A Systematic Review of Research on the Meaning, Ethics and Practices of Authorship across Scholarly Disciplines

Ana Marušić1*, Lana Bošnjak2, Ana Jerončić1
1 Department of Research in Biomedicine and Health, University of Split School of Medicine, Split, Croatia, 2 Office for Science and Department of Research in Biomedicine and Health, University of Split School of Medicine, Split, Croatia

Abstract

**Background:** The purpose of this systematic review was to evaluate evidence about authorship issues and provide synthesis of research on authorship across all research fields.

**Methods:** We searched bibliographical databases to identify articles describing empirical quantitative or qualitative research from all scholarly fields on different aspects of authorship. Search was limited to original articles and reviews.

**Results:** The final sample consisted of 123 articles reporting results from 118 studies. Most studies came for biomedical and health research fields and social sciences. Study design was usually a survey (53%) or descriptive study (27%); only 2 studies used randomized design. We identified four general themes common to all research disciplines: authorship perceptions, definitions and practices, defining order of authors on the byline, ethical and unethical authorship practices, and authorship issues related to student/non-research personnel-supervisor collaboration. For 14 survey studies, a meta-analysis showed a pooled weighted average of 29% (95% CI 24% to 35%) researchers reporting their own or others’ experience with misuse of authorship. Authorship misuse was reported more often by researcher outside of the USA and UK: 55% (95% CI 45% to 64%) for 4 studies in France, South Africa, India and Bangladesh vs. 23% (95% CI 18% to 28%) in USA/UK or international journal settings.

**Interpretation:** High prevalence of authorship problems may have severe impact on the integrity of the research process, just as more serious forms of research misconduct. There is a need for more methodologically rigorous studies to understand the allocation of publication credit across research disciplines.

Introduction

Recently, PubMed – the largest bibliographical database in biomedicine made a new record in the number of authors on the byline of an indexed article: 2080 authors needed 165 lines on the PubMed site to spell out their surnames and initials. The paper was from high energy physics [1] and the number of authors probably did not surprise any physicist. It also probably did not surprise those involved in clinical trials, where the number of authors can also reach thousands [2]. But researchers in many areas of social sciences and humanities may expect to be sole authors, or perhaps discuss the senior authorship between a supervisor and a doctoral student [3].

Regardless of the practices in the number of authors, authorship and publication credit is the currency system of research and academic community, with both positive and negative implications [4]. To improve the practices of responsible authorship, it is important to understand the definition(s) of authorship, its impact on research productivity and roles of different stakeholders in the allocation of publication credit. The purpose of this systematic review was to evaluate evidence about authorship issues and provide a synthesis of research on authorship across research fields.

Methods

**Selection Criteria**
All articles describing empirical quantitative or qualitative research from all scholarly fields on the definition of or criteria for authorship, authors’ contribution to the research and manuscript, order of authors on the byline, opinions of researchers and/or editors on different aspects of authorship were selected for the review. We excluded articles describing research that used journal articles and their authors for analyzing collaborative or citation networks; authorship in the context of citation analysis; analysis of research collaboration outputs of institutions, groups, research fields; trends in authorship in journals, groups of journals, fields, institutions, countries, geographical regions; gender of authors in journals, groups of journals, fields, institutions, countries, geographical regions. Articles describing research on authorship attribution in literature, taxonomy, and psychology/cognitive research were also excluded. Articles that did not provide...
methodological and/or numerical information (such as found in letters and conference proceedings) were also excluded.

Database Search and Retrieval of Articles

Electronic databases were searched on 17 January 2011 using a general text search term ‘authorship’ to increase the sensitivity of the search. Where possible, the search was limited to original research articles and reviews. The search included all databases available from the on-line source of the Croatian Academic Network (CARNet); Databases included Agricola (1970 to 2011 Week 3); Business Source Complete (since 1896); CINAHL (since 1981); Current Contents (1993 Week 27 to 2011 Week 3); EBM reviews (2005 to 2011 Week 3), including Cochrane Database of Systematic Reviews, ACP Journal Club, DARE, CCTR, CMR, HTA, and NHSEED; ERIC (1965 to 2011 Week 3); GeoRef (since 1966); Food Science and Technology Abstracts (1969 to 2011 Week 3); INSPEC (1969 to 2011 Week 3); Library, Information Science & Technology (since mid-1960ties); MEDLINE (1950 to 2011 Week 3); PsycINFO (1967 to 2011 Week 3); SCOPUS (1960 to 17 Jan 2011); and Web of Knowledge (1991 to 17 Jan 2011), including Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI). There were no language restrictions. There was no attempt to search grey literature because our study was focused on authorship research in the mainstream science. Hand search of relevant journals was not performed because authorship topics are published in a variety of journals and because we used a sensitive rather than specific search; only the theme issues of JAMA, related to peer review conferences were searched by hand.

The titles and available abstracts of retrieved records were examined for possible inclusion in the review. Selected full text articles were used as a starting point for the berrypicking search, a technique which included footnote, citation and author searching [5], as well as searching of ‘Related citations’ feature in MEDLINE, where appropriate. Our own work and knowledge of the literature, as well as other experts in the field, were also used to find possible articles for inclusion.

Titles and abstracts of all retrieved articles were screened by one author to determine if they met inclusion criteria, and the selection was verified by the other author. Disagreements were discussed and full text articles were retrieved in cases of doubt for review and decision on inclusion. Full texts of the articles were reviewed by both authors; disagreements were resolved by discussion. A description of the population and extractable data were the minimum for the inclusion in the systematic review.

Analysis and presentation of findings

We used a data collection form (Table S1) to extract study type, intervention, setting, participant demographics, and outcome measures. Study quality was assessed on the basis of study design, sample size and sampling frame, response rate, and outcome measures. Disagreements in the assessment and data extraction were resolved by discussion and consensus. As most of the included studies were observational studies with heterogeneous measurements, we could not perform a statistical pooling of the results. Instead, we performed a qualitative synthesis of the results, providing a narrative description of the results. We also identified themes arising from the study results and assigned the studies to these defined categories.

For the percentage (proportion) of respondents who recalled their own problems or problems of colleagues with authorship issues (N = 14 studies), we were able to perform quantitative data synthesis. The data were transformed with Freeman-Tukey variant of the arcsine square root [6]. Pooled effect size was calculated as the back-transform of weighted mean of the transformed proportions, using DerSimonian-Laird weights for random effects model [6]. Homogeneity was tested with Cochran’s Q test based upon inverse variance weights [7]. Differences between groups of studies were tested with Mann-Whitney U test using inverse variance weighted averages. Publication bias was assessed with funnel plot Harbord bias indicator [6]. The statistical analyses were run on an SPSS software package 17 for Windows (SPSS Inc., Chicago, IL, USA), using the ‘MeanES’, ‘MetaF’ and ‘MetaReg’ macros by David B. Wilson [7].

Results

998 references were retrieved from the bibliographic database search (Figure 1). After excluding 7703 overlapping records, 1285 abstracts were screened for eligibility. After excluding 1109 records, 176 full text articles were assessed for the inclusion in systematic review. Out of these, 61 articles were excluded on the basis of full-text assessment because they did not present research results (N = 32), did not address authorship as defined in the inclusion criteria (N = 22) or had no extractable data (N = 7). The berrypicking search of full articles yielded 8 articles, and no additional relevant articles were identified by experts in the field. Thus the total number of included articles with original data was 123 [8–130], presenting 118 studies (list of articles in Table S2). All articles were published in English except 1 in Spanish, 1 in Portuguese and 1 in Dutch.

Most of the articles were published in health sciences (N = 66), including 52 studies from general medicine and/or biomedicine (1 study was presented in 2 articles [38,52]), 6 from nursing, and 7 from more than one research field. There were 33 articles from social sciences, including 12 studies from psychology, 12 from economics/business/marketing, 3 from social work, 2 from education research, 1 from information research and 3 from more than one research field. Out of 9 articles from natural sciences, 3 were from physics (results from 1 study presented in 2 articles [79,101]), 3 from chemistry (1 study presented in 3 articles [119,126,127]) and 1 each in agriculture and ecology. There were 15 articles covering more than one scientific area, where 2 articles presented results from 1 study [8,9]. No studies on authorship in humanities could be identified.

Most of the studies were performed in international science journals (N = 47) or in the USA (46 studies reported in 49 articles). Five studies were performed in Canada, 4 in Australia, 2 in South Africa, 2 in the Netherlands and 1 (2 articles) in the international physics laboratory in Europe (CERN). A study was performed in each of the following countries: Bangladesh, Brazil, Croatia, France, India, Iran, Pakistan, Spain, Sweden and UK. Finally, 1 study had respondents from both the US and Canada, and for 1 study it was not clear whether it was performed in the UK, US or both countries.

