Quantification of Authors' Contributions and Eligibility for Authorship: Randomized Study in a General Medical Journal

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BACKGROUND: Assessment of authorship contribution is often based on unreliable questionnaires.

OBJECTIVE: To assess if the use of different formats for the disclosure of authorship contributions influences authors' compliance with the criteria of the International Committee of Medical Journal Editors (ICMJE).

DESIGN: Randomized study.

PARTICIPANTS AND MEASUREMENTS: Eight hundred sixty-five authors of 181 manuscripts submitted to the *Croatian Medical Journal* from January to July 2005 were randomly allocated into 2 groups: 456 authors (94 manuscripts) received an ordinal rating form to rate their contributions to the submitted manuscript in 12 categories on a scale from 0 (none) to 4 (full), whereas 409 authors (87 manuscripts) received a binary rating form to tick the categories in which they made a contribution.

RESULTS: The ordinal rating form identified twice as many authors (87.9%) as meeting the ICMJE criteria than the binary rating form (39.2%, $P < .001$). The group answering the ordinal rating form also had 5 times more manuscripts (71.6%) with all authors meeting the ICMJE criteria than the binary rating form group (15.5%, $P < .001$). The fraction of authors who reported contributions on each item on the binary rating form was similar to the fraction of authors who reported at least moderate participation to the same items on the ordinal rating form except "Final approval of the article."

CONCLUSIONS: Ordinal scales for reporting authors' contributions to manuscripts were more sensitive than tick boxes for assessing the appropriateness of authorship. The exception is "Final approval of the article," which should be considered a dichotomous variable and may not be appropriate for the ICMJE definition of authorship.

KEY WORDS: authorship; contribution disclosure form; International Committee of Medical Journal Editors (ICMJE).

Abbreviations

ICMJE	International Committee of Medical Journal Editors
CMJ	Croatian Medical Journal

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INTRODUCTION

The number and quality of published scientific articles are among the most important measures of a scientist's productivity. Publishing is often a requirement for academic advancement and brings considerable rewards,¹ especially if the articles are published in high-impact journals.^{2,3} The increasing pressure to publish was found to be associated with unethical research practices, such as gift authorship⁴ or ghost authorship.⁵ In an attempt to ensure honest practices, the International Committee of Medical Journal Editors (ICMJE) defined contributions making a person eligible for authorship on a scientific article.⁶ According to the ICMJE definition, authorship credit should be based on the following 3 criteria: (1) substantial contribution to the conception and design, acquisition of data, or analysis and interpretation of data; (2) drafting the manuscript or revising it critically for important intellectual content; and (3) final approval of the version to be published. An author should meet all 3 criteria to be credited an authorship.

Many biomedical scientific journals have adopted the ICMJE criteria,^{7–9} but there is still a considerable proportion of undeserving authors—persons on the byline who do not meet the ICMJE criteria.^{10–16} This proportion differs among journals, which can be at least partially attributed to the fact that journals use different disclosure forms for assessing authors' contributions.¹⁴ Our previous randomized study in a single journal showed that the way questions are formulated in the disclosure form affected the proportion of authors who were identified as not deserving authorship.¹⁵ This and other research from our journal¹⁶ also indicated that the contribution disclosure form should be regarded as a psychometric instrument assessing self-reported behavior with all its advantages and disadvantages.^{17–20} Consequently, the format of contribution disclosure forms should be carefully designed to obtain the truest representation of authors' contributions to the submitted work.

Psychometric research shows that offering a range of responses in a questionnaire provides a reference range for the respondent to assess the behavior to be reported, and the range of response alternatives influences the respondent's answer.^{17–20} To assess whether the kind of responses on a disclosure form would affect contribution disclosure and eligibility for authorship, we performed a randomized study among the authors who submitted their manuscripts to the *Croatian Medical Journal*

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(*CMJ*) comparing an ordinal response format with a binary response format. We hypothesized that the ordinal response format would identify more authors deserving of authorship according to the ICMJE criteria than the binary format.

PARTICIPANTS AND METHODS

The study included all manuscripts with more than 1 author that were submitted to the *CMJ* between January and July 2005 (181 manuscripts, 865 authors). Manuscripts were randomly allocated into 2 groups (Fig. 1) using the method of randomly permuted blocks.²¹ The corresponding authors of the manuscripts were e-mailed individual contribution disclosure forms for each byline author on their manuscripts and were asked to distribute the forms to their coauthors. Coauthors returned the completed and signed forms to the corresponding author who sent them back to the *CMJ*'s office by fax or regular mail.

