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Rozing, M.P.; Leeuwen, T.N. van; Reitsma, P.H.; Rosendaal, F.R.; Aziz, N.A.

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M. P. Rozing[1,2,3] **· T. N. van Leeuwen**[4] **· P. H. Reitsma**[5,6] **· F. R. Rosendaal**[7] **· N. A. Aziz**[7,8]

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Abstract

The surge in the number of authors per article in the biomedical field makes it difficult to quantify the contribution of individual authors. Conventional citation metrics are typically based on the number of publications and the number of citations generated by a scientist, thereby disregarding the contribution of co-authors. Previously we developed the *p*-index that estimates the dependency of a scientist on co-authors during their career. In this study we aimed to evaluate the ability of the *p*-index to identify researchers with a relatively high degree of scientific dependence on co-authors. For this purpose, we retrieved articles, which were rejected for publication in Journal of Thrombosis and Haemostasis and subsequently published elsewhere. Assuming that authors who were added to a later version of these articles would not fulfill the full authorship criteria, we tested whether these authors showed a larger dependency on co-authors during their scientific career as would be evident from a higher *p*-index. In accordance with this hypothesis, authors who were added on later versions of articles showed a higher *p*-index than their peers, indicating an enduring pattern of dependency on other co-authors for publishing their work. This study underscores that questionable authorship practices are endemic to the biomedical research, which calls for alternative methods to evaluate a scientist's qualities.

Keywords Citation metric · Authorship · *p*-Index

✉ M. P. Rozing
mroz@sund.ku.dk

1 Department of Public Health, Section of Epidemiology, University of Copenhagen, Øster Farimagsgade 5, P.O. 2099, 1014 Copenhagen, Denmark

2 Center for Healthy Aging, University of Copenhagen, Copenhagen, Denmark

3 The Research Unit for General Practice and Section of General Practice, Department of Public Health, University of Copenhagen, Copenhagen, Denmark

4 Centre for Science and Technology Studies (CWTS), Leiden University, Leiden, The Netherlands

5 Department of Thrombosis and Hemostasis, Leiden University Medical Center, Leiden, The Netherlands

6 Einthoven Laboratory for Experimental Vascular Medicine, Leiden University Medical Center, Leiden, The Netherlands

7 Department of Clinical Epidemiology, Leiden University Medical Center, Leiden, The Netherlands

8 German Centre for Neurodegenerative Diseases (DZNE), Bonn, Germany

Introduction

During recent decades, the biomedical field has seen a substantial increase in the average number of authors per research article. The average number of authors has tripled from two per article in 1965 up to almost six in 2016 (https://www.nlm.nih.gov/bsd/authors1.html). Concomitantly, there is a steep rise in the number of hyper-authored articles, including hundreds or even thousands of authors. This rise in the number of authors may reflect the growing need for collaboration within biomedical research (Scott et al. 2012). The increasing multidisciplinary character of modern biomedical research and the need for large sample sizes strongly encourages collaboration between research groups and centers (Scott et al. 2012).

However, the rise in the number of authors per article, and the practice(s) of honorary authorships, makes it increasingly hard to evaluate the individual author's merits. Various citation metrics, which are used to evaluate a researcher's productivity and citation impact, focus on the number of publications and citations an author generates. The *h*-index, defined as the number of articles which are cited at least *h* times, is among the most popular of these metrics (Hirsch 2005). However, this and most other citation metrics, do not take into account the co-authorship pattern of a researcher. Two researchers may have the same *h*-index, while the first appeared only as co-author on articles with large collaborations and the second author exclusively published single-author articles (Ioannidis 2008). In order to develop a more fair method of comparison between researchers we previously developed the "profit-(*p*)-index" (Aziz and Rozing 2013), which takes into account both the number of co-authors as well as the ranking of authors on an article. We demonstrated that within the biomedical field, co-authorship substantially contributes to an individual researcher's track record, and that adjustment for the contribution of co-authors substantially affects a researcher's citation metrics. More importantly, we showed that a lower dependence on co-authorships, as evidenced by a relatively lower *p*-index, differentiated Noble prize winners and Spinoza awardees ("The Dutch Noble prize)" from other, excellent, researchers; a difference which was not apparent from their respective unadjusted *h*-indices. This suggests that the *p*-index can identify researchers with a high degree of scientific independence.

