ROYAL SOCIETY OF CHEMISTRY

TALENT

Is publishing in the chemical sciences gender biased?

Driving change in research culture

Contents

1.

Foreword

Chemistry should be for everyone. For the chemical sciences to prosper and deliver against global challenges, we must attract, develop and retain a diverse range of talented people. That's not merely an opinion – diverse teams deliver better results.

As a professional and membership body and a leading voice for the chemistry community, we have a responsibility to promote inclusivity and accessibility in order to improve diversity. When we audited the diversity landscape of the chemical sciences, we uncovered a lack of data and a need for greater transparency.

That is why we undertook this study to assess gender bias in our publishing activities. We are a global not-for-profit chemical science publisher – reinvesting any surplus we make back into the chemistry community. Analysing and making data available from our own publishing, supports the community by bringing to light the hidden inclusion challenges that need tackling.

We found that there is a complex interaction of subtle biases occurring throughout the publishing pipeline, which combine to put women at a disadvantage when disseminating their research. We must recognise where this happens. We are committed to further scrutinising our own processes at each stage – and we are calling on other publishers to do the same. We want to work together to make scientific peer-reviewed publishing fit for the modern age.

Ensuring that the chemical science community fairly encourages, enables equal access and retains a more diverse range of voices will lead to better science and, by extension, will benefit society.

That's why we are working to make chemistry for everyone.

Robert Parker
Chief Executive, Royal Society of Chemistry

2.

Executive summary

In early 2018, we published a report, *Diversity Landscape of the Chemical Sciences*[1], which raised many questions about the current state of diversity in the chemical sciences and in particular highlighted the lack of progression of women. We explored the causes of poor retention and progression of women in our *Breaking the Barriers*[2] report and made commitments to counteract them.

We are not only a professional body but also a publisher of peer reviewed research articles for the chemical sciences. Recognising that both the publication of research articles and the number of citations that those articles gather remain established markers of scientific success, we have carried out the first in-depth gender analysis of each stage of the publication process within the chemical sciences community.

Analyses of the gender profile of international publishing outputs, authorship and peer review[4-6] have highlighted that both gender and geography have an impact on article acceptance and citation rates.

Here*, we have analysed the gender profile of the publishing pipeline of the Royal Society of Chemistry's journals between 2014 and 2018, showing that there are biases at each stage in the publication process. This report also contains views from the chemical science research community about the biases within publishing, the factors that might be contributing to these biases, and what we can do to tackle them.

It is likely that many of these biases are inadvertent; however beyond the response from our interviewees this report does not make assumptions of how these biases are introduced, consciously or unconsciously.

Biases exist at each step of the publishing profile. Many of these biases appear minor in isolation, yet their combined effect puts women at a significant disadvantage.

Women are less likely to hold positions towards the end of the author list, in particular that of corresponding author.

Women are less likely than men to submit to journals with higher impact factors, and they are also more likely to have an article rejected without review.

Women are under-represented as reviewers but are more likely to be chosen to review articles by female corresponding authors.

Both reviewer gender and author gender affects article acceptance.

Biases operate at editorial level too. The choice of reviewer and editorial agreement with a review are influenced by gender.

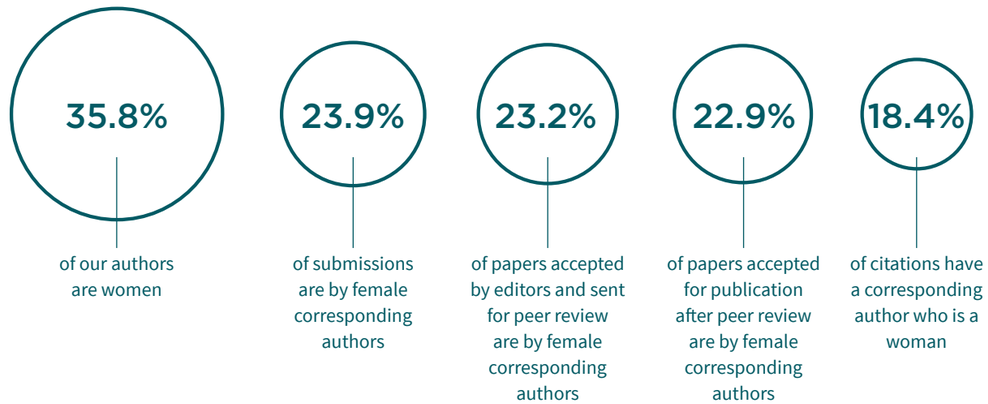
Women cite fewer research papers than men overall, and men are less likely than women to cite papers authored by women.

