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Best Practice to Order Authors in Multi/Interdisciplinary Health Sciences Research Publications

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ABSTRACT
Misunderstanding and disputes about authorship are commonplace among members of multi/interdisciplinary health research teams. If left unmanaged and unresolved, these conflicts can undermine knowledge sharing and collaboration, obscure accountability for research, and contribute to the incorrect attribution of credit. To mitigate these issues, certain researchers suggest quantitative authorship distributions schemes (e.g., point systems), while others wish to replace or minimize the importance of authorship by using “contributorship”—a system based on authors’ self-reporting contributions. While both methods have advantages, we argue that authorship and contributorship will most likely continue to coexist for multiple ethical and practical reasons. In this article, we develop a five-step “best practice” that incorporates the distribution of both contributorship and authorship for multi/interdisciplinary research. This procedure involves continuous dialogue and the use of a detailed contributorship taxonomy ending with a declaration explaining contributorship, which is used to justify authorship order. Institutions can introduce this approach in responsible conduct of research training as it promotes greater fairness, trust, and collegiality among team members and ultimately reduces confusion and facilitates resolution of time-consuming disagreements.

KEYWORDS
Authorship; ethics and public policy; multidisciplinary research teams; publication; publication ethics; research integrity; responsible conduct of research

Introduction
In the contemporary system of science, the number of single authored published works in health science research is decreasing (Gingras 2014; Wuchty, Jones, and Uzzi 2007) while collaborative arrangements are increasingly commonplace. Teams must choose whom to name as authors in order to convey credit and responsibility for the work. Not all authors are considered equal on the byline; certain positions such as first, last, and corresponding author are highly coveted and considered more valuable in health science research (Bennett and Taylor 2003). Members of research teams may argue that they respectively merit a
particular authorship position based on the quantity and value of their work compared to others. This debate can be particularly contentious and complicated because the norms regarding authorship naming and ordering often differ depending on their respective discipline, fields, subfields, cultures, and institutions. As a result, disputes and grievances regarding authorship are commonplace (Dance 2012; Kwok 2005; Marušić, Bošnjak, and Jerončić 2011; Scheetz 1999; Wilcox 1998) giving rise to questions about the fair and equitable distribution of authorship (Master 2011).

Unethical practices regarding authorship distribution are prevalent. Including all research from 1970–2011, a recent meta-analysis (n = 118 studies) across various fields of research showed that 29% (pooled weighted average) of researchers reported that they or their colleagues had experienced misuse of authorship (Marušić, Bošnjak, and Jerončić 2011). Reports on authorship disagreements have been shown to be as high as 27% (Sandler and Russell 2005), 36% (Okonta and Rossouw 2013), and 66% (Nylenna, Fagerbakk, and Kierulf 2014). Generally, authorship misuse includes ghost authorship, which excludes individuals who have substantially contributed to the research (Lacasse and Leo 2010) and gift authorship where individuals are given authorship when they have made little to no contribution (Teixeira Da Silva and Dobrânszki 2015). Finally, naming authors in an order that is unfair or is not in keeping with scientific norms and values can also be considered authorship misuse. The high rates of unethical authorship practices are said to create a tense or even hostile work environments that undermines good communication and collegiality fundamental to the integrity of research (De Vries, Anderson, and Martinson 2006; Martinson, Anderson, and De Vries 2005; Marušić, Bošnjak, and Jerončić 2011).

To promote transparency and accountability, and mitigate authorship issues, many health journals include self-reported declarations whereby each author’s contribution is listed (ICMJE 2015; WAME 2007). Most contributor declarations—often called “contributorship”—outline general research tasks including, study design, data collection, analysis, and writing. While such declarations explain who did what, they remain vague as to the specific tasks done by each researcher and how much each researcher contributed to the project. Recent developments of more detailed taxonomies serve to further identify and clarify different sets of contributions including, for example, such tasks as methodological design, data curation, supervision, or project administration among others (Allen et al. 2014). Additionally, each task category is represented by a “badge” or icon which links to an online researcher identification website (Chawla 2014; Chawla 2015; Resnik 1997). This newer system of contributorship is being touted as the solution to authorship disagreements (Allen et al. 2014; Chawla 2014). Advocates maintain that it could be more important to researchers than authorship itself because it offers greater specificity respecting the nature of the contributions made by each individual. Although there have been some empirical studies regarding contributor declarations which do show how labor is
distributed in research studies, none have showed a link between authorship disagreement and contributorship (Bates et al. 2004; Flanagin et al. 1998; Hwang et al. 2003; Kovacs 2013; Larivière et al. 2016).

The use of authorship and contributorship in multidisciplinary and interdisciplinary (multi/interdisciplinary) teams in the health sciences adds further complexity due to clashes of disciplinary cultures and differences in values researchers attribute to various types of contributions. Despite the growth of multi/interdisciplinary research in many areas of health science, including public health, bioethics, women’s studies, and science and technology studies (Australian Research Council 2014), there has been little scholarly work undertaken respecting authorship order in such diverse, multi/interdisciplinary contexts. While there have been attempts to develop schemes to order authors based on a quantitative account of contribution, these mechanisms do not fully consider the diversity of multi/interdisciplinary practices of authorship, research methodology, and the types and value of different forms of contribution.

