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Title: A Qualitative Study of Equal Co-First Authorship

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A Qualitative Study of Equal Co-First Authorship

Abstract

Over the past several years, there has been a significant increase in the number of scientific articles with two or more authors claiming "Equal Co-First Authorship" (ECFA). This study provides a critical background to ECFA designations, discusses likely causes of its increased use, and explores arguments for and against the practice. Subsequently, it presents the results of a qualitative study that sought the opinion of 19 authors listed among equal first authors of recent publications in leading scientific journals about ECFA designations. Results show that circumstances leading to ECFA designations vary significantly from each other. While the development of policies for these situations would not be easy, participants suggested that the lack of clear and consistent policies regarding the attribution and evaluation of ECFA contributes to tensions amongst ECFA authors and obscures their preferred attributions of credit.

Keywords: Authorship, Publications, Ethics, Equal Contributions, Equal Co-First Authorship

A Qualitative Study of Equal Co-First Authorship

Introduction

Over the past several years, there has been a significant increase in the number of scientific articles with two or more authors claiming "Equal Co-First Authorship" (ECFA), the practice of two or more authors declaring themselves to be equally the "first" author of a given paper. (Most typically, this designation is accomplished by asterisks next to the names of the relevant authors on the byline, with a claim of equal contributions in a footnote or towards the end of the article, such as in the authors' contribution section.) While ECFA articles still comprise only a small share of the total number of published research manuscripts, the rising trend has been striking. The increase has been documented in leading medical journals in general (Akhabue and Lautenbach 2010; Conte, Maat, and Omary 2013) and in various disciplines, including Molecular Biology (Hu 2009), Critical Care Medicine (Wang et al. 2012), Spine Surgery (Jia et al. 2016), Pharmacy and Anesthesia (Huang, Hsieh, and Lin 2016), and Public Health (Lei et al. 2016). The trend is not restricted to the medical sciences, as the same tendency can be seen in the humanities and social sciences (Macfarlane 2017; Wuchty, Jones, and Uzzi 2007). Increasingly, articles with ECFA are being submitted by researchers based in different countries and from all parts of the world (Jia et al. 2016; Wang et al. 2012).

Reactions to ECFA and its growth are varied. Some commentators consider it a welcome development that facilitates giving individual researchers appropriate and fair credit for their work in the increasingly collaborative nature of contemporary science (Conte, Maat, and Omary 2013). Others view it as a practical means of smoothing over potential contentiousness about authorship credit between collaborators, by helping resolve tensions about the first author status,

(Anderson et al. 2011; Bozeman and Youtie 2017) or as a way to encourage and reward good mentorship, by allowing mentors to share in first authorship credit (Cappell 2016). Some regard ECFA more warily, skeptical of the notion that two or more researchers can contribute equally to a given project (Agoramoorthy 2017; Moustafa 2016), or out of concern that ECFA dilutes responsibility and accountability (Habibzadeh and Marcovitch 2011). Still other observers note that "contributed equally" designations can be abused, such as by listing oneself as the first of the co-first authors on a CV while in the publication itself, the ordering is different (Resnik et al. 2020). There is also evidence that ECFA designations may work to the disadvantage of female first authors (Aakhus et al. 2018; Broderick and Casadevall 2019; Fishman et al. 2017). Most critically, a few commentators openly deride ECFA as the "vanity fair" of scientific publishing, presumably because it shows authors' preoccupation with the perceived status of their contributions (Heinemann and Beyersdorf 2016, 1543), or a "lie and a sham," implying that authors often use ECFA to claim more credit than they are due (Drug Monkey 2012, para. 2).

However, aside from studies on its increased use and arguments pro and con, almost no published research has examined the views of Equal Co-First Authors themselves. (A notable exception is Resnik et al. 2020.) The current paper attempts to help fill that gap by presenting the results of 19 interviews conducted with authors of recent publications with an ECFA designation. The interviewees were from a range of fields, including various medical sub-disciplines, chemistry, and biochemistry. As will be seen below, these participants had positive views of ECFA on the whole and thought that at least in their own cases, ECFA designations had been fair to both themselves and their co-authors. However, some participants expressed reservations that implied realistic limits to the usefulness of "contributed equally" designations.

While claims of equal authorship can be made for any position in the authorship byline–first, middle, and last–in most disciplines, equal authorship designations are most commonly claimed for the first author (Hosseini 2020). For example, the percentage of first-author designations (relative to total equal authorship designations) comprises 70.4% in selected public health journals (Lei et al. 2016) and more than 90% in selected pharmacy and anesthesia journals (Huang et al. 2016). This is not altogether surprising: in many disciplines, the first author receives more credit than the other authors, as the person in this role is presumed to have done more of the work than those further down the list. In some fields, middle authorship effectively counts for little or nothing in terms of annual evaluations and other assessments of individual productivity. Sometimes the last position is customarily reserved for the head of the lab or research group who may have had little direct input to the findings reported in the paper. Since the first-author designation is often most valuable and coveted, for purposes of the present study, the focus is exclusively on equal co-first authors.

Though no published studies explained exactly *why* ECFA is increasing, it is likely driven by three recent trends. The first of these trends is the growing use of metric indicators of scientific merit (Van Noorden 2010), and the most important of quantitative metric of this kind is number of authored journal articles. In one study, researchers identified the number of authored publications as the single most influential component of their performance review (Walker et al. 2010). Often, publication counts assign the first author role much more weight than a middle author role. This emphasis on first authorship is frequently coupled with a stress on publication in "high impact" journals. (Journal Impact Factor [JIF] quantifies average citation rates for articles published a given journal.) A recent survey of trainee bench scientists found that over

56% of respondents thought it necessary to have a first-authored publication in a premier journal such as *Cell*, *Nature*, or *Science* when seeking an academic position. (Boulbes et al. 2018, 11).

Secondly, over the past couple of decades, competition for faculty positions has increased. The current supply of PhDs in many fields now far exceeds available academic positions (Edwards and Roy 2017; Stephan 2012). In biomedicine, for example, the number of new PhDs increased dramatically over the past couple of decades, far outpacing the number of available tenure-track jobs.[1] In consequence, in some fields it has become virtually impossible for a new PhD or Post-Doc to land a tenure-track faculty position without a significant number of first-authored publications (Borenstein and Shamoo 2016).

Finally, science has concomitantly become more collaborative (Bordens and Gomez 2000; Wuchty, Jones, and Uzzi 2007; Bozeman and Youtie 2017). The rise of "team science" and other research partnerships is driven by several factors, including greater specialization. Growing professionalization after World War II spurred specialization and with it, the rise in co-authorship (de Beaver and Rosen 1979; Simonton 2013). Increased co-authorship also reflects the growth of multi-disciplinary and multi-institutional research, which is often encouraged by research universities and federal funding agencies managing shrinking allocations of grant funding.

[1] As of 2016, some 84 percent of new Ph.Ds in the field will fail to secure a tenure-track position, and a comparable over-supply problem exists in disciplines like chemistry and biology (Kolata 2016). Federal grant funding has become more competitive as well. The average age for a first time PI on an R01-equivalent NIH grant increased to 43, and while 30.5 percent of NIH grant applications were successful in 1997, by 2014 that number had shrunk to 18 percent (Edwards and Roy 2017).