*Is there a gender gap in chemical sciences scholarly communications? Day, Corbett and Boyle, *available from ChemRXiv*, Under Review

What are the consequences for female authors?

Our findings show that biases do exist both pre- and post-publication.

These subtle biases, which occur throughout the publishing pipeline, combine to put women at a disadvantage when disseminating their research. Female authors are less likely to benefit from the visibility provided by being a corresponding author.



What can we do about it?

Only by recognising the biases that are introduced at decision points by authors, reviewers, editors and publishers, can we act to reduce them.

We will therefore continue to scrutinise our own processes at each stage of the publishing pipeline to aim to eliminate these sources of bias.

We have identified four key areas for action. We will:

1 Increase transparency

Undertake comprehensive analysis and reporting of our authors, reviewers and editorial decision makers by sub-discipline – and publish this annually. We call on other publishers to do the same.

2 Reflect our research community

Recruit and train reviewers, editorial board members and associate editors to reflect the current gender balance of our research community: our target for 2022 is at least 36% women.

3 Empower and innovate

Provide new training and resources to empower our editors to eliminate bias. We will test new models throughout the publishing profile to address bias from submission to publication.

4 Encourage intervention

Partner with others and lead the development of a new *Inclusion & Diversity Framework for Action* to set the standard for driving change within the academic publishing industry.

Ensuring that the chemical science community fairly rewards and retains a more diverse range of voices will lead to better science[3] and by extension will benefit society.

3.

Background to this study

As a leading voice and publisher for the chemistry community, we have an opportunity to promote inclusivity and accessibility in order to improve diversity within the chemical sciences. This is not only a moral obligation – by increasing the diversity of voices within chemistry we can increase the quality of research[3], inspire and attract the next generation of chemists, and ensure that chemistry is relevant to all in society.

Our 2018 report, *Diversity Landscape of the Chemical Sciences*[1], highlighted the need for more progress around gender equality, especially regarding the retention of women and their advancement to leadership positions.

Our follow-up study, *Breaking the Barriers*[2], identified three key impediments to career progression that disproportionately affect women:

- **Academic funding structures** combined with current definitions of scientific excellence and success
- An **academic culture** that is driving talented women elsewhere
- Practical barriers caused by the need to **balance professional responsibilities** with personal ones such as caregiving

Other organisations have previously identified gender biases specifically within publishing.

Elsevier's *Gender in the Global Research Landscape* analysis[4] examined the outputs, quality and impact of STEMM research worldwide by gender, and reported several findings relevant to our current study:

- Women publish fewer research papers on average than men
- Women are less likely to collaborate internationally on research papers
- Women are slightly less likely than men to collaborate on research papers across academic and corporate sectors
- Women's output includes a slightly larger proportion of inter-disciplinary work

In 2018, the Institute of Physics (IOP) published an analysis of inclusion and diversity within peer review at IOP Publishing[5], using gender and geographical data on authors, reviewers and editorial board members between 2014 and 2018. It was found that:

Papers with female corresponding authors have a slightly lower chance of being accepted

- 40% Female
- 43% Male

An examination of peer review outcomes of more than 30,000 submissions to the journal *eLife*[6] revealed that:

- Women and those from nations outside of North America and Europe were underrepresented as editors and peer-reviewers
- Editors and reviewers were more likely to favour manuscripts from authors of the same gender and same country as themselves
- Acceptance rates for male corresponding authors were higher than for women, and this inequity was more pronounced if all reviewers were male

Publication metrics remain well recognised markers of scientific success and have an impact on career progression and therefore retention. Any biases within the publishing system, added to the barriers we previously uncovered[2], have the potential to culminate in women having an undeservedly poorer publication record.

As a key publisher in the chemical sciences, we want to uncover biases and work with the research community to reduce and remove them – making sure that chemistry is for everyone.

That is why we have carried out the first in-depth gender analysis of each stage of the publication pipeline within the chemical science community.

"The knock-on effect is not simply that much fantastic research never sees the light of day. It is also that many talented people from minority backgrounds do not see their careers progress in the way their excellence would warrant. This is not good for science, let alone the individuals."