The design of most studies was cross-sectional survey (63 studies published in 65 articles), with response rates ranging from 16% to 100%. There were 32 descriptive studies (published in 34 articles), mainly literature analysis. One involved mathematical modeling [43], 1 was a test-retest study [94] and 1 combined a survey and intervention design [93]. Five studies were qualitative (1 published in 2 articles) [34,79,101,104,116,128] and 2 randomized [86,102]; there were 3 before-and-after studies [90,106,121] and 1 cohort study [92].

Many studies (N = 85) had methodological limitations. Out of 65 studies involving survey designs, 27 did not report details on survey development or testing. All before-and-after studies had no
controls. Out of 6 articles on qualitative studies, 5 did not report on the protocol and details of the sample or data analysis procedure or independent confirmation of identified themes and their analysis. Randomized studies involved questionnaires and were single blinded; 1 described piloting of the questionnaire. Quality assessment of the articles (Table S2) revealed that most studies had clearly stated objectives, but the description of the sample and sampling procedures sometimes lacked detail. Study findings were stated with varying levels of detail and in some reports it was difficult to discern the findings of qualitative and quantitative analyses.

The first identified study addressed the differences in name ordering of Nobel laureates from different disciplines in comparison to their colleagues in 1967 [8,9], followed in 1970 by a study on name ordering in physiology journal [10] and a seminal survey of publication credit assignment practices in psychology [11]. In the 80ties, there were only 7 studies across all disciplines, whereas the 90ties witnessed the increasing trend in authorship research, particularly in health sciences (Figure 2).

We identified 4 general themes studied across research disciplines: authorship perceptions, definitions and practices [n = 58 articles], defining order of authors on the byline [n = 45], ethical and unethical...
Authorship practices (n = 46), and authorship issues related to student/non-research personnel-supervisor collaboration (n = 19). Most of the articles explored one of these themes (n = 90), 21 explored 2, 11 explored 3 and 1 article addressed all 4 themes.

Authorship definitions, perceptions and practices

Fifty-four studies examined the perceptions of authorship buy different stakeholders, authorship definitions in use and actual practices, and contributions for deserving authorship (TABLE 1 and TABLE S3): 31 studies from the health research field [13,16,23,25,26,31,35,36,41,47,50,52,54,57,60,65,66,77,80,82,84,102,106,110–112,121];12 studies from social sciences [11,12,14,18,24,27,33,34,48,49,55,91], 6 studies from more than one research field [29,45,90,116,122,128] and 5 studies from natural sciences, published in 6 articles [46,58,79,101,119,126].

Conception of research/research design and writing the manuscript were identified as most qualifying contributions for authorship across different sciences, geographical regions and the time span from 1970ties to present [12,16,18,23,24,26,27,35,47–50,66,82,110]. Deserving authorship was not restricted or granted to researchers but to other member of the research team who made important contribution [13,14,16,36,41,55,126]. Recently, collective or community authorship has emerged in different disciplines involved in research with Indigenous communities [116]. In health research, the position of medical writers and statisticians/methodologists has been explored in more detail. Most professional medical writers would expect authorship when they contributed to the collection and/or analysis of data and contribute to the manuscript writing [103] but authorship as acknowledgment for medical writing assistance was reported by 16% or authors [52]. Methodologists were recognized as authors in 65% to 88% articles in general medical journals [54], and editorial teams of Cochrane review groups for systematic review/meta-analyses made important contributions to published articles [57].

Five surveys asked for a single contribution that would qualify for authorship: the most frequent choice for psychologists was choice of statistical method and data analysis (55%) [11], manuscript drafting for nursing professionals (53%) [13], design of the study for postdoctoral fellows from different disciplines (92%) [29], providing statistical advice on an ongoing basis for researchers at a medical school (92%) [31] and data interpretation or doing 20–50% of the work for business/non-business faculty (90%) [33]. In the latter study, more business than non-business faculty would grant authorship for only final preparation and submission of a manuscript (44% vs. 21%).

Several studies explored if stakeholders in research provided authorship guidance. A 1999 study of the professional organizations in the USA showed that up to 56% of them had non-specific criteria for authorship [45]. A recent study from Australia demonstrated that, even when there are national authorship policies, the universities do not fully comply with them [122]. Biomedical journals, which generally declare to follow the authorship criteria of the International Committee of Medical Journal Editors (ICMJE) [131], often do not explicitly state these criteria in their guidelines for authors or have outdated versions [60,100,111,112]. It is thus not surprising that just over 60% of authors in health research journals satisfy authorship criteria [24,39,41] and that many authors and editors are not familiar with such criteria or think they are not realistic or fair [31,39,41,65,66,77]. Similar lack of knowledge or use of guidelines was demonstrated for postdoctoral fellows or active researchers in physics in the USA [46,58] and faculty and students in psychology [48]. A study of postdoctoral fellows at the National Institutes of Health in the USA in 2007 showed that training in responsible conduct of research did not significantly change the awareness and use of authorship guidelines [90]. For faculty in departments of chemistry in the USA, the factors that explained the variance in influences on authorship decisions was graduate...
Table 1. Definitions of authorship, contributions for deserved authorship and authorship practices*.

| Article | Study population | Study topic |
|---------|-----------------|-------------|
| Spiegel, 1970 [11] | Psychologists in USA | Single contribution that qualifies for authorship; Preferred solution to multiple authorship |
| Bridgewater, 1981 [12] | Academic psychologists in USA | Agreement of respondents on qualifying contributions for authorship |
| Werley, 1981 [13] | Nursing professionals in USA | Single contribution that qualifies for authorship; Preferred solution to multiple authorship |
| von Glino, 1982 [14] | Professionals associated with management journals in USA | Opinion of editors vs. editorial review board on collection of data as deserving authorship contribution |
| Waltz, 1985 [16] | Health professionals in nursing in USA | Contributions that do not deserve authorship |
| van der Kloot, 1991 [18] | Social psychologists and psychometricians in The Netherlands | Scores on a continuum scale of deserving authorship for different contributions |
| Digiusto, 1994 [23] | University research staff in Australia | Value of contributions for deserving authorship |
| Floyd, 1994 [24] | Authors of articles published in management journals | Importance of contributions for authorship |
| Goodman, 1994 [25] | First authors or research articles in general medical journal | Prevalence of authors who satisfied ICMJE authorship criteria |
| Shapiro, 1994 [26] | First authors from USA of research articles in general medical journal | Most frequent contributions by all authors as reported by first author |
| Wagner, 1994 [27] | Single, first or second author in a psychology journal | Contribution importance for authorship |
| Eastwood, 1996 [29] | Postdoctoral fellows at a university | Sufficient contribution for authorship |
| Bhopal, 1997 [31] | Staff from university medical school in UK | Reported agreement with ICMJE authorship criteria; Contributions that alone merit authorship |
| Hamilton, 1997 [33] | Business and non-business university faculty in USA | Deserving joint authorship for a single contribution |
| Netting, 1997 [34] | University faculty and student in focus groups in USA | Emerging themes in authorship |
| Almeida, 1998 [35] | Mental health professionals (physicians and non-physicians) in Brazil | Opinions of physicians vs. non-physicians on contributions valid for granting authorship |
| Butler, 1998 [36] | Nurses expected to publish research in Canada | Agreement among nurses of different professional status on different authorship scenarios |
| Hoen, 1998 [39] | Authors of articles published in national general medical journal in The Netherlands | Awareness and fulfilment of ICMJE criteria |
| White, 1998 [41] | First authors of papers on nursing research from USA | Knowledge of authorship guidelines; Reported contributions to different aspects of manuscript; Prevalence of articles with all authors qualifying for authorship |
| Rose, 1999 [45] | Ethics statements from scientific professional organizations in USA | Prevalence of statements on authorship in ethics codes |
| Tarnow, 1999 [46] | Postdoctoral fellows in physics in USA | Knowledge of association authorship guidelines; Discussion of authorship criteria with supervisor; Criteria for designating postdocs or others as authors |
| Yank, 1999 [47] | Articles in general medical journal | Contributions declared for authors and persons in acknowledgment lists |
| Bartle, 2000 [48] | Faculty and students from psychology departments in USA | Most important contributions for authorship; Opinion of students vs. faculty on APA ethical guidelines |
| Hart, 2000 [49] | Co-authors of papers in library science | Importance of research tasks for authorship |
| Price, 2000 [50] | Faculty from institutions granting graduate degrees in nursing in USA | Criteria most important for authorship; Opinion on number of criteria needed for authorship; Role of journals in authorship issues |
| Phillips, 2001 [52] | Authors of articles in large and small medical journals | Acknowledgement of medical writing assistance as authorship |
| Altman, 2002 [54] | Authors of articles in general medical journals | Recognition of a methodologist as an author |
| Laband, 2002 [55] | Authors in economic and agricultural economics journals | Fraction of production team given authorship rights in economics vs. agricultural economics |
| Mowatt, 2002 [57] | Corresponding authors of Cochrane systematic reviews | Contributions of authors vs. Cochrane editorial team |
| Tarnow, 2002 [58] | Members of American Physical Society (APS) | Use of APS authorship guidelines; Preference of authorship guidelines |
| Foote, 2003 [60] | Biomedical journals | No. journals without definition of authorship in guidelines |
| Cohen, 2004 [65] | Members of US and Canadian Academy of Pathology (USCAP) | Use of authorship guidelines; Expressed preference of authorship guideline |
| Etemadi, 2004 [66] | Editors of medical journals in Iran | Opinions on criteria for authorship |
| Pignatelli, 2005 [77] | Senior clinical researchers in France | Practices in authorship; Agreement with ICMJE criteria |
| Birnholz, 2006 [79] | Researchers in high energy physics | Themes in authorship in high energy physics |
| Burbonniere, 2006 [80] | Researchers at a clinical centre in Canada | Satisfaction with use of in-house authorship guideline |
| Dhaliwal, 2006 [82] | Faculty in teaching hospital in India | Acceptable criteria for authorship |
school education (31%), institutional or other sources (19%) and personal values (14%) [119]. Experience from a medical setting in Canada indicated that researchers may be satisfied with guidelines developed in-house [80], whereas a study of authors from clinical psychology journals demonstrated that the satisfaction with both the process and outcomes of authorship decisions significantly increases with the use of guidelines [91]. Authors from clinical psychology journals identified the first authors as the most common deciders on co-authorship, and indicated factors other than effort and contributions which affected authorship decisions: taking project leadership, loyalty or obligation, power issues, and publish or perish pressures, with tenured faculty giving significantly less value to these factors, being more satisfied with the process and perceiving themselves to have more power relative to others [91]. One study described the influence of a specific subfield, number of publications, county of PhD degree, and previous experiences with authorship in providing credit research contributions on the academic chemistry environment in the USA [126].

