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Equal Co-Authorship Practices: Review and Recommendations

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Abstract:	There has been an increase in the number of journal articles that are co-authored by researchers who claim to have made equal contributions. This growth has sparked discussions in the literature, especially within medical journals. To extend the debate beyond medical disciplines and support journal editors in forming an opinion, the current review collates and explores published viewpoints about so-called Equal Co-authorship (EC) practices. The Web of Science core database was used to identify publications that mention and discuss EC. Within the limited number of publications that were found on the Web of Science database, the most-cited item was used to trace other papers that discuss EC. In total, 39 papers (including articles and editorials) met the inclusion criteria. This review identifies four main themes within the sample including the growth of EC, challenges of attributing EC, guidelines and policies about EC and gender issues in the attribution of EC. Based on the survey and analysis of publications that discuss EC, this review provides recommendations regarding journal policy statements, and EC indicators. Those recommendations include: 1) Journal policies should address EC; and 2) Use should be made of available functionalities (CRediT, for example) to capture and indicate equal contributions.

Abstract

There has been an increase in the number of journal articles that are co-authored by researchers who claim to have made equal contributions. This growth has sparked discussions in the literature, especially within medical journals. To extend the debate beyond medical disciplines and support journal editors in forming an opinion, the current review collates and explores published viewpoints about so-called Equal Co-authorship (EC) practices. The Web of Science core database was used to identify publications that mention and discuss EC. Within the limited number of publications that were found on the Web of Science database, the most-cited item was used to trace other papers that discuss EC. In total, 39 papers (including articles and editorials) met the inclusion criteria. This review identifies four main themes within the sample including the growth of EC, challenges of attributing EC, guidelines and policies about EC and gender issues in the attribution of EC. Based on the survey and analysis of publications that discuss EC, this review provides recommendations regarding journal policy statements, and EC indicators. Those recommendations include: 1) Journal policies should address EC; and 2) Use should be made of available functionalities (CRediT, for example) to capture and indicate equal contributions.

Keywords: Scientific Authorship, Equal Co-authorship, Equal Contribution, Authorship Attribution, Recognition

Introduction

The practice of sharing (at least) one of the positions in the byline between two or more authors is often referred to as Equal Co-authorship (EC). In 2009, Xiaojun Hu was the first academic to inform the scientific community about the rise of EC using a quantitative analysis. She illustrated the growth of EC in the *Journal of Biological Chemistry* over a 10-year period. Furthermore, she showed that a similar pattern exists in other journals within the discipline of Biochemistry and Molecular Biology (*Proceedings of the National Academy of Sciences of the United States of America* (*PNAS*), *Journal of Immunology* and the *Journal of Virology*). Considering the growth of EC to be an unfortunate affair that resulted from putting too much emphasis on authorship order and bibliometric analysis, Hu concluded that more research on EC is warranted (Hu 2009). Since then, the rise of EC has been measured in other areas of medicine, and sometimes explored within the context of emerging issues in scientific authorship or publication ethics.

While the discussion of EC by medical researchers and ethicists (some of whom are also trained medical professionals) has been fruitful, it has resulted in a siloed debate that mainly takes place in medical journals. Consequently, after a decade of measuring the growth rate of EC in different medical disciplines and discussing it from different perspectives, the debate is likely to be unfamiliar to researchers and journal editors from other areas of Science where EC might be on the rise. On that basis, this review aims to collate published viewpoints, discussions and explanations in support or rejection of EC, to help the debate spread beyond medical disciplines and support journal editors in developing policies about EC. Towards that aim, this review conducts a systematic search to identify published items that discuss EC and provides an analysis of how EC is viewed in the literature.

Methods

For this review, the Web of Science (Clarivate Analytics 2020) core collection was used to find relevant sources. In order to retrieve the most useful sources that pay specific attention to EC, the following combination of terms were used to search in the titles of publications: “equal*” AND “author*”, “equal* contribution*” AND “author*”, and “equal*” AND “co-author*”. The search was not limited by date and all publications published in English were included. After reviewing titles and abstracts of the resulted items, papers in which equal or equality were not referring to the practice of sharing authorship were excluded. Further, the most cited paper among the shortlisted items — (Akhabue and Lautenbach 2010)[1] — was used to trace articles that discuss EC but do not mention it in their titles. The title and abstracts of all papers that cited Akhabue and Lautenbach’s 2010 article were reviewed too. Additionally, the references of retrieved items were examined to identify any additional papers that discuss EC. At this stage, 70 items were shortlisted for full-text reading. Among those that were fully read, 31 were excluded because they did not discuss EC in a significant way, or only mentioned the growth of EC as explored by others without adding further insights (See figure 1).

