

Authorship and Team Science

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The complexity, scope, and scale of scientific research have expanded substantially. During the past several decades, there has been increasing prevalence of large, international, multi-center clinical trials; multidisciplinary investigations involving interventional studies or observational research; and studies that combine large data sets (“big data”) from multiple cohorts or research consortia and use sophisticated analytic methods, such as in some studies involving genomic research or machine learning. This trend toward increasingly collaborative research involving multiple investigators and research groups has been referred to as group science, ensemble science, or more commonly, team science.¹ How authors and nonauthor collaborators can be identified in publications to ensure appropriate credit and recognition of team science is evolving, can be challenging, and is of great importance to the scientific community and individual investigators.

Team science has real and potential advantages, including the ability to bring expertise and experience from numerous investigators or disciplines to address an important research topic from multiple perspectives and the ability to collect or combine data from various sites or cohorts to generate large data sets to address scientific questions efficiently and effectively. Team science is likely to increase with the growth of research networks and consortia and the continued emergence of big data and data sharing.²

Team science also creates potential challenges, including identifying the optimal group of investigators to address the study questions of interest; rigorously addressing issues of heterogeneity in attempts to combine data or data sets; ensuring engagement, appropriate participation, and supervision of all members of the scientific team; reaching agreement and consensus regarding presentation and interpretation of study findings; and appropriately recognizing the contributions of individual members of the research team in scientific publication.

Team Science and Authorship

Team science in biomedical and basic science research has been accompanied by corresponding trends in the numbers of authors included in scientific publications. For instance, for scientific articles indexed in PubMed from 1975 through 2016, the mean number of individuals listed as authors increased from 1.9 to 5.67 per article,³ and the mean proportion of scientific articles with a “collective name” (such as group or corporate authorship) increased from 1.01 to 1.08.³ Muth and Golub⁴ assessed authorship trends in research articles published in 3 leading general medical journals (*JAMA*, *The Lancet*, and *New England Journal of Medicine*) in 2005, 2010, and 2015. The median number of authors per article increased in all 3 journals (from a range of 8-11 in 2005 to 11-18 in 2015), and the percent-

age of articles with group authors increased as well (from a range of 17%-37% in 2005 to 30%-45% in 2015).

In addition, some reports involving major research discoveries have listed hundreds to thousands of individuals as authors. For example, in 2001, 2 articles^{5,6} reported the sequencing of the human genome; one included more than 270 individuals named as authors,⁵ and the other listed a research consortium that included more than 20 centers and more than 240 individual authors and collaborators.⁶ Examples of recent articles in biomedical journals that have involved team science include a report from the Global Burden of Disease Cancer Collaboration, with 182 individuals named as authors,⁷ and a report on genetics and maternal obesity-related traits and birth weight, with 64 individuals identified as authors reporting for the Early Growth Genetics Consortium.⁸

Authors of all scientific publications, ranging from opinion articles involving 1 or 2 individuals to team science research reports involving multiple investigators and research consortia, must adhere to the same principles and standards to ensure the necessary accountability and responsibility for the work being reported. Even though there may be different opinions and perceptions regarding the designation of authorship of these reports, many biomedical journals, including *JAMA* and the *JAMA Network* journals, subscribe to and follow the authorship criteria established by the International Committee of Medical Journal Editors (ICMJE) in 1985.⁹ All *JAMA Network* journals require that every individual named as an author on any article must complete and submit an individual authorship form (**Figure**) that provides formal attestation that they have met these criteria.^{10,11}

According to current ICMJE recommendations,⁹ authorship should be “based on the following 4 criteria:

- Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND
- Drafting the work or revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.”

The ICMJE also indicates that “In addition to being accountable for the parts of the work he or she has done, an author should be able to identify which co-authors are responsible for specific other parts of the work. In addition, authors should have confidence in the integrity of the contributions of their co-authors.”

The ICMJE also recommends that “All those designated as authors should meet all four criteria for authorship, and all who

Figure. JAMA Network Journals Authorship Form

JAMA Network Journals Authorship Responsibility, Criteria, and Contribution

Each author should meet all criteria below (A, B, C, and D) and should indicate general and specific contributions by reading criteria A, B, C, and D and checking the appropriate boxes.