Although psychologists used to declare their contributions in published articles already in the 1970ties [11], contribution declaration was implemented by many medical journals only 20 years later [132]. This policy did not show any effect on the number of authors [106,121] and a test-retest study demonstrated that the reliability of contribution declaration forms used in journals is too low to warrant their use in making conclusions on authorship [94]. A randomized study in a medical journals demonstrated that using ordinal rating scale instead of binary ‘yes-no’ declaration of contributions significantly increased the number of authors satisfying the ICMJE authorship criteria [102].

Four studies, published in 5 articles, qualitatively explored authorship issues [34,79,101,104,128]. Although most of them had methodological limitations, they identified emerging themes on authorship in social sciences, high energy physics, biomedicine, and multidisciplinary teams in health research. All studies identified common social factors in authorship decisions, best summarized in the study of Louis et al from 2008 [104], which identified fairness, reciprocity and sponsorship as main guiding factors in making authorship decision by high-profile researchers in biomedicine. For high energy physics, where collaborations increase to thousand co-authors [1], the individual still remains the unit of the research effort but larger collaborations increases the range of contributions and includes both infrastructure and discovery efforts [79,101]. In such situation, it is particularly difficult for a young researcher to balance the practice of attributing credit to a large group with their individual need for recognition and promotion, so they have to develop pragmatic strategies for professional survival.

Table 1. Cont.

| Article                                      | Study population                        | Study topic                                      |
|----------------------------------------------|-----------------------------------------|-------------------------------------------------|
| Funk, 2007 [90]                              | NIH postdoctoral fellows in USA          | Awareness and use of authorship guidelines after RCR training |
| Geelhoed, 2007 [91]                          | Authors of research articles in clinical psychology journals | Most common opinions on authorship decision process |
| Ilakovac, 2007 [94]                          | Authors of research articles in general medical journals | Reliability of contribution declaration form for corresponding author |
| Wager, 2007 [100]                            | Guidelines for authors in medical journals | Presence of authorship guidance; Reference to ICMJE authorship criteria |
| Birnholtz, 2008 [101]                        | Researchers in high energy physics      | Emerging themes in authorship                   |
| Ivanis, 2008 [102]                           | Authors of research articles in general medical journal | Prevalence of authors satisfying ICMJE criteria when declaring contributions in a binary vs. ordinal rating scale |
| Lang, 2008 [103]                             | Experienced medical writers from USA    | Opinion on deserved authorship for medical writers |
| Louis, 2008 [104]                            | High profile researchers in biomedicine in USA | Identified guiding factors for authorship decisions |
| Baerloccher, 2009 [106]                      | Original research articles in general medical journals | Number of authors after introduction of contribution disclosure requirement |
| Pulido, 2009 [110]                           | Spanish authors in health who publish in international journals | Most important contributions for any author vs. first author; Knowledge of ICMJE criteria |
| Rowan-Legg, 2009 [111]                       | Guidelines published in biomedical journals | Prevalence of journals with authorship addressed in guidelines |
| Samad, 2009 [112]                            | Pakistani medical and dental journals   | Prevalence of journals with no guidance on authorship |
| Castleden, 2010 [116]                        | Researchers involved in research with Indigenous communities in Canada | Collective/community authorship as emerging practice |
| House, 2010 [119]                            | Faculty from departments of chemistry in USA | Factors explaining deserved authorship; Factors explain and influences on authorship |
| McDonald, 2010 [121]                         | Articles from medical journals          | Influence of authorship restriction policies on number of authors, 1986 to 2006 |
| Morris, 2010 [122]                           | All (n = 39) Australian universities    | No. universities with authorship policy and policy rating |
| Seeman, 2010 [126]                           | Faculty from departments of chemistry in USA | Situational differences in authorship decisions |
| Street, 2010 [128]                           | Staff and doctoral candidates in health research at Australian universities | Emerging themes in authorship |

*Abbreviations: ICMJE, International Committee of Medical Journal Editors; APA, American Psychological Association; NIH, National Institutes of Health, USA; RCR, responsible conduct of research.
*Partial or full replication or modification of questionnaire by Spiegel and Keith Spiegel, 1970 [11].
*Sub-analysis of data from Flanagin et al [38].
*The same study as Birnholtz, 2006 [79].
*House and Seeman [119] and Seeman and House [126] present results from the same study.

doi:10.1371/journal.pone.0023477.t001
Table 2. Order of authors on the byline*.

| Article | Study population | Study topic |
|---------|------------------|-------------|
| Zuckerman, 1967 [8] | Nobel laureates in USA and matched scientists | 1st authorship of laureates vs. others |
| Zuckerman,* 1968 [9] | Nobel laureates in USA and matched scientists | Ratio observed/expected frequency of papers with 6 or more authors and name order pattern for laureates vs. others |
| Over, 1970 [10] | Articles published in J Physiol 1961–1964 | Percent authors with A–E vs. P–Z surnames in a journal with alphabetical author listing |
| Spiegel, 1970 [11] | Psychologists in USA | Preferred method for authorship order when contributions are equal |
| Werley, 1981 [12] | Nursing professionals in USA | Preferred method for authorship order when contributions are equal |
| von Glinow, 1982 [14] | Professionals associated with management journals in USA | Preferred method for ordering authors |
| Over, 1982 [15] | Articles in psychology journals | Change in number of articles with alphabetical ordering of authors from 1949 to 1979 |
| Waltz, 1985 [16] | Health professionals in nursing in USA | Preferred method for authorship order when contributions are equal |
| Gay, 1987 [17] | Educators in nursing USA | Methods for determining authorship |
| Manton, 2006 [85] | Business faculty in USA | Opinion on method of listing authors |
| Laband, 2006 [84] | Articles in economics journals | Mean change in prevalence of alphabetical authorship in co-authored articles from 1974 to 1999 |
| Einaw, 2006 [83] | Faculty of economic or psychology departments, Econometric Society (ES) fellows, Nobel laureates and Clark Winners, authors of articles in economics journals in USA | Increase in probability for tenure status with each letter closer to the front of the alphabet; Percent multi-authored articles with alphabetical authorship in economics journals |
| Pignatelli, 2005 [77] | Senior clinical researchers in France | Practice of ordering authorship |
| Brown, 2006 [81] | Multi-authored articles from academic institutions published n marketing journals | Percent alphabetical ordering of authors |
| Hilmer, 2005 [74] | Faculty members of agricultural economics departments in USA and their publications | Prevalence of alphabetical authorship in co-authored vs. multi-authored articles; Estimated annual salary return to an additional article depending on alphabetical authorship |
| Apparao, 2005 [72] | Members of Society for Social Work and Research in USA | Opinions on method of listing authors |
| Moore, 2006 [87] | Authors of articles in educational research journals | Preferred method of authorship order |
Table 2. Cont.

| Article | Study population | Study topic |
|---------|------------------|-------------|
| Baezlocher, 2007 [89] | Articles in general medical journals | Satisfaction of ICMJE criteria 1 and 2, depending on byline position |
| Kuri, 2007 [95] | Chairs of surgery departments in USA medical schools | Likelihood for authorship position in regard to serving as chair |
| Mantov, 2007 [96] | Faculty of colleges of business in USA | Preferred method of listing co-authors |
| van Praag, 2008 [105] | Articles published in mainstream economics journals | Prevalence of articles with alphabetical authorship |
| Hu, 2009 [107] | Articles in biomedical or multidisciplinary journals | Increase in prevalence of equal first authorships |
| Maciejovsky, 2009 [108] | Faculty members and advanced graduate students from economics, marketing and psychology in USA/UK | Prevalence of alphabetical authorship; Preferences for credit to a position in multiauthored papers; Inferences based on authorship order |
| Akhabue, 2010 [115] | Original research articles from general medical journal | Trends in equal authorships from 2000 to 2009 |
| Chan, 2010 [117] | Multi-authored original research articles from academic real estate journals | Prevalence of alphabetical authorship from 1990 to 2006; Likelihood for alphabetical authorship |
| Frandsen, 2010 [118] | Articles from economics, library information science (LIS) and high-energy physics (HEP) journals | Yearly change in share of articles with alphabetic authorship from 1978 to 2007 |
| Walker, 2010 [129] | Corresponding authors of original research articles in medical journals | Opinion on authorship position with greatest merit for promotion; Practice of ordering authorship position |

*Abbreviations: ICMJE, International Committee of Medical Journal Editors.