[FIGURE 1 HERE]

Consequently, a total of 39 papers were analyzed using an inductive approach. The analysis involved highlighting segments that contained viewpoints about EC and creating a label for that part. After reducing overlaps and redundancy among labels, each paper was assigned a theme that indicates what aspect of EC is being explored (in a significant way) in that paper.

[1] According to The Web of Science, until August 2019 this paper was cited 41 times.

Results

Characteristics of the sample

Papers that met the inclusion criteria either exclusively discuss EC, or, explore EC within a wider context (e.g. ethical issues of scientific authorship). In analyzing these papers, four main themes emerged. These themes include challenges of attributing EC (14 papers), policies and guidelines regarding EC (12 papers), the growth of EC in various disciplines (10 papers), and gender issues in the attribution of EC (3 papers).

Challenges of attributing EC

Most papers that engage with challenges of attributing EC analyze this practice in the context of collaborative authorship and mention EC as one of the complexities of scientific authorship that may contribute to ethical issues (See table 1).

[TABLE 1 HERE]

For instance, Esposito (2016) argues that since EC complicates determining the primary contributors to publications, it may contribute to the loss of scientific credibility of publications. Furthermore, it might also enable post-publication malpractices such as swapping equal authors' positions in the CVs. Difficulties in identifying the sequence of equal authors is another challenge. In most disciplines, first and last positions in the byline are the most coveted, and in attributing EC, controversies might emerge in choosing the very first of equal authors.[2] Even an alphabetical ordering of names, which seems neutral is believed to discriminate against those whose last names start with letters nearer to the end of the alphabet (Patel et al. 2019; Smith 2017).

[2] In case of shared last position, it is perhaps the very last position that will be desired more.

The rare possibility of making exactly equal contributions is another challenging aspect in the attribution of EC (Agoramoorthy 2017; Habibzadeh and Marcovitch 2012). Ideas and arguments are believed to be incommensurable to quantification, and hence, accurate division of all contribution types would, in principle, be impossible. In relation to various tasks that are often carried out in biomedical and other interdisciplinary projects[3], it is argued that having made *exactly* equal contribution would only be possible once contributors repeat each other's work. Even if having contributed equally to a task would be possible, two or more contributors cannot be equally involved in drafting the manuscript in the strictest sense (Moustafa 2016). From that follows that if it is impossible to have made an exactly equal contribution, it is likely to have some contributors short-changed and some over-credited.

Since contributions are reported by groups (or sometimes only by the corresponding author), suspicions about the veracity of claims to equal contributions remain firm. Given the inability of editors to authenticate claims to EC, some consider EC as ethically questionable (Agoramoorthy 2017). This suspicion is not only put forward by editors but also by researchers. Results of a survey that investigated the perceptions of author position versus contribution among Chinese medical researchers showed that 42.7% of respondents who were asked about claims to EC, believed that these claims are unreliable (Jian and Xiaoli 2013).[4]

The so-called diffusion of responsibility is a key concern raised by various papers. For instance, Habibzadeh and Markovitch highlight ambiguities in the attribution of responsibilities in short reports with equal co-authors: "If an 800-word medical case report is submitted to a journal with eight authors, does that mean the ridiculous fact that each co-author is responsible for just 100

[3] "An experiment involving DNA cloning, cell culture, or DNA extraction cannot be 'equal' to an experiment involving an immunofluorescence assay, western blot, or transcriptome analysis, neither methodologically nor temporally; neither can scientific interpretations and arguments built on such experiments or on others be equal" (Moustafa 2016, p. 389).