Arguments for and Against ECFA

As mentioned above, intuitive arguments have been made both for and against designations of equal co-first authorship. Assuming that contributions to the project are what should determine an individual's relative rank in the list of co-authors—regardless of what form these contributions take—one argument in favour of ECFA is that it may be the fairest and most appropriate way to convey the input of two or more-co-authors. When multiple authors contribute equally, ECFA enables 'giving credit where credit is due'.

Some have questioned the likelihood that two or more authors' contributions are genuinely equal (Agoramoorthy 2017; Kumar 2018). In this connection, Fontarosa, Buchner and Flanagin mention a recent contribution to *JAMA* in which five of eight co-authors requested equal listing as first authors, with only one of the eight willing to be listed as a middle author (2017). Others convey that many authors withdrew claims of ECFA authorship when editors pressed for a justification of the claims (Heinemann et al. 2019). While such anecdotes give pause, it is also worth noting the inherent ambiguity in the notion of a *substantial contribution*. Authors' contributions can vary in substantiality in multiple directions: some may contribute more effort and time, some may contribute rarer or more refined skills or expertise, others may contribute more through the originality of their ideas. Without a single metric by which to compare such disparate inputs to the research process, designating two or more contributions as "equal" may be perceived to be the fairest or easiest way to resolve what would otherwise be a potentially fraught and contestable comparison. Contributors' roles can be especially distinct in biomedical and clinical research (Smith and Master 2017; Larivière et al. 2016), which may partly explain why ECFA designations have become relatively common in these disciplines. ECFA may also be useful in diffusing tensions between researchers from different disciplines

and in international collaborations, where disparate authorship conventions may be in play (Anderson et al. 2011). Lastly, ECFA has been defended on the ground that it can encourage strong mentoring relations, by allowing a way to balance a mentor's superior experience with the greater amount of time and effort expended by a trainee (Cappell 2016).

On the other side, at least four arguments against ECFA have been made. They express concerns that seem especially pertinent given that few scientific journals have authorship policies that explicitly address the issue of equal contribution statements (Resnik et al. 2016). One argument is simply that prevailing metrics often lack a good way to quantify the contributions of ECFA authors. Although many commentators bemoan the outsize impact that mere quantities of authored publications have on hiring, tenure and promotion decisions, quantities of authored articles are almost invariably given considerable weight, in part because reliance on numbers seems to make decisions more "objective" and less disputable. Consider then a case in which two authors are designated as equal co-first authors. If each is given the customary credit for first authorship of a paper, the result is a kind of "double-counting" which effectively inflates the credit generated by the paper for its authors as compared to the standard case (Resnik et al. 2016; Kornhaber, McLean, and Baber 2015). Giving each only half a credit for first authorship of a paper seems flawed in the opposite direction, however; conceptually, it certainly is possible that two or more co-authors could be integral to a paper as a whole in a way that is seldom the case for those who end up in the second author role. Consider that in timed events in the Olympics and other sports competitions, two athletes who tie for the fastest time each win a gold medal, not half a gold medal.[2]

[2] In the Olympics, for example, when two competitors tie for first, both receive gold medals, no silver medal is awarded, and a third athlete is awarded the bronze medal. Following out the logic, one might argue that unlike ECFA, when there is a tie for first, the Olympics award system implies each winner in effect is a gold/silver medalist, but in absence of an effective way to "split the difference" between gold and silver, each is awarded the

Precisely because of this quantification ambiguity, ECFA can be a way of perniciously "coining false brownie points by awarding each [first] author [first] author credit for the whole thing" (Price 1981, 986). Though obviously it need not be intended for this purpose, ECFA designations can easily aid and abet a subtle kind of "promiscuous co-authorship," albeit one that seems ethically less egregious than "honorary" or "gift" authorship. The double-counting becomes more obvious when each of the various ECFA authors lists him- or herself as "first of the first" co-authors on CVs and assessment documents, that is, at least one co-author departs from the byline ordering on the published version of the article (Resnik et al. 2020). An inverse version of the double-counting problem stems from the fact that citation and referencing styles generally lack sufficient means of indicating that two or more of the authors contributed equally. A parenthetical citation of (Author A and Author B 2020) will almost invariably be interpreted as implying that B was the subordinate, second author, and not an equal contributor of A's (Cormode, Muthukrishnan, and Yan 2013). Accurately crediting and citing multi-authored papers is already a thorny problem (Osório 2018); without a reasonable and accurate way to credit ECFA articles as compared to single first-authored papers, ECFA only exacerbates existing bibliometric ambiguities and concerns.

A second and related argument against ECFA is that it may facilitate a kind of "gaming" one's way to better evaluations. Authorship of publications is in reality a proxy measurement for what should ultimately matter when evaluating scientific merit: the quality and quantity of researcher's contributions to science. Simple quantitative metrics such as first-authored publications tend to be subject to Goodhart's law, which is the tendency of those being evaluated to start aiming not at what matters, but at the metric proxy for it. As Muller puts it, "what gets

gold. By comparison, the ambiguity of crediting norms in the ECFA case makes apportionment in those contexts murkier.

measured gets 'gamed'" (Muller 2018, 79; see also Biagoli and Lippman 2020), meaning that people tend to respond to metric proxies by adapting their behaviour to best satisfy the metric standard rather than by aiming at whatever it is the metric purports to measure. As applied to academic productivity assessments, this would mean researchers try to maximize authorship credits, and first authorship credits in particular, rather than maximizing the scientific productivity that authorship is presumed to indicate. As regards ECFA, the concern is that ECFA potentially allows researchers to gain relatively easy first authorship credit, which may thereby incentivize scientists to seek out projects in which ECFA authorship can be readily attained, bypassing projects that better serve science. Authorship in general (and ECFA in particular) can be traded for access to resources and data (Penders 2017), so much so that potential collaboration and support relationships are frequently assessed prospectively in terms of whether collaborators will have to share or lose authorship (Müller 2012). Systems that incentivize first authorship will tend to produce more first authors, but this does not necessarily mean that they have produced more or better science.

Empirical confirmation of this kind of strategic gaming of quantitative measures can be seen in a recent study on the behavior of Italian scientists. In 2010, a law was passed in Italy demanding that academics meet various metric indicators for productivity, one of which was citation counts. After the law took effect, professors dramatically increased their self-citations rates, including a 179% increase for assistant and associate professors in economics (Seeber, Cattaneo, and Meoli 2019). Other evidence of such strategic gaming can be seen in the way law professors in The Netherlands exploit ambiguities in the fuzzy lines that separate different kinds of publication output categories (Waltenbrunner and de Rijcke 2017). Note also that in a 2010 *Nature* survey, 71% of participants said they feared that colleagues were gaming the metrics in

these kinds of ways (Abbott et al. 2010). The destructive impact of gaming of individual evaluations in research contexts also can be seen in a recent large-scale study over 4,000 scientists, most of whom were from The UK. It reports that the importance of metrics is often stressed in ways that "reduce morale and encourage researchers to game the system" (Abbott 2020, 461).

A third argument against ECFA is that it can exacerbate the diffusion of responsibility already implicit in collaborative research (McNutt et al. 2018; Anderson et al. 2011; de Beaver and Rosen 1978). Authors bear responsibility for the work they publish to ensure that the underlying research was performed competently and that it is being reported accurately in the paper. Collaborative research by its nature obscures responsibility to a degree; as de Beaver and Rosen note, divisions of labor make it "difficult for others within the profession to assess responsibility; the ensuing tendency is to give credit, but to withhold blame" (de Beaver and Rosen 1978, 69). When the first author role is occupied by two or more individuals, however, responsibilities are obscured still further. One can easily imagine situations in which co-first authors mutually point fingers at each other, ethically speaking, further muddying waters of accountability that may already be quite unclear, especially to outsiders.