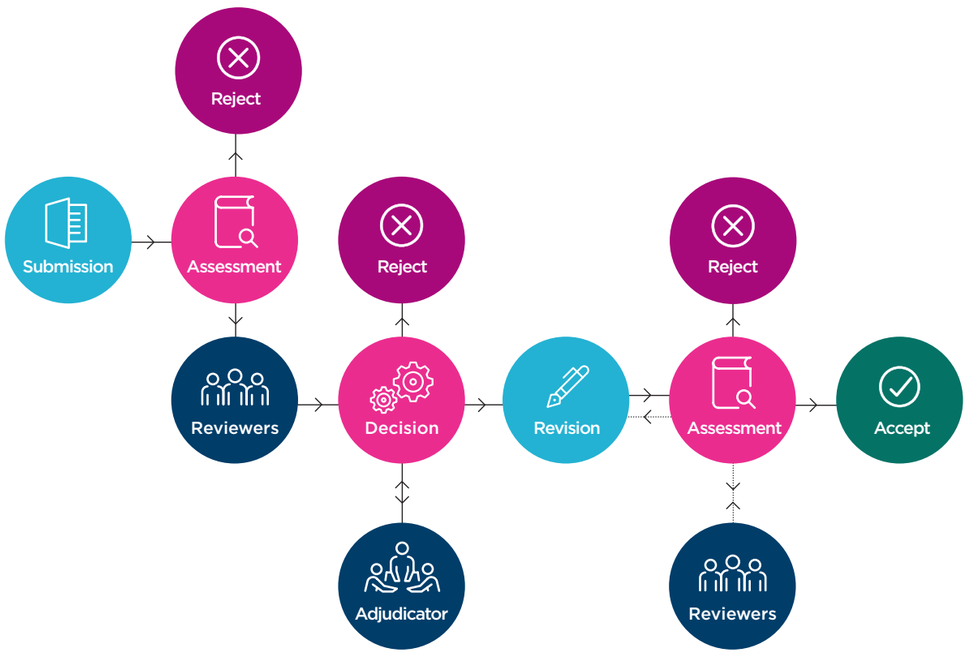
Melinda Duer and **Dame Athene Donald** *Times Higher Education supplement 2019*

Our publishing activity

The Royal Society of Chemistry publishes more than 40 peer-reviewed journals (over 35,000 articles in 2018), around 2,000 book titles and a collection of online databases and literature updating services. Our international publishing portfolio covers the core chemical sciences including related fields such as biology, biophysics, energy and environment, engineering, materials, medicine and physics.

From submission to peer review to publication, every paper submitted to our journals will go through the publishing process shown below. The editorial structure of the different journals, however, does vary slightly. Some have associate editors, active researchers in the field, who handle papers and work closely with the in-house editorial team. Others have teams of in-house specialist editors. All editorial teams are fellow scientists who work closely with our international authors, reviewers and readers throughout the publishing process.

An overview of our publishing process:



4.

Methodology

In this study, we analysed the gender profile of authors of 717,108 manuscript submissions across all our journals from January 2014 until the end of July 2018 and 141,073 citations between our journals from August 2011 until September 2018. Gender was assigned to names by following the approach used in the Gender Profiles in UK Patenting report authored by the UK Intellectual Property Office[7]. One limitation of this approach is that gender could only be assigned in binary terms. Calculations reflect the percentage of the population with known gender, so that people with unknown gender were removed from the data set[8].

We used these data to:

1

Gain a picture of the gender profile of the Royal Society of Chemistry's author community over the time period analysed

2

Determine the gender balance at each stage of the publishing pipeline

3

Where appropriate, investigate interactions between variables such as editor gender, reviewer gender, and author gender to check whether these affect the percentage of articles by gender at each stage in the publishing pipeline.

The results that follow have been compared to the baseline of female chemistry researchers in the Royal Society of Chemistry's author community.

5.

Gender balance in our publishing community

We investigated the gender balance among different publishing roles, to uncover how women are represented at various stages of the publishing pipeline.

The proportion of female authors submitting to our journals was 35.8%. This number tallies with other measures we used to assess the overall gender balance of the chemistry community.