According to previous research in which 60% of the *CMJ*'s authors did not meet the full ICMJE authorship criteria,¹³ we expected a similar proportion of undeserving authors in the binary rating form group and hypothesized that the opportunity to rate their contributions on the ordinal scale would reduce the prevalence of undeserving authors by at least 30%. To detect this difference in the prevalence of undeserving authors, we needed at least 54 authors per group to achieve the power of 0.9 with the level of significance set at $P=.05$.

Contribution Disclosure Forms

We used 2 types of contribution disclosure forms: ordinal rating form and binary rating form (Appendixes 1 and 2). Both types of

forms had the same contribution categories listed in the same order: (1) Analysis and interpretation of data; (2) Critical revision of the manuscript for important intellectual content; (3) Obtaining of funding; (4) Provision of study materials or patients; (5) Conception and design of the study; (6) Drafting of the manuscript; (7) Administrative, technical, or logistic support; (8) Acquisition of data; (9) Final approval of the article; (10) Statistical expertise; (11) Guarantor of the study; and (12) Other. Categories 1, 5, and 8 are included in the first ICMJE criterion; categories 2 and 6 in the second ICMJE criterion; and category 9 in the third ICMJE criterion. The forms provided no instructions or reference to the ICMJE authorship criteria.

The ordinal rating form (Appendix 1) asked authors to rate their contributions on a five-point Likert type scale: 0—none, 1—small, 2—moderate, 3—large, and 4—full, for each of the 12 contribution categories (88 manuscripts, 430 authors). The binary rating form (Appendix 2) offered the same 12 contribution categories and asked authors to tick the category to which they made a contribution (84 manuscripts, 396 authors). Contributions on both types of forms were listed in the same random order for all participants, as our pilot randomized study using ordinal rating forms with 3 random listings of 12 possible contribution categories showed that the order of the contribution on the form did not influence the proportion of undeserving authors (11.9% out of 226 authors vs 14.3% out of 210 authors vs 7.2% out of 208 authors; $\chi^2_2 = 5.472$, $P=.065$).

An author who met the ICMJE criteria for authorship,⁶ i.e., who contributed to at least 1 category included in each of the 3 ICMJE criteria, was considered a true or deserving author. An undeserving author was defined as a byline author who did not meet at least 1 ICMJE criteria for authorship.⁶ For the binary rating form group, we considered that a contribution was made

Figure 1. Flow of manuscripts and authors through the study.

if it was ticked on the list. For the ordinal rating form group, we used 3 different criteria for the declaration of sufficient author's contribution: "1—small," "2—moderate," or "3—large."

Statistical Analysis

The number of authors and affiliated institutions per manuscript and number of reported contributions per author were expressed as medians and 95% confidence intervals (95%CI). The Mann–Whitney *U* test was used to assess differences in the number of authors per manuscript and number of affiliating institutions between the groups. The Kruskal–Wallis test was used to assess the differences in the number of reported contributions. The chi-square test was used to assess the differences in the number of authors who did or did not satisfy the ICMJE criteria, as well as for comparison of manuscript characteristics. *P* values of <.05 were considered statistically significant. Statistical analysis was performed with SPSS for Windows (release 13, SPSS, Chicago, IL, USA) and MedCalc for Windows (7.1.0.1, MedCalc, Mariakerke, Belgium).

RESULTS

Nine manuscripts (5%) authored by 39 authors (4.5%) were excluded from the analysis because the authors did not return the contribution forms (Fig. 1). Category 12 (other) was excluded from the analysis because only 12 out of 826 authors reported this contribution, describing it as "submitting the article" (*n*=2), "translation and language editing" (*n*=6), and "collecting the literature" (*n*=4). The final sample consisted of 396 authors (84 manuscripts) who used the binary rating form and 430 authors

(88 manuscripts) who used the ordinal rating form (Fig. 1). The groups did not significantly differ in the number of byline authors, affiliations by country, number of affiliating institutions, type of manuscript and research field, or editorial decision (Table 1).