A. I certify that

- the manuscript represents original and valid work and that neither this manuscript nor one with substantially similar content under my authorship has been published or is being considered for publication elsewhere, except as described in an attachment, and copies of closely related manuscripts are provided; and
- I agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; and
- if requested, I will provide the data or will cooperate fully in obtaining and providing the data on which the manuscript is based for examination by the editor or the editor's assignees; and
- for papers with more than 1 author, I agree to allow the corresponding author to serve as the primary correspondent with the editorial office, to review the edited manuscript and proof, and to make decisions regarding release of information in the manuscript to the media, federal agencies, or both, or, if I am the only author, I will be the corresponding author and agree to serve in the roles described above.

B. I have given final approval of the submitted manuscript.

C. I have participated sufficiently in the work to take public responsibility for (check 1 of 2 below)

- part of the content.
- the whole content.

D. To qualify for authorship, you must check at least 1 box for each of the 3 categories of contributions listed below.

I have made substantial contributions to the intellectual content of the paper as described below:

1. (check at least 1 of the 2 below)

- conception and design
- acquisition, analysis, or interpretation of data

2. (check at least 1 of 2 below)

- drafting of the manuscript
- critical revision of the manuscript for important intellectual content

3. (check at least 1 below)

- statistical analysis
- obtaining funding
- administrative, technical, or material support
- supervision
- no additional contributions
- other contributions (specify) _____

meet the four criteria should be identified as authors. Those who do not meet all four criteria should be acknowledged.⁹⁹

Thus, authorship requires meaningful substantive contributions to the study or work and to the manuscript. Simply contributing data to a study or serving as a representative of a research consortium does not alone fulfill criteria for authorship. Prespecified agreements that guarantee authorship to individuals or research groups in return for agreeing to be part of an

investigation, often by contributing data, are not appropriate if each individual does not also fulfill the authorship criteria. Authorship must not be bestowed in an honorary fashion.¹¹⁻¹³

As the numbers of individuals involved in team science investigations continue to increase, it is essential to ensure that each individual author is accountable for the validity, veracity, and integrity of the scientific investigation. Individuals who do not meet authorship criteria but who have made important substantive contributions to the work should be acknowledged for their contributions and can be listed as collaborators.

The following list of common terms and definitions also may be helpful in assessing and applying norms of credit for authors and non-author collaborators in team science.

Contributor: Anyone, such as an author, a collaborator, or others who have assisted or contributed in a meaningful way to the work.

Author: A type of contributor who has participated sufficiently in the work to take public responsibility for the content, either all of the work or an important part of it, and meets defined criteria for authorship. Identification of authorship in a manuscript and published article can appear in 2 places:

Byline author: Author name included the article byline

Nonbyline author: Author name not included in the article byline, but listed elsewhere, typically in an Acknowledgment or Article Information section.

Group author: A group of individuals, usually involving multicenter study investigators, members of working groups, and official or self-appointed expert boards, panels, or committees, who wish to display a group name to indicate authorship.

Collaborator: Another type of contributor who is a nonauthor member of a formal group and who contributes significantly to the work but does not qualify for authorship. These individuals may be listed as collaborators in an Acknowledgment or Article Information section.

Other contributors: Anyone else who contributed in some meaningful way and who is not an author or a nonauthor collaborator. These individuals can be listed under Additional Contributions in an Acknowledgment or Article Information section.

Author and Research Group Designations

Manuscripts reporting results of investigations based on team science typically involve large numbers of authors and non-author collaborators, often include multiple research consortia, and frequently have a designated group name representing the scientific team.

Reports of research based on team science research have several options for designating authorship, based on whether the author byline of the report includes the names of individual authors, the names of research groups, or the names of both.

In all cases, the following guidelines apply for *JAMA* and the *JAMA* Network journals:

1. All individuals named in the byline must meet authorship criteria and are designated as authors; all authors are required to complete authorship and disclosure forms and should indicate their specific contributions to the work, affiliations, and disclose potential conflicts of interest. Others who contributed substantially can be designated

as collaborators with their contributions and affiliations indicated in the Acknowledgment section of the article.

2. There is no limit on the number of authors for a report of research (provided the authorship criteria are met).
3. A long list of authors (eg, more than 50) may not fit in the space available for the author byline on the title page of the print/PDF version of an article, which also includes the title and abstract. In these cases, other options may need to be considered, such as publishing a group name only in the byline and listing the individual author members of the group in the Acknowledgment section along with their affiliations, contributions, and conflicts of interest disclosures. With this approach, all authors are listed in the order they appear in the group in the Acknowledgment section and in PubMed and the group name is also listed in PubMed.
4. The author byline may include the name of a research group or consortium in several ways, such as in combination with named authors or alone in the byline as described in the examples below. In each case, all author members of a group must meet the criteria for authorship and must be identified as authors (either in the byline or in the Acknowledgment section). Other nonauthor members of the group who contributed substantially should be listed separately as collaborators in the Acknowledgment section. If properly identified, all author members of the group and the group name as well as the nonauthor collaborators will be listed in PubMed.
5. More than 1 research group or consortia may be listed in the byline, provided there is justification and the above guidelines are followed.