Compared to this baseline we found that there were:

36.9%

Slightly more female first authors

29.2%

Substantially fewer female corresponding authors

40.4%

More female editors

24.5%

Substantially fewer female reviewers

The data regarding female corresponding authors are interesting in light of previous data from our own analyses[1] which show that female chemistry researchers are not progressing to senior positions in the same proportion as their male counterparts. Does this potential lack of visibility as corresponding authors impact on women's academic progression?

Another possible impediment to women's progression is that they are less likely to collaborate internationally when publishing research articles[4]. Ascertaining if there are barriers that prevent women from leading international collaborations is outside the scope of this work and something to be explored in the future.

The low proportion of female peer reviewers seen across our journals is mirrored by data published in the physics community. The IOP found no significant difference in the propensity for men or women to accept review invitations, which suggests that there is a pool of women who are not being invited to review. Our own data agreed – the low incidence of reviews provided by women is principally due to them being invited less often than male counterparts.

> *"…when I choose reviewers as an editor I certainly try to ask as many women as men….I can see how this happens because people talk a lot about asking the 'very important person'.. I actually know what 'big people' means… mostly one type of person."*
>
> **Author, reviewer and editor**

What is the proportion of women in the RSC publishing community?

29.2%
Women
Corresponding authors

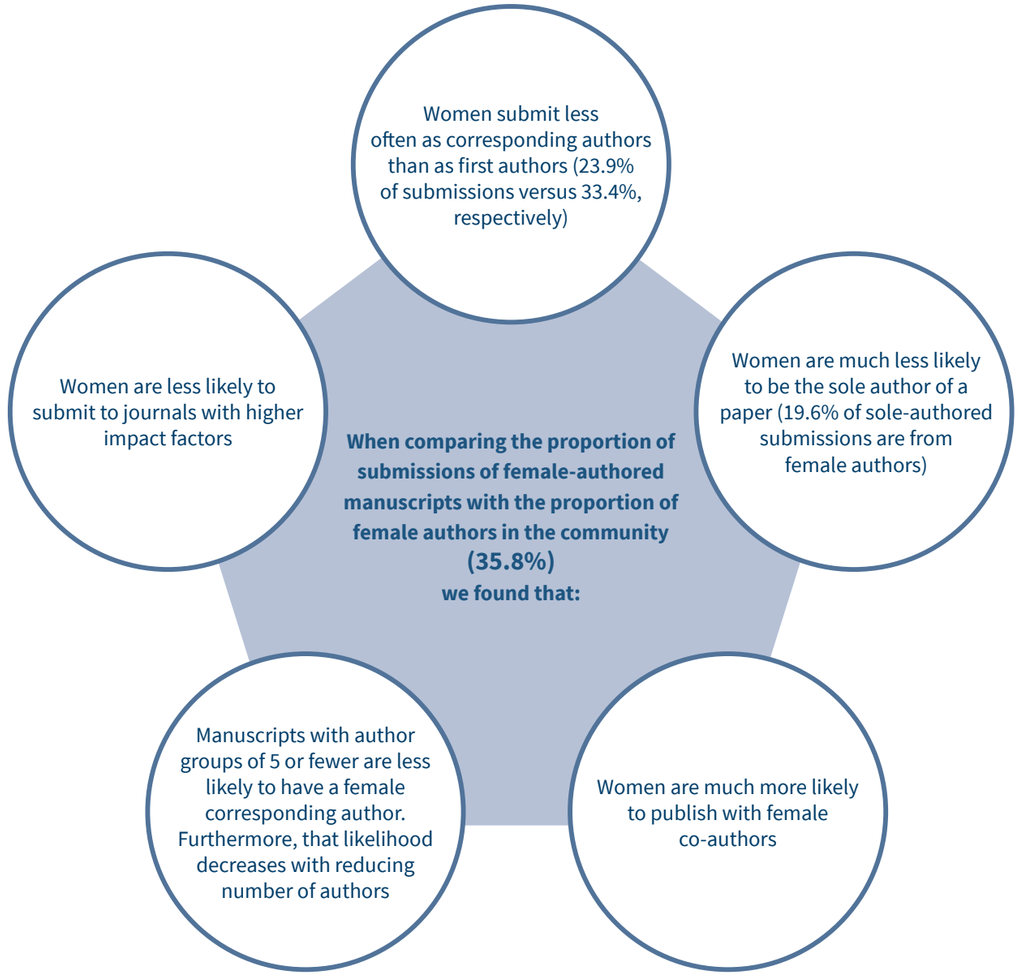
36.9%
Women
First authors

24.5%
Women
All reviewers

40.4%
Women
All editors

6.