[4] While Jian and Xiaoli do not clarify how many of surveyed researchers had ever been involved in publications with EC, in absence of other quantitative/qualitative studies about researchers who were an equal co-author, further exploration of the issue of the reliability of claims to EC is currently not possible.

words?" (2012, p. 40). Others believe that in cases where EC is granted based on having made similar contributions to various tasks (instead of contributing to a single task that was equally shared), EC could erode individual responsibility and accountability (Smith 2017).

Among the practical challenges, disagreements about EC are believed to delay the publication process (Scott-Lichter 2012). Furthermore, the fact that EC is currently not captured and shown consistently by indexing websites such as Google Scholar (Alphabet Inc. 2020), PubMed (NCBI 2020), and ScienceDirect (Elsevier 2020) can confuse users. In cases where EC was deserved, not having these attributions reflected in indexing websites may result in discrimination against equal authors (Brown and Merad 2015; Cappell 2016). For instance, in cases of equal first-authorship, it is only the first listed author who fully enjoys the benefits of being the first author in their digital records. A major practical challenge is the lack of guidelines on how EC should be attributed and how they should be used in academic assessments and promotions (Beshyah et al. 2018; Faulkes 2018; Gasparyan et al. 2013). In a 2016 study, Resnik and his colleagues analyzed authorship policies of a random sample of 600 journals and noticed that none of the considered journals addresses EC within their authorship policies. In stressing the need for clearer guidelines on how EC should be attributed, they note that "since equality could be based on the quality or quantity of the author's contribution to the research", authors should receive guidance on what counts as an equal contribution (Resnik et al. 2016, p. 201).

Policies and guidelines regarding EC

These papers consist of a dozen editorials that communicate journals' stance in relation to EC and/or conditions for accepting submissions with EC. All these editorials are published in medical journals and while announcing the recognition of EC in these journals, they put forward dissimilar terms and conditions for accepting submissions with equal co-authors (See table 2).

[TABLE 2 HERE]

Among these editorials, some require that authors indicate who contributed equally via a statement in the byline or footnote (Alfonso et al. 2019; Cleary et al. 2012; Supak-Smolcic and Simundic 2015). However, the majority of journals put forward stricter conditions and ask for further explanations that clearly describe why certain contributors are equal. Explanations should often be accompanied by contributorship statements that describe individual contributions (Casadevall et al. 2019; Fontanarosa et al. 2017; Heinemann & Beyersdorf 2016; Hinds et al. 2018; Kressel 2015; Yao and Jiang 2018).

A few journals go one step further, and in addition to accepting submissions with EC, also suggest methods to improve the recognition of EC in reference lists and in-text citations. For instance, the editors of the journal of *Gastroenterology* added a new line in their instructions to authors, which encourages researchers to highlight the last names of equal first authors in the reference lists using bold letters (Dubnansky and Omary 2012). Similarly, in a concerted effort, five medical journals featured a change of policy to highlight joint first authors in the reference lists using bold letters or underlining (Omary et al. 2015). In addition to acknowledging articles with equal authors in the references, the editor of the Journal of *Molecular Biology of the Cell* suggests mentioning all equal first authors on in-text citations "(e.g., Flannagan, Canton *et al*., 2014)" to prevent giving undue credit to the first listed author (Drubin 2014, p. 1937).

Different policies exist in relation to the number of authors who may share first or last positions in the byline. Some journals limit the number of equal lead authors to three or six, and some other journals have not specified any limitations. Similarly, diverse practices exist in relation to how many corresponding authors are allowed in each paper. For example, the *Journal of Scientific Reports* allows three, the *American Journal of Human Genetics* a maximum of two, and the *Journal of Neuron* only one corresponding author per submission (Yao and Jiang 2018). *JAMA* and JAMA Network Journals mention the benefits of having one corresponding author but also note that requests for having up to two corresponding authors will be considered (Fontanarosa et al. 2017).

EC is growing

The growth rate of EC is mainly measured in biomedical disciplines. Within the selected sample, ten papers note the growth rate of EC (See table 3).

[TABLE 3 HERE]

Most of these papers analyze the growth rate of EC in one or more prominent journals within a certain discipline in a specific timeframe. There is a consensus among these papers on several issues. For instance, all these papers claim that designating equal credit is for the most part due to the rise of multidisciplinary and multi-center research projects (Akhabue and Lautenbach 2010; Conte et al. 2013; Dotson 2013; Hu 2009; Huang et al. 2016; Jia et al. 2016; Lei et al. 2016; Li et al. 2013; Tao et al. 2012; Wang et al. 2012). These complex projects require a wide range of resources and expertise, and hence, EC is believed to enable the attribution of equal credit to authors who made equal contributions.

