Perceptions of authorship criteria: effects of student instruction and scientific experience

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Objective: To analyse medical students', graduate students' and doctors' and medical teachers' perceptions of research contributions as criteria for authorship in relation to the authorship criteria defined by the International Committee of Medical Journal Editors (ICMJE).

Design: Medical students with (n=152) or without (n=85) prior instruction on ICMJE criteria, graduate students/doctors (n=125) and medical teachers (n=112) rated the importance of 11 contributions as authorship qualifications. They also reported single contributions eligible for authorship, as well as acceptable combinations of two or three qualifying contributions.

Results: Conception and design, Analysis and interpretation and Drafting of article formed the most important cluster in all four groups. Students without prior instruction rated Critical revision and Final approval lower than the other three groups. "Final approval" was a part of the least important cluster in all groups except among students with instruction.

Conclusions: Conception and design, Analysis and interpretation and Drafting of article were recognised as the most important of the ICMJE criteria by all participants. They can be considered independent of previous instruction or experience. Final approval and Critical revision should be actively taught as important authorship criteria to future scientists.

Authorship of a scientific article can bring substantial academic, social and financial benefits, and it is perhaps not surprising that the abuses of authorship have been documented.^{1–2} In an attempt to limit the abuses of authorship, the International Committee of Medical Journal Editors (ICMJE), a small working group of general medical journal editors, established a set of criteria that distinguish authors from other contributors. The criteria were first proposed in 1985,³ and revised in 2000⁴ to include the acquisition of data as a contribution that merits authorship. According to the present version of the Uniform Requirements for Manuscripts Submitted to Biomedical Journals,⁵ the ICMJE defines authorship as: (1) substantial contribution to the conception and design, or acquisition of data, or analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content; and (3) final approval of the version to be published. Authors are supposed to meet conditions 1, 2 and 3. More than 500 biomedical journals worldwide have embraced the ICMJE Uniform Requirements worldwide, but the proportion of authors who do not meet the strict ICMJE criteria remains relatively high even in those journals.^{1–9}

The cause of the observed discrepancy must be either in the criteria or in the authors. Some critics have claimed that ICMJE criteria are too restrictive and unrealistic.^{10–11} Others have shown that many researchers in biomedicine do not agree with ICMJE criteria¹² or do not even know them.¹³ The question remains as to which criteria for authorship would researchers agree upon. Moreover, it is not known whether the ICMJE criteria would be more widely recognised and accepted if they are systematically taught to medical students—that is, future researchers and authors. The aim of our study was to find out which contributions for authorship are considered to be most important by medical professionals with respect to their research experience. We also explored how a short instruction on the ICMJE criteria would influence medical students' perception of deserved authorship.

METHODS

Participants

Four groups of participants were recruited for the study (table 1), and all were made aware of their right to refuse to participate. The first group included second-year graduate medical students from the Zagreb University School of Medicine. This group received a 45-min lecture on responsible conduct of research but without any information or discussions about authorship criteria in subsequent seminars and group work. They received written instruction on authorship criteria at the end of the course. The second group included second-year graduate medical students who were briefly but specifically instructed on the ICMJE authorship criteria during a 45-min lecture on the responsible conduct of research. In both groups of students, the questionnaire was given 4 days after the lecture, during a seminar on analysis and presentation of data. We could not prevent personal contacts between the two groups of students, so we decided to question the uninstructed group first. In this way, the instructed group, who received the information about the ICMJE criteria and filled in the questionnaire 2 months later, could not influence the responses of the uninstructed group. The third group included graduate students attending graduate courses and doctors attending continuing medical education (CME) course "How to plan and write research". Graduate students and doctors attending the CME course were grouped together because they were both uninstructed on the ICMJE criteria, had a medical degree and were considered to be without substantial research experience. Courses attended by graduate students did not cover the issues of authorship and research integrity, and doctors attending the CME course filled out the questionnaire before the lecture on the responsible conduct of research. The fourth group included medical teachers experienced in scientific research—that is, those who have published at least five articles in journals

Abbreviations: CME, continuing medical education; ICMJE, International Committee of Medical Journal Editors