What are the gender patterns of manuscript submissions?



Conversations with our community provide evidence for these trends:

> *"I am aware, based on personal experience and in my role as a Head of Department, that in general, it seems to be harder for female scientists to publish in a higher impact journal. It seems to me that these papers have to go through things [that] appear harsher. I think there is a direct correlation between [women being less likely to submit to high impact journals] and the difficulty in accepting a rejection."*
>
> **Author and reviewer**

> *"I see [this] with my students. I will say, look at the highest impact journal or the place where you think your paper is the best suited and you would love to be able to publish in, and my female students will systematically say 'that's not going to get through'. Whereas, in general, I think my male students are more likely to just go for it."*
>
> **Author and reviewer**

> *"There are always exceptions, but I think women are much more careful about looking at the criteria. Men will say, 'my paper doesn't meet those 100% but I'll go for it anyway'. Whereas women tend to say: 'I don't meet that particular criterion, I should therefore moderate which journal I go for'. I think that may well be a factor."*
>
> **Author, reviewer and guest editor**

> *"I see no valid reason why women shouldn't be submitting […] to high-quality journals. In my experience there is no variation in the quality of the science."*
>
> **Author, reviewer and editor**

They also indicate that time pressures and balancing professional and personal responsibilities may play a role:

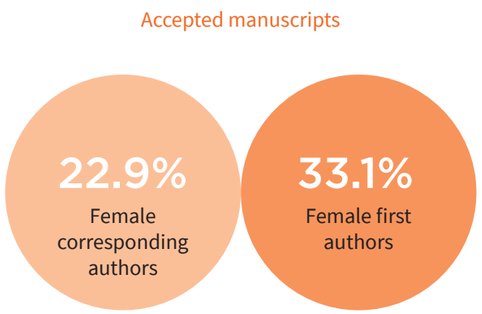
> *"..because of reduced time, for high level academics there are certain incompatibilities with family responsibilities. You start to think 'can I really afford to get this paper rejected twice at different journals? No, I'm just going to go for a safe bet because I need to publish this.' This is not something that is applicable only to females, I've seen male colleagues who've got stronger family commitments or caring responsibilities struggling. The current system is self-supporting and self-promoting a very non-diverse set of authors."*
>
> **Author and reviewer**

7.

How does gender affect manuscript review and acceptance rates?

The academic publishing process relies on the ability of editors, reviewers and other stakeholders, such as editorial boards, to act as gatekeepers in order to uphold the quality and novelty of research publications. To determine whether gender biases exist during this process, we looked at the gender profile at each stage of review, from initial assessment of the article based on suitability for the journal, to the final editorial decision to accept, revise or reject a manuscript.

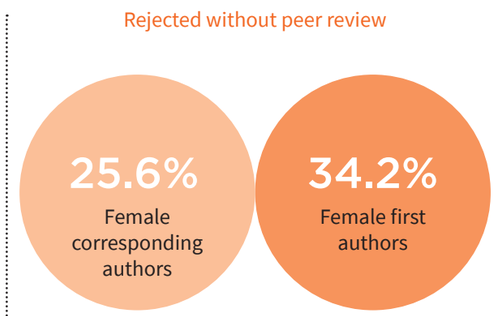
In terms of *accepted* manuscripts, we found a slightly lower percentage by female corresponding authors and female first authors compared to those originally submitted.



This aligns with the IOP's findings, which stated that papers with female corresponding authors have a slightly lower chance of being accepted[3].

Looking more closely at the data for our journals indicates the existence of biases at two review stages: initial assessment by the editor and peer review.

Regarding the first point, we found that **initial submissions from female corresponding and first authors are more likely to be rejected without peer review** compared to the average percentage of all research manuscripts (rejected and accepted) submitted by female corresponding authors and female first authors.