In this article, we outline a best practice that uses both authorship and contributorship to determine the order of authors in multi/interdisciplinary health science teams. We first demonstrate the diversity of values and practices in authorship distribution among different disciplines. Secondly, we argue that disciplinary proposals to order authors, which rely solely on quantitative measures of contributions, are unlikely to work in a multi/interdisciplinary context. While a few contributorship advocates suggest that contributorship should replace authorship, we explain why this is unlikely to happen. We propose a more feasible approach in which a detailed contributorship taxonomy coexists with and justifies authorship ordering. We promote an authorship distribution model for multi/interdisciplinary research based on collegial dialogue and decision-making among team members, which uses both authorship and contributorship to distribute merit and responsibility while also acknowledging the value and amount of work. Our procedure ends with a declaration in the article itself detailing contributions and justifying authorship order. To facilitate the implementation of this best practice, we recommend greater involvement of academic institutions (colleges, universities, and research institutes) in the oversight of authorship and training of researchers to promote fairer authorship practices. Responsible conduct of research training should discuss contributorship and authorship order in multi/interdisciplinary health sciences including showing researchers the diversity of authorship norms and practices, and providing helpful tools to order authors. Additionally, institutions have a responsibility to ensure researchers are treated fairly and receive due authorship credit and should develop services to better address authorship issues within multi/interdisciplinary teams.
Authorship attribution and order in multi/interdisciplinary research

International bodies comprising of academic journal editors have provided guidance as to who can and cannot be an author (ICMJE 2015; WAME 2007). The most widely adopted set of standards for attributing authorship in health science publications are the recommendations of the International Committee of Medical Journal Editors (ICMJE), which state as follows:

- 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. (ICMJE 2015, 2)

While the ICMJE criteria provide guidance on which contributions merit authorship, nothing is said about authorship order (Smith and Boulanger 2011; Smith and Williams-Jones 2011). Moreover, the ICMJE recommendations are tailored specifically to medicine and biomedical science and do not apply to all disciplines or multi/interdisciplinary fields (Master 2011).

Although requiring empirical confirmation, it seems logical to suggest that there is greater variation in authorship assignment and order among researchers who work in multidisciplinary and interdisciplinary teams. A discipline may be defined as a “department of learning or knowledge, a community of scholars who share common assumptions about training, modes of inquiry, the kind of knowledge that is sought, and the boundaries of the subject matter proper to the discipline” (Sulmasy and Sugarman 2010, 5). Multidisciplinary research involves the collaboration of researchers from multiple disciplines working together on a research project where different approaches and theoretical underpinnings are combined. On the other hand, interdisciplinary research involves the integration of information, results, methods, and theories from more than one discipline to address a research question (National Academies [U.S.] et al. 2005). While it remains difficult to differentiate between multi- and interdisciplinary, the degree of integration across disciplinary boundaries is an important feature in distinguishing them (Porter, Roessner, and Heberger 2008). Although multi/interdisciplinary research has been highly successful in delivering results, developing products and services, and influencing policy in the health sciences, it can also be challenging to manage interactions among team members from different disciplines.

Decisions about authorship order are often heavily influenced by disciplinary culture and tradition as different disciplines have preferred conventions and practices (Pontille 2004). For example, in the biomedical sciences, those who contribute most substantially to the article are often named first.
(usually a graduate student or postdoctoral fellow) and authors are ordered based on decreasing contributions while the last author is typically the Principal Investigator (PI) (Tscharntke et al. 2007). However, in the case of large biomedical science teams, some or all authors may be named in alphabetical order (Waltman 2012). Another growing trend in the health sciences is to attribute equal authorship for publications by placing an annotation beside one or more authors’ names to explain they have contributed equally (Akhabue and Lautenbach 2010; Dotson 2013; Wang et al. 2012). In health economics, accounting, and social sciences, authors are typically ranked alphabetically regardless of the type and amount of contribution (Chan, Chen, and Cheng 2009; Endersby 1996; Frandsen and Nicolaisen 2010; Van Praag and Van Praag 2008). In the case of philosophy, applied health ethics, health law, and other humanist disciplines, single authorship is still revered. While we represent these authorship positions as “typical practices,” there remains variation in authorship assignment and order within a discipline, groups, and individual projects.

The division of labor within a research discipline can significantly affect authorship order. Larivière and colleagues (2016) analyzed the distribution of contribution and empirically shown how labor distribution is field dependent. For example, biomedical research and clinical science research are particularly fragmented; often authors contribute separately and exclusively to one or two different research tasks. However, in many other disciplines such as mathematics, physics, and professional fields, i.e., law, multiple individuals often participate in several tasks throughout the research process. Also, the research task predominantly acknowledged for authorship varies according to discipline; in medical research, it is planning and the analysis of the data that is most valued while in other disciplines, such as the humanities, writing the paper is the principal task linked to authorship.