A fourth and final important argument against ECFA worth mentioning is that it may work to the disadvantage of women and others who have less power and authority in a particular research context. Former editor of the *British Medical Journal,* Richard Smith, once complained that authorship was becoming "a matter of politics, not science" (Smith, 1997, 992). Applying Smith's general worry to ECFA, the concern is that in cases in which a certain group (e.g. white male researchers) is overrepresented in terms of seniority, lab head status, and other sources of power in research contexts, they may be able to leverage power differentials to gain or, dispense

credit as they wish through ECFA designations. This might happen by becoming or giving away an equal co-first author position when otherwise a middle or last author position would have been appropriate, or by exploiting superior power or authority to become "first of the firsts" amongst equal co-first authors.

Available evidence suggests that something like this may be occurring, at least in some collaborative projects. Broderick and Casadevall report that after an analysis of over 3000 publications from 1995-2017 in which multiple authors claimed first authorship, males predominated "first of the firsts" designations. They found, however, that the disparity had diminished during the past decade (Broderick and Casadevall 2019). Similarly, Aakhus et al. (2018) found that in 10 leading scientific journals, between 2005 and 2014 ECFA designations with mixed gender authors occurred in 862 published articles (2018). Female authors were listed first in 50% of these 862. Curiously, in clinical journals male ECFA authors were listed first 63% of the time. Reasons for the discrepancy between basic science journals and clinical journals are not clear; the difference may be the result of increased seniority of males in clinical research groups, or differences in divisions of labor, gender bias, or other factors.

Despite these arguments, almost none of the ECFA authors interviewed in our sample expressed the kinds of reservations about ECFA common amongst commentators. Indeed, the overwhelming majority of those interviewed were supportive of ECFA both in general and in the instances in which they had been ECFA authors. Some explanations of their support will be discussed below after considering their comments in greater detail.

Materials and Methods

Participant Invitation and Recruitment

The authors began by jointly creating a research protocol, developing a semi-structured questionnaire (Appendix 1), and securing Institutional Review Board approval (details withheld for blind review). Potential participants were identified by searching the top five scientific journals according to a listing from the National Institutes of Health (NIH, NIEHS 2019). The list of journals comprised of *The New England Journal of Medicine*, *The Lancet*, *Chemical Reviews*, *Nature Reviews Cancer*, and *JAMA*. Bylines of all articles published in these five journals between January 1, 2018 and March 31, 2019 were checked manually to identify all articles that had ECFA designations. A Google search was conducted to find email addresses of at least one ECFA author from each of these articles, a necessary step since corresponding authors are not always first authors. Articles for which contact information for at least one ECFA author could not be found were disqualified. This process resulted in a list of 139 articles and a total 177 email addresses.

Both authors were involved in the recruitment process. Invitations were sent in waves of ten at time with follow-up invitations sent two weeks later if no response had been received. The goal was to identify a total of 20 participants. The solicitation requested an interview to be conducted either online (via Skype or FaceTime) or by phone (at the participant's discretion) to discuss the circumstances that led to the equal co-first authorship of the identified article, the participant's reflections on the resulting authorship designations and his or her views on ECFA in general. As a token of appreciation for participating, each interviewee was offered a $30 e-voucher of their choice.

Interviews

After sending 177 emails, we received 19 positive responses and after having secured informed consent, conducted the interviews. All interviews took place between April 18th and May 22nd, 2019. On average, each interview lasted 22 minutes. Sometimes it was not possible for both co-authors of the present study to participate in a given interview, in which case the interview was conducted by the interviewer located in time zone proximity to the interviewee. Nine of the 19 interviewees were based in American Universities, four were working at British Universities, three were based in Australian Universities, and three were located at institutions in other geographical regions (Africa, Mainland Europe, and the Middle East).

Analyzing interviews

The audio recordings of the interviews were professionally transcribed by a third-party (Rev.com) and inductive analysis of the transcribed interviews began using the inductive coding method described in (Thomas 2006) and (Elo and Kyngäs 2008). Initially, one of the co-authors of the present study analyzed and coded three interviews selected randomly to generate a provisional list of coding categories. After discussing the results, a set of 18 category codes was judged provisionally acceptable by both co-authors and agreed upon. These codes are subsumable under two general headings:

1. *Process* (Codes included several aspects of the circumstances leading to the ECFA designation, tasks conducted by equal co-authors, manuscript drafting, relevant institutional norms, relevant journal policies of the target journal, supervisor/PI perspectives, negative experiences, order of equal authors, and communication between the parties.)

2. *General views about ECFA* (Codes included the interviewees' attitude and perspectives regarding available guidelines, general advantages and shortcomings of ECFA, possible sources of disagreement between ECFA co-authors, suggestions for improving ECFA implementation, suggestions for guideline improvement, and views

about how ECFA designations should be evaluated by institutional administrators and outsiders.)

All of the interviews were analyzed and coded separately by both co-authors, the results were shared and discussed, and the categories were further refined and clarified. After several follow-up discussions, an Excel Sheet consolidating the analyses of both co-authors was produced yielding a final synthesis.

Results

Characteristics of the sample of articles with ECFA (139 articles)

As table 1 shows, within the examined sample, the total number of co-authors per publication, including both ECFA and non-ECFA authors, ranged from 2 to 72. The modal number was 4 and the average number of co-authors per paper was 15.

Number of co-authors per paper	**Number of papers with ECFA in the sample**
2 co-authors	2
3	8
4	13
5	8
6	10
Between 7 and 11 co-authors	16
11-15	12
16-20	14
21-25	18
26-30	13
31-35	7
36-40	8
40-72	10
Total	139

Table 1. Number of authors per paper within the sample of papers with ECFA

The examined sample included articles with two, three, four, five, six, eight, and in one extreme case, 18 equal co-first authors (See table 2).

Various combinations of ECFA	**Number of papers with ECFA in the sample**
Two equal first authors	85
Two equal first and two equal last authors	15
Two equal first and other combination of last authors (three equal last authors, and four equal last authors)	3
Three equal first authors	16
Three equal first and various combination of last authors (two, three and four equal last authors)	4
Four equal first authors	8
Three equal first and various combination of last authors (2 equal last, and 3 equal middle)	2
Five equal first authors	2
Five equal first authors and four equal last authors	1
Six equal first authors	1
Eight equal first authors	1
18 equal first authors	1
Total	139

Table 2. Different combinations of equal contributions in papers with ECFA

Characteristics of the interviewed sample (19 interviewees)

Most interviewees had been an equal co-first author on more than one publication (See table 3).

How many articles with ECFA?	**Interviewees**
One	4
Two	5
Three	3
Four publications or more	7

Table 3. Interviewees' involvement in publications with ECFA

The sample included a reasonably good balance between male and female authors of different academic ranks, and also those who were listed first and second among the equal authors (See table 4).