When we used the category "small" as sufficient for eligibility on the ordinal rating form, the ordinal rating form identified twice as many authors (*n*=378, 87.9%) as deserving authorship according to the ICMJE criteria than the binary rating form (*n*=156, 39.4%; $\chi^2_1 = 212.7$, *P*<.001). When we assessed eligibility for ICMJE authorship using the choice of "moderate" on the ordinal rating scale as sufficient for individual contributions, the number of deserving authors was still significantly higher than in the binary rating form group: 328 (76.3%) vs 156 (39.4%); $\chi^2_1 = 117.1$, *P*<.001 (Table 2). The difference remained significant even when the choice of "large" on the rating scale was considered as a sufficient contribution for authorship eligibility: 202 (47.0%) vs 156 (39.4%); $\chi^2_1 = 5.157$, *P*=.023.

Again when using "small" as sufficient for eligibility on the ordinal rating form, the group answering the ordinal rating form had 5 times more manuscripts (*n*=63, 71.6%) with all authors identified as deserving according to the ICMJE criteria than the group using the binary rating form (*n*=13, 15.5%; $\chi^2_1 = 54.9$, *P*<.001).

Authors answering the ordinal rating form reported contributions in more categories (median=9, 95%CI=9–10) than those in the binary rating form group (median=4, 95%CI=4–4; *P*<.001, Kruskal–Wallis test). Authors satisfying the ICMJE criteria in the ordinal rating form group reported more contributions than those in the binary rating form group: median=10, 95%CI=10–10 vs median=6, 95%CI=4–7; *P*<.001; Kruskal–Wallis test. The same was true for undeserving authors: median=5, 95%CI=5–6 in the ordinal rating form group vs median=3, 95%CI=3–3 in the binary rating form group; *P*<.001, Kruskal–Wallis test.

When responses to individual contribution items on the rating forms were analyzed, the fraction of authors who reported that they made an individual item on the binary rating form was similar to the fraction of authors who reported "moderate," "large," or "full" participation to the same item on the ordinal

Table 1. Characteristics of the Authors and Manuscripts in the 2 Study Groups

Parameter	Contribution disclosure form*		
	Binary rating response	Ordinal rating response	<i>P</i> value
No. of manuscripts	84	88	
No. of authors	396	430	.251 [†]
No. of authors from Croatia (%)	198 (50.0)	210 (48.8)	.738 [†]
Authors per manuscript, median (95%CI)	4.0 (4.0–5.0)	4.0 (3.7–5.0)	.799 [‡]
Institutions per manuscript, median (95%CI)	2.0 (2.0–2.0)	2.0 (2.0–2.6)	.914 [‡]
Type of article, no. of articles (%)			.643 [†]
Research articles	60 (71.4)	60 (68.2)	
Other	24 (28.6)	28 (31.8)	
Field of research, no. of articles (%)			.635 [†]
Basic science	17 (20.2)	16 (18.2)	
Clinical science	44 (52.4)	42 (47.4)	
Public health	23 (27.4)	30 (34.1)	
No. of accepted manuscripts (%)	33 (39.3)	27 (30.7)	.237 [†]

*Binary rating response—on a list of 12 possible contributions, a respondent had to tick off the contributions he or she made; ordinal rating response—a respondent had to rate each contribution on a scale from 0 (none) to 4 (full).

[†]Pearson's chi-square test.

[‡]Mann–Whitney *U* test.

Table 2. Number of Authors Satisfying the ICMJE Criteria for Authorship

Criterion	No. (%) of authors who satisfied the authorship criteria according to		
	Binary rating response	Ordinal rating response	
		Less strict criteria*	Strict criteria [†]
ICMJE criterion 1—conception and design/acquisition of data/analysis of data	339 (86)	423 (99)	398 (93)
ICMJE criterion 2—writing of manuscript/substantial revision	270 (68)	412 (96)	375 (87)
ICMJE criterion 3—final approval of manuscript	202 (51)	387 (90)	356 (83)
All 3 ICMJE criteria	155 (39)	377 (88)	328 (76)

All differences among the groups for all criteria were statistically significant (*P*<.05, χ^2 test).

*A contribution was considered justifiable if author's participation was at least "1—small" on a scale from "0—none" to "4—full."

[†]A contribution was considered justifiable if author's participation was "2—moderate," "3—large," or "4—full" on a scale from "0—none" to "4—full."

rating form (Fig. 2). This was true for both deserving and undeserving authors and for all contribution items except "Final approval of the article," the third ICMJE authorship criterion where the fraction of authors failing to report this contribution was the same for undeserving authors, regardless of the form they filled out (80.8% in the ordinal rating form group and 80.4% in the binary rating form group; Fig. 2a).