Table 1 Study participants and application of the questionnaire

Groups of participants	2nd-year graduate medical students		Postgraduate students and doctors	Medical teachers
	Uninstructed	Instructed		
Participants (n)	85	152	125	112
Assessment*	During the 1 st module of the mandatory course "Principles of Scientific Research in Medicine"	During the 2 nd module of the mandatory course "Principles of Scientific Research in Medicine"	During postgraduate and continuing medical education courses	By a postal survey
Time of assessment	March 2004	June 2004	Spring and autumn 2004	Autumn and winter 2004
Response rate (%)	100	100	100	72

*There was no time limit imposed for filling in the questionnaires handed out during courses. It usually took up to 30 min to complete the questionnaire.

indexed in Medline. They were selected from the list of medical teachers at all four schools of medicine in Croatia, and their publication record was ascertained by a Medline search.

The study was approved by the Ethics Committee of the Zagreb University School of Medicine.

Instrument

The questionnaire used in the survey consisted of two parts (appendix A). In the first part, participants were offered 11 possible contributions to the research article and were asked to rate their importance for qualifying a person as an author. Each contribution was rated on a four-point Likert-type scale (1, no importance; 2, little importance; 3, moderate importance; and 4, great importance). The four-point scale was used to prevent participants from choosing a mid-scale answer. Contributions were listed in the following order, with A, B, C, D, E and J being eligible for the ICMJE criteria:

- (A) Conception and design of the study
- (B) Analysis and interpretation of data
- (C) Drafting of the article
- (D) Critical revision of the article for important intellectual content
- (E) Final approval of the article
- (F) Provision of study material or patients
- (G) Statistical expertise (not analysis of data)
- (H) Obtaining funding
- (I) Administrative, technical or logistic support
- (J) Collection and assembly of data
- (K) Guarantor of the study

The ICMJE formula for authorship is (A or B or J) and (C or D) and E, meaning that only a combination of at least one contribution from each of the three groups qualifies someone as an author.⁵ The questionnaire itself did not show the actual ICMJE formula for authorship.

In the second part of the questionnaire, we explored which of the above-listed contributions or combinations of contributions the study participants considered sufficient for the authorship of a scientific paper. There were three possibilities, each represented in a separate question field: (1) the participants could consider a single contribution sufficient to qualify a person for authorship (eg, A or B or G or H and so on) (2) they could consider that a combination of two contributions would qualify for authorship (eg, A+B, G+H and so on) or (3) they could consider that a combination of three contributions would qualify for authorship (eg, A+B+G or B+G+H and so on).

Finally, participants were asked a single yes/no question is to whether they knew ICMJE criteria for authorship.

Statistics

We used the Kruskal–Wallis test to find the differences in importance ratings for each contribution among the four

groups. When the Kruskal–Wallis test showed a statistically significant difference among groups, the Mann–Whitney U test with Bonferoni correction for multiple comparisons was used for post-hoc comparisons. Using $\alpha = 0.05$ and Bonferoni correction for six comparisons, the difference between two groups was considered significant if $p < 0.008$. Only the results of these post-hoc comparisons are reported.

The frequency of appearance as an authorship criterion (single or in combinations of two or three) was counted for each contribution. We used four sets of data (mean importance, frequency as a single criterion, frequency in a combination of two and frequency in a combination of three) to perform a hierarchical cluster analysis using the between-groups linkage clustering method for each group of study participants.¹⁴

On analysing the combinations suggested by participants as authorship criteria, we counted the number of correct combinations according to the ICMJE criteria, and compared the four groups of participants using a χ^2 test. The same test was used to compare the four groups on their declared knowledge about the ICMJE criteria, as well as the differences in the number of correct ICMJE combinations stated by the participants who declared that they knew or did not know the ICMJE criteria. All analyses were performed using SPSS V.13 for Windows.

RESULTS

Generally, all participants considered Conception and design as the most important contribution for authorship (fig 1). However, the group of students without instruction on authorship criteria rated it significantly lower than graduate students and medical teachers (Mann–Whitney U test, $p < 0.001$). Analysis and interpretation of the data and Drafting of the article received lower ratings, but were still considered moderately to very important. Students without instruction rated Analysis and interpretation lower than teachers (Mann–Whitney U test, $p = 0.004$), and Drafting of the article lower than graduate students (Mann–Whitney U test, $p < 0.001$).