Sex	Position	Academic rank
Male	1st	Professor
Male	2nd	Professor
Female	1st	Associate Professor
Female	1st	Associate Professor
Female	2nd	Associate Professor
Female	2nd	Assistant Professor
Male	2nd	Assistant Professor
Male	2nd	Assistant Professor
Female	1st	Lecturer
Female	2nd	Lecturer
Male	2nd	Research Fellow
Female	1st	Research Fellow
Female	1st	Research Fellow
Female	1st	Post-Doc
Female	1st	Post-Doc
Male	1st	Post-Doc
Male	1st	PhD researcher
Male	2nd	PhD researcher
Male	2nd	PhD researcher

Table 4. Interviewees' gender, position among the equal authors and academic rank

Circumstances that led to ECFA

The point in the research process at which a decision to use an ECFA designation was made provided fruitful insights into the internal dynamics of the research collaborations. Some projects were described as having faced a major challenge along the way for which ECFA was seen as a creative solution. For instance, the unanticipated absence of a major contributor due to family obligations or changing labs sometimes led to adding a new collaborator to fill the role of the absent contributor. In these instances, the added researcher assumed first authorship position and order (first among co-first equal authors, or "first of the firsts") and the absent contributor became second in ECFA ordering. In other instances, ECFA designations were the result of managerial complexities involving numerous contributors or unusually lengthy projects. In some cases, ECFA authorship was requested or suggested by journal editors for some members of a

larger group or team. In one instance, upon being asked by editors to merge two or three submissions into one, two groups agreed on ECFA as a reasonable way to acknowledge the first authors of each original manuscript. In a different case, methodological suggestions offered by reviewers required additional expertise that were unavailable within the existing group. Offering an ECFA position to an additional contributor allowed the research group to adequately address the reviewers' suggestions.

Sometimes the ECFA decision was made at the outset or even months before the start of the project. Most of these involved bulky and time-consuming research efforts such as large literature reviews and ECFA was used strategically to get collaborators on board, which made workloads manageable amidst other research responsibilities. At other times, the ECFA decision was made at the end of the project or during drafting of the manuscript. In these instances, project success required multiple researchers to fill equally important roles and contribution-types. In other instances, the shared task of drafting the manuscript led to the ECFA designation.

Equality in what?

As mentioned previously, one of the common arguments against ECFA is the issue of whether it is possible for two or more authors to make equal contributions, and if so, *equal in what sense?* We asked interviewees to name the most important factor by which they merited equal authorship. Implicitly, a distinction emerged between instances in which equal authors contributed to the same task and instances in which the contributions were to dissimilar but equally significant tasks. The former occurred when ECFA was the result of dividing a sizable undertaking between multiple contributors. For example, with respect to a large literature review conducted by two co-authors, each chose half of the items needing to be reviewed and analyzed:

"half of the length [of the writing of the article], half of the citations" (Interview 18). In a project requiring laboratory work, contributors "split the experimental work like [*sic*] completely down the middle" (Interview 7). In these two instances, ECFA authors had the same level of seniority, and they also were both involved in drafting the manuscripts. The task of writing was negotiated and each took charge of writing a section. For example: "[co-author] did most of the introduction and discussion section whereas I did most of the methods and results" (Interview 4). But equal roles in the drafting process were relatively unusual in our sample.[3] Out of 19 interviewees, only three reported that equal authors made overall equal contributions to the task of writing; more typically, one co-author or another wrote more. When this occurred, the point was mentioned by participants descriptively rather than as a complaint.

In circumstances in which authors performed dissimilar tasks, the conditions of equality were described more impressionistically. In response to the question of *equality in what?*, interviewees' most responses were along the lines of "contributions to the final project [were] comparable" (Interview 13), "we nicely complemented each other" (Interview 14), "I felt that in all fairness it was very much a joint task" (Interview 8), and "it just felt like we did it together" (Interview 12). In these cases, co-authors seem to believe that "different people contribute [to] different things at different times" (Interview 10). ECFA designations are thus thought to be deserved because the authors' contributions complemented each other's rather than being equal in the quantitative sense of having contributed an identical amount of work. These projects involved multiple complex research tasks and the need to involve researchers with different skillsets was vital:

[3] Strictly speaking, it is not entirely clear what playing an equal role in drafting the manuscript might consist of. One might think it means each writes an equal number of words. Not only is this highly unlikely; typically, not all parts of the paper are equally difficult to write. And the writing process involves more than generating words: editing, proofreading, tracking down and properly formatting citation information, and so forth: these are all integral to the drafting process, yet they resist easy quantification.

> You generate all the data, but you cannot, by yourself, analyze them so you collaborate with somebody who has not generated the data but has made sense out of it. . . . we could not get the same results if we did not have that help (Interview 7).

The location where Equal Co-Authors were based

Although most interviewees agreed that being based at the same institution and having regular face-to-face meetings improves collaborations, representation from multiple institutional affiliations did not impede ECFA collaborations. In some cases, equal authors had communicated only by email and had never met in person. Nonetheless, physical proximity and significant interaction with equal contributors was recognized to be beneficial: "it probably would be better to be able to have face to face, or team meetings, to help everyone appreciate the role that everyone else is playing" (Interview 15).

Target Journal's stance

Among the five journals used to identify interviewees, only two mentioned ECFA in their authorship guidelines at the time of the drafting of the present manuscript. None of our interviewees reported a negative experience with journal editors who published their articles. Interviewees did not find it difficult to prepare a cover letter and explain individual contributions or circumstances that justified the need for ECFA designations. Journal editors were characterized as supportive and as readily accepting provided explanations of the circumstances that led to the ECFA designations.

Despite having had positive experiences with journal editors, some interviewees added that had the target journal not accommodated their requested authorship arrangements, they would have considered publishing with another journal.

Senior researchers' and PI's roles

Supervisors were always at the center of ECFA designations. Various supervisors dealt with the issue in different manners and at different times, which impacted how equal authors felt about the dynamic of collaboration and the resulting ECFA designations. Sometimes supervisors were proactive in laying out expectations and responsibilities at the beginning of the collaboration. In the eyes of other equal co-authors, this prevented conflicts down the line. In some cases, equal authors were not involved in the decision-making process at all, and the decision was communicated to them by memo. Nevertheless, in most cases supervisors had conversations about ECFA designations with equal authors at some stage, if not in the beginning, then at a later stage of the process. As described by one interviewee: "as we got a little bit farther into it there were a few discussions saying, 'how do you feel about having a second co-first author?'" (Interview 2).

What sometimes surprised equal authors was that supervisors discussed these issues with them only verbally. In one instance, in which an attempt to discuss the ECFA designation was blocked and postponed by the supervisor, the equal co-author (who was listed second among equal authors) resented that moment: "Now I think I would have the confidence, and perhaps the seniority as well, to be able to say no, you know what this is important. This is a conversation that needs to happen now" (Interview 15). Our participants also described a lack of communication with non-equal authors about ECFA designations. Discussions usually involved only equal co-authors and supervisors. On rare occasions in which the decision was discussed with subordinate co-authors, what occurred was a short conversation during a meeting organized for other purposes. Minor changes were made to the rest of the authorship list but ECFA designations were left unchanged.

Sequence of equal authors

Even among equal co-first authors, being the "first of the firsts" is desired. In fact, all interviewees agreed that the listing order of the equal authors is the most contentious aspect of ECFA designations. Nevertheless, since supervisors and PIs are the ones who invariably resolve these tensions, most contributors feel that they have little influence on the authorship order. Interviewees reported different reasons for being the first of firsts. Sometimes the decision was made based on each ECFA author having made comparatively greater contributions to a distinct task, such as the experimental work, analysis or writing. In some of these instances, and depending on the complexity of conducted tasks, tensions arose over whether the second ECFA author would be an equal first or ordinary second author. "It was obvious that I would be first and the question would be whether they were second or equal" (Interview 17). Other times, when ECFA authors contributed to the same task, choosing the first was described as more challenging: "It's sort of arbitrary judgment, one person having contributed a little more in terms of concept or writing, or experiment-wise" (Interview 14). Whether or not order determinations were difficult, supervisors always had the authority to make the final call.