In each of these cases, it is important to separately identify authors and nonauthor collaborators of a group or consortia. *JAMA* and the *JAMA* Network journals will publish the names of authors along with their affiliations, specific contributions, and conflict of interest disclosures in the article. Following the author information, the names of nonauthor collaborators are listed. PubMed has separate fields to list authors, group names, and collaborators.

The byline may include several possible authorship designations; the following are the most commonly used.

Individual Authors, No Group Name. Individuals who meet authorship criteria are listed in the author byline of the article, without the name of any research group. The name of a research group or research consortia involved with the study and the members of those groups could be listed in the Acknowledgment section at the end of the article. In PubMed, the individuals listed in the byline are designated as authors. The byline would appear as “Authors A, B, C, ...”

Individual Authors “for” a Research Group (All Members of the Group Are Not Authors). Individuals who meet authorship criteria are listed in the author byline of the article, followed by the name of the research group. The nonbyline members of the research group *are not* authors, but they may be formally listed as collaborators. The named authors are listed first, followed by an indication that they are serving as authors on behalf of or representing the research group, designated as “for” the research group. The name of a research group and the members of that

group are listed in the Acknowledgment section at the end of the article. In PubMed, the individuals listed in the byline are designated as authors, and the nonauthor members of the research group may be designated as collaborators. The byline would appear as “Authors A, B, C, ... for the Research Group”

Individual Authors “and” a Research Group (All Members of the Group Are Authors). Individuals who meet authorship criteria are listed in the author byline of the article, followed by the name of the research group. All members of the research group *are* authors as designated by “and” the research group in the byline. The name of a research group and the nonbyline author members of that group are listed in the Acknowledgment section at the end of the article. The individuals named in the byline and the individual author members of the research group are listed as authors along with the group name followed by any nonauthor collaborators in PubMed. The byline would appear as “Authors A, B, C, ... and the Research Group”

Research Group (All Members of the Research Group Are Authors), No Individual Authors Named in the Byline. The byline includes the name of the research group only without the names of individual authors. All author members of the research group are listed as authors in the Acknowledgment section at the end of the article. Any nonauthor members of the group who contributed substantially may be listed as collaborators in the Acknowledgment section. The PubMed record lists the individual author members of the research group and the group name followed by any nonauthor collaborators. The byline would appear as “The Research Group”

Subgroup of Authors “for” a Research Group (All Members of the Subgroup Are Authors), No Individual Authors Named in the Byline. The byline includes the name of a subgroup of authors who are members of the research group, such as a “writing committee” and the name of the research group, without including the names of individuals in the subgroup or the research group. All members of the subgroup are authors and are designated as authors in the Acknowledgment section at the end of the article. Any nonauthor members of the larger group who contributed substantially may be listed as collaborators in the Acknowledgment section. As in the previous example, the PubMed record lists the individual author members of the subgroup and the group name followed by any nonauthor collaborators. The byline would appear as “The Writing Committee for the Research Group”

Other Authorship Considerations

Designation of Author Contributions

To help allocate credit and accountability for contributions to a scientific article, *JAMA* and the *JAMA* Network journals collect self-reported information from all authors regarding their specific contributions to the report according to the ICMJE authorship criteria (such as study conception and design, data collection, and analysis) and to the manuscript (such as writing and reviewing), and publish these Author Contributions in the Acknowledgment section at the end of the article. The contributions listed in the *JAMA* Network journals’ Authorship Form may help team science researchers decide among themselves who qualifies for authorship and who should be

listed as nonauthor collaborators (Figure). It is the responsibility of each author to report this information accurately and honestly and to attest to the veracity of this information, and it is the responsibility of the corresponding author to review and approve this information in the final version of the article. This has become increasingly important as issues of reproducibility and transparency have emerged.

Recently, an initiative called Contributor Roles Taxonomy (CRediT), which follows the rationale for identifying specific contributions as recommended by the ICMJE, has been developed to provide “a classification of the diverse roles performed in the work leading to a published research output in the sciences.”¹⁴ The taxonomy includes the following roles: conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing (ie, original draft preparation), review and editing, visualization, supervision, project administration, and funding acquisition. This taxonomy is intended to identify contributions of all who contribute to research that is published, including authors and nonauthor collaborators, and may be helpful to researchers publishing in journals in disciplines other than biomedicine. This taxonomy could be expanded to ensure appropriate credit for authors who share data for others to reanalyze but prefer not to be authors of articles based on the reanalyses. Ensuring appropriate credit has emerged as an important issue in the discussion about sharing data.