**The same study as Zuckerman, 1967 [8].

Partial or full replication or modification of questionnaire by Spiegel and Keith Spiegel, 1970 [11].

doi:10.1371/journal.pone.0023477.t002

Authorship order

The order of authors on the byline was specifically addressed by 46 studies (Table 2 and Table S4): 22 studies from the health research field [10, 13, 16, 17, 22, 26, 28, 30, 36, 37, 41, 47, 51, 57, 59, 63, 65, 70, 72, 74, 81, 83, 85, 87, 96, 105, 108, 117], 18 studies from social sciences [11, 14, 15, 21, 27, 49, 55, 60, 72, 74, 81, 83, 85, 87, 96, 105, 108, 117], 5 studies from more than one research field [8, 9, 43, 84, 118] and 1 study from natural sciences [58].

For researchers in most sciences, the amount of work and not prestige or position were the preferred method for determining authorship order [10, 11, 13, 15–17, 36, 49, 51, 57, 59, 72, 77, 85, 87, 96, 108]. Notable exceptions were the fields of management research [14] and most areas of economy [21, 43, 55, 74, 81, 83, 84, 105, 108, 117], where alphabetical ordering of authors has been the norm for a long time. Economists calculated that with each letter closer to the front of the alphabet there was an increase in the probability to be tenured at top economy departments and receive professional recognition [83], as well as a significant increase of 0.41% in estimated salary return for an additional article with alphabetical authorship [74] and a 3.3% chance that 1% lower ranked alphabet letter would increase total and annual publication output in mainstream economics journals [105]. In real estate journals, likelihood for alphabetical authorship was greater in higher quality articles or higher academic ranking of authors or with authors from Europe [117]. Greater academic ranking or prestige, such as Nobel prize, was associated with more generosity in giving prominent place to collaborators or accepting alphabetical authorship [8, 9, 83]. Nobel laureates had more first authorship at 20 years of age but less when they were 40, compared to scientists matched in discipline, age, type of affiliation, and initial letter of the surname [8]. Alphabetical authorship seems to be a constant feature of economics journals and perhaps and emerging one for social sciences journals, with a mean increase in prevalence of 9.9% and 18.6%, respectively, from 1974 to 1999, compared to a sharp decrease of 47.8% in general journals such as Science and Nature, 82% in medical journals, and 39.1% in natural science journals in the same period [84]. A recent study analyzing changes from 1978 to 2007 confirmed that alphabetical authorship was stable in economics and common for authors in high energy physics, but decreasing for articles in library information research [118].

Several studies explored the importance of the author’s position on the byline, particularly in the field of biomedical research. Most prestige and greatest contribution was expected from the first author [26, 28, 30, 47, 59, 63, 89, 129], whereas seniority brought prestige with the last author position [22, 26, 37, 47, 59, 63, 95]. In medicine and multidisciplinary journals, there is a recent trend of equal authorship of the first 2 or more authors [107, 115].

Most of the researchers psychology, nursing and social work favored pre-study agreement as the best policy for ordering names on the byline [11, 13, 16, 72]. In medicine, this was reported as a common practice [129]. Only 5% of first authors from the USA on nursing research papers reported that they were aware of any agency or institution guidelines for authorship sequencing [41]. In physics, the probability of change after initial authorship list was determined was 4% for decrease and 12% for increase [58], similar to pathology researchers in medicine (3% and 18%, respectively) [65].

Ethics of authorship

Ethical and unethical practices in authorship and perceptions about them were analyzed in 51 studies (Table 3 Table S5): 34 studies from the health research field [13, 16, 17, 30, 31, 36, 38, 41, 42, 50, 53, 56, 57, 61, 62, 64, 65, 67, 69, 70, 73, 75, 77, 82, 86, 92, 93, 97, 99, 109, 114, 120, 123, 125], 10 studies from social sciences [11, 14, 18, 33, 68, 71, 76, 83, 91, 96], 3 studies from natural sciences [46, 58, 127] and 4 studies from more than one research field [29, 90, 107, 113].

In 4 studies that used variations of the same survey questionnaire [11], researchers in psychology and nursing showed agreement in their opinion on ethical authorship decisions: not giving authorship to a colleague who failed to keep agreement on study work and multiple publications from the same study, provided that there is indication that they are part of the same study [11, 13, 16, 17]. Across disciplines, adding undeserving authors or excluding deserving authors was considered unethical.
Table 3. Ethical and unethical authorship practices*.

| Article                  | Study population                                   | Study topic                                                                 |
|-------------------------|---------------------------------------------------|------------------------------------------------------------------------------|
| Spiegel, 1970 [11]      | Psychologists in USA                               | Ethical practices in granting authorship                                     |
| Werley, 1981 [13]       | Nursing professionals in USA                       | Ethical practices in granting authorship                                     |
| von Glinow, 1982 [14]   | Professionals associated with management journals in USA | Ethical practices in granting authorship                                     |
| Waltz, 1985 [16]        | Health professionals in nursing in USA             | Ethical practices in granting authorship                                     |
| Gay, 1987 [17]          | Health professionals in nursing in USA             | Ethical practices in granting authorship and publishing multiple publications from the same study |
| van der Kloot, 1991 [18] | Social psychologists and psychometricians in The Netherlands | Agreement about authorship between professors and junior researchers     |
| Eastwood, 1996 [29]     | Postdoctoral fellows at a university in USA        | Willingness to engage in giving undeserved authorship                       |
| Slone, 1996 [30]        | First authors from USA on papers from a radiology journal | Reported undeserved authorship for co-authors; Reasons for undeserved authorship; Time of decision on authorship |
| Bhopal, 1997 [31]       | Staff from university medical school in UK         | Reported problems with authorship; Gift authorship                          |
| Hamilton, 1997 [33]     | Business and non-business university faculty in USA | Views on unethical authorship practices                                     |
| Bulter, 1998 [36]       | Nurses expected to publish research in Canada      | Agreement among nurses about ethical issues in authorship                   |
| Flanagan, 1998 [38]     | Corresponding authors from USA on articles in large and small medical journals | Reported prevalence of research articles with undeserved or undisclosed or ghost authorship |
| White, 1998 [41]        | First authors from USA on papers on nursing research | Reported issues, problems and concerns about author inclusion or ordering |
| Wilcox, 1998 [42]       | Cases brought to university ombuds office in USA   | Authorship issues in cases 1991/92 vs. 1996/97                             |
| Tarnow, 1999 [46]       | Postdoctoral fellows in physics in USA              | Reported papers where supervisor did not satisfy APS guidelines; Reasons for inappropriate authorship |
| Price, 2000 [50]        | Faculty from institutions granting graduate degrees in nursing in USA | Experiences and opinions on unethical authorship practices                 |
| Reidpath, 2001 [53]     | Authors of articles published in general medical journal | Reported authorship was among stipulations for sharing data-set from their article |
| Mainous, 2002 [56]      | Corresponding authors of research articles in medical journals | Personal or professional concerns in authorship; Opinion on effective ways for authorship decisions |
| Mowatt, 2002 [57]       | Corresponding authors of Cochrane systematic reviews | Prevalence of honorary authors or ghost and honorary authors               |
| Tarnow, 2002 [58]       | Members of American Physical Society (APS)         | Probability that an additional author is inappropriate; Comfort for younger vs. older respondent to deny undeserving authorship |
| Hwang, 2003 [61]        | Research articles in medical journal               | Prevalence of undeserved ICMJE authorship                                  |
| Bates, 2004 [62]        | Research articles in medical journals with different contribution declaration forms | Prevalence of undeserved ICMJE authorship                                  |
| Buchkowsky, 2004 [64]   | Clinical trials published in medical journals      | Increase in author affiliation with industry from 1981/1984 to 1997/2000   |
| Cohen, 2004 [65]        | Members of US and Canadian Academy of Pathology (USCAP) | Probability that an additional author is inappropriate; Reported denying undeserved authorship |
| Marušić, 2004 [67]     | Research articles in general medical journal       | Prevalence of undeserved ICMJE authorship                                  |
| Meyer, 2004 [68]        | Editorial members of accounting journals and young accounting faculty members in USA | Perceived behaviour appropriateness/behaviour occurrence/actual knowledge of occurrence of co-authorship issues |
| Procyshyn, 2004 [69]    | Research articles on antipsychotic drugs in medical journals | Prevalence of authors affiliated with 3 pharmaceutical firms               |
| Szirony, 2004 [70]      | Nursing faculty members in USA                     | Formal teaching to graduate students about authorship credit in publications; Ethical decisions in authorship |
| Appgar, 2005 [71]       | Members of Society for Social Work and Research in USA | Unethical granting of authorship                                           |
| Freda, 2005 [73]        | Editors of nursing journals                        | Reported prevalence of ethical issues about authorship encountered in editorial work |
| Joubert, 2005 [75]      | Authors of research papers from university in South Africa | Reported prevalence of ethical issues in authorship                        |
| Mixon Jr, 2005 [76]     | Articles published in more and less prestigious economics journals | Ratio between number of authors and contributors in acknowledgment        |
| Pignatelli, 2005 [77]   | Senior clinical researchers in France               | Opinions and reported experience on gift and ghost authorship              |
Table 3. Cont.