We found the effect of teaching on ratings of two contributions eligible for the ICMJE criteria—Critical revision of the article for important intellectual content and Final approval of the article. The group of students without instruction rated these two contributions lower than the other three groups (Mann–Whitney U test, $p < 0.001$, for all comparisons except for the difference between graduate students and teachers in rating Final approval of the article, where $p = 0.003$ and $p = 0.007$, respectively). On the other hand, the group of students who received instruction did not differ in their ratings of these two contributions from either graduate students or teachers.

Teachers rated the most recently added ICMJE authorship contribution* Collection and assembly of data lower than graduate students (Mann–Whitney U test, $p = 0.007$).

Graduate students rated non-ICMJE contributions Provision of study materials or patients, Statistical expertise and Obtaining of funding as more important than the other three groups (Mann–Whitney U test, $p < 0.001$ for all comparisons,

Figure 1 Importance of authorship contributions rated by medical students without prior instruction on International Committee of Medical Journal Editors (ICMJE) criteria (A), medical students with prior instruction on ICMJE criteria (B), graduate students and doctors (C) and medical teachers experienced in scientific publishing (D). White bars: 1, no importance; light-grey bars: 2, little importance; dark-grey bars: 3, moderate importance; black bars: 4, great importance.

except for difference from teachers in rating statistical expertise where $p = 0.007$). Guarantor of the study was seen as a moderately important contribution by all four groups.

We performed a cluster analysis to explore whether the contributions chosen by participants clustered similar to the ICMJE clustering of contributions into three criteria. The analysis showed that the most important cluster in all four groups of participants consisted of three contributions: Conception and design, Analysis and interpretation and Drafting of the article (fig 2). Final approval of the article was grouped into the lower-importance clusters' except for the group of students who were instructed on authorship criteria, where Final approval grouped into a more important cluster.

Self-reported knowledge of the ICMJE criteria was relatively poor among all groups of participants' except medical students who received instruction. The proportion of participants who reported knowing the ICMJE criteria compared to those who reported not knowing them was highest among students with instruction, lower among teachers and lowest among students

without instruction and among graduate students and physicians ($\chi^2_3 = 118.55$, $p < 0.001$).

We counted how many combinations of contributions suggested by study participants corresponded with the ICMJE criteria. Study participants used 160 out of 165 possible combinations of three contributions. Six combinations of three contributions would fully satisfy the ICMJE definition, but the number of participants who selected even one of those was negligible in all groups, except for the group of students with instruction on authorship criteria ($\chi^2_3 = 38.03$, $p < 0.001$).

DISCUSSION

All groups of medical students and professionals in our study considered Conception and design of the study, Analysis and interpretation of data and Drafting the article as the most important contributions that qualified a person for the authorship of a scientific article. These three contributions, which are included in the ICMJE criteria for the authorship,⁵ may thus be considered "intuitive", as the high importance awarded to

Figure 2 Clustering of authorship contributions as reported by four groups of participants. The contributions eligible for authorship according to the International Committee of Medical Journal Editors (ICMJE) criteria are in bold. A, Medical students without prior instruction on ICMJE criteria; B, Medical students with prior instruction on ICMJE criteria; C, Graduate students and physicians; and D, Medical teachers experienced in scientific publishing.

them neither depended on the instruction nor could be related to previous experience. Other contributions included in the ICMJE criteria—Collection and assembly of data, Critical revision of the manuscript and Final approval—were generally less acknowledged, but the effect of teaching was evident.

Naive students did not recognise the importance of Critical revision and Final approval, but their instructed colleagues did, just as doctors and medical teachers. It has been previously reported that the importance of Critical revision and Final approval of the article was well recognised by the authors of research articles.¹⁵ Our study showed that a simple instruction on the ICMJE criteria to medical students had a similar effect as years of experience in medical work or research.