In this article we seek to assess the opposite: can the *p*-index identify researchers with a lower degree of scientific independence, that is, researchers who depend on the efforts of their co-authors more than contributing substantially themselves? To this end we used the manuscript database of the Journal of Thrombosis and Haemostasis (JTH). This dataset contains information on all manuscripts submitted to JTH. We chose JTH for the sake of convenience not because we think that this journal is importantly different from other journals in terms of publication policies. Access to the JTH dataset allowed us to retrieve articles, which were rejected for publication in JTH and subsequently published elsewhere. We checked these published articles for authors, which were added after rejection by JTH. Given that these authors could not have contributed to the article in terms of conception, design, data analysis, and (early) drafting of the article, unless they were inappropriately not listed as authors on the first submission, we considered it unlikely that they satisfied the full authorship criteria. We tested whether these added authors showed an enduring pattern of scientific dependency, as would be evident from a higher *p*-index than the original authors.

Methods

Data

Two of the authors (FRR and PHR) are joint Editors in Chief of the 'Journal of Thrombosis and Haemostasis' (JTH). In the past this journal applied a limit to the number of authors on a manuscript. Until about 2008 this limit was eight authors per article, whereas at the start of their Editorship FRR and PHR increased it to twelve authors per article. From the journal's database, which included both accepted and rejected submissions for each calendar year, we identified all those articles which were submitted between 1 July 2012 and 1 July 2013, but were subsequently rejected for publication in JTH ($n=636$). These articles included manuscripts which were rejected either before or after external peer review. For each of these articles, we then interrogated Medline and Embase to assess whether the article was subsequently published in another journal (until February 25, 2015).

Bibliometric analysis

Within the Center for Science and Technology Studies (CWTS), a version of the Web of Science (WoS) has been made fit for bibliometric analysis. CWTS has constructed a database that contains clustered publications of authors, identifying accurately the publications that belong to one single person (except for Chinese and Korean scientists where the algorithm does not function properly due to the low number of surnames available in these language areas. Aspects that play a role in the identification procedure to link publications to a single person are field, journals, correspondence addresses, co-authorships as well as references, all of which are amongst the most important identifying elements (Caron and van Eck 2014). Using these newly developed algorithms, for each enlisted author, either on the initial submission to JTH or subsequent publication elsewhere, we attempted to retrieve the entire oeuvre for bibliometric analysis.

In attempting to retrieve the entire published oeuvres of these authors, it became clear that not all author names were unique, i.e. a larger number of authors carried an identical surname and initials combination. Non-unique author names are a well-known complication in bibliometric research (Gasparyan et al. 2014), and in our case, could potentially lead to too many false positives. However, we were able to solve this issue by using publications on which author names appeared after re-submission. We used the code of the publication in WoS database to select the correct author clusters to which the authors belonged, eventually resulting in a much more accurate recall of the categories of 'Added Authors' and 'Original Authors'. However, we could not employ this strategy in the 'Removed Authors' category since these were removed from the initial authors' lists and, thus, could not be linked to a unique publication code in the WoS database. Therefore, for the removed authors, we could not retrieve accurate bibliometric information.

Definitions

We defined 'Added Authors' as those authors who were not included in the authors' list on the initial submission, but who, nevertheless, appeared on the article after the manuscript was rejected by JTH and published elsewhere. Conversely, we defined 'Removed Authors' as those whose names were present on the initial submission, but then disappeared from the authors' list when the article was published in another journal. Finally, 'Original Authors' were defined as those whose names were present both on the initial submission to JTH as well as the subsequent publication elsewhere.

Statistical analysis

We characterized the different author groups using both conventional bibliometric indices (including total number of publications, total number of citations, mean number of citations per published item and *h*-index) as well as several bibliometric indices which we recently developed [including monograph equivalents, *p*-index, adjusted *h*-index and p_h-index (Aziz and Rozing 2013)]. Given the non-normal distribution of many of the bibliometric indices and the presence of outliers, intergroup comparisons were made using either the non-parametric Wilcoxon signed rank-sum test (WSR, related samples) or Mann–Whitney *U* test (MWU, unrelated samples). Data are presented as median (interquartile range (IQR)) unless otherwise specified. All statistical tests were two-tailed. Statistical analyses were performed in R (Studio Version 1.0.136, R base 3.3.2).

Results

Changes in author numbers after rejection

An overview of the articles which were rejected by JTH between 1 July 2012 and 1 July 2013 is presented in Table 1. In about a year and a half, at least 468 out of the 636 initially rejected articles had found their way into another journal (i.e. 73.6%). The median number of authors on the initial submission was 6 (IQR 5 to 8), whereas the median number of authors on the final publication had increased to 7 (IQR 5 to 8). The number of authors changed on 121 of the publications, of which *101* (21.6%) showed an increase and *20* (4.3%) a decrease. The number of authors remained unchanged on *347* (74.1%) of the publications.