Given the significant diversity of labor distribution across disciplines, it is not surprising that conflicting norms regarding authorship distribution may lead to inequitable or biased outcomes. For example, bioethics is an interdisciplinary field comprised of health lawyers, ethicists, sociologists, philosophers, physicians, lawyers, nurses, and biomedical scientists among others. Many coming from the humanities disciplines may substantively contribute to conceptual arguments, develop counterarguments, and significantly edit the manuscript, but they may not receive authorship credit for their contribution if they do not write a major part of a conceptual research article. This is because of the high value humanists place on drafting the manuscript as is often the case in bioethics (Resnik and Master 2011). Yet, in this same multidisciplinary collaboration, researchers from medicine or the biomedical sciences may expect authorship credit for similar or less intellectual contribution because of a different understanding of intellectual contribution. For biomedical researchers, being part of the team and discussing a topic might
be sufficient to receive authorship credit even if they do not participate heavily in writing or critically revising the manuscript.

As different disciplinary cultures diverge in the value placed on different forms of contribution, multi/interdisciplinary fields are likely to see greater variation in authorship practices. This in turn may lead to differing opinions surrounding authorship distribution and potentially to authorship disagreements. With science becoming increasingly multi/interdisciplinary, a best practice for authorship order in such a context is needed and could be used as a tool to promote fairness and mitigate authorship conflicts. While authorship order procedures are proposed, their quantitative or disciplinary nature does not sufficiently consider a multi/interdisciplinary context.

**A critique of quantitative means to distribute authorship in multi/interdisciplinary research**

In disciplinary research, literature on the fair distribution of authorship has often included quantified evaluation schemes (e.g., point systems) to rank authors in an effort to make evaluation seem more “objective” (Ahmed et al. 1997; Belwalkar and Toaddy 2014; Bhopal et al. 1997; Gaeta 1999; Hunt 1991; Kosslyn 2002; Kovacs 2013; Paneth 1998; Clement 2014; Schmidt 1987; Sheskin 2006; Warrender 2016; Winston 1985). Quantitative schemes to order authors share common features, but also have several differences, as follows:

1. Research phases are described based on the ICMJE criteria (conception, data collection, data analysis and writing) but may vary in the details breaking down these four phases further;
2. Numerical values are assigned based on the magnitude and value of the type of contribution in each of the phases;
3. A minimal bar is set to determine whether a researcher can be an author by the research team or it may be pre-set as indicated in the model; and
4. Authors are ordered on the byline based on the total number of points accrued (see (Warrender 2016) for a thorough analysis of current models).

Although these schemes are noteworthy attempts and valuable to disciplinary research, such quantification models have three important shortcomings when applied to multi/interdisciplinary research.

First, quantitative models for authorship distribution have value-laden claims that are not universally accepted across all disciplines. For example, Clement (2014) developed a four-category model wherein each researcher must contribute to ideas, work, writing, or stewardship. Clement (2014) explains as follows:
Several ideas, especially the ones suggested in open forums such as group meetings or seminars, are primarily shared as technical suggestions; and no one really knows whether these suggestions are feasible ahead of time. Even great ideas require considerable amount of work and writing to bring to fruition. Therefore, in most cases, the weight assigned to ideas should be less than the weight assigned to work and writing which are the two most important elements. (352)

However, many scientists, including behavioral researchers, social scientists, bioethics scholars, lawyers, and biomedical scientists also draft conceptual research papers where they form well-articulated arguments in which the “ideas” are most valuable. While drafting the paper is important, fleshing out the idea, formulating potential counterarguments and points to refute them are equally important elements of conceptual research papers. At its very core, conceptual research has a different set of contribution that includes reviewing the relevant literature, analyzing and evaluating arguments, responding to objections and counter arguments, and writing the manuscript (Resnik and Master 2011). In another example, Ahmed et al. (1997) emphasizes greater value in conception of the research and is used to break the tie for first authorship because “conception is the key contributing factor, and the person with the highest score for this item should be first author” (43).

The value of different contributions typically takes place by assigning different points to individual contributions (Ahmed et al. 1997; Bhopal et al. 1997; Gaeta 1999; Hunt 1991; Kosslyn 2002; Kovacs 2013; Paneth 1998; Clement 2014; Sheskin 2006; Warrender 2016; Winston 1985). Creators of these models emphasize contributions they deem important—perhaps due to norms and practices in their discipline along with their personal experience. Since researchers from diverse fields place different value on types of contribution, quantitative schemes, by their very nature, remain difficult to apply in multi/interdisciplinary research. Moreover, as new research methods develop, potentially with increasing complexity and sophistication, or when novel methods become routine, quantitative approaches to authorship distribution may become stale as they cannot account for the value of different contributions. It is unlikely that contributions from differing types of projects will be accurately measured or captured within one universal point system; rather, the measurement must be adaptive to capture both the magnitude of work (e.g., time and effort), and its value and importance to the project (Dyck 2012).

A second limitation to several, but not all, quantitative models is their narrow scope in capturing different types of contribution and dependency on the general ICMJE criteria: conception and design, data collection, data analysis, and writing the manuscript (Ahmed et al. 1997; Gaeta 1999; Kosslyn 2002; Schmidt 1987). Many quantitative models discount various other forms of contribution or remain unclear as to how they fit under the
categories used in the model. Contributions in research are far more complicated and detailed than the general ICMJE criteria. While it remains unclear whether all contributions merit authorship credit or not, various contributions such as technical assistance, providing resources (e.g., reagents, access to patients, instrumentation), statistical expertise, project administration/management, supervision, either individually or accumulatively, could deserve authorship credit. For example, the ICMJE recommendations explain that obtaining funding by itself is insufficient for authorship credit, but it remains unclear whether many other contributions are worthy of authorship credit either independently or when combined. The changing landscape of research and the combination of different disciplines and fields make it a complex space, and it is unlikely that the abundant ways researchers contribute to a particular project can neatly fit within the general categories outlined in quantitative models, primarily based on the ICMJE criteria.

