptions that exist within the Australian NHMRC-funded community, all participants were asked which elements *they* believe are the most important for high-quality research.

As shown in Figure 1 overleaf, overall, the majority of participants believed that **rigour** was the most important aspect of high-quality research (73%). Over half of participants also felt that high-quality research reflects research that is **ethical** (69%), **beneficial to society** (57%), and **accurate** (53%). In addition, 41% of participants selected **transparency**, which is regarded by the NHMRC as a key aspect of high-quality research (along with rigour and reproducibility).

In contrast, participants were least likely to identify **openness** (10%) and **legality** (8%) as the most important aspects for high-quality research (noting that participants were only able to select up to five responses).

[8] https://www.nhmrc.gov.au/about-us/publications/nhmrcs-research-quality-strategy

Figure 1: Most important aspects of high-quality research

Base: All participants; up to 5 responses accepted

OVERALL (n=1,766)	Research students (n=149)	Junior researchers (n=284)	Mid-career researchers (n=397)	Senior researchers (n=657)	Institutional representatives (n=105)	HREC members (n=126)	AEC members (n=48)
Rigorous 73%	60%	67%	78%	79%	73%	63%	52%
Ethical 69%	74%	68%	63%	65%	86%	90%	92%
Beneficial to society 57%	68%	68%	59%	50%	53%	63%	38%
Accurate 53%	54%	53%	55%	53%	51%	45%	48%
Innovative 42%	38%	37%	41%	51%	39%	19%	27%
Transparent 41%	56%	50%	38%	34%	49%	42%	38%
Honest 35%	38%	29%	35%	40%	33%	25%	19%
Original 32%	25%	26%	37%	38%	30%	15%	19%
Justified 24%	24%	25%	19%	18%	30%	44%	71%
Respectful 18%	19%	19%	15%	13%	15%	46%	33%
Open 10%	16%	13%	11%	9%	7%	6%	2%
Legal 8%	6%	7%	5%	4%	18%	21%	29%
Other 2%	2%	1%	2%	3%	2%	2%	4%

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Benchmark result (Nuffield 2014* – scientists): When survey respondents were asked to select five words from a list that best describe their understanding of high quality research, the five most frequently selected words were: rigorous, accurate, original, honest and transparent.

Q10. Which of the following do you believe are most important for 'high-quality research'?

** Percentage results were not publicly available. Please note that comparisons against the benchmark results should be treated with caution, due to differences in response options. Please also note that throughout the report, colour coding does not apply to benchmark results.*

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Perceptions in relation to the definition of research quality were generally consistent across participant groups. However, there were some variations (see Figure 1 for full results):

- Compared to senior and mid-career researchers, research students were *less likely* to nominate **rigour** as an important aspect of high-quality research (60% versus 78%-79%), and were *more likely* to select **beneficial to society** (68% versus 50%-59%) and **transparent** (56% versus 34%-38%).
  - However, AEC members were the *least likely* to nominate both **rigour** and **beneficial to society** as the most important aspects of high-quality research (52% and 38%, respectively).
- Institutional representatives and ethics committee members were *more likely* than other participant groups to believe that being **ethical** (86%-92% – compared to 63%-74% of research students / researchers) and **legal** (18%-29% versus 4%-7%) were the most important aspects of high-quality research.
- Additionally, both AEC and HREC members were:
  - *more likely* than other participant groups to feel that the most important aspects for high quality research are that it is **justified** (44%-71% – compared 18%-30% of other participant groups) and **respectful** (33%-46% versus 13%-19%); and
  - *less likely* to feel that being **innovative** (19%-27% versus 37%-51%), **original** (15%-19% versus 25%-38%) and **honest** (19%-25% versus 29%-40%) were most important.

Validity of research

Overall, research students / researchers felt that their **experimental design** mattered most to the validity of their research (79%), followed by the avoidance of **experimental biases** (61% – see Figure 2 overleaf). Very few (8%) placed importance on the past work of others.

There were no large differences in responses by participant group.

Use of research resources

Overall, more than half of research students / researchers reported that *the conduct of unnecessary research that might have been avoided if all negative or neutral studies were routinely published* was a factor that substantially contributed to **inefficient use of research resources** (58% 'a lot' or 'to a great extent' – see Figure 3 on page 23). Furthermore, around half felt that *problems for researchers when previous experiments or studies are unreliable because of biases or inadequate sample size*, and *failure to build on what is already known from previous research* also greatly contributed to inefficient use of research resources (49% each).

By participant group, research students were *more likely* to feel that the following factors greatly contributed to inefficient use of research resources, all of which became less prevalent with seniority:

- *conduct of unnecessary research that might have been avoided if all negative or neutral studies were routinely published* (70% – compared to 52% for senior researchers);
- *time wasted when essential information on study methods or materials are poorly described or inaccessible* (59% versus 41%); and
- *failure to consider whether and how research results might have value to downstream users, such as other researchers, clinicians, etc.* (56% versus 32%).

Figure 2: Factors which mattered most to the validity of research

Base: Research students / researchers; up to 3 responses accepted

	OVERALL (n=1,472)	Research students (n=146)	Junior researchers (n=280)	Mid-career researchers (n=392)	Senior researchers (n=654)
Your experimental design	79%	75%	85%	79%	77%
Avoidance of experimental biases	61%	65%	59%	59%	62%
The statistical power of your experiments	42%	40%	38%	39%	46%
Validation via publication in a peer-review journal	34%	32%	29%	33%	37%
The absence of conflicts of interest	26%	29%	29%	27%	23%
Your hypothesis	18%	17%	17%	16%	19%
The past work of others	8%	15%	8%	7%	6%
None of the above	2%	1%	2%	3%	3%

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q13. Which of the following do you think matters most to the validity of your research?

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Figure 3: Factors which contribute to inefficient use of research resources

Base: Research students / researchers

	OVERALL (n=1,426-1,452)		Research students (n=139-143)	Junior researchers (n=268-273)	Mid-career researchers (n=377-386)	Senior researchers (n=638-650)
q14b. Conduct of unnecessary research that might have been avoided if all negative or neutral studies were routinely published	27% 31% 27% 14%	**58%**	70%	66%	56%	52%
q14c. Problems for researchers when previous experiments / studies are unreliable because of biases or inadequate sample size	17% 32% 33% 17%	**49%**	49%	49%	51%	49%
q14a. Failure to build on what is already known from previous research	21% 28% 27% 21%	**49%**	41%	48%	49%	52%
q14d. Time wasted when essential information on study methods or materials are poorly described or inaccessible	17% 28% 31% 23%	**45%**	59%	48%	44%	41%
q14e. Failure to consider whether and how research results might have value to downstream users (other researchers, clinicians, etc.)	17% 22% 26% 29% 6%	**38%**	56%	45%	37%	32%

To a great extent
A lot
A fair amount
A little
Not at all

% a lot or to a great extent

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q14. To what extent do you think each of the following contribute to inefficient use of research resources?

Environmental features encouraging the production of high-quality research

When research students / researchers were asked about environmental features that encourage the production of high-quality research, overall, the following three features were believed to have the most **positive effect** (see Figure 4 overleaf):

- initiatives that promote integrity in research, such as codes of conduct (76% 'very positive' or 'positive' effect overall);
- ethical review processes (73%); and
- data sharing policies (73%).

Seventy-two percent also selected provision of professional education, training and supervision.

In contrast, the three features which participants felt had the most **negative effect** and hence discouraged the production of high-quality research were:

- how funding for specific projects and programmes is awarded (52% 'very negative' or 'negative' effect overall);
- emphasis on publishing in top-tier journals (44%); and
- how researchers are assessed for promotion during their careers (44%).

As illustrated in Figure 4 overleaf, perceptions of which environmental features had the most positive or negative impact on encouraging the production of high-quality research were broadly aligned, though there was some variation by participant group:

- *How multidisciplinary and collaborative research is supported* was a top **positive** feature unique to AEC members, while *commercialisation of research* was a top **negative** feature also unique to this participant group.
- *The grant peer review system* was a top **negative** feature unique to mid-career and senior researchers.

Researchers (particularly senior researchers) were generally more critical of the effect that environmental features have in terms of encouraging researchers to produce high-quality research, while research students, institutional representatives and ethics committee members (particularly AEC members) were generally more optimistic in their ratings.

Figure 4: Effect of environmental features on encouraging the production of high-quality research (continues overleaf)

Base: All participants

	OVERALL (n=942-1,363)	Research students (n=31-90)	Junior researchers (n=108-205)	Mid-career researchers (n=203-295)	Senior researchers (n=461-572)	Institutional representatives (n=63-78)	HREC members (n=58-106)	AEC members (n=18-38)	Benchmark (Nuffield 2014* – scientists)
q58n. Initiatives that promote integrity in research, such as codes of conduct	16% 61% 21% **76%**	86% ☆	77% ☆	75% ☆	71% ☆	88% ☆	86% ☆	89%	60%
q58l. Ethical review processes	17% 55% 18% **73%**	84% ☆	73%	68%	67% ☆	87% ☆	91% ☆	92% ☆	Over half (>50%)
q58o. Data sharing policies	14% 58% 24% **73%**	90% ☆	76% ☆	72% ☆	68% ☆	71%	80%	85%	Almost two-thirds (~66%)
q58j. Provision of professional education, training and supervision	11% 60% 22% **72%**	80%	76% ☆	69% ☆	65%	85% ☆	90% ☆	91% ☆	Almost half (~50%)
q58g. The journal peer review system	57% 17% 15% **64%**	74%	59%	59%	62%	70%	84%	77%	71%
q58d. How multidisciplinary & collaborative research is supported	46% 17% 21% **55%**	78%	58%	51%	45%	67%	72%	93% ☆	41%
q58e. Support of open access publishing	42% 38% 8% **52%**	77%	62%	51%	38%	64%	76%	79%	61%
q58m. Research governance and contractual processes	42% 28% 16% **51%**	78%	56%	44%	41%	68%	72%	71%	Around a quarter (~25%)
q58f. The grant peer review system	40% 11% 30% 14% **45%**	65%	38%	36% ⓘ	42% ⓘ	70%	72%	75%	–

Very positive effect overall
Positive effect overall
No effect overall
Negative effect overall
Very negative effect overall

% positive or very positive effect overall

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

☆ Top 3 features by % positive or very positive effect overall
ⓘ Top 3 features by % negative or very negative effect overall

Q58. What effect do you think the following features of the Australian research environment have on researchers in terms of encouraging the production of high-quality research?
** Exact percentage results were not publicly available for all questions (~ indicates an approximate result). Please note that comparisons against the benchmark results should be treated with caution, due to differences in statement wording. Additionally, the 'Don't know' option has been treated as missing in the current analysis and it is not known whether this was also undertaken for the benchmark results.*

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	OVERALL (n=942-1,363)					Research students (n=31-90)	Junior researchers (n=108-205)	Mid-career researchers (n=203-295)	Senior researchers (n=461-572)	Institutional representatives (n=63-78)	HREC members (n=58-106)	AEC members (n=18-38)	Benchmark (Nuffield 2014* – scientists)
q58a. The Excellence in Research for Australia (ERA) framework	36%	41%	16%		**40%**	74%	45%	32%	34%	52%	57%	78%	25%^
q58q. Emphasis on publishing in top-tier journals	34%	16%	31%	14%	**39%**	36% !	32% !	35% !	39% !	54% !	50%	75%	–
q58i. How researchers are assessed for promotion during their careers	33%	20%	34%	9%	**36%**	34% !	29% !	33%	39%	39% !	38% !	41% !	22%
q58c. How funding for specific projects and programmes is awarded	32%	11%	39%	13%	**36%**	47% !	29% !	32% !	34% !	49% !	55% !	61% !	–
q58k. Commercialisation of research	31%	33%	25%		**36%**	47%	36%	36%	32%	42%	40%	46% !	–
q58b. International and national University rankings	32%	38%	23%		**34%**	47%	36%	29%	28%	39%	56%	71%	–
q58h. Media coverage of research	28%	40%	23%		**30%**	48%	38%	26%	22%	39%	53%	53%	–
q58p. Monetary rewards for research achievements	23%	35%	27%	12%	**26%**	40%	31%	25%	19%	31%	35% !	59%	–

Very positive effect overall
Positive effect overall
No effect overall
Negative effect overall
Very negative effect overall

% positive or very positive effect overall

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Top 3 features by % positive or very positive effect overall
Top 3 features by % negative or very negative effect overall

Q58. What effect do you think the following features of the Australian research environment have on researchers in terms of encouraging the production of high-quality research?
** Please note that comparisons against the benchmark results should be treated with caution, due to differences in statement wording. Additionally, the 'Don't know' option has been treated as missing in the current analysis and it is not known whether this was also undertaken for the benchmark results.*
^ The Nuffield survey referred to the Research Excellence Framework (REF) in the UK.

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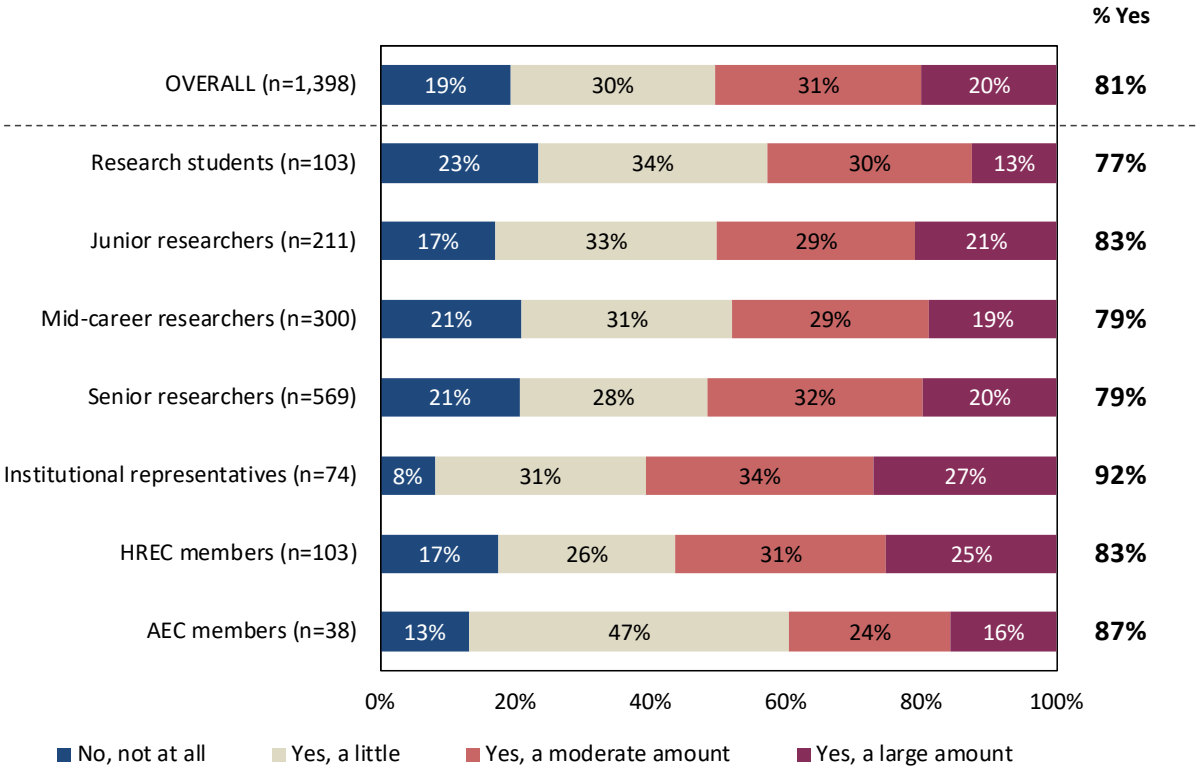
Effect of ensuring research quality on workload

Overall, the majority of participants felt that ensuring research quality **added to their workload** (81%) – be it a little (30%), a moderate amount (31%) or a large amount (20%). As illustrated in Figure 5, institutional representatives were *most likely* to indicate that ensuring research quality adds to their workload (92%), while research students were *least likely* to feel this impact (77%).

Figure 5: Effect of ensuring research quality on workload

Base: All participants



Q63. Do you think that ensuring research quality adds to your workload?

Reproducibility of results

Overall, almost all participants (93%) believed that reproducibility was 'quite' or 'very' important to research.[9] By participant group:

- Senior researchers and AEC members were *most likely* to indicate that they felt that reproducibility was important to research (96% each).
- Research students and HREC members were *least likely* to view reproducibility as important to research, although the proportion who felt this was still high at 89% and 86% respectively).