Designation of Shared Author Responsibilities

Another trend in the era of team science has been the designation of shared responsibilities for key contributions to the manuscript. Most commonly, this designation involves shared credit as first authors (usually recognized as the principal investigator) or last authors (traditionally perceived as the “senior” author). In addition to reporting the specific contributions of these authors (along with the contributions of all authors), articles in *JAMA* and the *JAMA* Network journals can have designated “co-first” or “co-last” authors. Requests for more than 2 co-first authors or co-last authors will be considered but require detailed justification. There is a concern that the proliferation of shared responsibility (or designation) as first or last author makes it difficult to assess individual contribution to articles. For example, for a recent manuscript with a total of 8 authors, 5 authors requested to be designated equally as first author, and 2 to be designated equally as last author; it appeared only 1 author was willing to be listed in the middle. This request did not seem justified or practical, and indeed requests such as these may diminish what it means to be a first or last author.

Thus, the number of individuals claiming a shared position in the byline will be limited to a number that reflects the total number of authors. A designation of equal contribution or shared authorship position is reported in the Author Contributions section in the Acknowledgment at the end of the article, as follows: “Dr A and Dr B contributed equally as co-first authors.”

Other shared responsibilities, such as equal contributions to the data analyses, will not be specifically designated, but all who contribute to data analysis and other important ac-

tivities are designated in the Author Contributions section of the Acknowledgment.

In addition, the role of corresponding author requires designation of a single author who is responsible for fulfilling the important duties for that role, such as serving as the point of contact for responding to and resolving all questions and issues regarding the submitted manuscript and published article.^{10,11} Postpublication issues often arise that require coordinated attention (such as responding to letters to the editor or news media inquiries and correction of errors). At times, more serious concerns may arise that require investigation and resolution (such as undeclared conflict of interest or correction of pervasive data errors). Having a single person acting for and representing the entire author group has been invaluable in resolving these issues. Accordingly, articles published in *JAMA* and the *JAMA* Network journals will designate a single corresponding author. Requests for having up to 2 individuals listed as corresponding authors on a published article will be considered and require detailed justification. In such cases, 1 author must be designated as the point of contact responsible for all communication with the journal about the manuscript and article, and this person will be listed first in the Corresponding Author section of the published article.

Changes in Authorship

Once a manuscript is submitted to *JAMA* or the *JAMA* Network journals for evaluation and consideration for possible publication, any changes in authorship (such as adding or removing authors, or changing the order of authors in the byline) raise serious concerns and must be convincingly explained and approved by all coauthors. For example, the addition or removal of an author’s name from the author byline in a manuscript under consideration but before acceptance requires the following:

1. a detailed explanation from the corresponding author providing the reason for the change in authorship;
2. a detailed explanation from the individual who is being added to or removed from the byline, clearly explaining her or his contributions to the manuscript and indicating agreement with being added to or removed from the byline; and
3. a statement from the corresponding author indicating that he or she has obtained agreement for the change in authorship from all coauthors. This can be a copy of a document signed by all authors or a compilation of emails received from all coauthors.

These same requirements are necessary for any changes in the order of authorship listing in the author byline. Request for changes in authorship or in order of authorship after publication are rarely justified and would require all of the above information, and if justified, the letter of explanation would be published along with a formal Correction notice.

Resolving Disagreements Among Authors

Ensuring agreement among all authors, especially as the numbers of collaborating authors and institutions continue to increase with team science investigations, is the responsibility of the authors. Journals and journal editors are not in the position to evaluate, adjudicate, or resolve disagreements or

disputes among authors. In the case of substantial disagreement among authors involving a manuscript under consideration, *JAMA* and the *JAMA Network* journals will suspend evaluation of the manuscript until those disagreements are resolved satisfactorily among all authors and the journal receives documentation from all authors that demonstrates a satisfactory and appropriate resolution.