A final critique to quantitative accounts of ordering authors is a lack of consensus among them. Clement’s (2014) authorship matrix considers “ideas, work, writing and stewardship.” Sheskin (2006) contains many more elements: “state the problem (constructing the hypothesis and reviewing the literature), design the experiment (identifying the variables, developing the methodologies), conduct the experiment (designing instruments, collecting the data), analyze the data (validating data, interpreting results), and write the manuscript (drafting manuscript, critically revising the draft).” Similarly, Winston (1985) contains the categories “conceptualizing and refining research ideas, literature search, creating research design, instrument selection, instrument construction/questionnaire design, selection of statistical tests/analyses, performing statistical analyses and computations, interpretation of statistical analyses, drafting manuscripts (first, second and redrafts) and editing the manuscript.” Hunt (1991) proposes the categories of “intellectual input, data capture, data processing/organizing, specialist input from related fields, and drafting the manuscript”. Belwalkar et al. (2014) and Winston (1985) emphasize instrument design, and selection and analysis of statistical tests focusing on quantitative social science research methods. And Ahmed et al. (1997) add “implementation” as a major contribution since their proposal is geared towards community-based research because such projects require extensive implementation efforts. The lack of consensus between schemes complicates matters and makes their application in a multi/interdisciplinary context more difficult.

Quantitative schemes for authorship distribution are value-laden and their designers place greater emphasis on contributions they deem important in research. These models rely primarily on empirical methods and do not sufficiently consider the diversity of methods used in multi/interdisciplinary research. Several mechanisms call for some form of discussion among authors in order to determine value and contribution of team
members (Ahmed et al. 1997; Bhopal et al. 1997; Winston 1985). While some criticize having team discussions as subjective, it remains unclear how quantitative mechanisms actually differ from a purely discourse method as we propose below. Subjectivity of authorship ranking will always remain because the value and magnitude of contribution depends on disciplinary culture and practice, the methods used, and the context in which the research takes place. In this sense, it almost seems as if each team will have to decide on an appropriate quantitative authorship scoring system, which then becomes no less subjective than a discourse-based model. Given the difficulties in distributing authorship credit and ordering authors fairly, several scholars have called for greater transparency and accountability by using contributorship.

“New” contributorship lists should justify authorship order

In addition to dealing with the complex nature of multi/interdisciplinary context, there is intense competition for authorship positions and it is exacerbated by pressures placed on researchers by research departments, institutions, funders, and others in assessing productivity (Holleman, Cofta-Woerpel, and Gritz 2015; Holleman and Gritz 2013; Tijdink, Verbeke, and Smulders 2014; Tijdink, Vergouwen, and Smulders 2013). For example, Ph.D. students may require a certain number of first author publications in order to graduate. Faculty members seeking tenure or promotion may need either first, last, or corresponding author publications (Hundley, Teijlingen, and Simkhada 2013). Given the importance and need for authorship, and issues of unfair authorship practices, several scholars have called for greater transparency and accountability by using contributorship.

In the late 1990s, the concept of listing each author’s contribution was introduced by Rennie, Yank, and Emmanuel (1997) as well as Resnik (1997) as a means to enhance transparency and promote accountability. The notion of contributorship has since been espoused by ICMJE and other international journal editor organizations but usually remain limited to conception or design, collection of results, data analysis, initial drafting of the manuscript, or revision for important intellectual content (COPE 2011; ICMJE 2015; WAME 2007). Given this top-down direction, several medical and bioscience journals have included contributorship lists in published manuscripts (Rennie 2001).

Since contributorship categories are rather general and can apply broadly to a number of team members, accountability of individual authors and their tasks is often imprecise and unclear. For example, it would be difficult, if not impossible, to determine individual accountability for fraud in a situation where seven individuals have contributed to the collection of results and four to data analysis just from a general contributorship declaration. To address
these shortcomings, Allen and colleagues have suggested a more detailed taxonomy of contributions consisting of 14 different categories (Allen et al. 2014). For example, they identify three different writing categories: 1) the initial manuscript preparation or writing the initial draft, 2) the critical review, commentary of revision, and 3) the visualization/data presentation category. They also introduce novel contributorship categories including supervision, project administration, funding acquisition, data curation, and the provision of materials or resources i.e., reagents, biological samples, animals, instruments, and access to patients.

The addition of tasks traditionally omitted from authorship standards is a notable strength of the new taxonomy; it increases the level of detail beyond that of previous contributorship declarations. Also, it more accurately reflects the evolution of research contributions; the increasing administrative skills required in collaborative, multidisciplinary research arrangements; the expanding scope and complexity of data analysis; and, the growing reliance on sophisticated computation and other specialized skills which are now valuable contributions to be noted in scientific publications (Katz and Smith 2014). The new taxonomy can provide useful information for funding agencies and prospective employers interested in researchers’ specific skills.