| Article | Study population | Study topic |
|---------|------------------|-------------|
| Dhallwal, 2006 [82] | Faculty in teaching hospital in India | Reported conflict over authorship |
| Manton, 2006 [85] | Business faculty in USA | Reported experience of unethical granting of authorship |
| Marušić, 2006 [86] | Authors of articles in general medical journal | Prevalence of authors not satisfying ICMJE criteria in different forms of contribution declaration |
| Funk, 2007 [90] | NIH postdoctoral fellows in USA | Ethically appropriate responses to case vignettes at 3 time points after training on RCR |
| Geelhoed, 2007 [91] | Authors of articles in clinical psychology journals | Experiences about fairness and ease of authorship decision process |
| Gotsche, 2007 [92] | Clinical trial protocols and publications from Sweden | Prevalence of ghost authorship |
| Hren, 2007 [93] | Medical students with or without instruction on ICMJE criteria, physicians and medical faculty in Croatia | Opinions on eligible contributions for authorship |
| Manton, 2007 [96] | Faculty of colleges of business in USA | Reported that co-authors did very little/no work |
| Peppercom, 2007 [97] | Articles on breast cancer clinical trials in medical journals | Prevalence of pharmaceutical company authorship on published studies |
| Tungaraza, 2007 [99] | Published clinical trials on psychiatric drug treatment | Prevalence of industry-authored studies |
| O’Brien, 2009 [109] | Corresponding authors of original research articles in general medical journals | Reported experience or opinion unethical authorship |
| Wager, 2009 [113] | Editors of journals published by Blackwell | Reported experience of ethical issues in authorship |
| Ahmed, 2010 [114] | Participants in bioethics course in Bangladesh | Experiences of authorship conflicts |
| Lacasse, 2010 [120] | Public policies of academic medical centres in USA | Prevalence of policies banning ghostwriting |
| Nastasee, 2010 [123] | Articles in medical journals | Increase in acknowledgment of medical writing from 2000 to 2007 |
| Rose, 2010 [125] | Clinical trials published in oncology journal | Odds for authors reporting financial ties to industry: |
| Seeman, 2010 [127] | Faculty from departments of chemistry in USA | Experience of unethical behaviour in authorship |

*Abbreviations: NIH, National Institutes of Health, USA; RCR, responsible conduct of research.
*Partial or full replication or modification of questionnaire by Spiegel and Keith Spiegel, 1970 [11].
*The same study as House and Seeman [119] and Seeman and House [126].
doi:10.1371/journal.pone.0023477.t003

[14,33,36,50,68,70,71,77,90,109], but was reported to be a practice by 10% to 89% of the respondents [10,31,41,46,50,58,63,68,73,82,85,91,96,109,114,127]. Prestige was an important factor in deciding on authorship, as articles from more prestigious economics journals had more authors and fewer contributors in the acknowledgment than those from less prestigious journals [76]. The reasons for agreeing on inappropriate authorship were similar across disciplines and included the feeling of obligation, crediting past and future relationships, team responsibility, power relations [45,56,68]. In two studies that assessed the opinions of physicists and pathologists about ICMJE authorship criteria and authorship guidelines of the American Physical Society (APS), the probability that an additional author would not satisfy APS or ICMJE criteria was 23% vs. 67% for physicists [50], and 43% vs. 65% for pathologists [65].

Journal editors also reported experiences with authorship disputes, from 5% in nursing journals [73] to 30% in journals from a major publisher [113]. Despite the reported prevalence of authorship problems, editors did not consider them to be severe and were confident in their management of the problems [68,113]. Authorship disputes were reported as an increasing problem for institutions [42], but ethics training at institutions may not have prevented the problem [76]. The prevalence of ghost authorship was reported in the range from 2% to 75% [38,50,57,92,113]. The highest prevalence was found in clinical trial protocols that were later published [92]. Editors considered that there was an increasing trend of ghost authorship, but did not perceive it as a severe problem in their work [113]. Although a recent study demonstrated increasing acknowledgments of medical writing [123], only 20% of academic medical centers in the USA had policies that explicitly banned ghostwriting [120].

Only a few studies looked at the possible interventions to prevent undeserved authorship. The measures proposed by
Figure 3. Forest plot of reported rates of problems with or misuse of authorship in self- or non-self reports in 14 survey studies [31,41,46,50,75,77,78,82,85,91,96,109,114,126]. The area of a square represent sample size, horizontal lines are 95% confidence interval, diamond and vertical dotted line show the pooled weighted estimate. doi:10.1371/journal.pone.0023477.g003

Figure 4. Forest plot of reported rates of problems with or misuse of authorship in self- or non-self reports in 12 survey studies from USA, UK or international journals [31,41,46,50,78,85,109,126]. The area of a square represent sample size, horizontal lines are 95% confidence interval, diamond and vertical dotted line show the pooled weighted estimate. doi:10.1371/journal.pone.0023477.g004
researchers in medicine were publishing the statements on authors’ contributions or limiting the number of authors on a byline [31,56]. When authors made decision about authorship during planning rather than later stages, the prevalence of undeserving authors was smaller, 23% vs. 47% [30]. Although only 44% nursing faculty members in the USA reported formal teaching to graduate students about authorship credit [70], instruction on authorship criteria may increase awareness of ethical decisions about authorship. In a study that looked at how medical students rated different contributions which were both eligible or not eligible for ICMJE authorship criteria, students without any instruction rated critical revision of the manuscript and final approval significantly lower than students with such instruction [93]. In the cluster analysis of ratings by medical students with or without instruction on ICMJE criteria, physicians, and medical faculty, conception/design, analysis/interpretation, and manuscript drafting clustered together, with final approval clustering only for students with instruction [93].

Fourteen survey studies asked the participants if they personally experienced problems and/or misuse of authorship or observed it for other colleagues [31,41,46,50,75,77,82,85,91,96,109,114,126]. Between 1.5% and 71% of respondents replied affirmatively (crude unweighted mean = 31%, 95% CI = 21% to 41%). Meta-analysis yielded a pooled weighted estimate of 29% (95% CI 24% to 35%), with significant heterogeneity (Cochran’s Q = 11.26, df = 13, P = 0.0001) (FIGURE 3). The indicators of publication bias were not significant (Harbord bias = -3.26 (95% CI -7.22 to 0.69), P = 0.391). There was no difference in reported prevalence between studies from health and non-health research fields (W = 36; Z = -1.16; P = 0.245; inverse variance weighted Mann-Whitney U-test). Pooled weighted estimate for USA/UK/international studies was 23% (95% CI 18% to 28%) (FIGURE 4), compared with 55% (95% CI 45% to 64%) for non-USA/UK studies (FIGURE 5), with significant heterogeneity in the USA/UK/international sample (Cochran’s Q = 61.23, df = 9, P < 0.0001), which persisted even after stratifying studies by location. Non-USA/UK studies were homogeneous (Cochran’s Q = 3.98, df = 3, P = 0.264). The indicators of publication bias were not significant for both study groups (Harbord bias = -3.26 (95% CI -7.22 to 0.69), P = 0.390, for USA/UK/international group and -3.78 (95% CI -18.25 to 10.69), P = 0.463, for non-USA/UK group).