A 'crisis of reproducibility' refers to reported international concerns about the inability of results to be validated though either replication, or the use of different methods and analysis that achieve the same outcome / conclusion. Overall, 73% of participants had heard of the term 'crisis of reproducibility' in relation to issues in research, primarily from discussions with their colleagues (48%)

[9] Q15. How important do you think reproducibility is to research?

and research journals (44% – see Figure 6 overleaf). Awareness of the term 'crisis of reproducibility' was *lowest* among ethics committee members (both HREC and AEC) and research students (39%-44% had not heard of the term, compared to 17%-25% of other participant groups).

Of all participants:

- 56% felt that there is a **significant** crisis of reproducibility;
- 40% believed that there is a **slight** crisis of reproducibility; and
- just 4% reported that there is **no** crisis of reproducibility.

By participant group, AEC members and junior researchers were *most likely* to indicate that there is a **significant** crisis of reproducibility (66% and 60% respectively), while HREC members were *least likely* to hold this sentiment (41% – see Table 3).

Table 3: Perceptions about the crisis of reproducibility

Base: All participants

Participant group	Significant crisis	Slight crisis	No crisis
OVERALL (n=1,301)	**56%**	**40%**	**4%**
Research students (n=89)	53%	44%	3%
Junior researchers (n=201)	60%	38%	2%
Mid-career researchers (n=304)	57%	40%	4%
Senior researchers (n=543)	56%	39%	5%
Institutional representatives (n=72)	53%	44%	3%
HREC members (n=63)	41%	51%	8%
AEC members (n=29)	66%	34%	0%
Benchmark (Baker 2016* – researchers)	56%	41%	3%
Benchmark (Nature 2018* – researchers)	38%	53%	9%

Q17. Which of the following statements do you feel is most accurate when thinking about reproducibility in research? ('Don't know / can't say' excluded from base, 23% overall)

** Benchmark results have been rebased to exclude 'Don't know' (7% for Baker 2016, 5% for Nature 2018), for comparability.*

Figure 6: Sources of awareness regarding the 'crisis of reproducibility'

Base: All participants; multiple responses accepted

	OVERALL (n=1,698)	Research students (n=137)	Junior researchers (n=266)	Mid-career researchers (n=377)	Senior researchers (n=650)	Institutional representatives (n=96)	HREC members (n=124)	AEC members (n=48)	Benchmark (Nature 2018* – researchers)
Yes, from discussions with my colleagues	48%	39%	53%	51%	52%	50%	30%	17%	58%
Yes, from research journals	44%	23%	41%	49%	51%	43%	25%	19%	56%
Yes, from discussions at conferences	35%	20%	35%	38%	38%	40%	23%	25%	36%
Yes, from the mainstream media	28%	15%	30%	32%	30%	33%	15%	17%	39%
Yes, from online sources (e.g. social media, podcasts, blogs)	2%	2%	3%	2%	3%	2%	1%	0%	–
Yes, from elsewhere	4%	5%	4%	3%	4%	5%	4%	4%	7%
No	26%	39%	24%	25%	20%	17%	44%	44%	11%

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q16. Have you heard of the term 'crisis of reproducibility' in relation to issues in research? ('Don't know / can't say' not shown, 2% overall)

** Please note that comparisons against the benchmark results should be treated with caution, due to slight differences in question text and response options.*

As illustrated in Figure 7 overleaf, 19% of participants overall agreed that a failure to reproduce a result most often means that the original finding is wrong, and many *disagreed* that such a failure rarely detracts from the validity of the original finding (57%). By participant group:

- Senior researchers and institutional representatives were *most likely* to agree that a failure to reproduce a result most often means that the original finding is wrong (23% each), while research students were *least likely* (9%).
- Research students were *most likely* to agree that a failure to reproduce a result rarely detracts from the validity of the original finding (26%), while senior researchers were *least likely* (14%).

Research students / researchers were asked about the extent to which they felt reproducibility is a problem. Fifty-four percent felt that the failure to reproduce research is a major problem for all fields, while 45% agreed this was a major problem in their own field (see Figure 8 overleaf). Differences in views were evident by research type, as shown in Table 4 below.

Table 4: Extent to which reproducibility is a problem in one's field
(By research type[10], % agree or strongly agree)
Base: Research students / researchers (n=240-594)

Highest agreement levels (top 3)	Lowest agreement levels (bottom 3)
52% Preclinical research	**33%** Qualitative research
52% Discovery research	**34%** Health services
47% Translational research	**35%** Implementation research

Q18c. I think that the failure to reproduce research is a major problem in my field.

[10] 'Research on research (meta-research)' has been excluded from this analysis.

Figure 7: Implications of reproducibility on the original finding

Base: All participants

	OVERALL (n=1,601-1,621)	Research students (n=125-130)	Junior researchers (n=255-257)	Mid-career researchers (n=360-361)	Senior researchers (n=619-627)	Institutional representatives (n=88-89)	HREC members (n=112-115)	AEC members (n=41-43)	Benchmark (Baker 2016* – researchers)
q18a. I think that a failure to reproduce a result most often means that the original finding is wrong	17% 39% 36% 6% **19%**	9%	12%	17%	23%	23%	21%	21%	Less than 31%
q18b. I think that a failure to reproduce a result rarely detracts from the validity of the original finding	16% 25% 49% 8% **18%**	26%	20%	19%	14%	16%	22%	20%	–

Strongly agree
Agree
Neither agree nor disagree
Disagree
Strongly disagree

% agree or strongly agree

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Figure 8: Extent to which reproducibility is a problem

Base: Research students / researchers

	OVERALL (n=1,247-1,368)	Research students (n=114-123)	Junior researchers (n=225-254)	Mid-career researchers (n=337-364)	Senior researchers (n=571-627)
q18d. I think that the failure to reproduce research is a major problem for all fields	9% 36% 26% 25% **54%**	55%	55%	52%	55%
q18c. I think that the failure to reproduce research is a major problem in my field	11% 43% 28% 15% **45%**	39%	48%	43%	47%

Strongly agree
Agree
Neither agree nor disagree
Disagree
Strongly disagree

% agree or strongly agree

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q18. Please indicate the extent to which you agree or disagree with the following statements.

** Exact percentage results were not publicly available. Please note that comparisons against the benchmark result should be treated with caution, due to slight differences in question text and response options.*

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Research students / researchers and institutional representatives were asked to indicate the extent to which a variety of factors were felt to contribute to a failure to reproduce results. As illustrated in Figure 9 overleaf, overall, the top three factors that were believed to contribute **'considerably'** or **'to a great extent'** were:

- selective reporting of results (71%);
- pressure to publish for career advancement (62%); and
- original findings obtained with low statistical power / poor statistical analysis (52%).

In contrast, the three factors which participants felt contributed only **'slightly'** or **'not at all'** were:

- bad luck (75%);
- fraud (i.e. fabricated or falsified results – 62%); and
- insufficient peer review of grant applications (60%).

While *selective reporting of results* and *pressure to publish for career advancement* featured in the top 3 most influential factors across all participant groups, there were some differences to note (see Figure 9 overleaf for all results by participant group):

- Senior and mid-career researchers additionally felt that *original findings obtained with low statistical power / poor statistical analysis* was a top 3 contributor.
- Junior researchers, research students and institutional representatives viewed *information not available from the original research group (e.g. protocols, data, code, reagent information)* as a top 3 factor contributing to a failure to reproduce results.

Figure 9: Factors which contribute to a failure to reproduce results (continues overleaf)

Base: Research students / researchers and institutional representatives

	OVERALL (n=979-1,425)					Research students (n=84-123)	Junior researchers (n=155-240)	Mid-career researchers (n=236-359)	Senior researchers (n=439-618)	Institutional representatives (n=65-85)	Benchmark (Baker 2016* – researchers)	Benchmark (Nature 2018* – researchers)
q19e. Selective reporting of results	30%	41%	22%	6%	**71%**	☆ 77%	☆ 72%	☆ 72%	☆ 70%	☆ 60%	~70%	66%
q19a. Pressure to publish for career advancement	29%	33%	24%	12%	**62%**	☆ 61%	☆ 68%	☆ 64%	☆ 59%	☆ 57%	~65%	55%
q19g. Original findings obtained with low statistical power / poor statistical analysis	16%	36%	34%	13%	**52%**	56%	52%	☆ 51%	☆ 52%	51%	~55%	49%
q19i. Information not available from the original research group (e.g. protocols, data, code, reagent information)	15%	33%	32%	19%	**48%**	☆ 57%	☆ 61%	48%	41%	☆ 56%	~45%	36%
q19f. Original findings were inadequately robust because of insufficient replication by the research group publishing the work	12%	33%	35%	18%	**45%**	50%	42%	43%	47%	39%	~55%	52%
q19b. Insufficient oversight / mentoring by principal investigator for the research group (e.g. reviewing raw data)	12%	32%	35%	18%	**44%**	50%	43%	48%	40%	52%	~50%	39%
q19l. Poor experimental design	12%	32%	35%	19%	**43%**	46%	51%	40%	42%	46%	~45%	27%

To a great extent
Considerably
Moderately
Slightly
Not at all

% considerably or to a great extent

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

☆ Top 3 contributors

Q19. To what extent do you feel that each of the following factors contribute to a failure to reproduce results?
Note that the bottom 3 contributors (as listed on page 32) did not differ across participant groups.
** Exact percentage results were not publicly available for all questions (~ indicates an approximate result). Please note that comparisons against the benchmark results should be treated with caution, due to differences in statement wording and response scale (benchmark percentage results represent % always / often contribute).*

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	OVERALL (n=979-1,425)		Research students (n=84-123)	Junior researchers (n=155-240)	Mid-career researchers (n=236-359)	Senior researchers (n=439-618)	Institutional representatives (n=65-85)	Benchmark (Baker 2016* – researchers)	Benchmark (Nature 2018* – researchers)
q19j. Methods need technical expertise that is difficult for others to reproduce	8% 26% 33% 28%	**34%**	36%	45%	34%	30%	25%	~30%	34%
q19d. Insufficient peer review of research publications	8% 23% 32% 28% 9%	**31%**	30%	29%	30%	34%	17%	~40%	~24%
q19h. Mistakes or inadequate expertise in reproduction efforts	23% 39% 30%	**28%**	32%	29%	28%	26%	26%	~40%	32%
q19k. Variability in standard reagents	19% 35% 33% 9%	**24%**	33%	28%	28%	19%	22%	~20%	~18%
q19m. Fraud (i.e. fabricated or falsified results)	9% 10% 19% 53% 9%	**19%**	34%	19%	21%	16%	10%	~40%	26%
q19c. Insufficient peer review of grant applications	10% 24% 37% 23%	**15%**	22%	18%	12%	15%	16%	–	–
q19n. Bad luck	19% 38% 37%	**6%**	9%	7%	5%	6%	4%	~10%	~5%

To a great extent
Considerably
Moderately
Slightly
Not at all

% considerably or to a great extent

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q19. To what extent do you feel that each of the following factors contribute to a failure to reproduce results?
** Exact percentage results were not publicly available for all questions (~ indicates an approximate result). Please note that comparisons against the benchmark results should be treated with caution, due to differences in statement wording and response scale (benchmark percentage results represent % always / often contribute).*

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Experiences of ethics committee members

Overall, the following information was most commonly *required*, as well as *routinely provided*, in proposals considered by ethics committees (see Figure 10 overleaf):

- how the number of participants / animals per experimental cohort was determined (75% required, 72% routinely provided);
- whether inclusion or exclusion criteria will be applied (72% required, 77% routinely provided);
- how statistical power was determined (63% required, 58% routinely provided); and
- whether participants / animals are to be randomly allocated to experimental cohorts (62% required, 67% routinely provided).

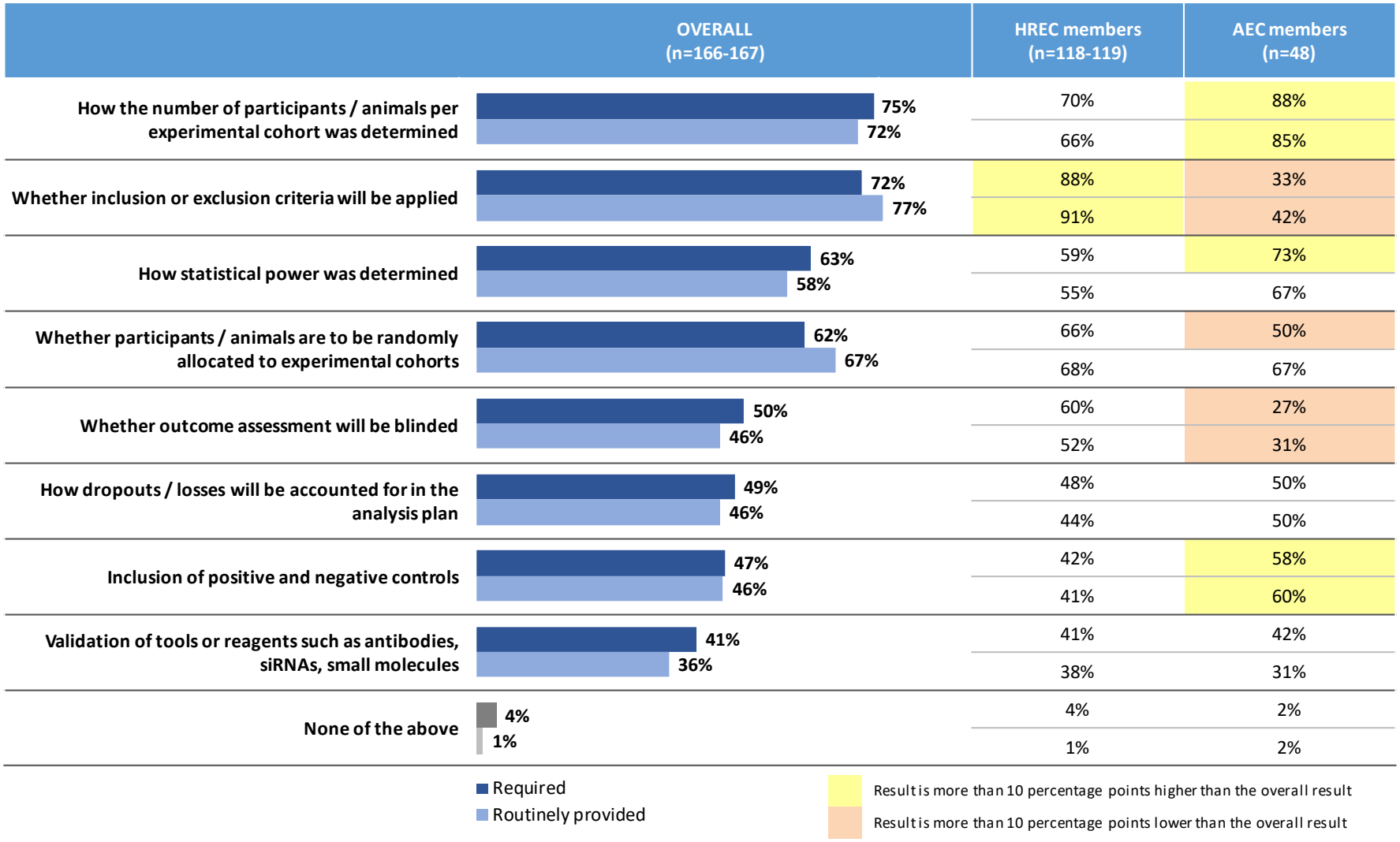
Results varied by participant group, with AEC members and HREC members reporting a range of differences in both the information that they require and are routinely provided. This may be attributed to the different types of studies considered by each type of committee.

When asked how they are assured about the quality of the design and methods for a project outlined in applications considered by their ethics committee, overall, the majority of ethics committee members reported that they trust the expertise of other members (73% – see Figure 11 on page 37), though 45% also felt they had sufficient expertise to assess such aspects themselves. Forty-two percent also indicated that they are assured by independent internal (institutional) peer review.

Again, some differences were evident by participant group (HREC members versus AEC members), which may be due to the different types of studies considered by each type of committee. No further analysis was undertaken within these participant groups due to low sample sizes.