Table 1 Overview of rejected submissions to the Journal of Thrombosis and Hemostasis

Total no. of rejected submissions	636
Not published elsewhere[a]	154
Published as dissertation, conference article or non-peer reviewed online material	5
Not sure whether same article	9
Left for analysis	468
Original articles	451
Reviews	17
No. of publications with authors	
Added	101
Removed	20
Unchanged	347

In the period spanning between July 1, 2012 and July 1, 2013

[a]As per February 25, 2015

Author profiling

On the 468 publications, a total of 2578 unique author names appeared. These included 181 individuals who appeared new on the resubmitted manuscripts (Added Authors), 83 individuals who were removed from the authors' list after resubmission and publication (Removed Authors), and 2314 individuals who were on both versions of the manuscripts (Original Authors).

An overview of individual level bibliometric indices for Added and Original Authors is displayed in Table 2. It appeared that Original Authors were more senior as judged by their higher number of publications and *h*-indices. However, despite a lower *h*-index, Added Authors had a higher *p*-index, indicating that, on average, they rely on other co-authors for publishing their work (Fig. 1a). Similarly, Added Authors had a higher p_h-index, suggesting that even for their most cited work these authors are more dependent on other co-authors than Original Authors (Fig. 1b).

Table 2 Overview of individual/author level bibliometric indices

	Total no. of publications	Monograph equivalents	*p*-index	*h*-index	*h*-index adjusted	p_h-index	Total no. of citations	Mean no. of citations
Added authors (n = 181)								
Min.	1	9.1×10^{-3}	0.66	0	0	0	0	0
1st Qu.	2	2.4×10^{-1}	0.82	2	1	0.53	15	6
Median	17	1.9	0.87	6	1	0.73	121	10.2
Mean	57.8	9.8	0.87	11.8	3.7	0.68	1495	15.1
3rd Qu.	53	8.2	0.92	16	5	0.87	1007	17.5
Max.	670	112.6	0.99	66	30	1	20015	121.3
Original authors (n = 2314)								
Min.	1	9.1×10^{-3}	0.22	0	0	0	0	0
1st Qu.	6	8.5×10^{-1}	0.78	3	1	0.53	33	5.4
Median	25	3.8	0.83	8	3	0.67	254	11.4
Mean	79.1	15.9	0.82	14.7	5.1	0.65	2248	16.2
3rd Qu.	94	17.4	0.88	20	7	0.78	1596	20.2
Max.	1493	384.1	0.99	178	58	1	148669	440.8
p value[a]	0.001	<0.001	<0.001	0.007	<0.001	0.009	0.007	0.54

[a]Mann–Whitney *U* test

Description of the different bibliometric indices used in table

Monograph equivalents is the estimated equivalent of the author's publications in the case he/she would have only produced monographs, i.e. single author articles. (Aziz and Rozing 2013)

p-index estimates the relative contribution of co-authors to the total publication record of a given author. (Aziz and Rozing 2013)

h-index A measure of a scientist's impact and productivity based on the number of publications and number of citations."A scientist has an index of h if his or her *Np* papers have at least *h* citations each and the other $(Np - h)$ papers have $\leq h$ citations each." (Hirsch 2005)

h-index adjusted is the adjusted equivalent of the *h*-index of a given author in the case he/she would have only produced monographs. (Aziz and Rozing 2013)

p_h*-index* is the adjusted estimate of the relative contribution of co-authors to the 'traditional' *h*-index of a given author. (Aziz and Rozing 2013)