Power issues in authorship

The practices and perceptions about authorship decisions in supervisor/professor – student/non-research persons was assessed in 19 studies (TABLE 4 and TABLE S6): 11 studies from social sciences [11,19,20,44,48,68,71,78,91,98,130], 4 studies from the health research field [13,16,17,70], 2 studies from more than one research field [32,40] and 2 studies from natural sciences [88,124].

Fairness of the research collaboration between professor-supervisor and a student was an important issue in psychology. Surveys since 1970 showed that psychologists generally regard students as sufficiently expert to warrant the 1st authorship on their master or doctoral theses, even when faculty makes significant contribution to the work and manuscript writing [11,19,44,48,98]. They also generally regarded that any collaborator, regardless of their position or payment for the work, deserved authorship if they made substantial contribution to most aspects of research and writing [11]. Similar perceptions were reported in nursing [13,16,17,70], multidisciplinary areas [32,40], accounting research [68], social work [71], ecology [88], agriculture, and education research [130].

Using critical incident technique, psychologists identified “taking other’s ideas or manuscripts”, “failure to give credit”
Table 4. Authorship in researcher – student/non-researcher collaborations*.

| Article                        | Study population                        | Study topic                                                                 |
|-------------------------------|-----------------------------------------|------------------------------------------------------------------------------|
| Spiegel, 1970 [11]            | Psychologists in USA                    | Opinion on deserved authorship for students/non-researchers; Preferred outcome for student-professor collaboration |
| Werley,* 1981 [13]            | Nursing professionals in USA            | Opinion on deserved authorship for students/non-researchers; Preferred outcome for student-professor collaboration |
| Waltz,* 1985 [16]             | Health professionals in nursing in USA  | Opinion on deserved authorship for students/non-researchers                   |
| Gaye, 1987 [17]               | Educators in nursing in USA             | Opinion on deserved authorship for students/non-researchers                   |
| Costa, 1992 [19]              | Psychology students and faculty in USA  | Faculty vs. students views of authorship order for published dissertation with different level of faculty input |
| Goodyear, 1992 [20]           | Editorial board members and authors of psychology journals in USA | Reported critical incidents related to student research                      |
| Brown-Wright, 1997 [32]      | Graduate assistants and faculty members in USA | Assistance in analysis of research data warrants authorship for graduate assistant – faculty vs. Assistants |
| Rose, 1988 [40]               | Graduate students in physics, biological, engineering and social sciences in USA | Opinion on deserved authorship for students; Perceived reporting of authorship problems |
| Louw, 1999 [44]               | Academic and non-academic psychologists and masters' degree students in South Africa | Deserving first authorship by academics, non-academics and students |
| Bartle, 2000 [48]             | Faculty and students from psychology departments in USA | Agreement of faculty vs. students on authorship from student-faculty collaboration |
| Meyer, 2004 [68]              | Editorial members of accounting journals and young accounting faculty members in USA | Perceived behaviour appropriateness/behaviour occurrence/actual knowledge of occurrence of co-authorship issues between faculty and students |
| Szirony, 2004 [70]            | Nursing faculty members in USA          | Opinions on unethical authorship in student-professor collaboration          |
| Appgar, 2005 [71]             | Members of Society for Social Work and Research in USA | Opinions on unethical authorship in student-professor collaboration |
| Sandler, 2005 [78]            | APA members and students with a publication from student-faculty collaboration in USA | Involvement in and reporting of perceived unethical or unfair authorship assignment |
| Weltzin, 2006 [88]            | Participants of ecology meeting in USA  | Opinion on first authorship in student-professor collaboration                |
| Geelhoed, 2007 [91]           | Authors of articles in clinical psychology journals | Opinion of students vs. faculty on influences on authorship decision making |
| Tryon, 2007 [98]              | Doctoral students in school psychology in USA | Different opinions on first authorship in publications from dissertations |
| Picard, 2010 [124]            | Students and supervisors from agriculture school in Australia | Agreement on authorship issues between students and professors |
| Welfare, 2010 [130]           | Students and faculty from US universities with graduate studies in education | Opinion of students vs. faculty for common and recommended practices in authorship |

*Abbreviations: APA, American Psychological Association.
*Partial or full replication or modification of questionnaire by Spiegel and Keith Spiegel, 1970 [11].
doi:10.1371/journal.pone.0023477.t004

Discussion

To the best of our knowledge, this is the first systematic review of research on authorship across all scholarly disciplines. Our search did not identify any systematic review in individual disciplines, although there were a number of overviews and theoretical discussions, including the recent series of the authorship history, current practices, and educational activities in social sciences, engineering and biomedical and life sciences [133–137]. The review of 118 studies reported in 123 articles revealed the absence of experimental research on authorship but also outlined our current knowledge about authorship across research disciplines. The available evidence demonstrated the diversity of authorship perceptions but also universal themes: there was a common perception that the conception of research/research design and writing the manuscript were the most important qualifying contributions for authorship – across disciplines, geographical regions and time. Also, respondents from most disciplines would grant authorship not only to the researchers but also to all members of the research team who had made an and “giving unwarranted credit” as most important problems in faculty-student collaboration [20]. Doctoral students in psychology considered it more desirable and ethical for a student to develop the dissertation idea and also though that it was desirable and ethical for the student rather than advisor to be first authors [98]. Although authorship problems occurred [40,68,78], students were not likely to, or considered it effective to talk to the dean, file a complaint or contact a journal [40]. The reported reasons for no action were fear of negative consequences, events instigated by respondent, or incident not reaching the level of importance [78]. More psychology students than faculty thought that power differences influenced authorship and saw themselves as having less power than other authors [91]. For students in education research, all recommended authorship practices in offered scenarios was greater than perceived practice [130]. Also, students put a significantly higher authorship value to the research tasks usually given to students, such as collection of qualitative data, entering data into statistical program or analyzing them, writing literature review for the introduction section or writing methods section, and the total time spent on a project.
important but formally undefined issue across disciplines, with clear differences between the minority enforcing alphabetical authorship, such as economy research, and the majority allocating the position on the byline according to the type and quantity of contribution. Power issues in authorship, especially in regard to the relationship between the supervisor/professor and students or non-research members of the team were particularly important in social sciences. Taking other’s ideas or manuscripts, failure to give credit and giving unwarranted credit were identified as most important problems in faculty-student collaboration but were rarely reported.

Ethical issues in authorship were common to all disciplines. For the subset of 14 studies that reported results of surveys asking researchers about their own or others’ experience of problems with or misuse of authorship, we were able to perform a meta-analysis, the first such analysis for authorship. On average, 29% of the respondents acknowledged such experience. This prevalence of ethical problems in authorship is more than 10-fold greater than the 2% prevalence of research misconduct of fabrication, falsification or data modification, reported in the recent meta-analysis [7]. While authorship misuse is not considered misconduct but a ‘questionable research practice’ by many official research integrity bodies, including the Office of Research Integrity (ORI) in the USA [138], the prevalence estimated in our meta-analysis indicates that authorship problems may have a greater impact on research than ‘classical’ misconduct activities of fabrication, falsification and plagiarism. Furthermore, it can be argued that omitting or adding authors on an article represents falsification or fabrication which directly damages the integrity of the research process, particularly because authorship credit is the foundation of career advancement, esteem in scientific community and funding for research [133]. Although authorship as a research topic is dominant in biomedicine and health [132], we did not find differences in reported problems with authorship between studies from health and other areas. However there was a clear difference between 23% authorship misuse prevalence reported in surveys conducted in the USA or UK settings or international journals with dominant US/UK authorship [91,109] and 55% in settings outside of USA and UK, from France to South Africa and Bangladesh and India. The reasons why authorship problems are more prevalent in some countries and not in others is not clear. While the USA has two formal bodies to oversee and direct research integrity activities [139,140], UK does not have a formal body [141], so official structures for preventing misconduct could not be an explanation for the observed difference. France, as most of the countries in Europe except for Scandinavian countries [142], does not have such national bodies, and we could find no evidence for similar national bodies in South Africa, Bangladesh and India. A possible explanation for the high prevalence of authorship misuse in these countries may rather be their position in the mainstream science, either because of the smallness of their scientific communities or language barriers [143].

The results of our systematic survey and meta-analysis are limited primarily by the poor methodological quality of retrieved studies and their heterogeneity. Of the 118 studies, 95 (81%) were either surveys or descriptive studies. Many studies did not report on the construction and pre-testing of surveys of their sampling frames and often with unclear or incomplete reporting of study findings; examples include the lack of interval range for Likert scales and reporting of only means without measures of variability. There were only 8 studies that evaluated some kind of intervention in authorship [86,90,93,94,102,106,121] but all had methodological limitations, so the conclusions on the effects sizes of any intervention to promote responsible authorship practices were not possible. The two single-blinded randomized studies [96,102] and a test-retest study [94] of authorship declarations demonstrated that currently used forms for declaring authorship contributions as defined by the ICMJE criteria [131], most widely accepted in biomedical and health fields [4,132,136], were not reliable instruments to make conclusions on authorship. They also indicated that several cognitive problems involved in reporting authorship contributions either for oneself or for others. This may in part explain the findings from several studies that researchers often were not familiar with ICMJE criteria or thought that they were not realistic or fair [34,39,41,65,66,77]. These findings were also confirmed by qualitative studies, which identified issues in authorship that could not be addressed by normative instructions provided by formal authorship definitions and policies [34,79,101,104,116,128].