Figure 10: Information required / routinely provided in ethics committee proposals

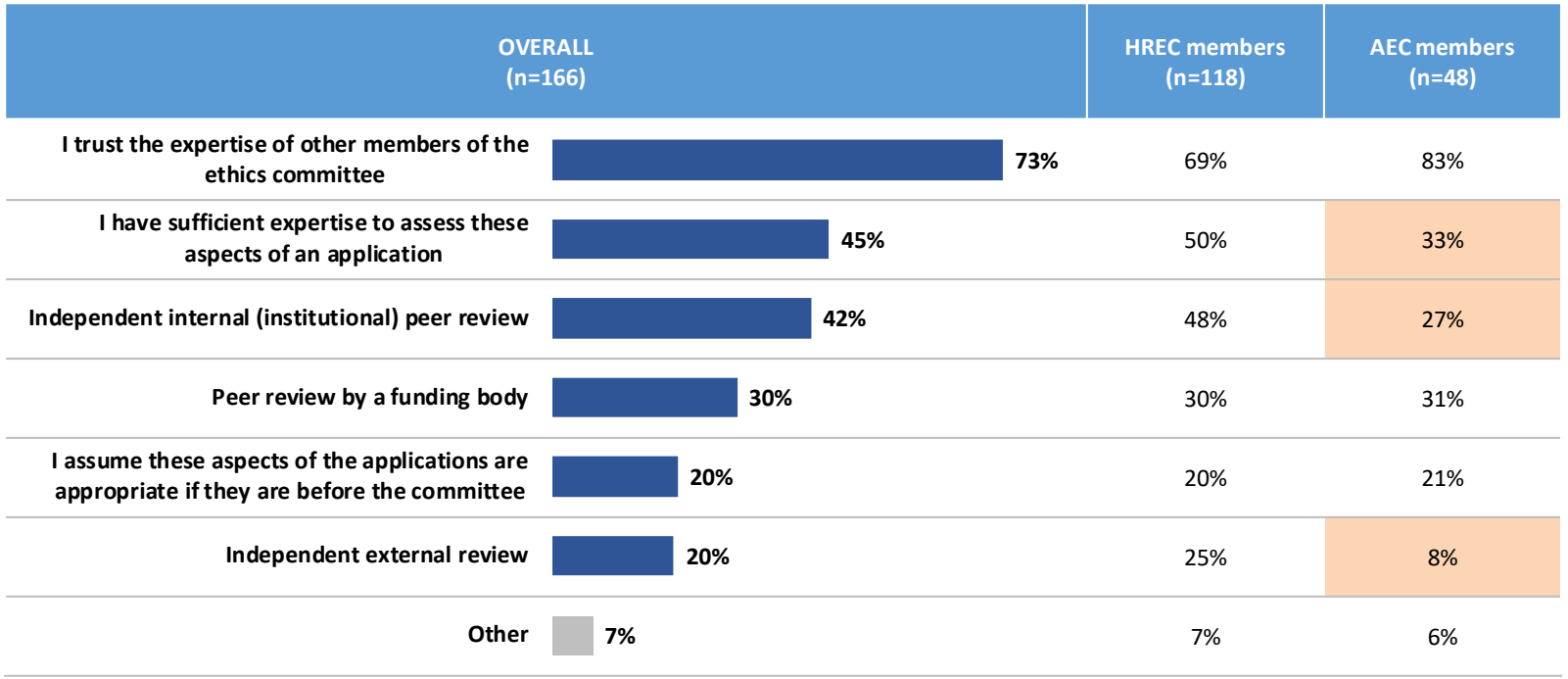
Base: Ethics committee members; multiple responses accepted



Q38. Which of the following information is required in proposals that your ethics committee considers? ('Don't know / can't say' not shown, 4% overall)
Q39. Which of the following information is routinely provided in proposals that your ethics committee considers? ('Don't know / can't say' not shown, 3% overall)

Figure 11: Assurances about the quality of the design and methods for a project outlined in applications considered by ethics committees

Base: Ethics committee members; multiple responses accepted



Q40. How are you assured about the quality of the design and methods for a project outlined in applications considered by your committee?

V. What environmental factors are identified and / or experienced as barriers and enablers to high-quality research?

Immediate environment (department / research group)

General perceptions

As shown in Figure 12 overleaf, the majority of research students / researchers overall agreed that:

- research practices in their department / research group follow established institutional policies regarding research (90%); and
- people in their department / research group implement data management principles within their research projects (86%).

Participants were *least likely* to agree that researchers in their immediate research environment are committed to open access publishing when publishing research results (55% agreed, while 17% disagreed).

Furthermore, 16% of participants *disagreed* that junior researchers are effectively mentored about responsible research practices[11] and 14% felt unsure (neither agreed nor disagreed).

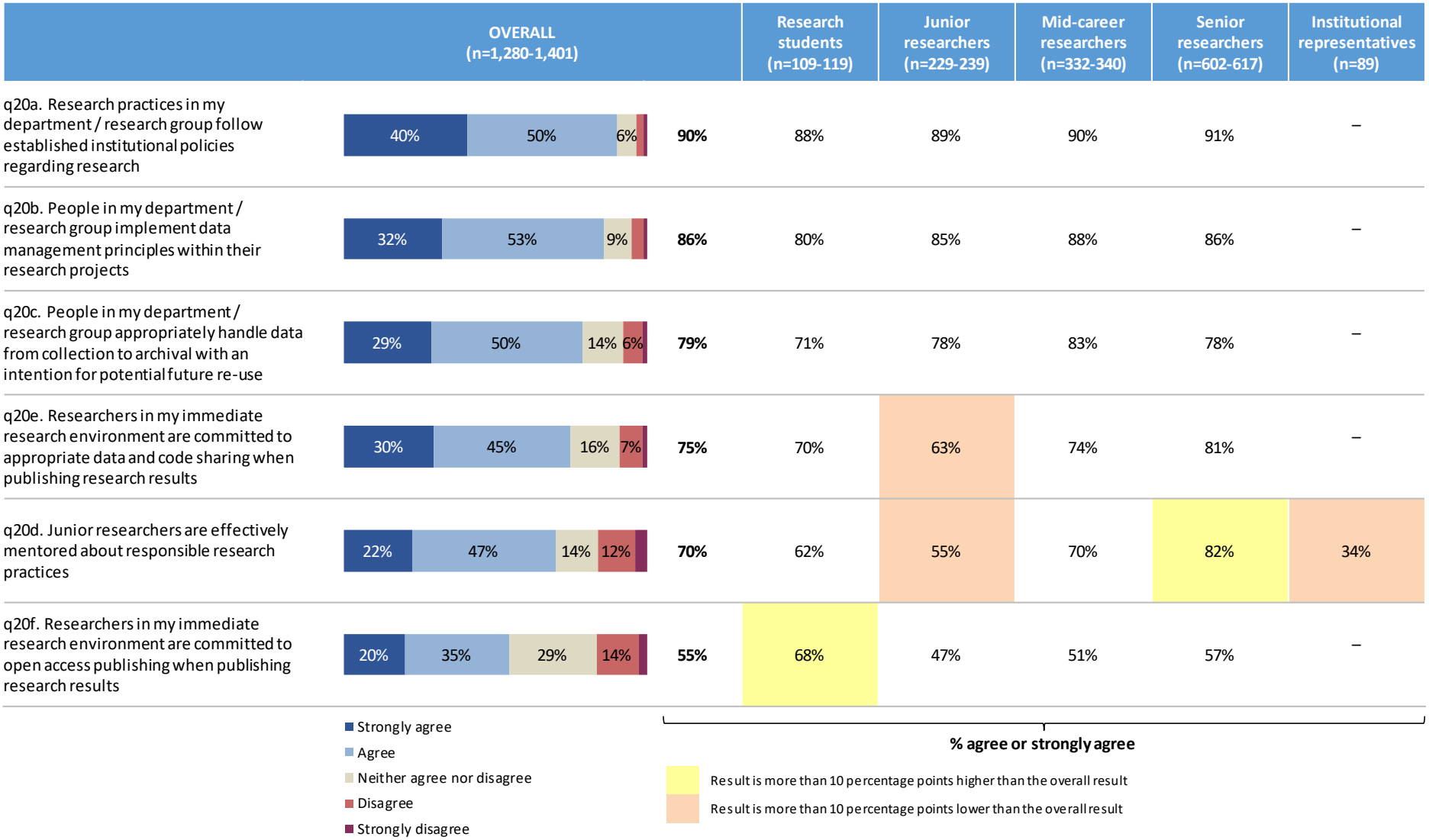
- Negative sentiment reduced with seniority (26% for research students, 25% for junior researchers, 16% for mid-career researchers, and 8% for senior researchers).
- Institutional representatives were substantially *less likely* than other participant groups to believe that junior researchers are effectively mentored about responsible research practices – just 34% agreed with this statement, while 38% disagreed.

In addition to these findings, the majority of research students / researchers felt that their department / research group prioritises honesty and integrity when researchers propose, perform and report research (81% 'very much' or 'completely').[12] Senior researchers were *most likely* to indicate that honesty and integrity were prioritised in their immediate environment (84% – compared to 78% for both junior and mid-career researchers).

[11] Responsible research practices are defined as those that ensure research is rigorous, transparent and reproducible.
[12] Q12. To what extent do you feel that your department / research group prioritises honesty and integrity when researchers propose, perform and report research?

Figure 12: General perceptions – immediate environment (department / research group)

Base: Research students / researchers and institutional representatives



Q20. Please indicate the extent to which you agree or disagree with the following statements.

Barriers to implementing procedures to improve reproducibility of results

Overall, 19% of research students / researchers reported that they or their research group had experienced barriers when trying to implement procedures to improve reproducibility of research.[13] A further 8% reported that they have never tried to implement such procedures.

The most common barriers encountered by participants are shown in Table 5, as provided through open-ended comments. The number one barrier experienced was related to the cost of implementing procedures, followed by time.

Table 5: Barriers to implementing procedures to improve reproducibility of results (Top 3 themes identified in open-ended responses)

Base: Research students / researchers who experienced barriers when trying to implement procedures to improve reproducibility of research, and provided a valid open-ended response (n=250)

Top 3 barriers experienced	
	Cost / lack of sufficient funding (41%)
	Time (21%)
	Resistance / hold up from others (17%)

Q25. Please list the barriers that you / your research group have encountered when trying to implement procedures to improve reproducibility of research.

Barriers were reportedly more common amongst senior researchers, with 22% indicating that they or their research group had experienced such barriers (compared to 19% for mid-career researchers, 17% for junior researchers, and 11% for research students) – however junior researchers and research students were also more likely to report that they have never tried to implement procedures to improve reproducibility of results.

Attempts to reproduce results

Research students / researchers were asked about their attempts to reproduce results from published papers. As shown in Figure 13 overleaf, overall, participants were:

- more likely to have attempted and been *able to fully reproduce a finding* from their own published paper, than from another researcher's published paper (50% versus 30%); and
- considerably more likely to have attempted but been *unable to fully reproduce a finding* from another researcher's published paper, compared to their own published paper (44% versus 8%).

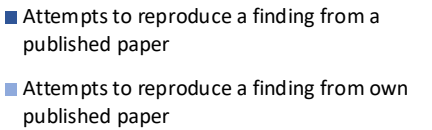
Some differences in experiences were reported by participant group, as illustrated in Figure 13.

[13] Q24. Have you / your research group experienced any barriers when trying to implement procedures to improve reproducibility of research?

Figure 13: Attempts to reproduce results from published papers

Base: Research students / researchers; multiple responses accepted

	OVERALL (n=1,313-1,326)	Research students (n=120-125)	Junior researchers (n=239-243)	Mid-career researchers (n=342-344)	Senior researchers (n=612-614)
Attempted, and able to fully reproduce the finding	30%	14%	21%	29%	36%
	50%	13%	34%	50%	64%
Attempted, but not able to fully reproduce the finding	44%	18%	28%	47%	53%
	8%	2%	2%	6%	14%
Not attempted	40%	68%	57%	35%	31%
	42%	54%	61%	46%	30%
No published work to date	–	–	–	–	–
	4%	30%	4%	<1%	<1%



Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Benchmark result (Mobley et al. 2013*): 54.6% of survey respondents reported that they had tried to reproduce a finding from a published paper, and were not able to do so (48.5% for trainees, 48.7% for junior faculty, and 66.2% for senior faculty).

Q26. Have you ever tried to reproduce a finding from a published paper?
Q30. Have you ever tried to reproduce a finding from your own published paper?
** Please note that comparisons against the benchmark result should be treated with caution, due to differences in question wording and response options.*

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Of those who had tried to reproduce a finding from **another researcher's published paper**, but were not able to fully reproduce the finding:

- 66% had tried to publish findings that disagreed with those in a published paper;[14]
  - The remaining participants were asked to elaborate on the reasons why they did not do so – the most common of which are presented in Table 6 below. In addition to these, 16% reported that they were still in the process of publishing such findings, whilst 6% reported they had not done so due to fear of causing conflict or negative repercussions / backlash.
- 30% reported that the differences in findings were resolved by themselves or another researcher.[15]

Table 6: Reasons for not publishing findings that disagreed with those in a published paper (Top 3 themes identified in open-ended responses)

Base: Research students / researchers who were not able to fully reproduce a finding from a published paper, and did not try to publish findings that disagreed with those in a published paper; and provided a valid open-ended response (n=180)

Top 3 reasons	
	Self-doubt / not confident had replicated exactly the same way (26%)
	Not felt to be important enough / not worth the effort (19%)
	Assumed to be difficult or unlikely to be published (17%)

Q28. Why did you not try to publish findings that disagreed with those in a published paper?

Benchmark results[16]

Mobley et al. 2013 (faculty and trainees):

- 33.3% of survey participants reported that the differences in results were resolved.
- 33.3% of survey participants reported that they published the results that disagreed with those in the literature.

Baker 2016 (researchers):

- 13% of survey participants published unsuccessful replication attempts.

[14] Q27. Did you try to publish findings that disagreed with those in a published paper?
[15] Q29. Were the differences in findings ever resolved by you or another researcher?
[16] Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.

In relation to **their own published papers**, research students / researchers were asked if they had ever been aware that their published finding was not able to be reproduced.[17] Ten percent indicated that they were aware of such a discrepancy. These participants were asked to provide further information on how this was resolved, if at all (see Table 7 below).

Table 7: Resolution of published findings which were not able to be reproduced (Top 3 themes identified in open-ended responses)

Base: Research students / researchers who were aware that their published finding was not able to be reproduced, and provided a valid open-ended response (n=123)

Top 3 reasons	
	Discrepancies were determined to be due to methodological differences (38%)
	Not yet been resolved (21%)
	Repeat or extension of study to attempt to validate findings (11%)

Q32. How was this resolved, if at all?

Institutional environment

General perceptions

Overall, participants provided positive feedback in relation to their access to a range of resources within their institutional environment. As illustrated in Figure 14 overleaf, most participants agreed that they have easy access to:

- their institution's policies / guidelines about responsible research practices (85%); and
- an individual(s) with appropriate expertise that they can ask for advice about responsible research practices (82%).

Research students / researchers overall were generally *less likely* to agree that they had access to the above resources, compared to institutional representatives and ethics committee members.

Furthermore, while 74% of research students / researchers agreed that they have access to sufficient **material resources** (e.g. space, equipment or technology) to conduct their research, 18% reported that they find it difficult to conduct research in a responsible manner because of insufficient access to **human resources** (e.g. statistical expertise, technical / administrative support).

[17] Q31. Have you ever been aware that a finding you had published was not able to be reproduced?

Figure 14: General perceptions – institutional environment

Base: All participants

	OVERALL (n=1,050-1,500)		Research students (n=79-117)	Junior researchers (n=179-228)	Mid-career researchers (n=284-327)	Senior researchers (n=508-594)	Institutional representatives (n=83-85)	HREC members (n=111-118)	AEC members (n=44-46)	Benchmark (QUEST 2018* – researchers)
q37b. I have easy access to my institution's policies / guidelines about responsible research practices	39%	46% 10%	**85%**	82%	78%	82%	87%	89%	89%	91%	49%
q37a. I have easy access to an individual(s) with appropriate expertise that I can ask for advice about responsible research practices	37%	45% 10%	**82%**	79%	78%	79%	84%	89%	85%	85%	37%
q37d. I have access to sufficient material resources (e.g. space, equipment or technology) to conduct my research	24%	50% 11% 12%	**74%**	80%	76%	73%	73%	–	–	–	35%
q37c. The regulatory committees that review my research (e.g. ethics committees) understand the kind of research I do	18%	49% 20% 10%	**67%**	74%	65%	65%	67%	–	–	–	25%
q37f. Senior administrators in my institution support data and code sharing when publishing research results	15%	46% 27% 9%	**61%**	59%	58%	55%	67%	–	–	–	27%
q37g. Senior administrators in my institution support open access publishing when publishing research results	14%	38% 31% 13%	**52%**	59%	51%	48%	54%	–	–	–	22%
q37e. I find it difficult to conduct research in a responsible manner because of insufficient access to human resources (e.g. statistical expertise, technical / administrative support)	14%	16% 43% 23%	**18%**	22%	22%	18%	16%	–	–	–	41%

Strongly agree
Agree
Neither agree nor disagree
Disagree
Strongly disagree

% agree or strongly agree

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q37. Please indicate the extent to which you agree or disagree with the following statements.