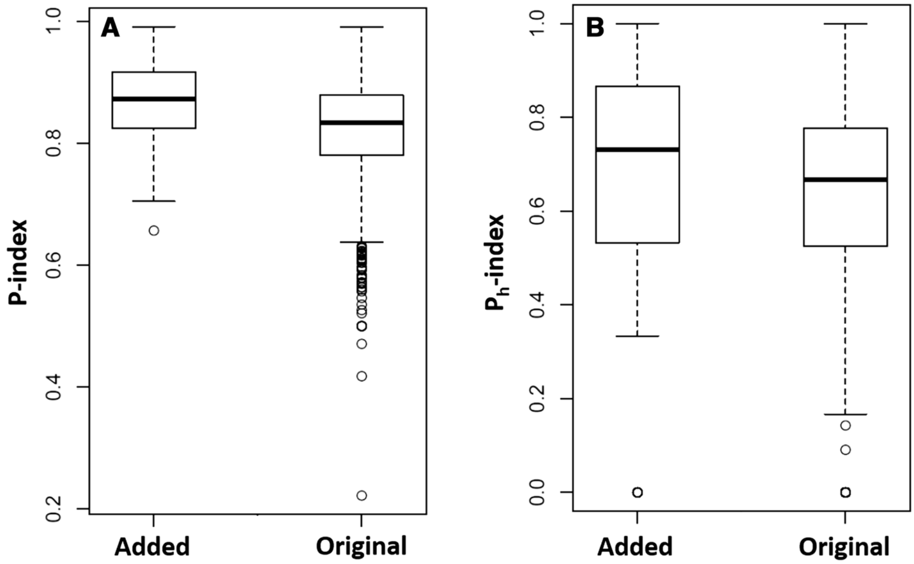

Fig. 1 Added Authors and profit-indices. Box plots showing that authors who were added to rejected article which were subsequently published elsewhere had significantly higher profit (p)-indices **a** as well as profit h (p_h)-indices **b** compared to authors who were enlisted on both versions of the manuscript, $p < 0.001$ and $p = 0.009$, respectively, by the Mann–Whitney U test. The thick horizontal lines within the boxes indicate the medians, box edges represent the interquartile ranges, and the outer horizontal lines designate the minimum and maximum adjacent values, with circles denoting outliers (i.e. points falling outside 1.5 × interquartile range)

Discussion

The p-index is a measure of the dependency on co-authors in the output of a scientist. In this article we aimed to evaluate the ability of the p-index to identify researchers with a higher degree of scientific dependence. For this purpose we tracked down articles which were rejected for publication in Journal of Thrombosis and Haemostasis (JTH) and subsequently published elsewhere. Assuming that authors who were added to a later version of these articles would not fulfill the full authorship criteria, we tested whether these authors showed a larger dependency on co-authors during their scientific career as would be evident from a higher p-index. In accordance with this hypothesis, authors who were added on subsequent versions of articles showed a higher p-index than the original authors.

The rise in the number of authors per article may have been accompanied by an increasing prevalence of inappropriate and ghost authorships, which has provoked a lively debate on the nature of authorship (Smith and Williams-Jones 2012). The use of professional writers, especially for industry-sponsored research, complicates this matter. Although no general consensus on criteria exists, the International Committee of Medical Journal Editors recommend that all authors listed in the article's byline (1) should have made substantial contributions to the conception, design, or the acquisition, analysis, and interpretation of data for the study, (2) were involved in drafting of the manuscript, (3) approved the final version of the article, and, (4) agreed to be accountable for all aspects of the work. (http://www.icmje.org) In some cases whether a contribution merits an authorship or not is open to discussion (Patience et al. 2018). Should technical staff, database managers and so forth performing routine tasks be included as authors or mentioned in the acknowledgements? However, not uncommonly, authorships are clearly unfounded (Luksanapruksa and Millhouse 2016). Gift authorships have been shown to be prevalent in high impact biomedical journals (Wislar et al. 2011). Reasons for gift authorships may be to increase the credibility of an article, curry the favor with superiors, or could be part of a tit-for-tat agreement between colleagues. Nevertheless, adding authors on this basis is not without repercussions. Gift authors unduly detract attention and credit from the authors who actually performed the work, and thereby negatively affect their chances of promotion or obtaining funding. Secondly, in cases of scientific misconduct, it is unclear who of the authors is responsible, and should be held accountable.