Even if contributorship addresses critiques concerning inadequate detail regarding research roles and responsibilities, the literature respecting the association or interaction of authorship and contributorship remains divided, unclear and inconclusive. In the 1990s, contributorship was suggested to replace authorship altogether which would be a considerable shift in the scientific system (Rennie, Yank, and Emanuel 1997; Resnik 1997; Smith 1997). While advocates of the new contributorship taxonomy do not explicitly call for the elimination of authorship altogether, they do present it as a solution that supersedes authorship, noting that “[t]hrough the endorsement of individuals’ contributions, researchers can start to move beyond ‘authors’ as the dominant measure of esteem” (Allen et al. 2014, 312). Yet to date, authorship continues to be a dominant form of credit distribution and recognition in academic science. In fact, both contributorship and authorship should and will continue to coexist.

Allen et al.’s (2014) detailed contributorship taxonomy does provide greater clarity in defining tasks and accomplishments, but it also has several shortcomings. Firstly, it does not offer a measure of the quantity or value of a contribution. In this respect, the detailed contributorship proposal does not help to identify who did the bulk of the work or who contributed more significantly than others on a team mainly because the importance and value of categories of contribution will differ depending on the type of research project. For example, data collection and analysis may be relatively straightforward in one project, while considerably more knowledge, effort, and skill may be required in another project. Certain teams in the health sciences
might only do conceptual work and not have any empirical tasks; this would render the categorization of applied tasks inapplicable. Abolishing authorship could reduce emphasis on quantity and value and would risk associating responsibility and credit to the type of task of research regardless of its relative importance to the research. Understandably, researchers will continue to seek key authorship positions and the associated credit.

A second shortcoming of the taxonomy proposed by Allen et al. (2014) is that it remains unclear how much an individual must contribute to be listed as a “contributor.” Should contributorship categories be fully inclusive and provide lengthy lists of names of team members including those individuals who provide minor contributions? Should individuals be listed only for substantial contributions that would otherwise make them deserving to be named as authors? This then begs the question asked by many respecting the ICMJE recommendations: What constitutes a “substantial contribution?” In this regard, some quantification of work is, and will always be, necessary. While there has been criticism of the notion of “substantial contribution” in defining authorship (Laflin, Glover, and McDermott 2005; Osborne and Holland 2009), a detailed contributorship list may not provide further clarity on the matter. Typically, contributorship declarations lack any measurement or ranking to value individual contributions.

A third shortcoming is that it remains unclear how citation and referencing would work if authorship is completely dropped. While citation styles without individual names could be designed to shift emphasis on digital object identifiers (DOIs), the entire referencing system would require a substantial overhaul. Even if articles are referenced in another manner, researchers must still be named in some order in the manuscript; this in turn could serve as a potentially new metric to ranking authors thereby rekindling the debate that advocates of contributorship aim to avoid. Undoubtedly, disagreements over contributorship order would arise and persist.

Ultimately, with only a detailed contributorship model as developed by Allen et al. (2014) in place, funding agencies, university tenure and promotions committees, and dissertation committees would no longer be able to rely on authorship as a metric of performance. Institutions routinely draft policies on authorship in order to ensure a degree or level of scholarly contribution and rigor necessary for graduation, promotion, and tenure. Funding agencies also require a listing of publications and peer reviewers examine authorship placement within publications during the review of grants and awards. It remains unlikely that colleges, universities, and funding agencies would adopt contributorship without authorship. Even if authorship and its related metrics have been criticized for contributing to an already highly competitive environment (Allen et al. 2014), a lack of metrics would only lead to more subjective and
arbitrary evaluation and decision-making of scholarly contribution. Despite the value of a detailed taxonomy of contributions, authorship would be required to ensure accountability and to provide just rewards of research.

**A “best practice” for contributorship and authorship through consensual decision-making and self-reported declarations**

In a multidisciplinary context, different disciplinary cultures coexist and challenge the *status quo* of authorship norms; as such, it is timely and useful to design a process that builds on the strengths of authorship and contributorship to achieve a fair and less contentious dynamic for the naming and ordering research contributors in publications. While there have been processes developed to help name and order authors for industry-sponsored clinical trial publications (Marušič et al. 2014) and for multicentered publications (Devine, Beney, and Bero 2005), our proposal is novel and intended towards academic health researchers working within multi/interdisciplinary groups where inflexible protocols are unlikely to apply in all situations. Our best practice below describes how contributorship and authorship would interact and function practically to help health researchers name and order authors.

This best practice will never be a universal, inflexible protocol that individuals simply follow; rather, it serves as a starting point to engage individuals in discussing and resolving authorship and contributorship issues in a fair and collegial manner. It is our contention that constructive debate about exemplary practices can aid in developing practical guidance to help teams approach authorship and contributorship in a more productive and less controversial fashion. It is also not within the scope of this article to develop a detailed ethical framework of norms and values to support either contributorship or authorship distribution. For a more in-depth discussion on the ethical norms of authorship, we recommend the following sources (LaFollette 1992; Louis et al. 2008; Resnik 1998; Smith Forthcoming). Rather, we propose a “best practice” based on reasonable values to facilitate consensus and decision-making respecting authorship order in multidisciplinary health research. The suggested procedure consists of the five steps in Table 1 (for practical application, please refer to the supplementary information for a more detailed table).