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in statement wording and response scale (benchmark percentage results represent % very / completely).*

In addition to concerns about access to sufficient human resources, research students / researchers also provided moderate agreement levels in relation to the support of senior administrators in their institution.

- 61% agreed that senior administrators in their institution support data and code sharing when publishing research results.
- 52% agreed that senior administrators in their institution support open access publishing when publishing research results.

Institutional culture

All participants were asked to provide comments in relation to the culture of their institution in regard to **responsible research practices**.[18] Overall, the results were mixed, suggesting that some institutions were appropriately supporting responsible research practices, whilst others were not (or were not to the same extent).

Of those who provided a valid open-ended response[19], 20% provided a general comment explaining that they felt that their institutional culture is good / that their institution supports responsible research practices. A further 13% provided a general comment that their institution does not value or support responsible research practices enough. In addition, a number of other more specific barriers were identified by around 10% of participants, as follows:

- The focus on publishing and obtaining grants / funding is a priority or more highly valued than responsible research practices (10%).
- Grants / funding are insufficient to support all responsible research practices (9%).

A small number also felt that even though their institution supported such practices, they were not necessarily being applied in practice (8%).

Systems for measuring, monitoring and reporting the quality and outcomes of research

Institutional representatives were also asked to outline the systems they have in place for measuring, monitoring and reporting the quality and outcomes of research.[20] The most common themes reported through open-ended comments related to research or ethics committees (23%) and progress / annual reporting (21%).

Comments regarding *research or ethics committees* primarily related to having periodic meetings to assess and monitor project progress. These comments mentioned this occurring through ethics committees (HREC and AEC), faculty research committees, various committees established for each project and recurrent review meetings.

[18] Q42. If you have any further comments you would like to make about the culture of your institution in regard to responsible research practices, please provide them in the space below.
[19] Note those that commented 'None', 'N/A' or similar were excluded from the base calculations of these proportions as the question was not relevant.
[20] Q41. What systems does your institution have in place for measuring, monitoring and reporting the quality and outcomes of research?

Comments regarding *progress / annual reporting* referred to the provision of periodic reports for approved research. These included reports provided to the HREC or AEC if the research involved humans or animals, and reports delivered to funding bodies as per grant agreements. Additionally, comments also mentioned internal reporting, including presentations for junior staff, informal reporting of quality indicators, and progress reports against deliverables at certain intervals.

Discussion about responsible research practices

All participants were asked to indicate how often they discussed responsible research practices with various individuals.

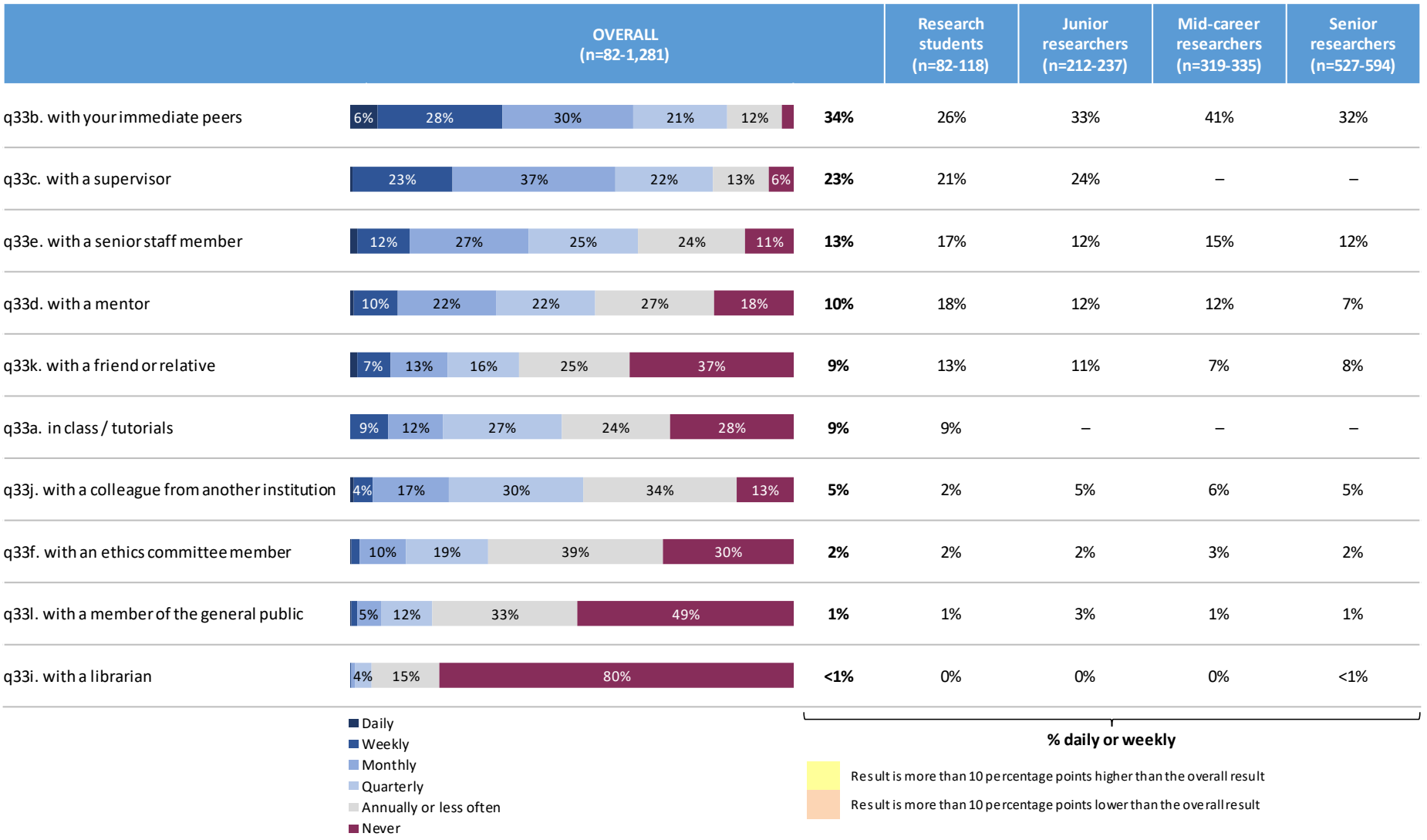
As shown in Figure 15 overleaf, overall, **research students / researchers** most often discussed responsible research practices with their immediate peers (34% daily or weekly), with a supervisor[21] (23%), and with a senior staff member (13%). Compared to researchers, research students were slightly *less likely* to have frequent conversations with their immediate peers, and slightly *more likely* to discuss the topic with a mentor.

Figure 16 on page 48 illustrates that overall, **institutional representatives / ethics committee members** discussed responsible research practices most frequently with staff at their institutional office or equivalent (29%), with a senior staff member (24%), and with a friend or relative (15%). Institutional representatives were *more likely* to have frequent conversations about responsible research practices in general, compared to ethics committee members – however the frequency with which ethics committee members discussed this topic may be related to the frequency of committee meetings.

[21] Asked of research students and junior researchers only.

Figure 15: Frequency of discussions about responsible research practices – Research students / researchers

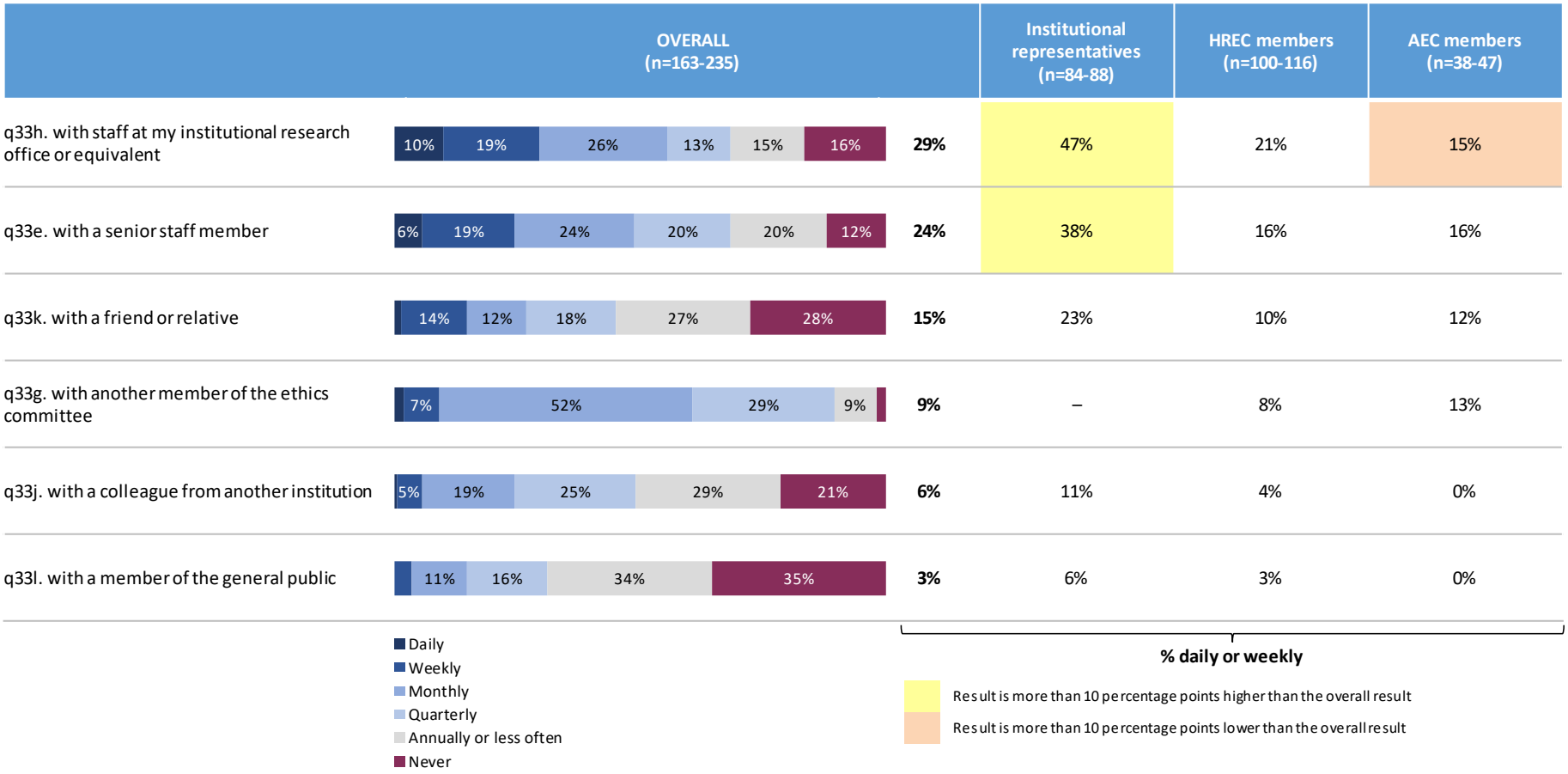
Base: Research students / researchers



Q33. Approximately, how often do you discuss responsible research practices…

Figure 16: Frequency of discussions about responsible research practices – Institutional representatives / ethics committee members

Base: Institutional representatives / ethics committee members



Q33. Approximately, how often do you discuss responsible research practices…

Research students / researchers were asked about when conversations about responsible research practices were occurring. Overall, research students / researchers primarily discussed responsible research practices with their supervisors / senior colleagues / senior administrators when data analysis is being discussed (77% – see Figure 17 overleaf). Other stages at which such discussions commonly occurred included:

- when ethics / grant applications are being prepared (69%);
- at regular research group meetings (68%); and
- when papers are being prepared for publication (67%).

When all participants were asked about more informal settings[22], overall, 67% indicated that they have informal discussions about responsible research practices, such as in social situations or after work. The following differences were observed:

- Research students / researchers overall were *more likely* to have informal conversations (70%), compared to institutional representatives (55%) and ethics committee members (56%).
- Further disaggregation revealed that informal discussions became *increasingly* common with seniority (research students 58%, junior researchers 68%, mid-career researchers 71%, and senior researchers 72%).

Overall, most participants felt comfortable and able to have discussions about responsible research practices[23], however 16% of participants reported that they had at some stage wanted to have discussions about responsible research practices, but had felt unable to do so. Perceived inability to have these discussions *decreased* with seniority (24% for research students, 22% for junior researchers, 15% for mid-career researchers, and 11% for senior researchers).

[22] Q34. Do you have informal discussions about responsible research practices (e.g. after work, in social situations)?
[23] Q35. Have you wanted to have discussions about responsible research practices but felt unable to do so?

Figure 17: Stages at which responsible research practices are discussed

Base: Research students / researchers; multiple responses accepted

	OVERALL (n=1,316)	Research students (n=124)	Junior researchers (n=242)	Mid-career researchers (n=341)	Senior researchers (n=609)
When data analysis is being discussed	77%	70%	79%	81%	75%
When ethics / grant applications are being prepared	69%	65%	74%	69%	69%
At regular research group meetings	68%	57%	65%	70%	71%
When papers are being prepared for publication	67%	58%	64%	71%	69%
During annual career development sessions	24%	20%	20%	23%	26%
When I first started work / study, but not since	1%	6%	0%	0%	1%
Other	7%	4%	7%	5%	8%
Never	3%	2%	2%	3%	3%

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q36. At what stages do you generally discuss responsible research practices with your supervisors / senior colleagues / senior administrators? ('Don't know / can't say' not shown, 2% overall)

Pressures

To further understand the environment within Australian NHMRC-funded institutions, participants were asked a series of questions in relation to the pressures that they feel are present during the different phases of the research process, including data analysis, data management, publication and research funding.

Overall, 54% of all participants were aware of **researchers** feeling tempted or under pressure to compromise on research quality. Awareness levels varied by participant group (see Table 8). Junior researchers were *most likely* to be aware of such instances, while ethics committee members (particularly AEC members) were *least likely*.

Research students / researchers were also asked if they had ever **personally** felt tempted or under pressure to compromise on research quality. Overall, 27% reported that they had felt this way, which is half the number of those who were aware of others experiencing such temptation / pressure (54%, see Table 8). Research students and junior researchers were *most likely* to feel such pressure, while senior researchers were *least likely*.

Table 8: Pressure to compromise on research quality

Base: All participants

Participant group	% Aware of researchers under pressure	% Personally felt under pressure
OVERALL (n=1,252-1,501)	**54%**	**27%**
Research students (n=112)	48%	35%
Junior researchers (n=224-226)	58%	35%
Mid-career researchers (n=323-324)	53%	30%
Senior researchers (n=591)	56%	22%
Institutional representatives (n=84)	56%	–
HREC members (n=120)	43%	–
AEC members (n=46)	37%	–

Q49. Have you ever been aware of [other] researchers feeling tempted or under pressure to compromise on research quality? (Square bracket component shown to research students / researchers only)

Q50. Have you ever personally felt tempted or under pressure to compromise on research quality?

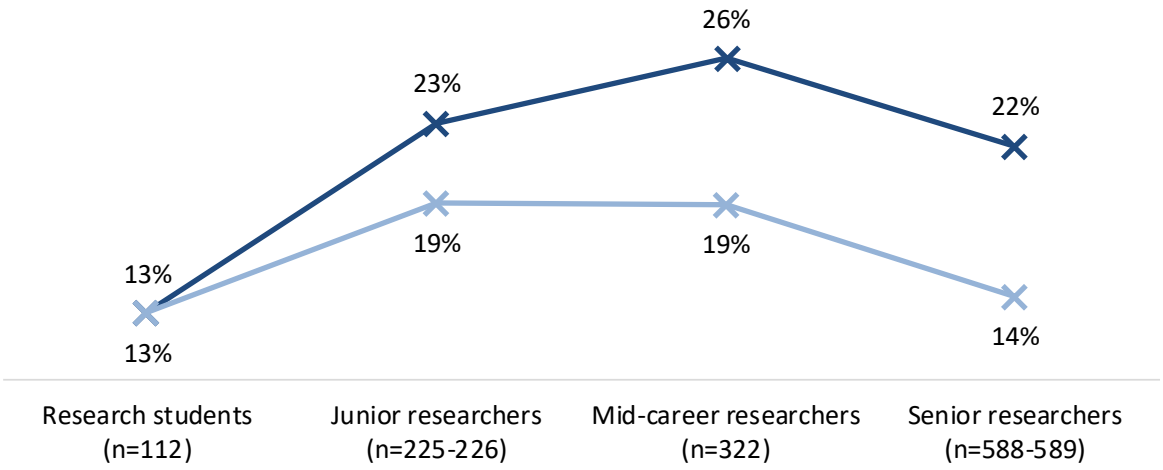
In terms of **external sources of pressure** faced by research students / researchers overall:

- 23% had reportedly experienced external pressure (from a mentor, supervisor or research colleague) to prove that his / her hypothesis was correct, even though the data generated may not have supported the hypothesis; and
- 16% reported that they had been asked to alter / suppress their results, or to select the best results which may not be representative of all the results.