Our interviewees considered manuscripts being rejected without peer review to be a considerable setback for women (and potentially other minority groups) and a missed opportunity. Receiving constructive feedback would better support their progression:

> *"One of the biggest problems based on my experience is not the actual reviewing but the screening of the editors. The key process is in passing the editorial [review stage]. What are the key parameters that editors use that decide whether to reject a paper at the initial screening stage? Because really there is no indication and no feedback on that process. That is what is turning off an enormous amount of people."*
>
> **Author and reviewer**

Later in the publishing pipeline, biases operate in both positive and negative ways towards both men and women. We found that:
More manuscripts from male corresponding authors are recommended by reviewers to be accepted or to require minor revisions than those from women
Overall, reviewers are more likely to recommend rejection or major revisions, rather than acceptance or minor revisions, for submissions from female corresponding authors than from male corresponding authors
Female reviewers are more likely to recommend major revisions rather than rejection
Female reviewers accept or recommend minor revisions for submissions from female corresponding authors more than their male counterparts
Male reviewers recommend rejection for submissions from female corresponding authors more than male corresponding authors

These trends agree with the analysis of *eLife's* article submissions[6], which showed that both editors and reviewers favour manuscripts from authors of the same gender and same country.

As a larger percentage of reviewers are male this meant that acceptance rates for male authors were higher than for women, especially if the reviewers were all men.

> *"I have never, ever looked at a gender of a corresponding author. However, I think there is an unconscious bias when you know the author, and so potentially this could be a gender bias."*
>
> **Author and reviewer**

> *"Sometimes editors are biased… but I never had any reason to believe that it was because of my gender."*
>
> **Author and reviewer**

> *"I'm not entirely sure it's a gender thing… they see the author, they see the profile and I think there is a bias."*
>
> **Author and reviewer**

The impact of biased reviews might be even more profound if the researcher is already working hard to overcome existing barriers to progression:

> *"I know there's all kind of stuff out there about trying to mentor women but the mentoring isn't going to do them any good if they get reviewed by biased reviewers. All the mentoring in the world isn't going to change that. In fact, it's only going to make things worse because they're going to think they're still not doing something right when it's really not their fault."*
>
> **Author, reviewer and contributing editor**

We also found that there is gender bias at the editorial decision-making stage, suggesting a propensity for female editors to choose and agree with female reviewers.

- Female editors are more likely to choose female reviewers.
- Male editors are more likely to choose female reviewers for articles by female corresponding authors.
- Editors are more likely to agree with female reviewers especially if the editors are themselves women.

This was perceived by researchers we spoke to as a positive proactive bias of women being more favourable towards women. Factors outside of the scope of this report may be at work.

> *"I do recognise editors are under enormous pressure… the sheer number of submissions is so overwhelming."*
>
> **Author and reviewer**

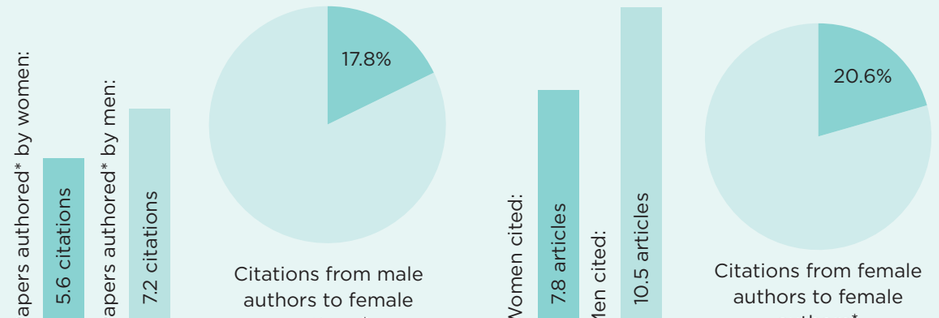
> *"I think the executive editors do the best they can to try to identify women and also to get other sorts of diversity as well into our boards."*
>
> **Author and reviewer**

8.

Are female authors cited less?

The number and impact of publications and citations not only gives an indicator of a researcher's influence on, and contribution to, a field of research, but also impacts on their visibility in the community, their ability to obtain grant funding and their career progression. In this analysis, we found significant differences in citation practices by gender:

- Papers by female corresponding authors are cited less than those from male corresponding authors (papers by female corresponding authors are cited on average 5.6 times; papers by male corresponding authors are cited 7.2 times)
- Men cite female corresponding authors less than male corresponding authors (17.8% of citations from male corresponding authors are to female corresponding authors)
- Women cite fewer articles overall (on average women cited 7.8 other papers, men cited 10.5)
- Women corresponding authors cite papers by female corresponding authors more than men do (20.6% of citations from female corresponding authors are to female corresponding authors)