Another similarity among all these papers is that the results of their analyses indicate that sharing the first position of the byline is the most common form of EC. This is linked to the growing importance of citation-based evaluations and the significance of first and last authorship for hiring and academic evaluations. Furthermore, authors of these papers conclude that given the growth rate of EC, detailed policies (e.g. when and how EC should be designated), are warranted. Although, some are concerned that given the frequency of misappropriations in authorship practices, further recognition of EC might increase the possibility of undeserved authorship status (Dotson 2013; Jia et al. 2016; Wang et al. 2012).

In terms of the geographical distribution of EC, limited information is available based on the affiliation of the corresponding authors. While within top three Spine Surgery journals, most of the papers containing EC were submitted by a corresponding author affiliated to an Asian institution (Jia et al. 2016), within the fields of Anaesthesiology (Tao et al. 2012), Anaesthesia (Li et al. 2013) and

Critical Care (Wang et al. 2012), most of equal co-authors were based in European institutions. Whether one country stands out within each region, or whether all equal co-authors of the same article were coming from the same countries, are not explored systematically. However, the 2016 study that analyzed EC in Public Health journals found that 57% of authors that received equal credit in a publication were based in different institutions (Lei et al. 2016).

Gender issues in the attribution of EC

Only three papers analyze gender in the context of EC (See table 4).

[TABLE 4 HERE]

Two of these papers measure the representation of female authors in articles with equal co-authors of different genders. While both studies show that, at least in some areas, female authors are less likely than their male counterparts to be listed first in bylines with co-first authors (Aakhus et al. 2018; Broderick and Casadevall 2019), one of these studies claims that the gap is getting smaller after 2007 (Broderick and Casadevall 2019). The third paper is a commentary published in *The Lancet* by two female researchers who share their experience of equal co-first authorship. They note that EC allowed both of them to take maternity leave by giving them the flexibility to keep up with their childcare commitments while obtaining the academic recognition which they deserved (Rose-Clark and Felmeth 2019).

Discussion

Why are various positions in the byline shared?

It is clear from this review that within discussions about EC, the conditions for and meaning of equality are among contentious issues. Analyzing articles that were eligible for this review shows that depending on the dynamics of collaborations, different positions in the byline may be shared.

Among various forms of EC, equal-first authorship refers to sharing the first position in the byline between two or more co-authors (Agoramoorthy 2017). Given the importance of the first position for tenure and promotion, equal-first authorship is the most contested, and yet more common form of EC (Huang 2016; Lei et al. 2016). The percentage of equal-first authorship designations of the total number of EC ranges between 70.4% in selected Public Health journals (Lei et al. 2016) to more than 90% in selected Pharmacy and Anesthesia journals (Huang 2016). Often linked to the growing number of contributors as well as complexity and size of scientific projects, equal-first authorship designations seem to be justified in projects where more than one author makes a significant contribution *throughout* the project (Conte et al. 2013; Jia et al. 2016).

Equal-middle authorship refers to sharing middle authorship position among the co-authors who are positioned between the first and last authors in the byline of papers with four, or more co-authors. Sharing middle positions in the byline is not as common as sharing first or last positions (Lei et al. 2016; Li et al. 2013). In general, equal-middle authors are believed to have contributed less to the project than the first or last authors and often consist of technicians and graduate students (Patel et al. 2019). The rise of equal-middle authorship is believed to enable “a more accurate and fairer way of distributing credit to members of a very large team” (Smith 2017, p.20).

Co-last authorship is another form of EC. Sharing the position of corresponding author (Hu 2009) or the last position in the byline is especially common (and justified) in multidisciplinary and multi-site projects where different levels of supervision are employed via multiple supervisors who lead different groups and manage various parts of the work (Alfonso et al. 2019). While not as common as equal co-first authorship, co-last authorship is the second most popular form of EC (Lei et al. 2016; Li et al. 2013).