The experience of such external pressures varied by participant group, though not necessarily in a linear manner, as shown in Figure 18. Junior and mid-career researchers were generally *more likely* to be impacted by external pressures, compared to research students and senior researchers.

Figure 18: External pressures (By participant group / career stage)

Base: Research students / researchers



Funding

Research students / researchers demonstrated some concerns regarding **funding** pressures. As illustrated in Figure 19 overleaf:

- 53% agreed that pressure to obtain external funding has a negative effect on the quality of research in their department / research group; and
- 46% agreed that their department's / research group's expectations of researchers for obtaining external funding were reasonable.

Junior researchers were *more likely* to feel that funding pressures negatively impact the quality of their research (63% agreed), compared to mid-career (57%) and senior researchers (48%). However, research students were the *least likely* to feel such an impact (44%), consistent with the general non-linear trends reported across these participant groups above.

Publishing

Publishing pressures

Research students / researchers were also asked to comment on their experiences in regard to **publishing** pressures – see Figure 19. Compared to funding pressures, overall, research students / researchers reported a more positive sentiment; with:

- 66% agreeing that publishing expectations were reasonable (compared to 46% who agreed that funding expectations were reasonable); and
- 33% agreeing that the pressure to publish findings has a negative effect on research quality (compared to 53% in relation to funding pressure).

Nonetheless, publishing pressures still appeared to have a substantial impact on research students / researchers. As shown in Figure 20 on page 55, overall:

- 67% agreed that publication pressure leads some colleagues (whether intentionally or not) to cut corners;
- 51% indicated that they experience stress at the thought of their colleagues' assessment of their publication output; and
- 49% felt that it is necessary to have a first authored publication in a prestigious journal when seeking an academic position or promotion.

As was the case for funding pressures, junior researchers were generally *more likely* to be impacted by publishing pressures, relative to mid-career and senior researchers.

Figure 19: Funding and publishing pressures

Base: Research students / researchers

	OVERALL (n=1,191-1,222)										Research students (n=89-99)	Junior researchers (n=206-221)	Mid-career researchers (n=317-322)	Senior researchers (n=576-585)
Funding pressures														
q51a. My department's / research group's expectations of researchers for obtaining external **funding** are reasonable	5%	41%	20%	24%	10%						**46%**	52%	43%	39%	50%
q51b. Pressure to obtain external **funding** has a negative effect on the quality of research in my department / research group	23%	30%	21%	21%	6%						**53%**	44%	63%	57%	48%
Publishing pressures														
q52a. My department's / research group's expectations of researchers with respect to **publishing** are reasonable	8%	58%	17%	13%							**66%**	69%	66%	61%	68%
q52b. The pressure to **publish** findings has a negative effect on the quality of research in my department / research group	10%	24%	24%	36%	7%						**33%**	23%	45%	37%	28%

Strongly agree
Agree
Neither agree nor disagree
Disagree
Strongly disagree

% agree or strongly agree

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Benchmark result (Martinson et al. 2013* – biomedical and social science faculty and postdoctoral fellows):
On a 5-point scale: (1) Not at All, (2) Somewhat, (3) Moderately, (4) Very, and (5) Completely

- How fair are your departments expectations of researchers for obtaining external **funding**? Mean rating = 3.53
- How true is it that pressure to obtain external **funding** has a negative effect on the integrity of research in your department? Mean rating = 4.09
- How fair are your departments expectations with respect to **publishing**? Mean rating = 3.75
- How true is it that pressure to **publish** has a negative effect on the integrity of research in your department? Mean rating = 4.14

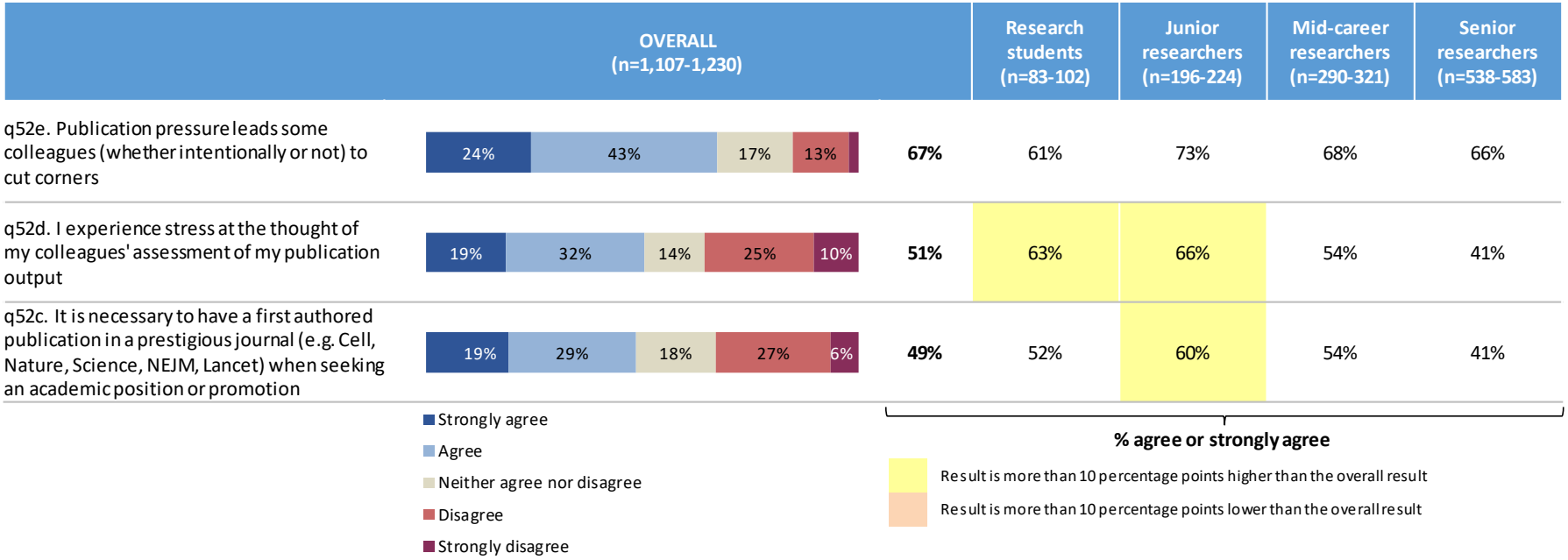
Q51. Please indicate the extent to which you agree or disagree with the following statements.

Q52. Please indicate the extent to which you agree or disagree with the following statements.

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response scale.*

Figure 20: Publishing pressures (continued)

Base: Research students / researchers



Q52. Please indicate the extent to which you agree or disagree with the following statements.

Use of reporting checklists

In recent years, some journals have required a 'reporting checklist' for all papers published in their journal. Research students / researchers were asked to indicate the extent to which they felt that the use of reporting checklists has improved various aspects of their published work / published work in their field.

As shown in Figure 21 overleaf, overall, the results suggested that use of reporting checklists has had a positive impact on various aspects of published work. Most research students / researchers felt that the use of reporting checklists has improved the following aspects by a 'moderate' or 'large' extent:

- reporting of study methods and procedures (81%);
- adoption of practices to reduce bias, such as blinding and randomisation (76%); and
- statistical analysis of studies (75%).

The use of reporting checklists was *least likely* to have led to increased data deposition in public repositories, though 57% still felt reporting checklists had a large or moderate positive impact on this aspect of published work.

By participant group, results suggested that perceived usefulness of reporting checklists was generally higher amongst those in more junior roles (including research students and junior researchers – see Figure 21 for full results).

Figure 21: Usefulness of reporting checklists

Base: Research students / researchers

	OVERALL (n=541-1,146)					Research students (n=30-84)	Junior researchers (n=82-207)	Mid-career researchers (n=138-307)	Senior researchers (n=291-548)	Benchmark (Baker 2016* – researchers)
q48a. Reporting of study methods and procedures	43%	38%	14%		**81%**	93%	88%	81%	76%	–
q48b. Adoption of practices to reduce bias (blinding, randomisation)	39%	37%	17%	7%	**76%**	85%	85%	76%	71%	27%
q48c. Statistical analysis of studies	37%	38%	19%	7%	**75%**	85%	78%	74%	72%	83%
q48e. Reporting of animal models	33%	35%	22%	10%	**68%**	63%	74%	72%	65%	30%
q48d. Reporting of reagents	29%	38%	24%	10%	**66%**	70%	66%	68%	65%	55%
q48f. Increased data deposition in public repositories	26%	31%	28%	15%	**57%**	67%	60%	60%	54%	58%

To a large extent
To a moderate extent
To a small extent
Not at all

% to a moderate or large extent

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q48. To what degree do you think that the use of reporting checklists has improved the following aspects of your published work / published work in your field?
** Please note that comparisons against the benchmark results should be treated with caution, due to differences in statement wording and response scale (percentage results represent % improved).*

Competition

Research students / researchers were highly likely to report a sense of competitiveness in relation to various aspects of their role. As illustrated in Figure 22 overleaf, at least 70% felt that almost all aspects listed were 'quite' or 'very' competitive. The one exception to this was in relation to gaining public recognition, although 55% still indicated that this was a 'quite' or 'very' competitive aspect of their role.

The most highly competitive aspects of research students' / researchers' roles were those with a strict limit to their availability, including:

- applying for funding (99%; 92% said this was 'very' competitive);
- applying for jobs and promotions (92%); and
- journal publication (81%).

By participant group, there was little variation in results. However, mid-career researchers were slightly *less likely* than others to experience journal publication pressure (73%, versus 82%-84% of other researcher participant groups).

All participants were also asked about the effect that they felt competition was having on the production of high-quality research. 70% felt that competition was having a *negative* effect overall, while 25% believed that competition was having a *positive* effect overall (though only 1% felt the impact was *very positive*). Results differed across participant groups, as shown in Table 9 below.

On the whole, research students / researchers and institutional representatives were less likely than ethics committee members to view competition in research as having a *positive effect* on the production of high-quality research (24% and 19%, versus 36% of both HREC and AEC members). More specifically, research students and junior researchers were least likely to indicate that competition had a *positive* effect on the production of high-quality research, while senior researchers and ethics committee members were most likely.

Table 9: Perceived effect of competition on the production of high-quality research

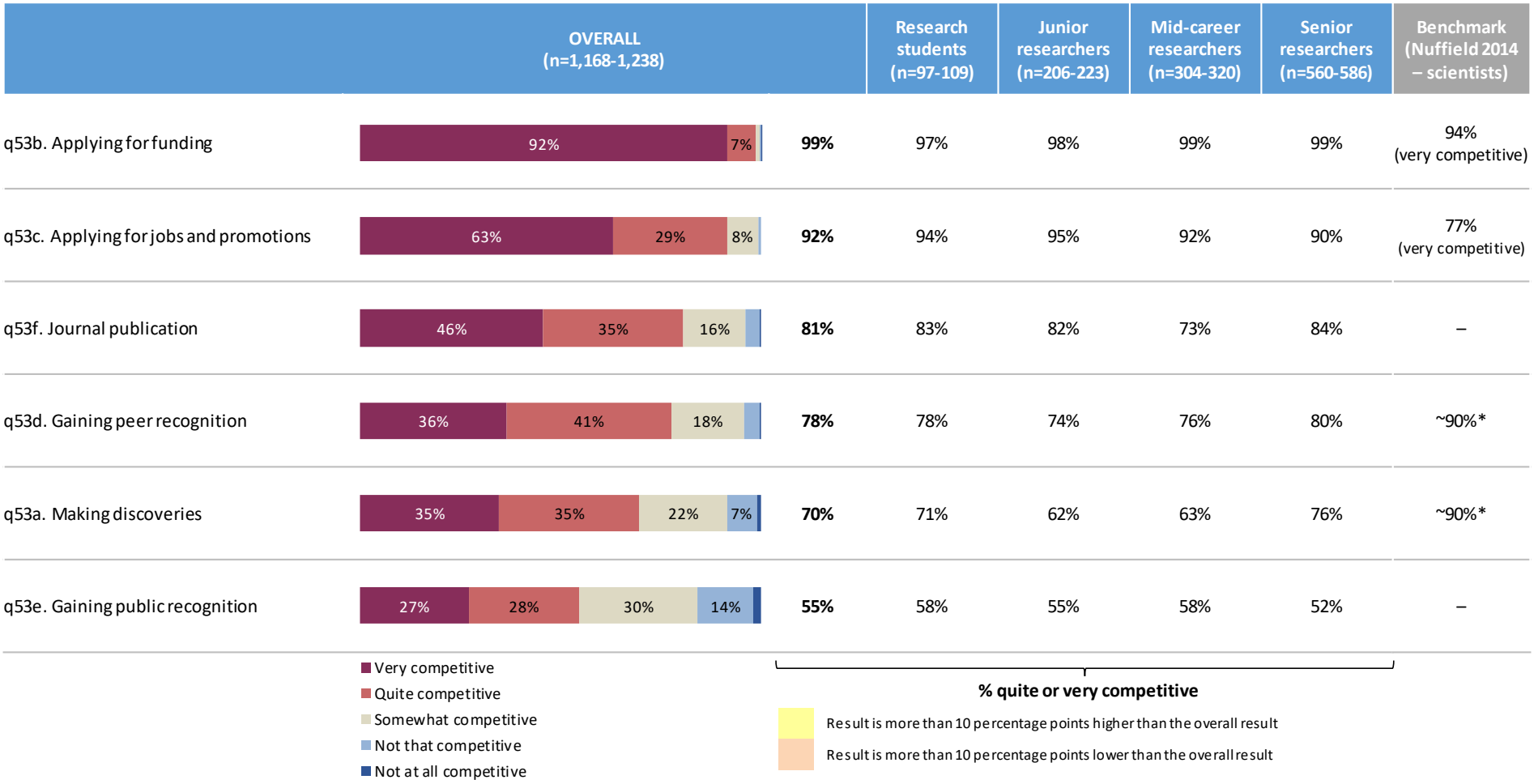
Base: All participants

Participant group	% Negative effect	% No effect	% Positive effect
OVERALL (n=1,275)	**70%**	**5%**	**25%**
Research students (n=75)	81%	3%	16%
Junior researchers (n=193)	83%	3%	15%
Mid-career researchers (n=299)	74%	6%	20%
Senior researchers (n=533)	63%	6%	31%
Institutional representatives (n=67)	75%	6%	19%
HREC members (n=83)	61%	2%	36%
AEC members (n=25)	60%	4%	36%

Q54. What effect do you think that competition in research is having on the production of high-quality research? (Negative effect includes 'very negative' + 'negative', Positive effect includes 'very positive' + 'positive').

Figure 22: Competitiveness of different aspects of a researcher's role

Base: Research students / researchers



Q53. In your experience, how competitive are the following aspects of a researcher's role?

** Exact percentage results were not publicly available (~ indicates an approximate result).*

Participants were also given the opportunity to comment further on the impact they felt that competition in research is having on the production of high-quality research. Common themes are presented in Table 10. The main theme that emerged from those who felt that competition in research had a *positive* impact was that it ensured higher quality research was produced overall. In contrast, those who felt competition in research was *negative* had observed the opposite effect – a reduction in research quality overall. However, it should also be noted that many acknowledged that competition in research can have both positive and negative impacts.

Table 10: Impact of competition on the production of high-quality research (Top 3 themes identified in open-ended responses)

Base: All participants who provided a valid open-ended response

Competition in research: Negative impact* (n=799)	
	Reduces research quality overall (responsible research practices not followed, cutting corners) (16%)
	Causes pressure to produce / publish work quickly / before others (14%)
	Causes pressure to publish more, prioritising quantity over quality (13%)

Competition in research: Positive impact* (n=266)	
	Ensures higher quality research overall (general comments) (40%)
	Motivates individuals to work harder / improve productivity (34%)
	Ensures more rigorous research methods / design (12%)

Q55. Why do you say that?