Sometimes seniority is the reason ECFA authors are listed first. In one case, the interviewee reported that in their lab, the more senior person would always be first: "it was kind of unspoken in our lab that even with co-first authorship, the more senior person goes first" (Interview 7). Explained more elaborately by another interviewee: "this was a very expensive study which had been given a very big grant of money. I felt it was important that the lead author was the person taking primary responsibility for the study. I think it's very important for the funders, that they see the senior people are taking responsibility" (Interview 8).

In three cases, the first author position was given to the contributor who needed a paper with first authorship. In one instance, this was because the first of the firsts was "looking for an academic position" (Interview 9). One interviewee, who acknowledged that someone else should have been the first equal author, described this as a "pragmatic decision" and noted: "I felt really spoiled to have my name first but I needed to come back from the fellowship with a paper as first author" (Interview 5).

In terms of the soundest criterion by which to order equal co-authors, interviewees had conflicting views. Some argued that if the claim to equality is genuine, then it should not matter who is first. Accordingly, they favored alphabetical ordering and considered such arbitrariness (relative to the project) a fair standard. Others, however, preferred to see an order that reflected the extent of contributions and considered alphabetical ordering to be unfair: "I don't think it's fair [for it to be] alphabetical because that's just luck of the draw in something else" (Interview 10).

Advantages and disadvantages of ECFA designations

None of the interviewees denied the benefits of ECFA designations, but each described the advantages in light of the specifics of their own situation. For instance, senior authors consider ECFA designations advantageous in that they can help them to solve problems of authorship order among contributors who have made more-or-less similar contributions. In the absence of ECFA, the second or third equal author would be an ordinary second or third author. As highlighted by one interviewee, ECFA "allows that second person to be recognized in a special way. In my experience it's been a positive thing to bring someone up" (Interview 2). Co-authors who have been involved in large and time-consuming projects believe that ECFA

designations provide an extra option in dealing with necessary but sometimes unpleasant decisions about attribution of authorship: “these things just they are [*sic*] not fun to deal with but that happens when you have big groups and a lot of people” (Interview 17). Interviewees who had dealt with unexpected circumstances such as family emergencies or a colleague’s sudden change of labs supported ECFA designations as an option that facilitated appreciating a substitute’s assistance in a special way. In cases in which the group was under time pressure, ECFA designations motivated second/third co-authors to alter their priorities and help the group to meet the deadline.

Regarding the disadvantages, some interviewees believe that the current popularity of ECFA designations can be counterproductive. In cases in which ECFA is not warranted, first authors will be frustrated and will resent other co-authors who are being promoted to equal-first position. Furthermore, some believe the growth of ECFA designations exacerbates the importance of the first position to the extent that some people can get “aggressive” about becoming first (Interview 11).

Most ethical guidelines suggest that having a discussion about authorship is necessary and also helpful. Yet some of our interviewees who had had negative experiences with ECFA designations (or had heard of them) argued that discussions do not necessarily resolve differences, even when tensions are obvious. As described by one interviewee, “although there was a discussion [about ECFA designation], no one tried to change it” (Interview 10). In these situations, the motivation for not raising complaints was described in strategic terms best articulated by one interviewee: “I didn't want to bring this up as I thought it was more important to pick my battles, if you see what I mean. I know that I will publish a lot with both of them [the supervisor and other equal author]” (Interview 15). In both cases in which authors had not

expressed dissatisfactions about ordering or adding an extra first author to colleagues, they did not regret the decision in hindsight. As a disadvantage of ECFA collaborations, one interviewee mentioned that they could engender future conflicts: "A lot of people retain, if you like, ownership of a program or work even though their contribution may have been at a single point in time for a specific aspect of a program" (Interview 19).

Interpersonal tensions exacerbated by ECFA designations

In some cases, interviewees reported difficulty between co-first authors merely due to having worked with each other closely for a long time. For instance, an extended working relationship with a collaborator who has a different personality was described as "particularly difficult" (Interview 13). These difficulties could be intensified when equal authors are at the same career stage. One such case involved two post-doctoral researchers who were both looking for stable jobs in the same field. Two interviewees expressed that increased pressure due to family emergencies and the consequent stress had made them feel particularly vulnerable. After they did not receive as much emotional support as they had expected from co-first authors with whom they had worked for a long time, they were frustrated and felt negatively about the whole collaboration.

Policies regarding ECFA and suggestions

By consensus, interviewees agreed that current journal policies and guidelines regarding ECFA designations need to be improved. Furthermore, interviewees expected policies to be more visible in journal websites and given more prominence during the submission process, and they relayed that the lack of clear and consistent policies contributed to tensions between authors.

Two interviewees whose groups had internal guidelines for attributions of ECFA appreciated these guidelines and considered them effective at resolving unclarity and inconsistency. That said, when asked whether they checked journal policies regarding ECFA before submission, most interviewees asserted that since there was precedent for ECFA in the target journal they had chosen, they had taken its acceptability for granted.

One suggestion mentioned by several interviewees was to use ECFA designations only in conjunction with contributorship statements. While most journals do require cover letters and contributorship statements for ECFA submissions, some early-career interviewees wanted to see these details in the publication as well. On the other hand, more senior interviewees were overall less interested in having these details published and more skeptical of their value:

> Do I really care about that when I'm reading a paper? Probably not, unless I was evaluating someone who had interviewed with me or something (Interview 18).

Some senior interviewees had opposing opinions about contributorship statements too. One described them as annoying:

> I think that's kind of annoying quite honestly . . . I think it's just one of those things that at the end was like, oh my God, it's one more thing I got to do to get this paper off, . . . I do not pay any attention to it (Interview 3).

Another senior author described it more positively:

> It is kind of a good way to check your gut on whether the author list is the way it should be. I like the practice (Interview 7).

Some interviewees suggested that ECFA designations should be better reflected in reference lists and in-text citations as well as indexing websites: “But one problem with this equal co-first authorships is that they are not being counted in indexes. For instance, in *PubMed* there is no way to search for co-first authors” (Interview 12).

Evaluation of articles with ECFA designations

Most interviewees believe that ECFA designations are not recognized adequately in evaluations, in part because there are almost no guidelines addressing how to do this. Only one of our interviewees worked at a university that had such a policy in place. That interviewee's first experience with ECFA occurred as a PhD researcher, and the policy pertained only to the evaluation of PhD theses:

> There is a certain format of submitting your PhD thesis in a paper format and for that each chapter of your thesis is an article. If you have three papers then that is like three chapters and enough for your PhD [to be approved]. Equal contribution would count as half, not a full chapter. I also had to bring in forms from the equal contributor claiming that they agree that I use the paper in my thesis. In some cases when the equal contributor is another PhD student, you are not allowed to include the same paper in two different PhD theses so you need to bring a form like a disclaimer from the second co-author that relinquishes their rights for using this paper in a thesis (Interview 17).