EC also happens when the first and last names in the byline claim to have made equal contributions. While this is not as common as equal-first or equal-last authorship practices, it seems to be more diverse (e.g. first and last, first two and last, first two and last two, first three and last, etc.). In this form of EC, the rationale for equality is *not* based on equal contribution to identical or comparable tasks, or, even the time spent on carrying out the tasks. The supporting argument is that due to mentors' experience, "equal authorship equitably balances the greater time spent by a mentee versus the greater impact of a mentor on manuscript quality" (Cappel 2016, p. 364).

Finally, sharing authorship among all co-authors implies an equal contribution of all, which has been common practice in disciplines such as Economics and Math (Smith 2017). Alphabetical ordering often insinuates equal contribution but sometimes equal contribution of all co-authors is mentioned explicitly (especially, in disciplines where alphabetical ordering is not a custom).

Other forms of EC might exist where the first author(s) and some of the middle authors, or the last author(s) and some of the middle authors claim to have made an equal contribution. While neither of these two situations is reported in studies that quantified the prevalence of EC, they can be a possibility.

How to identify EC in published articles?

Currently, to identify equal co-authors of a published item, one has to look for names that are followed by superscript characters in the byline (e.g. Jones[†], Wang[#], etc.) and check footnotes for further descriptions. However, superscript characters are not used consistently across different platforms and some websites do not specify equal co-authors. For instance, ScienceDirect (Elsevier 2020) uses [†], PubMed (NCBI 2020) uses [#], and Google Scholar (Alphabet Inc. 2020) does not display EC at all.

Identifying equal co-authors from in-text citations and reference lists is more challenging. As mentioned in the section on policies and guidelines regarding EC, some journals that recognize this

practice encourage the specification of equal authors in references and in-text citations. This recognition is facilitated by using bold lettering or underlining names in references, and mentioning all equal authors in citations (e.g. Jones, Wang, Ali et al. instead of Jones et al.). However, since referencing journal articles with EC is not mentioned in academic style guides[5], or, recognized by reference management applications[6], these suggestions remain arbitrary to adhere to, and may contribute to inconsistent practices. Consequently, in cases where the claim to equality is justified and approved, omissions (e.g. in cases of equal co-first authorship) are believed to discriminate against the second of equal authors, who will be viewed and evaluated as a lesser contributing author when these publications are being cited (Cappel 2016). Moreover, in cases where numerous authors make an equal contribution, or articles with equal co-first and equal co-last authors (e.g. three equal first and three equal last), an accurate reflection of EC on in-text citations would be much more complicated. Therefore, while displaying EC on some indexing websites and within citations and references of some journals can be seen as positive steps in recognizing equal contributions, a lack of consistency among these efforts is noticeable.

Limitations of this review and suggestions for future research

This review is limited by the small sample of papers that were reviewed. Although several methods were employed to find papers that investigated EC in a significant way, this review is not representative of debates that took place on the blog-sphere, online forums or within the grey literature. Exploring these outlets could be useful for future research. In addition, this review only considered contributors who were listed as authors, and therefore, viewpoints and issues about the equal contribution of acknowledged names could be among possible directions for future research.

[5] Examining style and referencing handbooks and websites shows that The Chicago Manual of Styles (17th edition), MLA Style (8th edition), and APA Style (6th edition) do not provide guidance on citing or referencing journal articles with EC (Pears and Shields 2019). Even the 7th version of APA style published in 2019 does not address EC (American Psychological Association 2020).

[6] At the time of submission Zotero, Mendeley and RefWorks neither support the display of EC, nor reflect EC in creating bibliographies.

The way in which EC practices are used in promotion and evaluation processes is another area where future research could focus.

Recommendations

This review shows that there is a consensus about the growth of EC in medical disciplines. While EC is identified as an inevitable side-effect of new forms of contribution to publications and prevalence of complex and multidisciplinary projects, it remains under-regulated. Academics continue to voice their concerns about the challenges of using EC without clear guidelines and publish their views in support or rejection of EC. While this article does not intend to arbitrate the debate, it recognizes tensions that may complicate collaborative authorship. As shown in this article, given their experiences about the application of EC in their respective research areas, several journal editors have clarified their personal/journal stance regarding EC in editorials.