** Based on response to Q54 (What effect do you think that competition in research is having on the production of high-quality research?)*

VI. What behaviours that may affect research quality are occurring in Australian NHMRC-funded institutions?

In order to further assess the current research culture within Australian NHMRC-funded institutions, research students / researchers were asked about the different behaviours that they may have observed, or been involved with through their work, over the last three years. Behaviours presented to participants were considered to be *undesirable* in the context of their potential impact on research quality in Australian NHMRC-funded institutions.

Overall behaviours

Table 11 overleaf illustrates the top 10 behaviours reportedly undertaken or witnessed overall by research students / researchers in the past 3 years. Overall, this group was generally more likely to report that they had **witnessed others** undertaking behaviours, than they were to report that they had **personally undertaken** such behaviours themselves.

- Detailed results regarding the various behaviours are reported throughout this chapter under four sub-headings – Research design and data collection, Data analysis, Reporting and publication, and Other behaviours.
- Behaviours are also colour coded by these broad areas in Table 11 overleaf (although no 'other behaviours' feature in the top 10).

In general, the largest proportion of behaviours undertaken were in relation to both research design and data collection, and reporting and publication[24], and less so in relation to data analysis and 'other behaviours'.

The main behaviour that research students / researchers admitted having *done themselves* in the past 3 years was in relation to reporting and publication – namely not attempting to publish a valid 'negative' or 'neutral' study (25% had personally done this). Furthermore, 16% claimed to have chosen an inadequate research design as it minimised costs, and 15% claimed to have proposed a research question that was easy to answer rather than needed (both related to research design and data collection).

Some consistencies were also evident in terms of the top three behaviours that research students / researchers had reportedly *witnessed* over the past 3 years, which included:

- proposing a research question which was easy to answer rather than needed (43%);
- choosing an inadequate research design because it minimised costs (40%); and
- using an unsuitable measurement method because it was readily available (35%).

[24] It should be noted that 11 behaviours were presented in relation to 'reporting / publication', compared to just 5-7 in all other categories.

Table 11: Top 10 behaviours witnessed or done in the past 3 years (overall)

Base: Research students / researchers (n=1,034-1,144)

	PERSONALLY DONE	WITNESSED OTHERS
1	Not attempted to publish a valid 'negative' or 'neutral' study (25%)	Proposed research questions which are easy to answer rather than needed (43%)
2	Chosen an inadequate research design because it minimised costs (16%)	Chosen an inadequate research design because it minimised costs (40%)
3	Proposed research questions which are easy to answer rather than needed (15%)	Used unsuitable measurement methods because they were readily available (35%)
4	Selective citation (14%)	Selective citation (34%)
5	Withheld information from a grant application that could have 'weakened' the application (13%)	Insufficiently reported study flaws and limitations (33%)
6	Reported an unexpected finding as having been hypothesised from the start (10%)	Inappropriately added or omitted an author or contributor (32%)
7	Selected the statistical method that provided the desired result (8%)	Selected the statistical method that provided the desired result (30%)
8	Performed data analyses not described in the study protocol without disclosure (8%)	Selection of the best data for publication, rather than representative data (28%)
9	Selection of the best data for publication, rather than representative data (7%)	Not attempted to publish a valid 'negative' or 'neutral' study (27%)
10	Used unsuitable measurement methods because they were readily available (7%)	Withheld information from a grant application that could have 'weakened' the application (26%)

Research design and data collection

In relation to **research design and data collection**, overall, 48%-87% of research students / researchers reported that they had **not** seen or done any of the listed behaviours in the past 3 years (see Figure 23 overleaf).

Furthermore, only a small proportion of research students / researchers (3%-16%) indicated that they had **personally undertaken** each of the behaviours. In contrast, a larger proportion (11%-43%) reported that they had **witnessed others** undertake each of the listed behaviours.

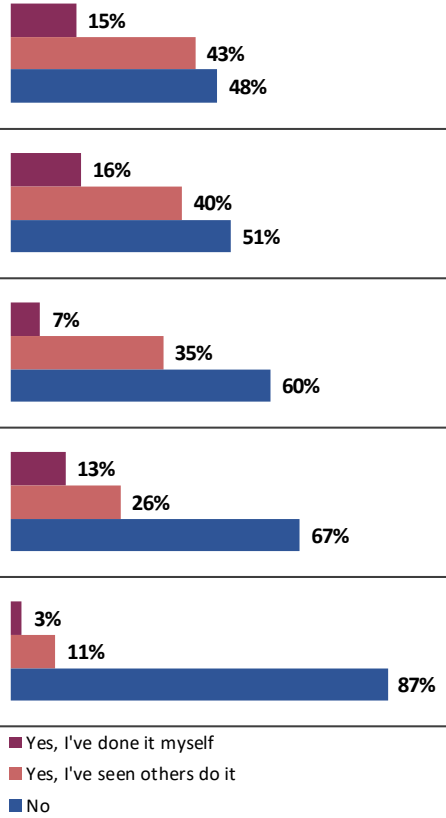
Of particular note, 40% or more reported that they had *witnessed others*:

- propose research questions which were easy to answer rather than needed (43%); and
- choose an inadequate research design because it minimised costs (40%).

Figure 23: Behaviours witnessed or undertaken – Research design and data collection

Base: Research students / researchers; multiple 'yes' responses accepted

	OVERALL (n=1,038-1,124)	Research students (n=78-98)	Junior researchers (n=190-205)	Mid-career researchers (n=258-288)	Senior researchers (n=502-538)	Benchmark (John et al. 2012* – psychologists)	Benchmark (Haven et al. 2019* – researchers)
q64a. Proposed research questions which are easy to answer rather than needed	15%	7%	16%	20%	14%	–	–
	43%	31%	43%	46%	43%	–	45%
	48%	64%	50%	42%	48%	–	55%
q64b. Chosen an inadequate research design because it minimised costs	16%	3%	17%	19%	17%	–	–
	40%	32%	39%	44%	39%	–	41%
	51%	65%	52%	47%	50%	–	59%
q64c. Used unsuitable measurement methods because they were readily available	7%	3%	6%	9%	7%	–	–
	35%	30%	34%	36%	37%	–	41%
	60%	67%	62%	59%	59%	–	59%
q64d. Withheld information from a grant application that could have 'weakened' the application	13%	1%	7%	13%	17%	–	–
	26%	13%	27%	29%	25%	–	15%
	67%	86%	67%	65%	65%	–	86%
q64e. Stopped data collection earlier than planned, without the application of pre-planned monitoring and stopping rules, because the results were already statistically significant	3%	1%	2%	3%	3%	16%	–
	11%	9%	12%	12%	9%	–	15%
	87%	90%	88%	86%	88%	–	85%



Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q64. In the past 3 years, have you done, or witnessed, any of the following in your role as a researcher?

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.*

Of all the listed behaviours, participants were *least likely* to have personally stopped or witnessed the stopping of data collection earlier than planned, without the application of pre-planned monitoring and stopping rules, because the results were already statistically significant (87% had not seen or done this in the past 3 years).

By participant group, research students were generally *less likely* to report having witnessed or undertaken the listed behaviours in relation to research design and data collection, compared to their senior colleagues. This was likely driven by the fact that they would have had less opportunity to do or see such behaviours due to a relatively shorter length of engagement in their role.

Data analysis

Research students / researchers reported highly diligent behaviours in relation to most aspects of **data analysis**, with 65%-94% indicating that they had **not** seen or undertaken any of the listed behaviours in the past 3 years (see Figure 24 overleaf).

The behaviour most likely **witnessed** by participants was the selection of a statistical method that provided the desired result (30%). This was also the behaviour that was most likely to have been **personally undertaken** by participants, along with the performance of data analyses not described in the study protocol without disclosure (although still relatively low at 8% each).

In contrast, the results suggested that the incorrect downward rounding of p-values and fabrication of data to complete a project or paper were being witnessed or undertaken very rarely (94% said they had not seen or done these behaviours in the past 3 years).

Again, research students were broadly *less likely* than their senior colleagues to report that they had seen or personally undertaken the listed behaviours in relation to data analysis (likely due to their shorter length of engagement in research), though the differences were less distinct than in relation to research design and data collection behaviours.

Figure 24: Behaviours witnessed or undertaken – Data analysis

Base: Research students / researchers; multiple 'yes' responses accepted

	OVERALL (n=1,034-1,142)	Research students (n=94-98)	Junior researchers (n=186-205)	Mid-career researchers (n=267-288)	Senior researchers (n=487-555)	Benchmark (John et al. 2012* – psychologists)	Benchmark (Haven et al.2019* – researchers)
q65b. Selected the statistical method that provided the desired result	8%	8%	9%	8%	8%	–	–
	30%	21%	31%	32%	31%	–	–
	65%	74%	63%	64%	65%	–	–
q65a. Excluded outlying data before performing data analysis without disclosure	4%	4%	6%	3%	3%	–	–
	20%	14%	22%	23%	20%	–	15%
	78%	84%	77%	76%	78%	–	85%
q65c. Performed data analyses not described in the study protocol without disclosure	8%	5%	9%	9%	8%	–	–
	17%	9%	20%	20%	16%	–	44%
	78%	87%	74%	75%	79%	–	56%
q65e. Incrementally added more data until the results became statistically significant	7%	3%	5%	7%	8%	56%	–
	16%	10%	18%	19%	15%	–	35%
	80%	88%	80%	78%	79%	–	65%
q65f. Concealed results that contradict earlier findings or hypotheses	1%	3%	1%	1%	1%	–	–
	14%	13%	19%	16%	12%	–	31%
	85%	85%	81%	84%	87%	–	69%
q65g. Fabricated / falsified data to complete a project or paper	<1%	1%	0%	0%	<1%	1%	–
	6%	7%	5%	6%	7%	–	6%
	94%	92%	95%	94%	93%	–	94%
q65d. Reported an incorrect downwardly rounded p-value	1%	0%	1%	1%	1%	22%	–
	5%	3%	8%	4%	6%	–	9%
	94%	97%	92%	95%	94%	–	91%

Yes, I've done it myself
Yes, I've seen others do it
No

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q65. In the past 3 years, have you done, or witnessed, any of the following in your role as a researcher?

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.*

ORIMA RESEARCH

Reporting and publication

In regard to **reporting and publication**, more than half of research students / researchers reported that they had **not** seen or undertaken any of the listed behaviours in the past 3 years (57%-93% – see Figure 25 overleaf and Figure 26 on page 68).

As mentioned at the beginning of this chapter, of all of the behaviours presented (across all areas), research students / researchers were *most likely* to report that they had **personally** not attempted to publish a valid 'negative' or 'neutral' study (25%). Furthermore, 14% admitted to personally undertaking selective citation.

In terms of the most **witnessed** behaviours, over 30% of research students / researchers reported that they had seen others undertake selective citation (34%), insufficiently report study flaws and limitations (33%), and inappropriately add or omit an author or contributor (32%).

In contrast, participants were *least likely* to have duplicated a publication without disclosure (93% said they had never seen or done this).

Similar to other behaviours discussed earlier in this chapter, research students were generally *less likely* than their senior colleagues to report that they had seen or personally undertaken the listed behaviours in relation to reporting and publication (likely due to their shorter length of engagement in research).

Other behaviours

Figure 27 on page 69 illustrates that overall, very few research students / researchers reported that they had personally done or witnessed others undertaking a range of additional behaviours related to pressures from sponsors / funders, failure to disclose important information, and refusals to share data or respond to allegations of a breach of integrity (85%-94% had **not** seen or undertaken any of the listed behaviours in the past 3 years).

Research students were again generally *less likely* than their senior colleagues to report that they had seen or personally undertaken these behaviours (likely due to their shorter length of engagement in research) – particularly a failure to disclose a relevant financial or intellectual conflict of interest (see Figure 27 for full results).

Figure 25: Behaviours witnessed or undertaken – Reporting

Base: Research students / researchers; multiple 'yes' responses accepted

	OVERALL (n=1,045-1,142)	Research students (n=86-98)	Junior researchers (n=186-205)	Mid-career researchers (n=267-292)	Senior researchers (n=493-547)	Benchmark (John et al. 2012* – psychologists)	Benchmark (Haven et al. 2019* – researchers)
q66g. Selective citation	14%	9%	9%	15%	16%	–	–
	34%	20%	31%	32%	38%	–	64%^
	58%	74%	65%	58%	52%	–	36%^
q66d. Selection of the best data for publication, rather than representative data	7%	5%	7%	6%	8%	–	–
	28%	18%	31%	30%	27%	–	–
	68%	78%	65%	69%	68%	–	–
q66a. Not attempted to publish a valid 'negative' or 'neutral' study	25%	12%	23%	28%	26%	–	–
	27%	28%	32%	28%	25%	–	46%
	57%	64%	55%	54%	58%	–	54%
q66e. Use of other researchers' ideas or phrases without permission or referencing	1%	2%	<1%	1%	1%	–	–
	20%	11%	17%	25%	21%	–	30%
	79%	87%	83%	75%	79%	–	70%
q66b. Reported an unexpected finding as having been hypothesised from the start	10%	11%	11%	10%	10%	27%	–
	20%	16%	25%	22%	17%	–	51%
	74%	76%	69%	73%	75%	–	49%
q66c. Not reported all study protocol stipulated results	4%	1%	5%	3%	4%	–	–
	16%	16%	19%	18%	13%	–	34%
	82%	83%	79%	81%	84%	–	66%
q66f. Not reported replication problems	3%	7%	2%	4%	3%	–	–
	11%	8%	13%	12%	10%	–	25%
	87%	86%	87%	85%	88%	–	75%

Yes, I've done it myself
Yes, I've seen others do it
No

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q66. In the past 3 years, have you done, or witnessed, any of the following in your role as a researcher?

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.*

^ This benchmark result is the average result across three questions related to selective citation for the purpose of enhancing own findings or convictions (66% observed) / pleasing editors, reviewers or colleagues (68% observed) / improving citation metrics (58% observed).

Figure 26: Behaviours witnessed or undertaken – Publication

Base: Research students / researchers; multiple 'yes' responses accepted

	OVERALL (n=1,118-1144)	Research students (n=90-97)	Junior researchers (n=198-203)	Mid-career researchers (n=284-296)	Senior researchers (n=537-554)	Benchmark (Haven et al. 2019* – researchers)
q67a. Insufficiently reported study flaws and limitations	6%	6%	7%	6%	5%	–
	33%	22%	36%	32%	36%	52%
	64%	74%	62%	65%	62%	48%
q67d. Inappropriately added or omitted an author or contributor	5%	8%	8%	4%	5%	–
	32%	25%	32%	37%	30%	51%^
	65%	72%	64%	61%	67%	49%^
q67b. Submitted or resubmitted a paper or grant application without consent from all authors	3%	2%	2%	5%	3%	–
	23%	11%	20%	26%	24%	29%
	75%	88%	78%	71%	73%	71%
q67c. Duplication of a publication without disclosure	<1%	0%	0%	0%	<1%	–
	7%	3%	4%	7%	9%	12%
	93%	97%	96%	93%	91%	88%

Yes, I've done it myself
Yes, I've seen others do it
No

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q67. In the past 3 years, have you done, or witnessed, any of the following in your role as a researcher?

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.*

^ This benchmark result is the average result across two questions related to inappropriately adding contributors (69% observed) / omitting contributors (34% observed).

Figure 27: Behaviours witnessed or undertaken – Other behaviours

Base: Research students / researchers; multiple 'yes' responses accepted

	OVERALL (n=1,103-1,151)	Research students (n=93-96)	Junior researchers (n=199-206)	Mid-career researchers (n=289-295)	Senior researchers (n=522-554)	Benchmark (Haven et al. 2019* – researchers)
q68d. Refused to share data (that you have the rights to share) with bona fide colleagues	1% 15% 85%	1% 8% 91%	0% 13% 87%	1% 17% 83%	1% 16% 83%	– 32% 68%
q68c. Failure to disclose a relevant financial or intellectual conflict of interest	<1% 10% 90%	0% 0% 100%	0% 9% 91%	0% 12% 88%	<1% 11% 89%	– 15% 85%
q68a. Modification of the results or conclusions of a study due to pressure of a sponsor / funder	1% 8% 92%	0% 7% 93%	1% 7% 92%	1% 6% 93%	1% 8% 91%	– 9% 91%
q68e. Refused to respond to an allegation of a breach of research integrity	<1% 6% 94%	0% 2% 98%	0% 5% 95%	<1% 6% 94%	0% 7% 93%	– 6% 94%
q68b. Failure to disclose a sponsor / funder of a study	<1% 5% 94%	0% 1% 99%	0% 6% 94%	1% 5% 95%	<1% 6% 94%	– 11% 90%

Yes, I've done it myself
Yes, I've seen others do it
No

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q68. In the past 3 years, have you done, or witnessed, any of the following in your role as a researcher?