*authors refers to corresponding authors

These results were mirrored by the experiences of some interviewees:

> *"I've experienced times where my papers have not been cited. I reviewed a book where there are two chapters devoted to research in which I've published seminal papers. There are about 300 references in there and I'm not cited at all. I didn't realise how important this was at the time."*
>
> **Author, reviewer and editor**

> *"I know somebody who has a first name that is [ ] male-sounding and also someone who travels to a lot of meetings and gets cited a lot."*
>
> **Author, reviewer and contributing editor**

> *"I think I suffer from this. I have papers that have been published in very good journals, but don't get the citation that you would expect....I genuinely believe that citations are about networks."*
>
> **Author, reviewer and editor**

However, others felt that poor citation practices could arise from networking and personal interactions:

> *"I do think it's quite common that there is a laziness or a very obvious bias. You reference the people that you know, or who you're most familiar with: 'I must reference that person because I saw them at a conference or I saw them give a talk, or I saw them on a panel.' It's who you interact with. I suspect if you're a male researcher who interacts very strongly with female colleagues and female collaborators and has that wider network then the natural tendency will be to cite their work, but I can see how that bias might arise."*
>
> **Author, reviewer and guest editor**

> *"Citation is sometimes a really quick job. The reality is that probably 90% of citations are carried out by students, and in a paper with 30 citations, there might be five or six that I feel strongly about based on scientific criteria and I say to the student make sure you include these papers. When I'm picking up references using keywords, nobody ever looks at the gender. I think it's the result of the smaller numbers [of women]. If I take any topic and I turn on Google Scholar, probably only two out of the first ten references are female. I think it's a self-perpetuating thing."*
>
> **Author, reviewer and guest editor**

Taken together, these results suggest that even when papers authored by women are published, their work is less likely to be cited. However, we cannot be sure whether this is due to a true gender bias, the result of hasty citation practices, or simply the smaller proportion of female authors available to cite. Although women tend to cite other women, there are fewer female authors in the researcher pool to do so.

Whatever the cause, the overall result is that women are significantly less prominent in the scientific literature, and less visible to those looking to commission articles or invite peer reviewers—and the cycle perpetuates.

9.

Conclusion and recommendations

Our analyses of gender bias across the Royal Society of Chemistry's publishing pipeline has highlighted several areas of imbalance in representation of male and female researchers in the chemical sciences.

This imbalance begins with the allocation of positions in the author list and the choice of where to submit a research paper. We then found that a higher proportion of women had their articles rejected after initial assessment. Although authors may have received constructive input on the suitability of their manuscript for the journal from the editor, for many authors this results in a missed opportunity to receive a detailed critique from several scholars in their field.

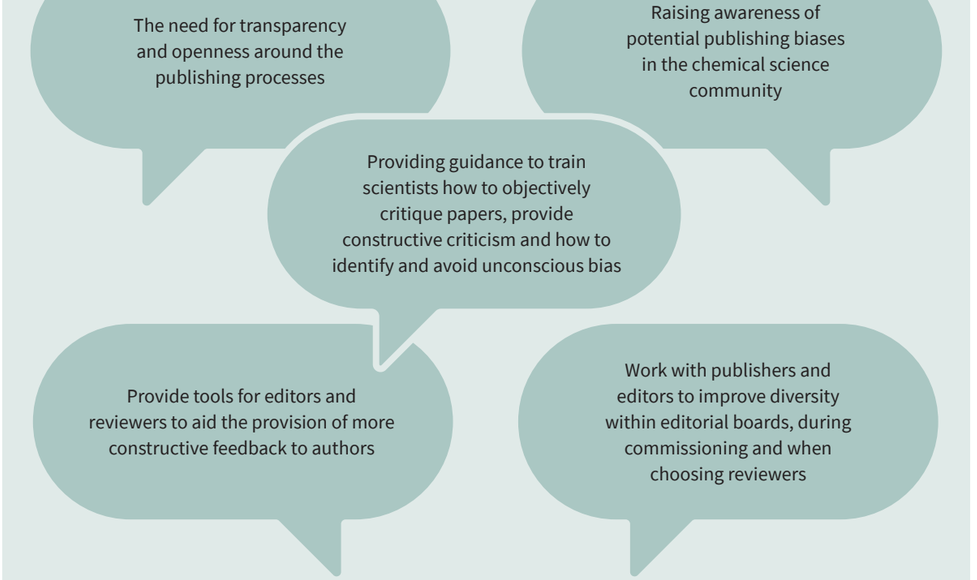
Our data and our interviews with researchers in our community suggest that the imbalance is persisting in the peer review process, which is therefore sometimes failing to provide an unbiased constructive critique of scientific ideas and arguments. The findings indicate that peer reviewers are more likely to reject papers from female authors, especially if the reviewer is male. This has a significant effect on authors from a minority group who consequently do not get an opportunity to improve their work.