The ICMJE recommends that discussions regarding authorship distribution should start when individuals are planning the work (ICMJE 2015). However, anecdotal evidence suggests that little or no discussion of authorship distribution or order happens at the outset of research. When individuals do talk about authorship, it is typically casual and unstructured; it may not involve all members of a team; and it seems to occur during manuscript
preparation or just before submission. This behavior may be due to reluctance and a degree of discomfort among researchers who think it presumptuous to discuss authorship before the project has begun.

We suggest a dynamic and noncontroversial approach to authorship and contributorship discussions. As the first step, team members should establish the roles and duties of individuals involved in the project at the outset of the project. They determine and agree as to who will do what, with the caveat that individual contributions may well evolve as the research progresses. The list of tasks provided in the detailed taxonomy of contributorship (Allen et al. 2014) would serve as a useful starting point in identifying and planning activities and outlining how work will be distributed. At this stage, it is important to establish leading roles, e.g., the researcher who will do the bulk of the research (likely the first author) and the PI overseeing the project in order to help establish key authorship positions.

At this juncture, team members should agree on a dispute resolution mechanism to address any authorship disagreements that might remain unresolved by the end of the project. No matter which ethical models, principles, and procedures are used, authorship decisions may remain difficult and complex. Although researchers are experts in their field with the best understanding of their own research, they may not be in the best position to compare and assess their own work relative to others. Teams need to acknowledge this caveat, which justifies developing the disagreement mechanism. Several scholars have discussed ways to resolve conflicts on morally contentious issues through dialogue (Gutmann and Thompson 2014; Master and Crozier 2012); we believe that this can help to resolve authorship conflicts. However, if assessment and dispute resolution is not possible among team members, a third party may help manage or adjudicate

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<td>Determine Authorship Order</td>
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<td>3</td>
<td>Continuous Dialogue</td>
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<td>4</td>
<td>Final Decision on Contributorship and Authorship Order</td>
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<td>5</td>
<td>Draft a Declaration on Contributorship and Authorship Order</td>
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problem areas. While outlining procedures for handling disagreements is beyond the scope of this article, we offer a few suggestions.

One procedure may involve having a neutral third party researcher or institutional administrator as arbitrator and decision-maker. Labs or teams can elect a neutral third party as an unbiased reviewer with no ties to any of the researchers in the project team. The research group should also make an earnest effort to accept the final decision of the third party reviewer. Moher and Altman suggest having a publication officer located within an institution to provide support and guidance to researchers in an attempt to improve accuracy in the publication process (Moher and Altman 2015). While the authors aim to improve research reporting in publications, publication officers, among other individuals, e.g., Research Integrity Officers (RIOs), may be ideal to help address authorship and contributorship issues. Universities are well poised to provide authorship mediation and resolution services as they do in other areas of conflict. However, in the absence of clear authorship order policies, which would not be conducive to the multiplicity of norms and practices of different disciplines, institutional officials may have difficulty resolving authorship disputes. It is for this reason why we suggest that members of a research team agree on a third party resolution system and make an honest effort to abide by the decision recognizing that some disagreements may not be resolvable. By having a dispute resolution system in place, issues surrounding power differences between junior and more senior researchers can be more readily addressed. In a separate section below, we further elucidate the role of academic institutions in helping address authorship disagreements.

As a second step, researchers must weigh individual contributions, and to the extent possible, order authors based on their amount of contribution to the project. Here, a minimum bar is also set for those who have contributed significantly enough would obtain authorship while others acknowledged. Individuals who do the most important and valuable work deserve greater recognition; however, this task is no small challenge. It is important to remember that while the fourteen-item taxonomy may be useful in describing who did what, it does not reflect the value and quantity of research contributions, which are extremely important to fairly order authors. In addition, although the detailed taxonomy has many categories for technical contribution, it does not adequately reflect the contributions used in conceptual work. As previously noted, elements of the taxonomy would rarely have equal or universal relevance or value across all research projects or diverse areas of the health sciences. For example, in some projects, data collection may constitute more than a quarter of the research effort while computational and statistical analysis may take up the bulk of effort. In other cases, the reverse may hold true. We suggest that, while the list provided by Allen et al. (2014) is extensive, researchers could modify it by adding
categories or tasks to better define the value and amount of each contribution pertinent to the research. Considering the diversity of contributions in multidisciplinary research, there must be discussion to reduce bias in prioritizing one type of work over another due to disciplinary preferences; this would mitigate unfairness. Valuing contribution is subjective, and it is for this reason that individuals must explain their subjective views concerning the importance of their work to others through open dialogue.

In most health research publications, authors are typically named in decreasing order based on contribution (Devine, Beney, and Bero 2005; Marušič et al. 2014); however, other types of orders are possible and acceptable in multi/interdisciplinary work. For example, some very large teams use partial or full alphabetical order (Waltman 2012). If contributions are relatively equal among several researchers in terms of time and value, then it would be acceptable to list authors alphabetically or with another means of distribution, such as an annotation mentioning equal contribution. In such cases, a hierarchical order could give the false impression that there were differences in contribution among team members when in fact they were similar. By contrast, if contributions were unequal, then ordering would be the most representative and further explained in a declaration. Authorship bylines can also contain partial order and equal contribution (e.g., co-first authors), while others are ordered based on decreasing contribution. In multidisciplinary research, several modalities can be used to order authors depending on the magnitude and value of individual contributions.