Authors of Opinion Articles and Brief Educational Articles

JAMA and the *JAMA Network* journals publish several types of opinion articles (such as Editorials, Viewpoints, Invited Commentaries, and Letters to the Editor) and brief educational articles (such as Clinical Challenge, Clinical Guidelines Synopsis, Clinical Evidence Synopsis, and others). Given their brief and focused nature, these short articles may include up to 3 individuals named in the author byline.¹⁰ Multiple authors or a group of authors may not be included in the byline. Other individuals who made contributions to the article or were involved in a larger report on which the article is based could be acknowledged at the end of the article. For examples of opinion articles with acknowledgments including other contributors, see the Viewpoints in the October 25, 2016, issue of *JAMA*.¹⁵ Although this limit on 3 authors may seem arbitrary, the so-called rule of 3 has been used for decades, such as limiting the maximum number of recipients to share some annual major prizes for science to no more than 3 individuals.¹⁶ Authors who are planning to prepare and submit manuscripts to *JAMA Network*

journals for consideration as opinion articles or brief educational articles should be aware of this policy and prospectively limit the number of authors of the manuscript.¹⁰

Conclusions

A dizzying array of authorship possibilities has emerged over the past few decades reflecting team science and concern about appropriate credit for those who have conducted or contributed to a research investigation. The definitions and policies for *JAMA* and the *JAMA Network* regarding authorship reflect what we believe represents current best practice, including ensuring that all authors, regardless of how they are named, fulfill authorship criteria and are appropriately listed in the publication of record and in PubMed and other bibliometric databases. Like all policies, these are subject to periodic reevaluation and modification as needed.

Team science has a critically important role in advancing biomedical research discovery, which reflects substantial scientific progress in many fields and advances in study design and analytic techniques. Team science not only requires rigorous attention to research methodology and scientific reporting, but also requires careful attention to authorship criteria to ensure that the efforts of those who qualify for authorship are recognized, that the contributions of those who do not qualify as authors are appropriately reported, and that the integrity of authorship in team science is maintained and its meaning and value are not diminished.

ARTICLE INFORMATION

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Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

REFERENCES

- Cooke NJ, Hilton ML, eds. *Enhancing the Effectiveness of Team Science*. Washington, DC: National Academies Press; 2015.
- Bauchner H, Golub RM, Fontanarosa PB. Data sharing: an ethical and scientific imperative. *JAMA*. 2016;315(12):1237-1239. doi:10.1001/jama.2016.2420
- US National Library of Medicine. Number of authors per MEDLINE/PubMed citation. <http://www.nlm.nih.gov/bsd/authors1.html>. Updated May 16, 2017.
- Muth CC, Golub RM. Trends in authorship in team science in major medical journals, 2005-2015. Presented at: Eighth International Congress on Peer Review and Scientific Publication; September 11, 2017; Chicago, IL. <http://peerreviewcongress.org/prc17-0167>.
- Venter JC, Adams MD, Myers EW, et al. The sequence of the human genome. *Science*. 2001;291(5507):1304-1351.
- International Human Genome Sequencing Consortium. Initial sequencing and analysis of the human genome. *Nature*. 2001;409(6822):860-921.
- Global Burden of Disease Cancer Collaboration. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015. *JAMA Oncol*. 2017;3(4):524-548. doi:10.1001/jamaoncol.2016.5688
- Tyrrell J, Richmond RC, Palmer TM, et al; Early Growth Genetics (EGG) Consortium. Genetic evidence for causal relationships between maternal obesity-related traits and birth weight. *JAMA*. 2016;315(11):1129-1140. doi:10.1001/jama.2016.1975
- International Committee of Medical Journal Editors. Recommendations for the conduct, reporting, editing, and publication of scholarly work in medical journals. <http://www.icmje.org>. Updated December 2016.
- JAMA* Instructions for Authors. <https://jamanetwork.com/journals/jama/pages/instructions-for-authors>. Updated November 15, 2017. Accessed November 28, 2017.
- Flanagin A. Authorship responsibility. In: Iverson C, Christiansen S, Flanagin A, et al, eds. *AMA Manual of Style: A Guide for Authors and Editors*. 10th ed. New York, NY: Oxford University Press; 2007.
- Rennie D, Flanagin A. Authorship! authorship! guests, ghosts, grafters, and the two-sided coin. *JAMA*. 1994;271(6):469-471.
- Greenland P, Fontanarosa PB. Ending honorary authorship. *Science*. 2012;337(6098):1019.
- CASRAI (Consortia Advancing Standards in Research Administration Information). CRediT. <http://casrai.org/credit>. Accessed November 16, 2017.
- Vital Directions from the National Academy of Medicine [theme issue]. *JAMA*. 2016;316(16):1615-1726. <https://jamanetwork.com/journals/jama/issue/316/16>.
- Goldstein JL. The rule of three for prizes in science and the bold triptychs of Francis Bacon. *Cell*. 2016;167(1):5-8. doi:10.1016/j.cell.2016.08.040

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