Finally, once published, women are less likely to have their articles cited than male researchers, contributing to an overall challenge of achieving and maintaining visibility in their field.

Overall, there appear to be small biases at every stage in the publishing pipeline which overall may be resulting in a significant cumulative effect that hinders women and favours more established, often male researchers. In turn, this limits the accessibility of journals to a more diverse authorship and narrows the range of perspectives that can be heard within the broader chemical science community.

How do we tackle these biases within the publishing process?

We asked members of our publishing community what they thought needed to change based on their experiences and the data presented here. A number of common themes emerged from these discussions:



> *"The first step I think is awareness that there is bias here. The numbers show it, so the first part is acknowledging it. I don't think it's as simple as just saying that we have equality in the balance of the reviewers. That's going to be very difficult to achieve and it could backfire, because you end up asking your female colleagues to do more reviewing or sitting on appointment panels rather than actually doing their next grant application or writing their next paper. But it's about having that awareness and that scrutiny of the reviewers to see, well, is there systematic bias in particular reviewers? I think it's something that the chemistry community needs to take hold of and own."*
>
> **Author, reviewer and editor**

> *"There is certainly a lack of diversity and I think this lack of diversity has to be addressed. I don't think it is all on the side of the publishing houses, there has to be support within the community, and from people like myself in leadership roles."*
>
> **Author, reviewer and editor**

> *"There has to be more transparency within the community about the challenges we all face."*
>
> **Author, reviewer and editor**

10.

What we will do

As part of our strategy on inclusion and diversity, we are committed to continuing to scrutinise our own publishing processes, in order to address gender bias at each stage of the publishing pipeline. This report is just one part of an ongoing conversation about inclusion and diversity across our publishing activities. We aim to increase awareness of these issues and drive change among all those involved in, and impacted by, our publishing processes.

We have identified four key areas for action. We will:

1 Increase transparency

Undertake comprehensive analysis and reporting of our authors, reviewers and editorial decision makers by sub-discipline – and publish this annually. We call on other publishers to do the same.

2 Reflect our research community

Recruit and train reviewers, editorial board members and associate editors to reflect the current gender balance of our research community: our target for 2022 is at least 36% women.

3 Empower and innovate

Provide new training and resources to empower our editors to eliminate bias. We will test new models throughout the publishing profile to address bias from submission to publication.

4 Encourage intervention

Partner with others and lead the development of a new *Inclusion & Diversity Framework for Action* to set the standard for driving change within the academic publishing industry.

Our call to other publishers

We call on other scientific publishers to commit to the same scrutiny of their own processes – to join us in reporting on their own activities.

Our call to the research community

We call for the chemical science community to be aware of the biases identified here. We must all consider how we recognise, name and avoid biases in the future. Ensuring that our publications feature a more diverse range of voices will lead to better science, a more diverse and productive chemistry workforce for the future[3], and will benefit all in society.

"Our challenge to publishers, editors and referees alike is to do more to check at every stage that there is no lurking bias, implicit or explicit – and to think about the knock-on effects, for gender equality, of everything they do."

Melinda Duer and **Dame Athene Donald** *Times Higher Education supplement 2019*

11.

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8. Is there a gender gap in chemical sciences scholarly communications? Day, Corbett and Boyle, *available from ChemRXiv*, Under Review

Acknowledgments:

This work, led by the Royal Society of Chemistry Inclusion and Diversity team, follows on from our latest report *Breaking the Barriers* and is part of an on-going collaborative project with the Publishing team.

We thank individuals who have taken part in interviews and those who provided input throughout the analysis and development of the report, in particular we thank members of the Royal Society of Chemistry Inclusion and Diversity Committee and the Publications Board.

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