We deliberately performed a systematic review with a wide scope, sensitive but not specific search, inclusive of all study designs and focused on mainstream publications in international bibliographical indexes because we wanted to provide the synthesis of existing evidence in all research fields and to identify gaps in knowledge. Despite the limitations of the review and retrieved evidence, the results provide an outline of common themes for future research across disciplines. To study authorship definitions, perceptions and practice, there appears to be little scope for conducting more small descriptive surveys or descriptive studies with heterogeneous methodology. To understand how authorship credit is awarded, we may benefit from methodologically rigorous qualitative studies, as well as studies to identify sociological factors associated with authorship and its use and misuse. All these studies would be more powerful if they were conducted across multiple sites and disciplines. This would be particularly relevant to address the observed differences in prevalence of authorship misuse among different geographical settings in the meta-analysis. Testing different sample characteristics in larger, multi-site studies with standardized methodology may reveal important correlates of misconduct in authorship.

As the evidence shows that decisions on authorship are often not made according to the official criteria, there is a need for research into the role of moral vs. normative judgments on authorship [144]. Our recent analysis of authorship statements and definitions in scholarly journals and ethics codes of professional organizations showed that the tone of authorship statements in journals was mostly aspirational, formulating suggestions for best or desired practices, while the statements in ethics codes predominantly used a normative language, conveying minimal standards for practice in authorship [145]. Further research into these differences may provide better tools to promote the moral autonomy of individual researchers and an environment where ethical behaviour in authorship is the norm.

The nature of authorship decisions is also relevant for educational interventions to promote integrity in authorship, which is a rather neglected area both in education and in research [133]. For example, if authorship issues are exclusively a matter of convention, then educational interventions should aim at informing students about authorship criteria and providing opportunities for applying them in practice. If, on the other hand, authorship is, at least partially, a moral issue, then educational interventions targeting moral judgment would be more appropriate [146,147].

Research avenues outlined here are not possible without collaboration among different stakeholders and across geographical regions and research disciplines. Given the social responsibility of science and its collective impact on human lives, regardless of the discipline, professional development for responsible authorship
and other aspects of research should be subjected to the same valid and rigorous forms of evaluation and testing expected for health interventions, such as medicines and medical devices.

Supporting Information

Table S1 Data extraction form.

Table S2 Overview of included studies.

Table S3 Results of studies addressing the definition of authorship, contributions for deserved authorship and authorship practices.

Table S4 Results of studies addressing the order of authors on the byline.

Table S5 Results of studies addressing ethical authorship practices.

Table S6 Results of studies addressing authorship in researcher – student/non-researcher collaborations.

Acknowledgments

The authors thank Dario Sambunjak, MD, PhD, for his critical comments during the review of articles. This study was presented in part at the Committee on Publication Ethics (COPE) Seminar in London, 18 March 2011.

Author Contributions

Conceived and designed the experiments: AM. Performed the experiments: AM LB AJ. Analyzed the data: AM LB AJ. Contributed reagents/materials/analysis tools: AM LB AJ. Wrote the paper: AM. Critical revision of the manuscript: LB AJ.

References

1. Khachatryan V, Sirunyan AM, Tumasyan A, Adam W, Bergauer T, et al. (2010) First Measurement of Bose-Einstein Correlations in Proton-Proton Collisions at root s = 0.9 and 2.36 TeV at the LHC. Physical Review Letters 105: 032001.
2. King C (2007) Multiauthor paper redux: a new peak at new peaks. Science Watch Nov.-Dec. Available at http://scientific.thomsonreuters.com/pt/pdf/lt/ld/184096/smultiauthor.pdf. Accessed: 1 August 2011.
3. Fine M (2003) Reflections on the intersection of power and competition in reflecting teams as applied to academic settings. J Marital Fam Ther 29: 349-354.
4. Claxton LD (2005) Scientific authorship. Part 2. History, recurring issues, practices, and guidelines. Mutat Res 589: 31-45.
5. Bates MJ (1989) The design of browsing and berry-picking techniques for the online search interface. Online Review 13: 407-412.
6. Field AP, Gillett R (2010) How to do a meta-analysis. Br J Math Stat Psychol 63: 665-694.
7. Fanelli D (2009) How many scientists fabricate and falsify research? A systematic review and meta-analysis of survey data. PLoS ONE 4: e3730.
8. Zuckerman H (1967) Nobel laureates in science: patterns of productivity, collaboration, and authorship. American Sociological Review 32: 391-403.
9. Zuckerman HA (1968) Patterns of name ordering among authors of scientific papers - study of social symbolism and its ambiguity. American Journal of Sociology 74: 270-291.
10. Cleverdon CW, Davies D, Over R, Smallman S (1970) Citation idiosyncrasies. Nature 228: 1156-1157.
11. Spiegel D, Keith-Spiegel P (1970) Assignment of publication credits - ethics and practices of psychologists. American Psychologist 25: 730-747.
12. Bridgewater CA, Bernstein PH, Walkenbach J (1981) Ethical issues and the assignment of publication credit. American Psychologist 36: 524-525.
13. Werley HH, Murphy PA, Gosch SM, Gottesman H, Newcomb BJ (1981) Research publication credit assignment - nurses' views. Research in Nursing & Health 4: 261-279.
14. Von Glisow MA, Novelli L (1982) Ethical standards within organizational behavior. Academy of Management Journal 25: 417-436.
15. Over R (1982) Collaborative research and publication in psychology. American Psychologist 37: 990-1001.
16. Waltz CF, Nelson B, Chambers SB (1985) Assigning publication credits. Nursing Outlook 33: 233-238.
17. Gay JT, Lavender MG, McCord N (1987) Nurse educator views of assignment of authorship credits. Image - the Journal of Nursing Scholarship 19: 134-137.
18. Van der Koot W, Willemsen T (1991) Authorship and the order of authorship: Academic psychologists' assessments of the usefulness of contributions to a research project. [in Dutch]. Nederlands Tijdschrift voor de Psychologie en haar Grensgebieden 46: 368-378.
19. Costa MM, Gatz M (1992) Determination of authorship credit in published dissertations. Psychological Science 3: 354-357.
20. Goodyear R, Crego C, Johnston M (1992) Ethical issues in the supervision of student research: A study of critical incidents. Professional Psychology: Research and Practice 23: 203-210.
21. Mercuri B (1999) Citations and individuals: first authorship across the alphabet. Review of Agricultural Economics 15: 307-312.
22. Shullin DJ, Goin JE, Rennie D (1993) Patterns of authorship among chairmen of departments of medicine. Academic Medicine 68: 688-692.
23. Dignazio E (1994) Equity in authorship - a strategy for assigning credit when publishing. Social Science & Medicine 38: 55-56.
24. Floyd SW, Schweder DM, Finn DM (1994) Only if I'm 1st author - conflict over credit in management scholarship. Academy of Management Journal 37: 734-747.
25. Goodman NW (1994) Survey of fulfillment of criteria for authorship in published medical research. BMJ 309: 1482.
26. Shapiro DW, Wenger NS, Shapiro MF (1994) The contributions of authors to multiauthored biomedical research papers. JAMA 271: 438-442.
27. Wagner MK, Dodds A, Bundy MB (1994) Psychology of the Scientist. 67. Assignment of authorship credit in psychological research. Psychological Reports 74: 179-187.
28. Davies HD, Langley JM, Speeert DP (1996) Rating authors' contributions to collaborative research: the PICNIC survey university departments of pediatrics. Pediatric Investigators' Collaborative Network on Infections in Canada. CMAJ 155: 877-882.
29. Eastwood S, Derich P, Leash E, Ordway C (1996) Ethical issues in biomedical research: Perceptions and practices of postdoctoral research fellows responding to a survey. Science and Engineering Ethics 2: 89-114.
30. Stone RM (1996).Coauthors’ contributions to major papers published in the AJR: Frequency of undeserved coauthorship. American Journal of Roentgenology 167: 571-579.
31. Bhopal R, Rankin J, McColl E, Thomas L, Kauer E, et al. (1997) The vexed question of authorship: Views of researchers in a British medical faculty. BMJ 314: 1009-1012.
32. Brown-Wright DA, Dubick RA, Newman I (1997) Graduate assistant expectation and faculty perception: Implications for mentoring and training. Journal of College Student Development 38: 410-416.
33. Hamilton JL, Greco A (1997) Ethical questions regarding joint authorship: business and nonbusiness faculty perceptions on noncontributing authorship. Journal of Education for Business 72: 325-330.
34. Netting FE, Nichols-Casebolt A (1997) Authorship and collaboration: Preparing the next generation of social work scholars. Journal of Social Work Education 33: 555-564.
35. Almeida O (1998) Authorship of scientific articles: What do such authors actually do? [in Portuguese]. Revista ABP-APAL, 20: 113–116.
36. Butler L, Ginn D (1998) Canadian nurses’ views on assignment of publication credit for scholarly and scientific work. Canadian Journal of Nursing Research 30: 171–183.
37. Drenth JPH (1998) Multiple authorship - The contribution of senior authors. JAMA 280: 219–221.
38. Flanagin A, Carey LA, Fontanarosa PB, Phillips SG, Pace BP, et al. (1998) Prevalence of articles with honorary authors and ghost authors in peer-reviewed medical journals. JAMA 280: 222–224.
39. Hoepfner LA, Beykermann RC, Overbeke AJPM (1998) What are the factors determining authorship and the order of the authors’ names? - A study among authors of the Nederlands Tijdschrift voor Geneeskunde (Dutch Journal of Medicine). JAMA 280: 217–218.
40. Rose M, Fischer K (1998) Do authorship policies impact students' judgments of perceived wrongdoing. Ethics & Behavior 8: 59-79.
41. White AH, Coudert NA, Goodwin CS (1998) From authorship to contributorship. Promoting integrity in research publication. Nurse Educator 23: 26-32.
42. Wilcox IJ (1998) Authorship - The coin of the realm, the source of complaints. JAMA 280: 216-217.
43. Engels M, Gans JS, Grant S, King SP (1999) First-author conditions. Journal of Retrospective Research. 26: 439-441.
106. Baerlocher MO, Gautam T, Newton M, Tomlinson G (2009) Changing author counts in five major general medicine journals: effect of author contribution forms. Journal of Clinical Epidemiology 62: 873–877.