While the initial ordering of authors may be difficult because not all the work has been completed, Step 2 should begin relatively early in the project. While the authorship order at its earliest stage is susceptible to change, having a discussion and establishing a system of ordering authors is important to encourage collegiality, fairness, and buy-in of the contributorship and authorship order procedure. It may also have the advantage of having a more structured and organized work environment planning for research as a team where individuals know their roles in various projects and can tackle disagreements as soon as they arise or maybe even pre-emptively. It is equally important to explain at the outset that established authorship orders are susceptible to change as the project evolves and most likely after peer review of the manuscript where reviewers may request more data collection or analysis.

As research projects evolve over time, a third step is to have continuous and open discussions about authorship order throughout the project in order to address changes and agree upon any necessary adjustment of contributorship and authorship order. Individuals from a lab may leave, new ones may enter, the research may alter direction, and new skills and expertise may be required. As such, contributorship and authorship would need updating to
reflect these changes. Ultimately, project leaders should inform all team members of such adjustments.

Not everyone can easily accept the idea that the research process may change, and we maintain that the fluidity of research does not always justify change to the responsibilities and roles of individuals, and concomitantly, to authorship order. Modifications of authorship order are necessary only with valid justification based on contribution. This would involve a collegial approach of open and ongoing dialogue, periodic updates, and a degree of mutual respect. It should be noted that those in a research team who are not leading the project or the team may find it frustrating if their roles evolve constantly and the credit they expect to earn is not obtained. Ultimately, this approach would promote greater understanding and consensus building among team members, facilitate change, mitigate potential disputes, and foster greater team synergy.

The fourth step involves a final discussion on contributorship and authorship order prior to submission of the manuscript for publication. In cases where conflicts over authorship remain unresolved, the process of decision-making outlined in Step 1 can help arrive at a fair outcome. This discussion should reach a final agreement before publication. It is in the team’s best interest to have all authors agree about the naming and order of authorship prior to publication. Delays or retractions of publications due to authorship disputes during the peer-review process or after publication can be a significant deterrent to individual researchers, group dynamics, the institution, and science as a whole.

The fifth step involves drafting a declaration on contributorship and authorship order within the manuscript. While contributorship declarations are becoming commonplace in journal publications, no journal has yet to establish a declaration explaining authorship order. An authorship order declaration may be communicated in a separate section, footnote, or acknowledgement section of the manuscript. Because different norms and practices coexist in the health sciences (especially in multidisciplinary research contexts), the meaning of a particular authorship order may be understood or interpreted differently by the respective disciplines leading to confusion (Bhandari et al. 2014). Declarations can be instrumental in providing the clarity necessary to mitigate differing and erroneous interpretations of authorship order. For example, if a research team exceeds 50 or more individuals where many have contributed similarly, some of the researchers might be listed alphabetically, while others who have contributed more significantly can be ordered and this may be explained in the declaration. The authorship order declaration should align with the detailed description of contributions so that contributorship justifies authorship order. Many medical science journals have standardized the declaration of contributorship, which can be freeform or a checklist of contributions (Bates et al. 2004). As such, the declarations provided by authors of a paper have to conform to journal
specifications. If journal standards permit flexibility, we encourage contributor-ship declaration to spell out the magnitude and value of individual contributions beyond the general categories outlined in ICMJE, i.e., conception, design, data collection, data analysis, and writing. An alternative strategy would be to permit full and detailed disclosure by researchers using an online platform (Frische 2012) in addition to the contributor declaration practices offered by journals. The idea is that contributorship should reflect authorship and both should be declared, ideally in the manuscript, explaining and justifying authorship order.

A call for greater institutional support for authorship and publication ethics

To implement best practices, universities, colleges, and research institutes need to better support authorship and publication ethics. In Step 1 of our best practice, we discuss the development of a dispute resolution system among team members. This aims to preserve the autonomy of the research team in order to develop a fair and equitable mechanism to address areas of contention in authorship distribution. While continuous discussion alone is likely to help achieve consensus on authorship order among team members, there may be situations in which a neutral third party may be called in to handle unresolved disagreements. The onus of having a resolution system should not be placed only on researchers; institutions are well poised to have a mechanism to resolve authorship disagreements. While it is not within the current purview of RIOs to address issues of authorship, many such issues do fall on the laps of RIOs. Given their training and experience, and that they are arms distance length from the research team, RIOs may be able to exercise an objective view to address authorship disagreements. An ad hoc publications committee or a publications officer may also serve to address authorship disagreements among other issues as it relates to research ethics. It is beyond the scope of this article to delve into the role of research institutions in authorship and publication ethics, but it is clear that institutions can do their part. Despite the additional duties that may fall upon existing institutional officials or the creation of a new position, greater research ethics support for researchers is likely to prevent authorship misbehaviors and ensure that minor misbehaviors do not escalate into egregious ones in the conduct of research.