In order to increase the transparency of individual author contributions, many journals have adopted the practice of contribution disclosure, in which authors state the nature of their respective contribution to the study. However, this method of authorship evaluation has been shown to be unreliable. Significant discrepancies were observed when authors were asked to declare their contribution to a manuscript at two different time points (Ilakovac et al. 2007). Alternatively, an ordinal rating disclosure form for quantifying the author contribution has been suggested which was shown to be more reliable than the binary rating, which is typically used by journals (Ivanis et al. 2008). Other authors have proposed to allocate credit on the basis of self-reported intellectual contribution to a publication (Boyer et al. 2017; Kovacs 2013; Rahman et al. 2017). These indices are relatively simple to apply and have the benefit of being comparable across different scientific fields, although they remain open to manipulation. Given the difficulties to decipher an author's contribution to a particular article, it may instead be more informative to take into account a researcher's full publication record when evaluating the academic performance. Most of the metrics however, such as the *h*-index, which are used to quantify the productivity and impact of individual researchers, rely on the number of publications and citations without considering the number of co-authors and the position in the author byline. To remedy this problem modified versions of the *h*-index which address the influence of co-authorships have been proposed before (Abbas 2011; Batista et al. 2006; Imperial and Rodriguez-Navarro 2007; Kovacs 2013; Rahman et al. 2017; Schreiber 2008; Tol 2011; Zhang 2009). Some of these modifications do not take into account author ranking (Batista et al. 2006; Schreiber 2008) or mainly allocate credit to the first authors (Imperial and Rodriguez-Navarro 2007; Zhang 2009) (see also (Aziz and Rozing 2013) for a more extended comparison of the *p*-index with other metrics). However, unlike these earlier modifications, the *p*-index used in the present article was specifically designed to assess the contribution of co-authors to the academic performance of a particular author. Interestingly, Ioannidis proposed an index which similarly provides an impression of the authorship pattern of a researcher during his or her career (Ioannidis 2008). This index depends on the number of articles of an author and the frequency with which the same co-authors appear in these articles. This index can be used to classify researchers ranging from those who mostly publish solitary during their career to those who routinely participate in multi-authored articles. Unlike the *p*-index however, the index proposed by Ioannidis does not convey information on the estimated relative contribution of individual authors to publications.

Certain limitations of our study should be acknowledged. We can only speculate as to the motives to include additional authors during subsequent submissions. Arguably, in some cases additional authors could have been invited to join an author coalition to try and salvage an otherwise unpublishable manuscript, in which case an authorship would actually be deserved. Admittedly, we were not able to empirically assess the validity of this argument. Secondly, our approach is unable to detect other forms of inappropriate authorships. Other authorship practices that are considered harmful include ghost authors (authors who contributed but are not listed, usually in order to hide conflicts of interests), conscripted authors (authors who are unwitting of their name appearing on an article), and orphan authors (contributing authors who were undeservedly omitted from the article). Finally, a critical aspect of the *p*-index is that it assumes that the authorship position is associated with the respective contribution to a publication. In biomedical research the first and last authors generally are the principal contributors to a publication, while intermediate authors have contributed less. Since the conventions of author placement differ per discipline, the *p*-index is mainly confined to biomedical sciences. However the weighing algorithm underlying the *p*-index it is relatively easy to adapt in order to incorporate disciplines with alternative conventions of authorship ranking (Aziz and Rozing 2013). It should be borne in mind that no guidelines whatsoever are exist for the position in an author list, and it is not unlikely that predominant use of any specific metric, particularly by funding agencies or by institutions to decide on promotions, may affect such index, following Goodhart's law (https://en.wikipedia.org/wiki/Goodhart's_law).

No single bibliometric measure will ever be sufficient to solve the problem of freeloading in scientific research. In fact, in the light of the aforementioned Goodhart's law, even if a more reliable index would become available, its reliability would soon be comprised, as there are numerous ways to "artificially" influence a metric. The added value of the *p*-index in itself might therefore be limited. However, when used conscientiously and in concert with other indices it could prove to be a helpful tool to tease out the merits of individual authors. The simultaneous use of different citation-based indices, each focusing on distinct dimensions of an author's publication record, would give a more nuanced rendition of a scientific career than a single bibliometric measure would be able to.

Problems associated with collaboration are central to many fields. A precondition for any collaboration is that individuals get more benefit out of the association than they invested, although not necessarily confined to one publication. The most desirable forms of collaboration are based on the principle of mutual benefit. The surplus of joint efforts or the combination of different kinds of expertise required to solve a particular research problem are examples of such a reciprocal collaboration. However, in a competitive environment less symmetrical strategies may pay off equally well (or better). In these collaborations one of the participants disproportionately gains more than he or she invested, thereby placing other participants at a disadvantage. However insignificant these detriments may seem, they should not be underestimated.

It is not our intention to discourage collaboration between authors. However, we do strive for an equitable allocation of author credits in a field where the fierce competition for limited financial resources between researchers is reflected in the dogma "publish-or-perish". The surge in the number of authors per article and the increasing size of international and interdisciplinary collaborations in research have made it difficult to identify what an individual author truly has contributed to an article. At the same time however, the digital revolution has provided us with new tools to easily and quickly collect author metadata and perhaps to reveal the true contribution of individual authors.

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Compliance with ethical standards

Conflict of interest The authors report no conflicts of interest.

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