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.*

VII. What are the opportunities for change and innovation to improve research quality in Australian NHMRC-funded institutions?

Current practices: Researchers

Procedures established

As described earlier in Chapter IV (see page 27), **reproducibility** is regarded by the NHMRC as a key aspect of high-quality research (along with rigour and transparency), and almost all participants:

- believed that reproducibility was 'quite' or 'very' *important to research* (93%); and
- felt that there is a 'slight' or 'significant' *crisis of reproducibility* (96%).

In line with these perceptions, 97% of research students / researchers reported that they / their research group had established procedures in place to ensure reproducibility in their work (just 1% said no procedures had been established, and 2% were unsure).[25]

As illustrated in Figure 28 overleaf, the key mechanism that research students / researchers had in place to ensure reproducibility was **transparent reporting of study design and methods** (88%). Other common procedures in place to ensure reproducibility in their work included:

- estimation of statistical power (73%);
- application of inclusion or exclusion criteria (69%); and
- estimation of the required number of participants / animals per experimental cohort (66%).

Few participants (34%) were undertaking in house replication before publication, potentially due to the cost and time considerations associated with such an undertaking (see Table 5 on page 40 for further details regarding barriers to implementation).

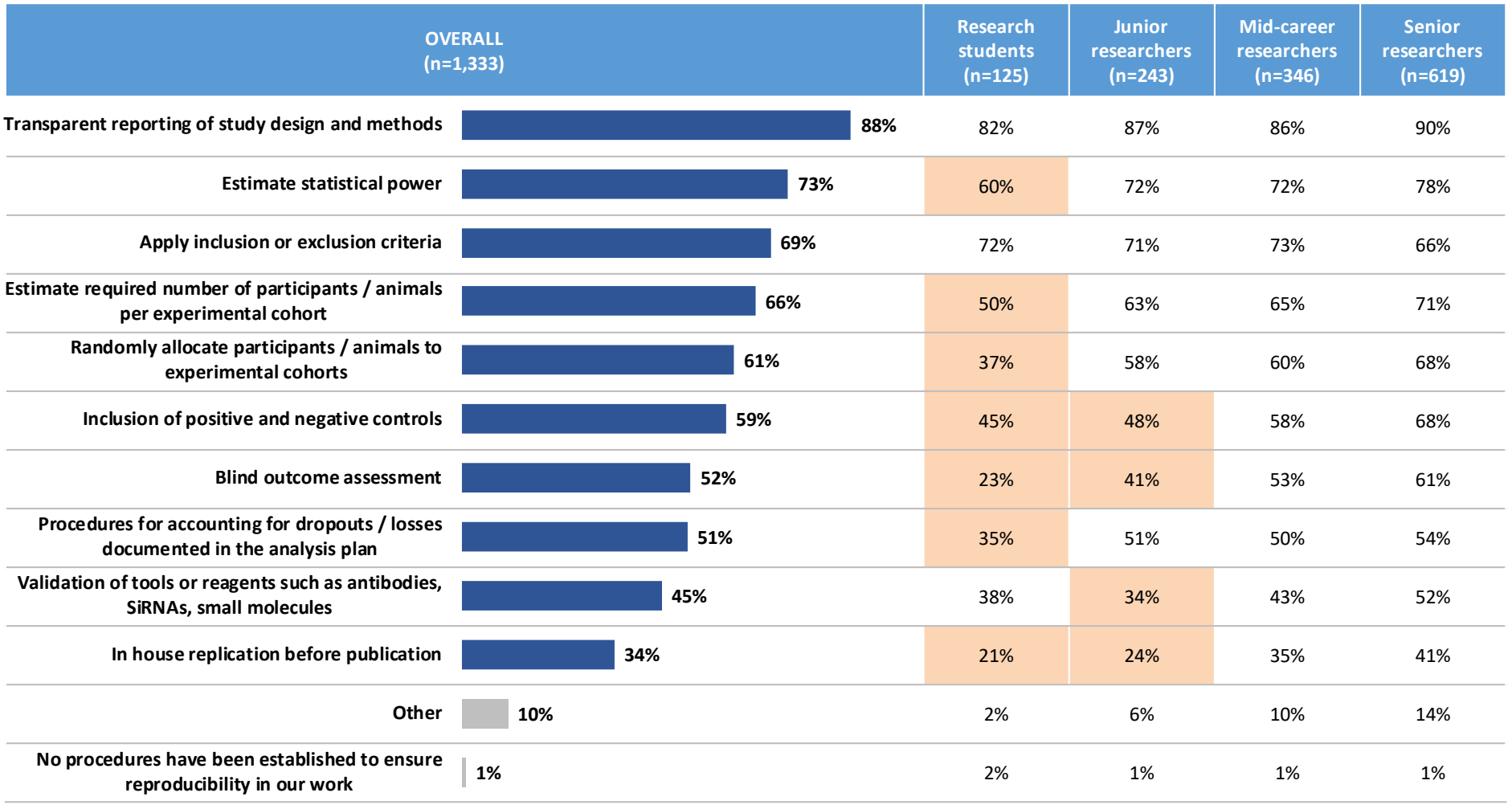
Figure 28 overleaf also illustrates that the establishment of procedures to ensure reproducibility generally increased with researcher seniority.

Additionally, it should be noted that a small proportion of participants took the opportunity to provide a comment under 'other' in relation to this question, explaining that they felt that procedures to ensure reproducibility were not relevant to the type of research they conduct (i.e. such procedures are more relevant to experimental or lab-based research). This should be considered when interpreting this result.

[25] Q21. Which of the following procedures have you / your research group established to ensure reproducibility in your work?

Figure 28: Procedures established to ensure reproducibility

Base: Research students / researchers; multiple responses accepted



Q21. Which of the following procedures have you / your research group established to ensure reproducibility in your work? ('Don't know / can't say' not shown, 2% overall)

Of those who had at least one procedure in place to ensure reproducibility, many stated that these procedures had been in place since they started working in their research group (66%), and a further 22% reported that they had been in place for more than five years. Very few indicated that the procedures in place within their research group were newly established, in the last two years (3%).[26]

Benchmark results[27]

Baker 2016 (researchers):

- 33% had established procedures for reproducibility within the past 5 years
- 7% had established procedures more than 5 years ago
- 26% had procedures in place since they started working in their lab
- 34% had not established procedures

Those who had experienced the implementation of a procedure within their research group were additionally asked to comment on the impact that they felt such procedures had made on the quality of their work. Overall, 61% felt that the quality of their research had improved as a result of the introduction of such procedures (see Table 12). A further 38% felt that the quality of their work had remained unchanged, whilst 1% felt that such procedures had made a negative impact.

- Given that 96% of research students / researchers overall felt that there was currently a 'crisis of reproducibility', there may be scope to improve the effectiveness of such procedures.

By participant group, senior researchers were *more likely* to indicate that the quality of their research remained unchanged after these procedures were introduced, whilst research students / junior researchers were *more likely* than others to feel that the quality of their research had improved.[28]

Table 12: Impact of introduction of procedures on quality of work

Base: Research students / researchers who had experienced the implementation of a procedure in their research group (n=309)

Participant group	Yes, the quality of my research *improved*	No, the quality of my research remained *unchanged*	Yes, the quality of my research *worsened*
OVERALL (n=309)	**61%**	**38%**	**1%**
Research students (n=9)	67%	22%	11%
Junior researchers (n=34)	68%	32%	0%
Mid-career researchers (n=90)	63%	34%	2%
Senior researchers (n=176)	59%	41%	0%

Q23. Did the quality of your research change after these procedures were introduced?

[26] Q22. When were such procedures first established within your research group?
[27] Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.
[28] Results should be interpreted with caution due to relatively small sample sizes (n=9-34).

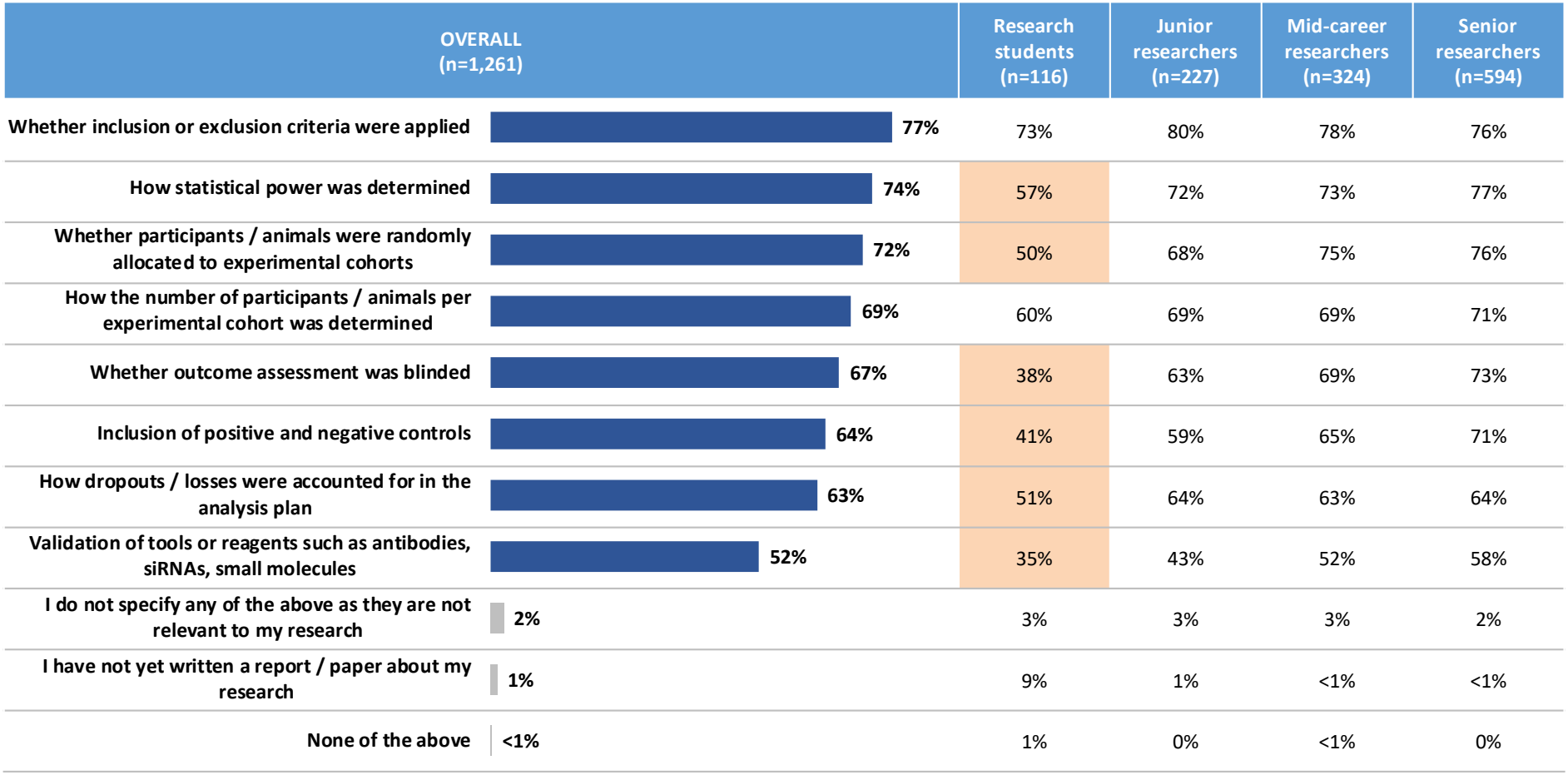
Reporting of specific items

Research students / researchers were also asked to comment on their current practices in relation to reporting. Figure 29 overleaf illustrates that overall, more than 60% of participants indicated that they currently specified each of the items presented when reporting. One exception was in relation to *validation of tools or reagents such as antibodies, siRNAs, small molecules*, with 52% reportedly specifying this when they write a report or paper (this finding is consistent with this being one of the procedures that was less frequently implemented by researchers / research groups – see Figure 28 on page 71).

By participant group, research students were generally *less likely* than their senior colleagues to indicate that they specify most of the items listed when they write a report or paper about their research.

Figure 29: Elements specified when writing a report or paper

Base: Research students / researchers; multiple responses accepted



Q47. When you write a report / paper about your research, which of the following do you specify? ('Don't know / can't say' not shown, 1% overall)

Current practices: Institutions

As outlined in Chapter V, institutions reportedly have a range of systems in place for measuring, monitoring and reporting the quality and outcomes of research (see page 45).

Participants were also asked to provide free-text comments regarding the culture of their institution in regard to responsible research practices, and the results were coded into themes (see page 45). Overall, the results were mixed, suggesting that some institutions were appropriately supporting responsible research practices, whilst others were not, or not to the same extent. Comments provided were mostly general in nature, however around 8% suggested that there was a need for more or improved mentorship or training about responsible research practices to ensure that there is a culture shift that continues for future generations.

Education and training

In order to gauge the type and extent of education and training about responsible research practices that is currently being offered across Australian NHMRC-funded institutions:

- institutional representatives were asked about **how they offer** such education and training; and
- research students / researchers and ethics committee members were asked about the training that they have **received**.

Figure 30 overleaf illustrates that overall, the majority of participants had offered or received education and training about responsible research practices (just 5% overall reported that they had never received training and 1% that their institute does not provide training). Ethics committee members were *most likely* to report that they had never received training (11%-15%, compared to 2%-6% of research students / researchers).[29]

The main ways that training had been offered or received included through mandatory institutional training (62%) and training by supervisors / mentors (55%).

Results varied by participant group (see Figure 30 for full results):

- Research students were *more likely* than other participant groups to have received education and training as part of undergraduate courses, and *less likely* to have received ad hoc training or attended external conferences / workshops.
- Institutional representatives were *more likely* to report that their institution *offered* education and training in certain ways compared to the proportion of research students / researchers and ethics committee members who reported to have *received* such training – particularly training by supervisor / mentor, ad hoc training, attendance at external conferences / workshops, and non-mandatory institutional training.
- Ethics committee members were *more likely* than other participant groups to have attended external conferences / workshops.

[29] Institutional representatives were not shown this response option.