On that basis, the first recommendation of this article is for all journal editors to clarify whether they allow the use of EC, and indicate their terms and conditions for that. Indeed, this recommendation echoes what was suggested by the Committee Of Publication Ethics (COPE):

> "to help prevent dispute, however, journals should have a policy on how they denote equal contribution, and consider publishing a section on the individual contributions of each author" (COPE 2014, p. 4).

In encouraging journal editors to clarify their position in relation to EC, international committees and societies can play a significant role. For instance, editors' committees such as the International Committee of Medical Journal Editors (ICMJE) are among parties that can encourage journal editors to take a clear stance regarding EC. Currently, the ICMJE guidelines neither mention EC as a possibility nor suggest to journal editors how to capture and recognize it (ICMJE 2018). Indeed, the

mentioning of EC in the ICMJE guidelines could contribute to the development of more consistent policies.

The second recommendation of this article aims to address the issue of recognizing equal contributions, and inconsistencies regarding the display of these contributions. Until all journal guidelines are adjusted and indexing websites as well as reference management applications provide their analysis regarding the display of EC practices consistently (e.g. infrastructural complexities, costs, etc.), deserved and justified equal contributions could be registered using other means. For instance, journals and institutions can adopt and encourage researchers to use CASRAI's CRediT taxonomy. CRediT provides an option for specifying the *degrees* of contribution to tasks and offers identifiers such as Lead, *Equal or* Supporting for contributors (CASRAI, 2019).[7]

Clarifying degrees of individual's contribution in projects that involve voluminous tasks, prevents shortchanging those who (may) deserve to be credited equally. In those contexts, using CRediT addresses most of the concerns about acknowledging equal contributions. Due to the clarity of tasks and contributions, questions such as *equality in what?* or *which equal author is responsible for what task?* will be much easier to address. Furthermore, given that ORCID records also allow the display of CRediT badges (Paglione, 2015a; Paglione, 2015b), these equal contributions will be easier to locate and showcase in academic resumes, hence giving researchers who contributed equally the recognition that they deserve.

Lastly, this article suggests continuing the discussion about EC, and on that basis, it invites comments and correspondence from those who wish to be involved in the debate. Especially, journal editors and experts who have been working in this field with experiences other than those that were reflected in this paper.

[7] This feature is currently optional, and only applicable to cases where multiple individuals contributed to a large task (e.g. several individuals can be introduced as an *equal contributor* to the role of supervision). More information on features, and also a list of publishers and institutions that have adopted CRediT can be found at CRediT's website (Last accessed Jan 7, 2020): https://casrai.org/credit/