Some interviewees highlighted that some supervisors consider each ECFA as a first authorship despite the sequence of equal authors: "in my context or so far, a co-first counts as lead" (Interview 12). One interviewee noted that if they were evaluating a candidate's resume and saw many publications with ECFA designations, they would not consider this a positive sign: "I would honestly start to frown down on it a little bit if you amassed more and more and more equal authors, right? I think more than two would probably catch my eye a little bit" (Interview 18). Nevertheless, given that 10 interviewees had been a co-first in more than two publications, and three interviewees in five or six publications, the number of publications with ECFA designations does not seem to be a common concern among evaluators, at least judging by the participants in our sample.

Discussion

These results merit emphasis of three points. One notable characteristic of the findings is that few if any of our interviewees mentioned the concerns (or even particular awareness of the concerns) noted in the arguments against ECFA discussed earlier. That is, few if any expressed the general misgivings about ECFA articulated by many commentators. To some extent, this is likely an artefact of our methodology. Since it was comprised of those willing to discuss their recent ECFA collaborations with us, the sample may have overrepresented the overall proportion of researchers who view ECFA designations favourably. This is added to the fact that researchers who have been ECFA authors view the designations more favourably than those who have not (Resnik et al. 2020). Other authors have found reservations about ECFA to be more common, particularly amongst graduate students and post-docs. For example, Müller remarks that interviewees showed "a certain distrust towards newer codifications that allow for *shared first authorship*… Postdocs at times expressed doubt concerning its significance and its ability to undermine the traditional reading of authorship conventions" (2012, 303). Also, because our interviewees were drawn from several of the most prestigious scientific journals, a broader sample from a greater variety of journals might produce somewhat different results.

A second noteworthy aspect of our findings is that they point towards the need for much more in the way of established policies and settled conventions regarding when ECFA designations are to be used and how they are to be represented in publications. Each of the five explored journals show ECFA designations differently. For instance, *The Lancet* uses superscript symbols * and provides two different descriptions to explain ECFA: "These authors contributed equally," and "Joint first authors." (It is not clear whether there is a difference between these two). *Chemical Reviews*, however, uses dissimilar superscript symbols in different articles such

as †, ‖, #. *The New England Journal of Medicine*, *Nature Reviews Cancer* and *JAMA* use no superscript symbols and only mention equal contributors in a footnote.

Inconsistencies are also noticeable in how authorship guidelines note ECFA. For instance, *The Lancet*, *Chemical Reviews* and *Nature Reviews Cancer* make no specific mention of ECFA in their authorship guidelines, whereas the *New England Journal of Medicine* dedicates a section to Co-First/Co-Senior authorship:

> The Journal will indicate when two authors contribute equally to a work. In print, this reads as, 'Drs. XXX and YYY contributed equally to this article.' When submitting an equally coauthored paper, authors can indicate dual first or senior authorship with an asterisk on the manuscript title page (*The New England Journal of Medicine* 2020).

Among the investigated journals, *JAMA* provides the most extensive discussion, including the claim that: "Requests for more than 2 co-first authors or co-last authors will be considered by require detailed justification" (Fontanarosa, Bauchner, and Flanagin 2017). Clearly, inconsistencies in terms of how ECFA is shown in publications and mentioned in authorship guidelines are not helpful. For the benefit of readers, authors, and administrative evaluators alike, it is reasonable to expect all journals that accept articles with ECFA to specify clearly, and adhere to their terms and conditions for accepting these articles, as ambiguities may invite abuse.

Finally, greater standardization and clarity concerning how ECFA designations are reflected in reference lists and in-text citations is needed. Journal editors have discussed various means of addressing this problem: the use of boldface letters or underlining for the last names of equal first authors in the reference lists are among the suggested methods (Dubnansky and Omary 2012; Omary et al. 2015). However, given that reference management software programs do not support equal authorships (Hosseini 2020), authors must implement these manually. Consequently, compliance is likely to be low. Furthermore, since these practices are not consistent across the board, they will be difficult to enforce and monitor.

Accurately reflecting ECFA within in-text citations has received attention as well. For instance, the editor of the Journal of *Molecular Biology of the Cell* suggests listing all equal first authors (e.g., Equal Author A, Equal Author B et al., 20XX) (Drubin 2014). While this suggestion may be adequate for publications with two or three co-first authors, in cases where numerous authors have a justified claim to ECFA, its implementation will be much more challenging. Ideally, such suggestions would be offered in conjunction with appropriate terms and conditions that would facilitate their standardization. For instance, one such condition is to limit the number of equal first authors to two or three. In absence of their support from influential and authoritative bodies such as COPE or ICMJE, ad hoc efforts by a handful of journal editors will spawn a wider proliferation of inconsistent practices. The sooner policies and guidelines are adjusted and regularized, the more manageable will be the task of indexing past ECFA articles in the literature.

Limitation

The chief limitation is sample bias as a result of the participant selection process. By inviting participation only from co-first authors of recent papers, this likely bypassed the input of those who might regard co-first authorship less favourably (See Resnik et al., 2020). Also, by soliciting interviewees only from authors who had published in one of a small number of leading journals, this bypassed the input of those from non-targeted journals who might have rather different views. Conducting interviews of the sort reported above but with a broader range of participants would be a worthy follow-up project to the one discussed here.

Conclusion

Our findings suggest that recent increases in the use of ECFA designations are likely to continue, as researchers often see them as a practical and fair solution to problems that arise in assigning authorship in collaborative contexts. Ethical arguments against the practice made by some commentators seemed to have had little impact on participants who tended to be more focused the practical aspects of ECFA related to their own projects. Continued increases in use, in turn, will likely result in broader acceptance and understanding of ECFA designations in the research community as a whole, and their prominence in leading scientific journals is likely to encourage explicit recognition by more and more publications. These increases accentuate the need to standardize how such designations are represented in publications and indexes and for greater clarity and guidance regarding their use for evaluation purposes.

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References

Aakhus, E., N. Mitra, E. Lautenbach, and S. Joffe. 2018. "Gender and byline placement of co-first authors in clinical and basic science journals with high impact factors." *Journal of the American Medical Association (JAMA)* 319 (6): 610-11. doi:10.1001/jama.2017.18672.

Abbott, A. 2020. "Stress, anxiety, harassment: Huge survey reveals pressures of scientists' lives." *Nature* 577 (7791): 460-461. doi:10.1038/d41586-020-00101-9.

Abbott, A., D. Cyranoski, N. Jones, B. Maher, Q. Schiermeier, and R. Van Noorden. 2010. "Do metrics matter?" *Nature* 465 (7300): 860-862. doi:10.1038/465860a.

Agoramoorthy, G. 2017. "Multiple first authors as equal contributors: Is it ethical?" *Science and Engineering Ethics* 23 (2): 625-627. doi:10.1007/s11948-016-9794-x.

Akhabue, E., and E. Lautenbach. 2010. ""Equal" Contributions and Credit: An Emerging Trend in the Characterization of Authorship." *Annals of Epidemiology* 20 (11): 868–871. doi:10.1016/j.annepidem.2010.08.004.

Anderson, M., F. C. Kot, M. A. Shaw, C. C. Lepkowski, and R. G. De Vries. 2011. "Authorship diplomacy: Cross-national differences complicate allocation of credit and responsibility." *American Scientist* 99 (3): 204. doi:10.1511/2011.90.204.

Beaver D. d., and R. Rosen. 1978. "Studies in scientific collaboration Part I. The professional origins of scientific co-authorship." *Scientometrics* 1 (1): 65-84. doi:10.1007/BF02016840.

Beaver, D. d., and R. Rosen. 1979. "Studies in scientific collaboration Part III. Professionalization and the natural history of modern scientific co-authorship." *Scientometrics* 1 (3): 231-245. doi: 10.1007/BF02016308.