107. Hu X (2009) Identities of special authorship functions: Linear growth in the percentage of “equal first authors” and corresponding authors. Journal of the American Society for Information Science and Technology 60: 2378–2381.

108. Maciejewsky B, Budescu DV, Ariely D (2009) The researcher as a consumer of scientific publications: how do name-ordering conventions affect inferences about contribution credits? Marketing Science 28: 589–598.

109. O’Brien J, Baerlocher MO, Newton M, Gautam T, Noble J (2009) Honorary coauthorship: does it matter? Can Assoc Radiol J 60: 231–236.

110. Pulido M, Gonzalez JC, Sanz F (1994) Original articles published in Medicina Clinica (1982-1992) - number of authors, interval between acceptance and publication, and references [in Portuguese]. Medicina Clinica 103: 770–775.

111. Rowan-Zegg A, Weijer C, Gao J, Fernandez C (2009) A comparison of journal instructions regarding institutional review board approval and conflict-of-interest disclosure between 1993 and 2005. Journal of Medical Ethics 35: 74–78.

112. Samuel A, Khanzada TW, Siddiqui N (2009) Do the instructions to authors of Pakistani medical journals convey adequate guidance for authorship criteria? Pakistan Journal of Medical Sciences 25: 879–882.

113. Wager E, Faas S, Graf C, Robinson A, Rowlands I (2009) Science journal editors’ views on publication ethics: results of an international survey. Journal of Medical Ethics 35: 348–353.

114. Alamud HS, Hadi A, Choudhury N (2010) Authorship conflict in Bangladesh: an exploratory study. Learned Publishing 23: 319–325.

115. Alkaebu E, Lautenbach E (2010) "Equal" contributions and credit: an emerging trend in the characterization of authorship. Annals of Epidemiology 20: 860–871.

116. Castleden H, Morgan VS, Neimanis A (2010) Researchers’ perspectives on collective/community co-authorship in community-based participatory indigenous research. Journal of Empirical Research on Human Research Ethics 5: 23–32.

117. Chan K, Hardin JW, Liano K (2010) Author order conditions and co-authorship in real estate journals. Journal of Real Estate Literature, pp 1841–1851.

118. Frandsen TF, Nicolaes J (2010) What is in a name? Credit assignment practices in different disciplines. Journal of Informetrics 4: 608–617.

119. House MC, Seeman JJ (2010) Credit and authorship practices: educational and environmental influences. Accountability in Research-Policies and Quality Assurance 17: 223–236.

120. Lacasse JR, Leo J (2010) Ghostwriting at elite academic medical centers in the United States. PLoS Medicine 7: e1000230.

121. McDonald RJ, Neff KL, Rethlefsen ML, Kallmes DF (2010) Effects of author contribution disclosures and numeric limitations on authorship trends. Mayo Clinic Proceedings 85: 920–927.

122. Morris S (2010) Cracking the code: Assessing institutional compliance with the Australian code for the responsible conduct of research. Australian Universities Review 52: 18–26.

123. Nastasee SA (2010) Acknowledgment of medical writers in medical journal articles: a comparison from the years 2000 and 2007. Current Medical Research and Opinion 26: S6–S6.

124. Picard M, Wilkinson K, Wirthensohn M (2010) Perceptions and expectations of authorship: Towards development of an e-learning tool facilitating discussion and reflection between post-graduate supervisors and candidates. Ergo - The Journal of the Education Research Group of Adelaide 1: 21–33.

125. Rose SL, Krzyzanowska MK, Joffe S (2010) Relationships between authorship contributions and authors’ industry financial ties among oncology clinical trials. Journal of Clinical Oncology 20: 1316–1321.

126. Seeman JJ, House MC (2010) Influences on authorship issues: An evaluation of receiving, not receiving, and rejecting credit. Accountability in Research-Policies and Quality Assurance 17: 176–197.

127. Seeman JJ, House MC (2010) Influences on authorship issues: An evaluation of giving credit. Accountability in Research-Policies and Quality Assurance 17: 146–169.

128. Street JM, Rogers WA, Israel M, Braunack-Mayer AJ (2010) Credit where credit is due: Regulation, research integrity and the attribution of authorship in the health sciences. Social Science & Medicine 70: 1458–1465.

129. Walker RL, Syles L, Hemmelgarn BR, Quan HD (2010) Authors’ opinions on publication in relation to annual performance assessment. BMC Medical Education 10: 21.

130. Welfare I, Sackett C (2010) Authorship in student-faculty collaborative research: Perceptions of current and best practices. Journal of Academic Ethics 8: 199–215.

131. International Committee of Medical Editors (2010) Uniform requirements for manuscripts submitted to biomedical journals: Ethical considerations in the conduct and reporting of research: authorship and contributorship. Updated April 2010. Available at http://www.icmje.org/ethical_1author.html. Accessed 15 May 2011.

132. Rennie D, Yank V, Emanuel L (1997) When authorship fails - A proposal to make contributors accountable. JAMA 278: 579–585.

133. Kalichman MW (2011) Overview: Undererved areas of education in the responsible conduct of research: Authorship. Science and Engineering Ethics Science and Engineering Ethics 17: 335–339.

134. Borenstein J (2011) Responsible authorship in engineering fields: An overview of current ethical challenges. Science and Engineering Ethics 17: 355–364.

135. Plummons D (2011) A broader discussion of authorship. Science and Engineering Ethics 17: 389–398.

136. Macrina FL (2011) Teaching authorship and publication practices in the biomedical and life sciences. Science and Engineering Ethics 17: 341–354.

137. Bebeau MJ, Monson V (2011) Authorship and publication practices in the social sciences: Historical reflections on current practices. Science and Engineering Ethics 17: 363–388.

138. Strack N (2006) Fostering integrity in research: definitions, current knowledge, and future direction. Science and Engineering Ethics 12: 53–74.

139. Department of Health and Human Services (2005) Public Health Service policies on research misconduct. Federal Register 70: 28369–28400.

140. National Science Foundation (2002) Research misconduct. Federal Register 67: 11936–11939.

141. Mervicovitch H (2011) Is research safe in their hands? BMJ 342: d284.

142. Bosch X (2008) Integrity: Croatia’s standards unusual in much of Europe. Nature 454: 574.

143. Marusic A, Katavic V, Marusic M (2007) Role of editors and journals in detecting and preventing scientific misconduct: strengths, weaknesses, opportunities, and threats. Medicine and Law 26: 545–566.

144. Turmel E (1983) The development of social knowledge: Morality and convention. Cambridge: University Press.

145. Bonjuk L, Marusic A (2011) Prescribed practices of authorship in scholarly publications: survey of codes of ethics from professional bodies and journal guidelines across disciplines. Submitted manuscript.

146. Sell DJ, Olivardez M, Baldwin DC (1998) The amount of small-group case-study discussion needed to improve moral reasoning skills of medical students. Academic Medicine 73: 521–523.

147. Haidt J (2001) The emotional dog and its rational tail: a social intuitionist approach to moral judgment. Psychology Review 108: 814–834.