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Tables and Figures

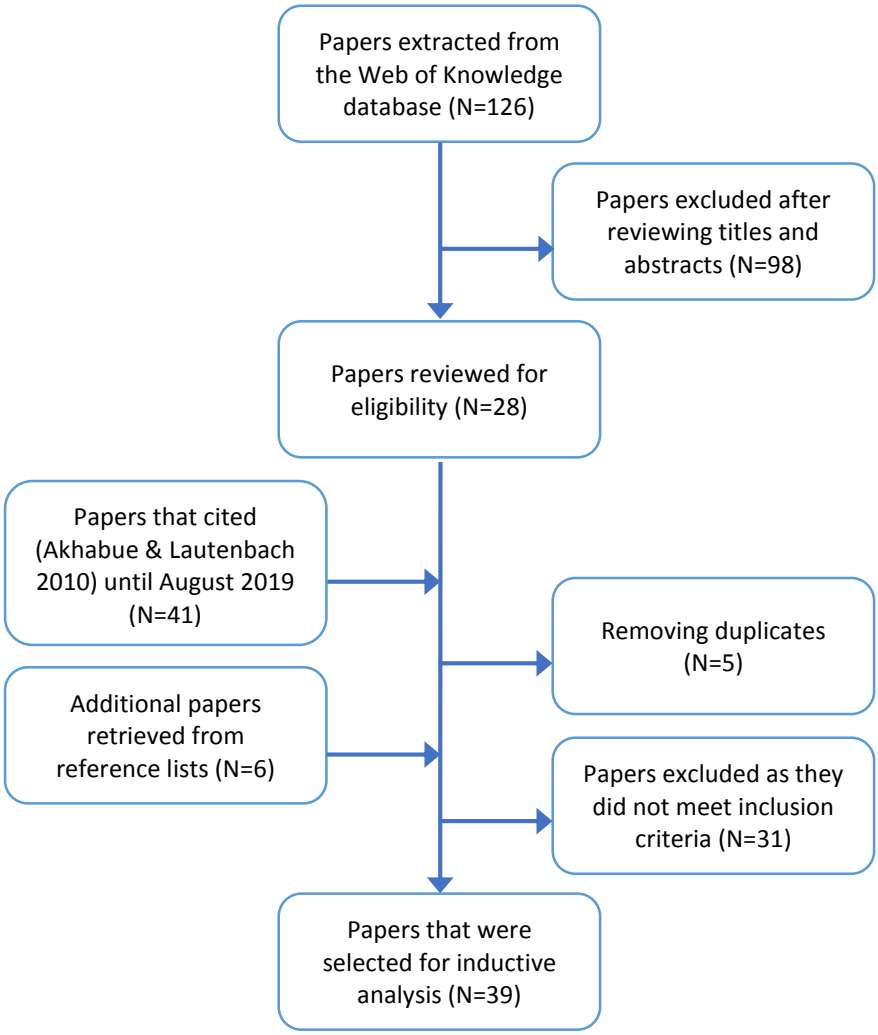

Figure 1. After conducting the searches and removing duplicates or documents that did not meet the inclusion criteria, 39 papers were deemed eligible for analysis.

Paper	Journal	Introduced Challenge(s)
Habibzadeh & Marcovitch 2012	*European Science Editing*	Ambiguities in relation to personal responsibilities.
Scott-Lichter 2012	*Learned Publishing*	It may lead to further disputes between co-authors and delay publications.
Gasparyan et al. 2013	*Rheumatology International*	No guidelines on how to attribute EC and use it in academic promotion.
Jian & Xiaoli 2013	*Scientometrics*	Claims to EC are not always reliable.
Brown & Merad 2015	*Nature*	EC is not reflected in indexing sites, in in-text citations or in reference lists.
Cappell 2016	*Journal of the Medical Library Association*	EC is not reflected in indexing sites, in in-text citations or in reference lists.
Esposito 2016	*International Journal of Oral Implantology*	EC contributes to a loss of credibility.
Moustafa 2016	*Trends in Biochemical Sciences*	Claims to EC are invalid.
Resnik et al. 2016	*Journal of Medical Ethics*	Equality could be based on different criteria.
Agoramoorthy 2017	*Science and Engineering Ethics*	Claims to EC cannot be authenticated.
Smith 2017	*Kennedy Institute of Ethics Journal*	Ambiguities in relation to personal responsibilities; Tension in identifying the sequence of equal authors.
Beshyah et al. 2018	*Ibnosina Journal of Medicine and Biomedical Sciences*	No guidelines on how to attribute EC and use it in academic promotion.
Faulkes 2018	*Research Integrity and Peer Review*	No guidelines on how to attribute EC and use it in academic promotion.
Patel et al. 2019	*Journal of the Royal Society of Medicine*	Tension in identifying the sequence of equal authors.

Table 1. List of papers that mention challenges of attributing EC.

Paper	Journal	Policy/Suggestion
Cleary et al. 2012	*Journal of Clinical Nursing*	Authors may write a statement of equal contribution.
Dubnansky & Omary 2012	*Gastroenterology*	Recognize cited articles with equal-first authors by using bold lettering for all last names and initials of the first authors in references.
Kressel 2015	*Radiology*	Indicate who are equal co-authors, this should be requested and justified in a cover letter.
Drubin 2014	*Molecular Biology of the Cell*	Equal-first authors will be mentioned in the footer of the PDF version. Cited articles with equal-first authors will be recognized by using bold lettering for last names of the first authors in references, and also mentioning the last name of all the equal authors within in-text citations.
Supak-Smolcic & Simundic 2015	*Biochemia Medica*	Joint authors must be clearly declared.
Omary et al. 2015	*Gastroenterology, Gastrointestinal Endoscopy, Gut, Journal of Hepatology, and Hepatology*	Recognize cited articles with equal-first authors by using bold lettering or underlining for all last names and initials of the first authors in references.
Heinemann & Beyersdorf 2016	*European Journal of Cardio-Thoracic Surgery*	If the claim to equality is well-founded, an acknowledgment should explain this.
Fontanarosa et al. 2017	*Journal of American Medical Association (JAMA)*	Requests for co-first authors or co-last authors will be considered but require a detailed justification.
Yao & Jiang 2018	*Zoological Research*	Emphasizing equal contribution of involved parties is fair and encourages teamwork.
Hinds et al. 2018	*Cancer Nursing*	First or last positions may be shared, but a statement of authors' contribution with a justification for the multiple role holders will be required.