Bhattacharya, J., and M. Packalen. 2020. "Stagnation and Scientific Incentives." *NBER Working Paper Series* 26752. doi:10.3386/w26752. Accessed March 19, 2020. https://www.nber.org/papers/w26752.

Biagioli, M., and A. Lippman. 2020. *Gaming the metrics: Misconduct and manipulation in academic research.* Cambridge, MA: MIT Press.

Bordens, M., and I. Gomez. 2000. "Collaboration networks in science." In *The web of knowledge: A festschrift in honor of Eugen Garfield*, edited by B. Cronin and H. B. Atkins, 197-213. Medford, NJ: Information Today Inc.

Borenstein, J., and A. E. Shamoo. 2015. "Rethinking authorship in the era of collaborative research." *Accountability in Research* 22 (5): 267-283. doi: 10.1080/08989621.2014.968277.

Boulbes, D. R., T. Costello, K. Baggerly, F. Fan, R. Wang, R. Bhattacharya, X. Ye, and L. M. Ellis. 2018. "A survey on data reproducibility and the effect of publication process on the ethical

reporting of laboratory research." *Clinical Cancer Research* 24: 3447-3455. doi:10.1158/1078-0432.CCR-18-0227.

Bozeman, B., and J. Youtie. 2017. *The strength in numbers: The new science of team science*. Princeton, NJ: Princeton University Press.

Broderick, N. A., and A. Casadevall. 2019. "Gender inequalities among authors who contributed equally." *eLife* 8: e36399. doi:10.7554/eLife.36399.

Cappell, M. S. 2016. "Equal authorship for equal authors: Personal experience as an equal author in twenty peer-reviewed medical publications during the last three years." *Journal of the Medical Library Association* 104 (4): 363-364. doi:10.3163/1536-5050.104.4.022.

Conte, M. L., S. L. Maat, and M. B. Omary. 2013. "Increased co-first authorships in biomedical and clinical publications: A call for recognition." *FASEB Journal* 27 (1): 3902-3904. doi:10.1096/fj.13-235630.

Cormode, G., S. Muthukrishnan, and J. Yan. 2013. "First author advantage: Citation labeling in research." In *Compsci13: Conference on Information and Knowledge Management*. San Francisco, CA. October 13-18. https://dl.acm.org/doi/10.1145/2508497.2508500.

Cowen, T. 2011. *The great stagnation: How America ate all the low-hanging fruit of modern history, got sick, and will (eventually) feel better*. New York: Dutton.

Drubin, D. G. 2014. "MBoC improves recognition of co-first authors." *Molecular Biology of the Cell* 25 (13): 1937. doi:10.1091/mbc.E14-05-0954

Drug Monkey. 2012. "Co-first authorship is a lie and a sham and an embarrassment to our profession." *Drug Monkey: Grants Research and Drugs* (blog), February 28. https://drugmonkey.scientopia.org/2012/02/28/co-first-authorship-is-a-lie-and-a-sham-and-an-embarassment-to-our-profession/ (Accessed April 14, 2020).

Dubnansky, E., and M. B. Omary. 2012. "Acknowledging joint first authors of published work: The time has come." *Gastroenterology* 143 (4): 879-880. doi:10.1053/j.gastr o.2012.08.009.

Edwards, M., and S. Roy. 2017. "Academic research in the 21st century: Maintaining scientific integrity in a climate of perverse incentives and hypercompetition." *Environmental Engineering Science* 34 (1): 51-61. doi:10.1089/ees.2016.0223.

Elo, S., and H. Kyngäs. 2008. "The qualitative content analysis process." *Journal of Advanced Nursing* 62 (1): 107-115. doi: 10.1111/j.1365-2648.2007.04569.x.

Fanelli, D., and V. Larivière. 2016. "Researchers' individual publication rate has not increased in a century." *PLoS One* 11 (3): e0149504. doi:10.1371/journal.pone.0149504.

Fishman, M., W. A. Williams, D. M. Goodman, and L. F. Ross. 2017. "Gender differences in authorship of original research in pediatric journals, 2001-2016." *Journal of Pediatrics* 191: 244-249. doi:10.1016/j.jpeds.2017.08.044

Fontanarosa, P., H. Bauchner, and A. Flanagin. 2017. "Authorship and team science." *Journal of the American Medical Association (JAMA)* 318 (24): 2433-2437. doi:10.1001/jama.2017.19341

Habibzadeh, F., and H. Marcovitch. 2012. "Authorship dispute among the league of extraordinary gentlemen." *European Science Editing* 38 (2): 40-41.

Heinemann, M. K., G. Brumfield, A. Boening, and B. Niemann, B. 2019. "More equal than others? An annoying habit." (Poster presentation) In *WCRI 2019: World Conference on Research Integrity*. University of Hong Kong (HKU), Hong Kong. June 2-5.

Heinemann, M. K., and F. Beyersdorf. 2016. "Two minds with but a single thought." *European Journal of Cardio-Thoracic Surgery* 49 (6): 1543-1544. doi:10.1093/ejcts/ezw137.

Helgesson, G., and S. Eriksson. 2019. "Authorship order." *Learned Publishing* 32 (2): 106-112. doi:10.1002/leap.1191.

Hosseini, M. 2020. "Equal co-authorship practices: review and recommendations." *Science and Engineering Ethics* (Online first). doi:10.1007/s11948-020-00183-8.

Hu, X. 2009. "Loads of special authorship functions: linear growth in the percentage of "Equal First Authors" and corresponding authors." *Journal of the American Society for Information Science and Technology* 60 (11): 2378-2381. doi:10.1002/asi.21164.

Huang, M., H. Hsieh, and C. Lin. 2016. "The co-first and co-corresponding author phenomenon in the pharmacy and anesthesia journals." *Proceedings of the Association for Information Science and Technology* 53 (1): 1-4. doi:10.1002/pra2.2016.14505301138.

JAMA. 2020. Instructions for authors. Last updated January 31, 2020. Accessed April 5, 2020. https://jamanetwork.com/journals/jama/pages/instructions-for-authors

Jia, Z., Y. Wu, Y. Tang, W. Ji, W. Li, X. Zhao, H. Li, Q. He, and D. Ruan. 2016. "Equal contributions and credit: An emerging trend in the characterization of authorship in major spine journals during a 10-year period." *European Spine Journal* 25 (3): 913-917. doi:10.1007/s00586-015-4314-2.

Kaltenbrunner, W., and S. de Rijcke. 2017. "Quantifying 'output' for evaluation; Administrative knowledge politics and changing epistemic cultures in Dutch law faculties." *Science and Public Policy* 44 (2): 284-293. doi: 10.1093/scipol/scw064.

Kolata, G. 2016. "So many research scientists, so few openings as professors. *The New York Times* (News), July 14. https://www.nytimes.com/2016/07/14/upshot/so-many-research-scientists-so-few-openings-as-professors.html

Kornhaber, R. A., L. M. McLean, and R. J. Baber. 2015. "Ongoing ethical issues concerning authorship in biomedical journals: An integrative review." *International Journal of Nanomedicine* 10: 4837-4846. doi:10.2147/IJN.S87585.

Kumar, S. 2018. “Ethical Concerns in the rise of co-authorship and its role as a proxy of research collaborations.” *Publications* 6 (3): 37. doi:10.3390/publications6030037.