The finding that medical teachers did not give a high rating to the Collection and assembly of data cannot be easily explained. One possibility is that teachers give less value to non-intellectual work but this remains a speculation because, to our knowledge, there is no published evidence to support this explanation. Another possibility is that teachers' decisions were guided by the older versions of the ICMJE criteria, to which Collection and assembly of data was added relatively recently.^{4, 5}

Graduate students, many of whom are in the position of a junior researcher, put a higher value on Obtaining funding, which is not recognised by the ICMJE as a qualifying contribution. This could be explained by the fact that junior researchers, in their effort to conduct research, often depend on the good will of their seniors, especially for logistic support. Consequently, they feel obliged to add a senior colleague as a coauthor on the paper, even if this colleague did not meet the strict authorship criteria.¹⁶

Combinations of qualifying contributions proposed by study participants generally did not correspond with the ICMJE criteria. Only in the group of students who received instruction did we find a higher level of congruence between proposed combinations and the ICMJE criteria, which could also be seen as the effect of teaching. This incongruence may indicate that most of the medical professionals do not consider these requirements to be the basis for authorship on a scientific article.¹³

The limitation of our study is that we asked the participants to report their knowledge of ICMJE criteria, but we did not check whether they, in fact, knew the criteria except for their self-report. It would be interesting to further explore the association between the self-reported and actual knowledge of the ICMJE authorship criteria.

Relatively poor self-reported knowledge of the ICMJE criteria among study participants is consistent with the findings from other research settings,¹³ and thus seems to be a universal attribute of the biomedical scientific and academic communities. However, the effect of teaching could be clearly seen among the students who received instruction on the ICMJE criteria.

The results of our study call for greater efforts into focused and systematic education of medical students—that is, future researchers—about research methodology and writing.^{17, 18} Such efforts could particularly increase the awareness of the importance of authorship contributions that are less intuitive, and for which the effect of teaching proved significant. Regardless of whether the ICMJE criteria will be fully accepted, in the future, modified or completely rejected and replaced with some alternative system,^{19–21} giving the medical students clear guidelines and exposing them to high ethical standards should be a long-term solution to the problem of authorship abuses in the field of medical research.^{9, 22}

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APPENDIX A

QUESTIONNAIRE USED IN THE STUDY (TRANSLATION FROM CROATIAN)

Dear colleague,

With this questionnaire we want to find out which contributions to scientific research (work) you consider the criteria for authorship on a scientific paper.

Please read carefully the list of possible contributions to scientific work (research) and rate their importance as to who can be considered the author of a scientific paper. Use the following key: **1, no importance; 2, little importance; 3, moderate importance; 4, great importance.**

Your next assignment is to decide which of the contributions YOU see as the authorship criteria. There are three possibilities:

(1) You may consider some contributions as a sole criterion to qualify a person for authorship (eg, A or B or G or H...)

(2) You may consider some of the contributions as insufficient for authorship by themselves, but satisfactory if combined with another contribution (eg, A+B, G+H...)

(3) You may consider some of the contributions as insufficient for authorship by themselves or in a pair, but satisfactory when combined with two more contributions (A+B+G or B+G+H)

So, we ask you to consider all the listed contributions with these three possibilities in mind. We emphasise that you may consider any of the contributions as sufficient by itself, but it may also be possible that you do not consider any combination of the contributions sufficient for authorship on a paper.

We are interested in YOUR PERSONAL OPINION regarding criteria that should be met to consider someone the author of the scientific paper.

Now, we ask you to write down:

1) Contribution/s that are BY THEMSELVES sufficient as the criterion for authorship. Example: A, B, C, D, ... (if you think there are no such contributions, leave empty).

2) Combination/s of TWO contributions as the criteria for authorship. Example: A+B, B+C, A+C, ... (if you think there are no such combinations, leave empty).

3) Combination/s of THREE contributions as the criteria for authorship. Example: A+B+C, A+C+D, B+C+D, ... (if you think there are no such combinations, leave empty).

Finally, we ask you to circle the answer on the following question:

Do you know which are the ICMJE authorship criteria (circle your answer)?

YES NO

● A Conception and design of the study	1---2---3---4
● B Analysis and interpretation of data	1---2---3---4
● C Drafting of the article	1---2---3---4
● D Critical revision of the article for important intellectual content	1---2---3---4
● E Final approval of the article before submission to a journal	1---2---3---4
● F Provision of study material or patients for the purpose of the research	1---2---3---4
● G Statistical advice and assessment	1---2---3---4
● H Obtaining funding for the research	1---2---3---4
● I Administrative, technical or logistic support	1---2---3---4
● J Collection and assembly of data	1---2---3---4
● K Taking responsibility for the study (Guarantor of the study)	1---2---3---4