DISCUSSION

Our study showed that the use of an ordinal rating disclosure form for quantifying authors' contributions to a manuscript identified a significantly higher proportion of authors as meeting the ICMJE criteria than the use of binary rating disclosure form, which is a standard in most journals.¹⁴ The aim of our study was to assess how the format of the disclosure form influences authors' responses and not to discover truly deserving or undeserving authors. Because we performed a randomized

study and groups were comparable in all relevant characteristics, it is likely that the randomization assured equal distribution of truly undeserving and deserving authors in each group. Consequently, the fact that the 2 groups differed in the proportion of authors identified as deserving authorship may be best explained by authors' tendency to report their contribution on the binary rating form only when it was substantial, i.e., moderate or large according to the ordinal rating form. This was true for all contribution categories, except "Final approval of the article." The percentage of authors who did not report contribution to this category was similar for undeserving authors in both groups, indicating that authors perceive "Final approval of the article" as a dichotomous variable, whereas they perceive all other contributions as at least ordinal variables. Our finding that "Final approval of the article" is separate from other ICMJE contributions is in accordance with our previous study where "Final approval of the article" was sorted in the cluster of authorship contributions considered less important by researchers, separate from all others included in the ICMJE criteria.²²

Figure 2. Frequency of responses by deserving (first column) and undeserving authors (second column) about their contribution to the submitted manuscript, reported in a binary or an ordinal contribution disclosure form. For the binary form, the frequencies of "yes" (green) or "no" (dark red) answers are presented; and for the ordinal contribution disclosure form, the frequencies of 5 possible contribution intensities are presented: full (dark green), large (light green), moderate (yellow), small (orange), and none (dark red). Frequencies of contribution declaration responses are grouped as contributions required (a) and those not required (b) by the ICMJE authorship criteria.

The results of the study should be interpreted with several limitations in mind. The corresponding authors were asked to ensure that all forms were completed and returned to the editorial office. As our previous study showed that corresponding authors serving as proxies for their colleagues reported fewer contributions for these colleagues,¹⁶ in this study, we asked all authors to fill out and personally sign the contribution disclosure forms. In this way, although we could not fully control whether individual authors actually filled out the contribution declaration form themselves, we minimized the chances of disclosure forms being filled out by corresponding authors instead of their coauthors.

The lack of participants' anonymity in the self-assessment of desirable behavior could have also affected the accuracy of the answers.²⁰ However, the randomized nature of the study and the homogeneity of the study groups made it likely that the observed differences between the 2 study arms were real and attributable to the differences in the contribution disclosure form.

Another problem with the accuracy of authors' answers may arise from the fact that the authors who submit their manuscripts may try to excessively comply with or even falsify their contributions according to editorial expectations based on ICMJE authorship criteria to have their manuscripts accepted for publication. However, this was not likely to have affected our results because contribution declaration forms did not provide any reference or definition of the ICMJE authorship criteria. In our previous studies in the journal, we used binary forms containing the definition of the ICMJE authorship criteria and a statement that our journal endorsed these criteria,^{13,15,16} but the proportion of authors identified as undeserving in the binary form group (60%) was similar to the results of the present study. This would suggest that authors simply do not read or do not take seriously the instructions provided in the contribution disclosure forms. Socially desirable responding in authorship contribution forms occurs only when the forms were structured to give direct instruction on the ICMJE criteria and the number of required contributions.^{14,15}

In conclusion, we found that the ordinal rating scale identified a higher proportion of authors as being deserving according to the ICMJE criteria. This finding is in accordance with psychometric research of questionnaires^{18,20} and suggests that this type of contribution disclosure form may be a more sensitive method for assessing authors' contributions. As honest reporting of authors' contribution is an important item, its assessment should not be based on unreliable instruments,¹⁶ and further research should explore different response formats, such as visual analog scales.²⁰ Our findings indicate that "Final approval of the article" is an inherently different category from other contributions, and thus it should not be considered as a criterion for authorship but as an administrative demand similar to declaring the conflict of interest or signing a copyright transfer. Bearing in mind the findings of this and previous research from our group^{13-16,21} and others,^{4,23} which showed that "Final approval of the article" is the ICMJE criterion least satisfied and most poorly understood by the authors, we recommend a revision of the ICMJE criteria which would exclude "Final approval of the article" from the authorship criteria.

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Conflict of Interest: AM and MM are the editors-in-chief, DS is the senior editor, DH is the statistical editor, and AI is the manuscript editor of the Croatian Medical Journal.

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APPENDIX 1. ORDINAL RATING FORM

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