Larivière, V., N. Desrochers, B. Macaluso, P. Mongeon, A. Paul-Hus, and C. R. Sugimoto. 2016. “Contributorship and division of labor in knowledge production.” *Social Studies of Science* 46 (30): 417-435. doi:10.1177/0306312716650046.

Larivière. V., Y. Gringas, C. R. Sugimoto, and A. Tsou. 2015. “Team size matters: Collaboration and scientific impact since 1900.” *Journal of the Association for Information Science and Technology* 66 (7): 1323-1332. doi:10.1002/asi.23266.

Lei, S., Y. Dong, W. Zhu and L. Li. 2016. “An emerging trend of equal authorship credit in major public health journals.” *SpringerPlus* 5: 1083. doi:10.1186/s40064-016-2771-7.

Liu, Y., Y. Liu, and M. G. B. Drew. 2020. “Clarifications of concepts concerning interplanar spacing in crystals with reference to recent publications.” *SN Applied Sciences* 2 (755). doi: 10.1007/s42452-020-2498-5.

Macfarlane, B. 2017. “The ethics of multiple authorship: Power, performativity and the gift economy.” *Studies in Higher Education* 42 (7): 1194-1210. doi:10.1080/03075079.2015.1085009.

McNutt, M., M. Bradford, J. M. Drazen, B. Hanson, B. Howard, K. H. Jamieson, V. Kiermer, E. Marcus, B. K. Pope, R. Schekman, S. Swaminathan, P. J. Stang, and I. M. Verma. 2018. Transparency in authors’ contributions and responsibilities to promote integrity in scientific publication. *PNAS* 115 (11): 2557-2580. doi:10.1073/pnas.1715374115

Moustafa, K. 2016. “Contributorships are not ‘weighable’ to be equal.” *Trends in Biochemical Sciences* 41 (5): 389-390. doi:10.1016/j.tibs.2016.03.001.

Muller, J. Z. 2018. *The tyranny of metrics*. Princeton, NJ: Princeton University Press.

Müller, R. 2012. “Collaborating in life science research groups: The question of authorship.” *Higher Education Policy* I25: 289-311. doi:10.1057/hep.2012.11.

National Institute of Environmental Health Sciences (NIEHS). 2019. “High Impact Journals.” *NIH* (Website). Accessed December 21, 2019. https://tools.niehs.nih.gov/srp/publications/highimpactjournals.cfm

Omary, M. B., M. B. Wallace, E. M. El-Omar, R. Jalan, and M. H. Nathanson. 2015. “A multi-journal partnership to highlight joint first-authors of manuscripts.” *Gut* 64 (2): 189. doi:10.1136/gutjnl-2014-308880.

Osório, A. 2018. “On the impossibility of a perfect counting method to allocate the credits of multi-authored publications.” *Scientometrics* 116 (3): 2161-2173. doi: 10.1007/s11192-018-2815-6.

Penders, B. 2017. “All for one or one for all? Authorship and the cross-sectoral valuation of credit in nutrition science.” *Accountability in Research* 24 (8): 433-50. doi:10.1080/08989621.2017.1386565.

Price, D. D. S. 1981. “Multiple authorship.” *Science* 212 (4498): 986. doi:10.1126/science.212.4498.986-a.

Resnik, D. B., E. Smith, Z. Master, and M. Shin. 2020. “Survey of equal contributions in biomedical research publications.” *Accountability in Research* 27 (3): 115-137. doi:10.1080/08989621.2020.1722947.

Resnik, D. B., A. M. Tyler, J. R. Black, and G. Kissling. 2016. “Authorship policies of scientific journals”. *Journal of Medical Ethics* 42 (3): 199-202. doi:10.1136/medethics-2015-103171.

Seeber, M., M. Cattaneo, M. Meoli, and P. Malighetti. 2019. “Self-citations as strategic response to the use of metrics for career decisions.” *Research Policy* 48 (2): 478-491. doi:10.1016/j.respol.2017.12.004

Simonton, D. K. 2013. “Scientific genius is extinct.” *Nature* 493 (7434): 602. doi: 10.1038/493602a.

Stephan, P. 2012. *How economics shapes science*. Cambridge, MA: Harvard University Press.

Smith, E. and Z. Master. 2017. “Best practice to order authors in multi/interdisciplinary health sciences research publications.” *Accountability in Research* 24 (4): 243-267. doi:10.1080/08989621.2017.1287567.

Smith, R. 1997. “Authorship: Time for a paradigm shift?” BMJ: *British Medical Journal* 314 (7086): 992. doi: 10.1136/bmj.314.7086.992.

The New England Journal of Medicine. 2020. Editorial policies. Accessed April 5, 2020. https://www.nejm.org/about-nejm/editorial-policies.

Thomas, D. R. 2006. “A general inductive approach for analyzing qualitative evaluation data.” *American Journal of Evaluation* 27 (2): 237-246. doi:10.1177/1098214005283748.

Van Noorden, R. 2010. “Metrics: A Profusion of Measures.” *Nature* 465 (7300):864-866. doi:10.1038/465864a.

Vijg, J. 2011. *The American technological challenge: Stagnation and decline in the 21st century*. New York: Algora.

Walker, R. L., L. Sykes, B. R. Hemmelgarn, and H. Quan. 2010. “Authors’ opinions on publication in relation to annual performance assessment.” *BMC Medical Education* 10 (1): 21. doi: 10.1186/1472-6920-10-21.

Wang, F., L. Tang, L. Bo, J. Li, and X. Deng. 2012. “Equal contributions and credit given to authors in critical care medicine journals during a 10-yr period.” *Critical Care Medicine* 40 (3): 967-969. doi:10.1097/CCM.0b013e318236f66a.

Wuchty, S., B. F. Jones, and B. Uzzi. 2007. “The increasing dominance of teams in production of knowledge.” *Science* 316 (5827): 1036-1039. doi:10.1126/science.1136099.

Appendix A

1. How many papers have you published involving equal co-first authorship?

2. In addition to published papers, are you currently involved in projects that are likely to result in co-first authored publications?

3. How did the research collaboration with your co-equal authors come about? Who initiated the collaboration and who suggested to have ECFA?

4. At what point in the project was the decision about authorship made – early on?, not until the manuscript was being drafted? Sometime in between? Was the issue contentious? Was there much discussion about it?

5. How did selection of a target journal figure in the process? For example, was the decision regarding equal co-first authorship made before or after looking at the journal's policies?

6. In your view, [for a specific paper], do you feel that equal first authorship accurately reflects the intellectual contribution of the various authors? Was any one shortchanged? Any one over-credited?

7. Overall, what is your view about equal co-first authorship?

8. Do you know of (or can you think of) systems of authorship that better or more accurately reflect the contributions of multiple authors, e.g., a contributorship model, where individuals' contributions are designed not by their relative importance, but only by the specific role(s) each researcher performed?

9. Was it the size/complexity of the task that convinced the group to divide the involved effort between contributors and consequently use ECFA? Where there other considerations involved?

10. If the ECFA participated in writing the manuscript (second criteria of the ICMJE), how did they make sure that they participated equally?

11. Was the involved task divided reasonably/exactly equal, and were all authors happy about sharing the first position? Was there any disagreement about who should be included?

12. Who made the final decision as to which authors would be named as equal? Did ECFA have any influence on that or was there a chance/willingness to raise concerns?

13. How do they reflect these ECFA designations in their resume?

14. Do they have any first-hand experience (or have they heard stories) about how the ECFA designations are assessed in evaluation committees?