Responsible conduct of research education on authorship order in multi/interdisciplinary research

Training on the responsible conduct of research (RCR) is a core component to scientific training no matter the discipline (Kalichman 2014; Master et al. 2016) and is mandated in many countries (National Science Foundation [NSF] 2009;
National Institutes of Health [NIH] 2009; Resnik and Master 2013; Tri-Agency 2011). In the United States, the Office of Research Integrity, as well as researchers, have outlined several core areas of RCR education, one of which is publication practice and responsible authorship (DuBois et al. 2010; Office of Research Integrity 2000). While major RCR topics are well known, several studies show significant divergence in content, instructor knowledge, background, and experience, and the instructional methods used (DuBois et al. 2010; Kalichman and Plemmons 2007; Mastroianni and Kahn 1999; Steneck and Bulger 2007). While there remains no empirical studies examining what elements of authorship and publication ethics are discussed in different RCR courses, seminars, and workshops, it is likely that authorship order is probably not discussed as widely, especially in the context of different research disciplines. We argue that RCR instructors should place some emphasis on authorship order and explain different models for authorship distribution. Instructors should explain that authorship is a contentious topic and researchers are likely to face authorship disputes (Kalichman 2011). While ICMJE recommendations serve a useful starting point to discuss contributions warranting authorship and acknowledgements, they do not discuss authorship order. Some mention of the culture and variation in authorship assignment among different disciplines should be mentioned and various publications explaining authorship order could be provided to trainees. The goal here is to have researchers discuss authorship order from the get-go and to identify a model most suitable to their research. This extra discussion in the section on authorship and publication ethics will not take much more time or resources and can easily be incorporated in multiple ways.

Important limitations

Three important limitations to our best practice merits further discussion. First, the authorship scenarios presented in the paper may seem overly optimistic. Given the diversity of norms and values in multi/interdisciplinary health research, disputes in large teams may ensue and may not be resolved to the satisfaction of all authors using an agreed upon dispute resolution system. The dominant hierarchical structure in universities bestows greater influence to senior level researchers in team settings. In light of this reality, we do not suggest that our proposed procedure is a panacea. Rather, our contention is that in most cases, authorship disputes can be significantly reduced or alleviated when a process of open and collegial dialogue respecting authorship decisions is established at the forefront and maintained throughout the life of the project. This dialogue is especially important when new collaborators join a project or more research is required.
A second critique focuses on the amount of time and resources that would be required of busy researchers who are already managing many duties and research ethics responsibilities. They could balk at participating in a procedure for ethical authorship as another demand on their time. While we agree that there will be additional time required, it would likely not entail much more than limited email, phone, or face-to-face group discussions. As well, open discussion is an investment in time that can be valuable and rewarding over the long term; there may well be a net savings in resources and time. This procedure can generate increased benefits including openness and collegiality, greater collaboration, and productivity, and enhanced trust among researchers within a team. Open dialogue can mitigate bad habits passed onto trainees, an unhealthy team environment, and finally, a negative appreciation of the norms and values of science.

A third critique is that the best practiced proposed here does not adequately consider those who have been left out of authorship. While contributor lists demonstrate greater accountability and transparency, these are passive instruments with the onus placed on authors and project leaders to accurately self-report their contribution. Other mechanisms should be further developed to address cases where power dynamics may prohibit a researcher from deserved authorship. We explain that an ombudsperson, publication officers, research integrity officers and other university administrators should play a prominent role in ensuring fair distribution of authorship credit. Having a top-down, institutionally driven oversight of all researchers to ensure authorship and publication ethics compliance may be unnecessary as it is unlikely to preserve ethical authorship in multi/interdisciplinary health research because there are no steadfast rules. It is equally unlikely that all researchers and teams will require such strict compliance measures. However, in cases where individuals behave unfairly and use status and power for personal gain, having an internal process for dispute resolution over authorship will be beneficial. Such services should be made known to all researchers.

**Conclusion**

In this article, we discuss authorship guidance in relation to the renewed interest in detailed contributorship declarations. Such taxonomies may be beneficial in that they increase transparency and acknowledge contributions previously disregarded for authorship credit. Some advocates for detailed contributorship taxonomies present them as a solution to resolve authorship disputes and perhaps replace authorship. Yet there are a number of practical applications for authorship such as in citation or the evaluation of scholars.
While contributorship notes what tasks individuals have done, authorship order puts emphasis on those who have contributed the most to the research and rewards them appropriately.

We recommend the following way forward. First, we posit that authorship and contributorship are most likely to coexist and thus it is necessary to clarify their function and relatedness. The best practice proposed in this article outlines how both contributorship and authorship order should and can work together to promote fairness and open discussion, and reduce misinterpretation in authorship order. The procedure calls for continuous group dialogue where team members discuss their roles and contributions to determine and justify authorship order. We suggest that this process be the beginning of more thorough responsible conduct of research training regarding authorship that goes beyond existing definitions and guidelines to also discuss how contributorship and authorship is part of a multifaceted reward system that includes patents, acknowledgements, tweets, reader counts, and citations (Desrochers et al. 2015).

We postulate that fairness in authorship order is neither an objective ideal, nor can it be attained by simple quantification schemes, especially in multi/interdisciplinary research. Rather, we suggest that a collegial process involving individuals sharing their perspectives of research contributions (influenced by their disciplinary culture, norms, and values) and arriving at a mutual agreement to fairly distribute authorship credit holds tremendous value to the research team. While perhaps less “objective” at first glance, this model is much more realistic because it adapts to the contextual realities of multi/interdisciplinary research teams and innovation in research. We recommend that publishers consider and adopt detailed contributorship and authorship order practices and declarations, and that institutions aid in the promotion of authorship and publication ethics and have mechanisms to address potential disputes.

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