Alfonso et al. 2019	*Clinical Research in Cardiology*	Articles with equal contribution designations should include a footnote clearly indicating that both authors equally contributed to the work.
Casadevall et al. 2019	*Journal of Clinical Investigation*	Using the phrase "contributed equally" is discouraged and replaced by the statement that "two or more authors share a specific author position." Once individuals share a position in the byline, information on how the authors' position was selected is required.

Table 2. List of papers that mention policies and guidelines about EC.

Paper	Journal	Analyzed field or journals (period)	Growth in the proportion of articles with equal co-authors from the sample size
Hu 2009	*Journal of the American Society for Information Science and Technology*	*Journal of Biological Chemistry (1999-2008)*	From less than 8% of the articles in 1999 to more than 25% in 2008
Akhabue & Lautenbach 2010	*Annals of Epidemiology*	Five medicine journals with the highest impact factor (2000-2009)	From 0.3% in 2000, to 4.38% in 2009
Tao et al. 2012	*Scientometrics*	Top four major Anesthesiology journals (2001-2010)	From 0.33% in 2001 to 6.68% in 2010
Wang et al. 2012	*Critical Care Medicine*	Top four journals in Critical Care medicine (2001-2010)	From 0.36% in 2001 to 12.37% in 2010
Conte et al. 2013	*Journal of the Federation of American Societies for Experimental Biology*	Top six Biomedical journals, three high-impact and three mid-level impact journals (1990-2012)	From 0.55% in 1990 to 27.65% in 2012
		Top six Clinical journals, three high-impact and three mid-level impact journals (2000-2012)	From 1.25% in 2000 to 9.01% in 2012
Dotson 2013	*American Journal of Pharmaceutical Education*	Three prominent Pharmacy journals (2012)	2.5% of all published articles had equally credited authors
Li et al. 2013	*PLOS ONE*	Top three Anesthesia journals (2002-2011)	From 0.4% in 2002 to 6.4% in 2011

Huang et al. 2016	*Proceedings of the Association for Information Science and Technology*	Top ten journals in Pharmacy (1995-2014)	From 0% in articles published between 1995-1999 to 11.51% in articles published between 2010-2014
		Top ten journals in Anesthesia (1995-2014)	From 0.05% in articles published between 1995-1999 to 5.79% in articles published between 2010-2014
Jia et al. 2016	*European Spine Journal*	Top three Spine journals (2004-2013)	From 0.13% in 2004 to 7.12% in 2013
Lei et al. 2016	*Springer Plus*	Top five Public Health journals (2004-2013)	From 0.59% in 2004 to 6.05% in 2013

Table 3. List of papers that measure the growth of EC.

Paper	Journal	Analyzed period	Results/Conclusion
Aakhus et al. 2018	*Journal of American Medical Association*	1995-2017	Among mixed-gender co-first authors publishing in high-impact clinical journals, women are more likely to be placed second.
Broderick & Casadevall 2019[8]	*eLIFE*	2005-2014	Within publications after 2007, there is no significant difference between male and female researchers of studies with mixed-gender co-first authors.
Rose-Clarke & Fellmeth 2019	*The Lancet*	N/A	EC helps female researchers to remain involved in high impact research while their careers are interrupted by maternity leave.

Table 4. List of papers that mention gender issues in the attribution of EC.

[8] An earlier version of this research was published in 2017 as a preprint with a different title, but since the 2019 version is more comprehensive, the earlier version was excluded from this research. The 2017 preprint is available at: https://www.biorxiv.org/content/10.1101/241554v1.full.pdf, Last accessed Jan 7, 2020.