Figure 30: How education and training is offered

Base: All participants; multiple responses accepted

	OVERALL (n=1,513)	Research students (n=116)	Junior researchers (n=228)	Mid-career researchers (n=325)	Senior researchers (n=596)	Institutional representatives (n=82)	HREC members (n=119)	AEC members (n=47)
Mandatory institutional training (including induction and refresher training)	62%	☆ 69%	☆ 64%	☆ 65%	☆ 64%	☆ 65%	☆ 40%	☆ 45%
Training by supervisor / mentor	55%	☆ 55%	☆ 57%	☆ 59%	☆ 56%	☆ 71%	39%	19%
Ad hoc training	46%	25%	☆ 40%	☆ 44%	☆ 52%	☆ 65%	☆ 47%	☆ 28%
Attendance at external conferences / workshops etc.	44%	31%	38%	43%	44%	56%	☆ 61%	☆ 62%
Non-mandatory institutional training (including induction and refresher training)	30%	21%	25%	31%	30%	46%	☆ 40%	☆ 28%
As part of undergraduate courses	28%	☆ 47%	36%	32%	22%	24%	28%	13%
As part of postgraduate courses	1%	1%	1%	2%	1%	0%	4%	2%
Other	7%	2%	6%	6%	7%	9%	12%	11%
I have never received such training	5%	6%	2%	3%	5%	–	11%	15%
My institution does not offer training	1%	0%	1%	<1%	1%	1%	1%	2%
I don't need training	<1%	0%	0%	<1%	<1%	–	0%	0%

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

☆ Top 3 training methods (Top 4 for HREC and AEC members)

Q43. How does your institution offer education and training about responsible research practices? [Institutional representatives] / How have you received education and training about responsible research practices? [Research students / researchers] / How have you received education and training about responsible research practices that are relevant to the proposal that your committee considers? [Ethics committee members]

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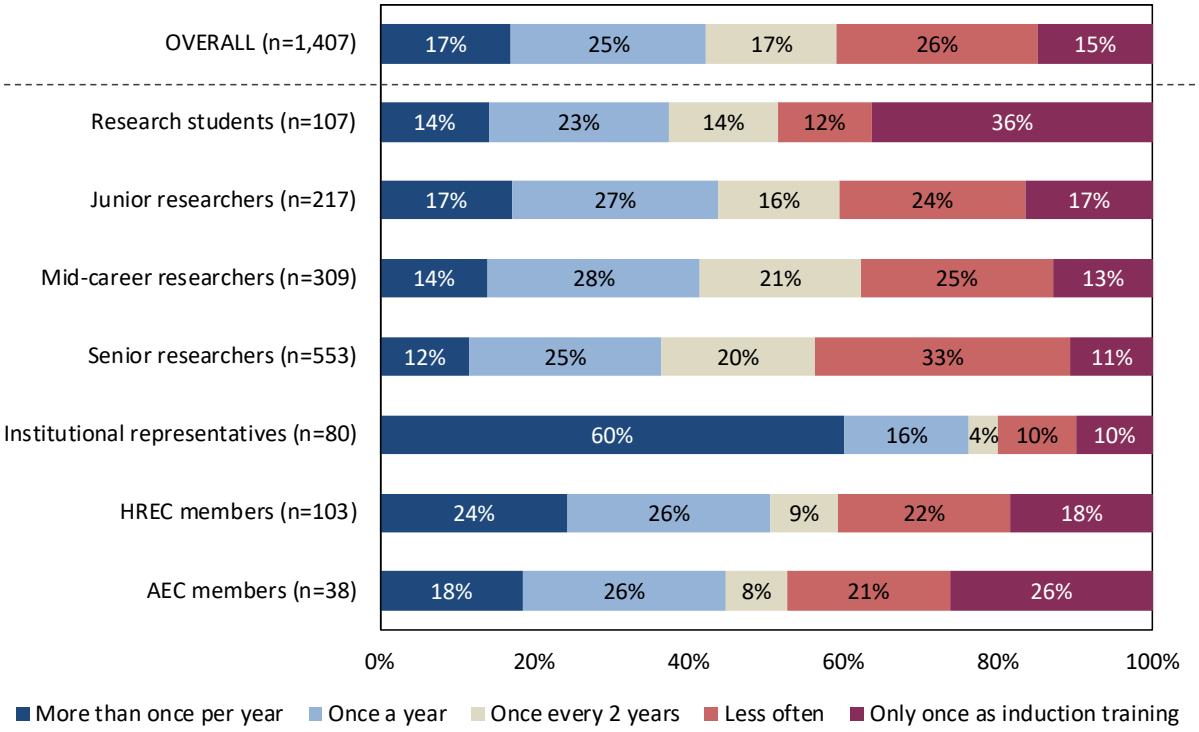
Participants who reported that they had offered or received education and training about responsible research practices were asked to indicate how often this had occurred. As illustrated in Figure 31, overall, 42% of participants offered or received such training at least once a year.

Among those who **received** education and training (research students / researchers and ethics committee members), HREC members reported receiving such training *most frequently* (50% at least once a year).

In contrast, 76% of institutional representatives indicated that they offered education and training at least once a year, suggesting that there is a discrepancy in the amount of training offered, and the amount being undertaken.

Figure 31: Frequency with which education and training is offered / undertaken

Base: All participants



Q44. How frequently does your institution offer / do you receive education and training about responsible research practices?

Institutional representatives were also asked to indicate who their institution provided education and training to.[30] The two key groups for whom institutional representatives reported they were providing training on responsible research practices included:

- individuals who were coming to the end of their studies, namely masters and PhD students (85%); and
- early and mid-career researchers (84%).

[30] Q45. Education and training about responsible research practices is provided to…?

Furthermore, 51%-60% indicated that training was provided to ethics committee members, whilst a smaller proportion indicated that training was provided to undergraduate students (38%).

All participants were also asked about their *perceptions* of training on responsible research practices. As shown in Figure 32 overleaf, overall, most agreed that appropriately educating and training researchers about responsible research practices will improve research quality (87%), and that education and training about responsible research practices is beneficial for their work / role (85%). However, despite this positive sentiment toward training, participants were *less likely* to agree that the education and training opportunities available at their institution were effective (53%). This suggests that there is opportunity to improve the training offered through institutions to meet the needs of the research community.

Figure 32: Perceived effectiveness of training on responsible research practices

Base: All participants

	OVERALL (n=1,358-1,481)		Research students (n=101-113)	Junior researchers (n=197-222)	Mid-career researchers (n=300-321)	Senior researchers (n=549-586)	Institutional representatives (n=73-81)	HREC members (n=103-115)	AEC members (n=35-43)	Benchmark (QUEST 2018* – researchers)
q46c. Appropriately educating and training researchers about responsible research practices will improve research quality	41%	46% 9%	**87%**	86%	87%	88%	84%	91%	91%	95%	–
q46b. Education and training about responsible research practices is beneficial for my work / role	27%	58% 12%	**85%**	91%	85%	86%	80%	95%	90%	93%	–
q46a. The educational and training opportunities available at my institution about responsible research practices are effective	3%	44% 31% 13%	**53%**	61%	46%	51%	54%	41%	58%	63%	29%

Strongly agree
Agree
Neither disagree nor agree
Disagree
Strongly disagree

% agree or strongly agree

Result is more than 10 percentage points higher than the overall result
Result is more than 10 percentage points lower than the overall result

Q46. Please indicate the extent to which you agree or disagree with the following statements about training on responsible research practices.
** Please note that comparisons against the benchmark results should be treated with caution, due to differences in statement wording and response scale (benchmark percentage results represent % very / completely).*

Suggested actions

All participants were asked a series of questions related to actions or changes that they think need to be undertaken by individuals or institutions to improve research quality within the sector. Chapter IV discusses the perceived impact that a range of **features** in the Australian research environment may have in terms of encouraging the production of high-quality research, with the results suggesting that policies and initiatives were more highly regarded compared to features that were likely to promote competition (see page 24).

In addition, participants were also asked about **who** they felt has the largest potential to improve research quality. At an overall level, it was reported that researchers themselves were the ones with the greatest potential to enact change (62%). However, further disaggregation of the results by participant groups revealed that individuals felt that improvements can in fact come from various sources, including from themselves (see Figure 33 overleaf).

Figure 34 to Figure 36 illustrate the actions that participants felt **researchers, academic / research institutions,** and **funders** could take, in order to improve research quality. One key take-out was that overall, 84% felt that **academic / research institutions** could make an impact by shifting industry norms within the research community (promotion of an environment where high-quality research and reproducible research is considered the required norm). In addition to this, it was felt that:

- **researchers** could have the most impact by specifying critical research design elements (71%) and obtaining statistical advice and developing a plan early (69%); and
- providing or ensuring appropriate training or mentoring programs are offered (by institutions / funders) or attendance at appropriate training or mentoring programs (by researchers) was an action that **all** could take (60-72%).

In contrast, participants were *least likely* to nominate providing a publishing platform for all research outputs, and providing public recognition of initiatives that ensure and promote research quality, as important actions (34% each – both actions that funders can take).

Furthermore, 6% of participants provided an unprompted free-text comment that indicated that they felt funders have the potential to improve research quality through the provision of more appropriate / improved funding.

There were some variations by participant group:

- Research students were *more likely* than others to view open publishing practices as an important action that researchers could take to improve research quality.
- Junior researchers were *more likely* than others to indicate that the use of reporting checklists by researcher had a large potential to improve research quality, while institutional representatives and ethics committee members were *less likely*.
- Institutional representatives and ethics committee members were generally *more likely* than others to identify participation or provision of education and training as having high potential to contribute to improved research quality.

Figure 33: Groups with the largest potential to improve research quality

Base: All participants; up to 3 responses accepted

	OVERALL (n=1,458)	Research students (n=109)	Junior researchers (n=219)	Mid-career researchers (n=307)	Senior researchers (n=579)	Institutional representatives (n=81)	HREC members (n=117)	AEC members (n=46)	Benchmark (Baker 2016* – researchers)
Researchers	62%	65%	62%	61%	67%	53%	50%	59%	91%
Funders	54%	57%	58%	60%	55%	46%	34%	39%	35%
Research institutions	54%	47%	52%	52%	51%	70%	62%	61%	–
Research group heads	46%	40%	47%	43%	52%	43%	35%	35%	83%
Publishers	26%	34%	27%	30%	25%	21%	15%	17%	53%
Ethics committees	15%	17%	15%	12%	8%	15%	47%	41%	–
Department heads	14%	14%	12%	12%	12%	22%	21%	15%	22%
Professional societies	9%	5%	5%	8%	9%	11%	18%	7%	16%
General public and politicians	7%	9%	7%	6%	6%	10%	4%	7%	–
None of the above	<1%	0%	0%	0%	0%	0%	1%	0%	–

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q59. Of the following, who has the largest potential to improve research quality (directly or indirectly)? ('Don't know / can't say' not shown, less than 1% overall)

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question type and wording of response options.*

Figure 34: Actions by researchers with the largest potential to improve research quality

Base: All participants; multiple responses accepted

	OVERALL (n=1,449)	Research students (n=109)	Junior researchers (n=218)	Mid-career researchers (n=305)	Senior researchers (n=574)	Institutional representatives (n=80)	HREC members (n=117)	AEC members (n=46)
Specifying critical research design elements	71%	75%	65%	71%	74%	75%	68%	72%
Obtaining statistical advice and developing a statistical plan before commencing a study	69%	72%	72%	68%	68%	75%	63%	80%
Participation in appropriate education and training about research quality	60%	67%	58%	56%	56%	76%	73%	74%
Appropriate disclosures of interests including funding sources	52%	53%	51%	49%	51%	53%	59%	52%
Open publishing practices	46%	61%	55%	44%	38%	54%	50%	52%
Use of reporting checklists	45%	50%	56%	50%	42%	30%	34%	33%
Reporting exclusions	40%	41%	40%	44%	39%	43%	32%	26%
Clearly distinguishing between discovery and hypothesis testing experiments	39%	32%	39%	35%	41%	33%	44%	46%
Replication by outside research groups	37%	33%	37%	38%	38%	41%	34%	35%
Pre-registration of research protocols	37%	46%	44%	37%	34%	40%	35%	22%
Other	5%	1%	5%	4%	7%	3%	3%	2%
None of the above	1%	0%	2%	1%	1%	0%	1%	0%

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q62. Which of the following actions by researchers do you think has the largest potential to improve research quality? ('Don't know / can't say' not shown, 2% overall)

Figure 35: Actions by academic / research institutions with the largest potential to improve research quality

Base: All participants; multiple responses accepted

	OVERALL (n=1,448)	Research students (n=109)	Junior researchers (n=219)	Mid-career researchers (n=303)	Senior researchers (n=574)	Institutional representatives (n=80)	HREC members (n=117)	AEC members (n=46)
Promoting an environment where high quality research and reproducible research is considered the required norm	84%	88%	79%	83%	85%	90%	87%	83%
Developing mentoring programs that address research quality as well as career development	72%	74%	77%	68%	70%	79%	75%	70%
Providing appropriate education and training for researchers about research quality	70%	76%	65%	66%	67%	86%	85%	78%
Requiring compliance with best practice for research design in ethics and grant applications and publications	59%	61%	54%	56%	57%	66%	71%	89%
Rewarding researchers who perform high quality research	51%	52%	47%	55%	51%	58%	44%	50%
Encouraging open publishing practices	47%	63%	51%	49%	41%	54%	45%	50%
Conducting audits to ensure maintenance of record keeping and responsible research practice	41%	47%	42%	35%	36%	54%	55%	61%
Providing increased funding / support	1%	2%	1%	1%	1%	1%	1%	2%
Other	6%	4%	5%	6%	7%	4%	3%	4%
None of the above	<1%	0%	1%	0%	0%	0%	0%	0%

Benchmark result (Nature 2018* – researchers):
When asked which actions survey respondents found research institutions undertaking to improve reproducibility:
- 37% selected 'fund training for researchers'
- 24% selected 'conduct audits to ensure maintenance of record keeping and good research practice'

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q61. Which of the following actions by academic / research institutions do you think has the largest potential to improve research quality? ('Don't know / can't say' not shown, 1% overall)
'Providing increased funding / support' was not included in the original list of response options presented to all respondents but was added as a code at the data processing stage as 1% provided 'other' comments addressing this area.

** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.*

Figure 36: Actions by funders with the largest potential to improve research quality

Base: All participants; multiple responses accepted

	OVERALL (n=1,453)	Research students (n=109)	Junior researchers (n=219)	Mid-career researchers (n=305)	Senior researchers (n=577)	Institutional representatives (n=80)	HREC members (n=117)	AEC members (n=46)
Ensuring appropriate training for peer review panel members about research quality	66%	67%	63%	68%	66%	73%	62%	65%
Ensuring grant application processes support submission and assessment of critical and relevant information	60%	68%	58%	55%	60%	63%	60%	63%
Providing guidance for researchers on how to ensure research quality is addressed in grant applications	58%	61%	59%	55%	56%	71%	60%	54%
Encouraging open publishing practices	48%	66%	53%	46%	43%	61%	47%	57%
Providing guidance for training of researchers about research quality	47%	51%	42%	45%	45%	53%	59%	57%
Providing a publishing platform for all research outputs	34%	52%	40%	34%	29%	29%	31%	46%
Providing public recognition of initiatives that ensure and promote research quality	34%	40%	34%	31%	30%	53%	44%	41%
Providing appropriate / increased / improved funding	6%	6%	8%	9%	7%	1%	0%	0%
Other	8%	6%	5%	6%	11%	9%	4%	9%
None of the above	1%	0%	2%	1%	1%	0%	1%	0%

Benchmark result (Nature 2018* – researchers):
When asked which actions survey respondents found funders undertaking to improve reproducibility:
- 33% selected 'encourage publication via OA'
- 23% selected 'provide a publishing platform for all experimental outputs'
- 19% selected 'provide training for researchers'
- 14% selected 'provide training for peer review panel chairs'

Result is more than 10 percentage points higher than the overall result

Result is more than 10 percentage points lower than the overall result

Q60. Which of the following actions by funders do you think has the largest potential to improve research quality? ('Don't know / can't say' not shown, 2% overall)
'Providing appropriate / increased / improved funding' was not included in the original list of response options presented to all respondents but was added as a code at the data processing stage as 6% provided 'other' comments addressing this area.
** Please note that comparisons against the benchmark results should be treated with caution, due to differences in question wording and response options.*

All participants were also given the opportunity to provide free-text comments in relation to anything else that they thought they, or their institution, could do in order to improve the quality of research conducted in Australian NHMRC-funded institutions. Comments were coded into key themes, as shown in Table 13 below.

Table 13: Suggestions to improve the quality of research (Top 3 themes identified in open-ended responses)

Base: All participants who provided a valid open-ended response (n=1,259)

Top 3 suggestions	
	More funding (to support better research) (16%)
	More / improved training / personal development and education (12%)
	Reduce administration burden / processes (by improving support or reducing bureaucracy (10%)

Q11. Is there anything you think that you, or your institution, could do in order to improve the quality of research?

Additionally, 9% also suggested that there was a need for a shift in workplace culture to an environment of sharing and collaboration, and 8% felt research quality would improve if there was less pressure to publish and more of an emphasis on 'quality' over 'quantity'.

VIII. Conclusion

The results from the survey of research culture in Australian NHMRC-funded institutions suggested that there were many individuals within the research community who felt positively about the current culture in their institution. However, there were also some with negative or mixed views. The research identified the following key actions or opportunities to influence research culture or responsible research practices within Australian NHMRC-funded institutions:

- Promoting an environment where high-quality research and reproducible research is the required norm;
- Focusing on training / mentorship (especially of junior researchers) about responsible research practice, and the effectiveness of such education and training;
- Addressing the perceived crisis of reproducibility, through factors that are seen to be contributing most to a failure to reproduce results (such as selective reporting of results or pressure to publish for career advancement);
- Promoting positive initiatives / processes rather than competition where possible;
- Encouraging open access publishing (due to perceptions that this is not happening as frequently as other measures that contribute to high-quality research), whilst considering the barrier of cost;
- Considering the impact of funding pressures / funding expectations on researchers, and the potential to explore other funding models; and
- Encouraging more rigorous reproducibility procedures (as procedures such as in-house replication before publication are not currently being undertaken frequently).