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Two new scientometric indices for measurement of collaboration activities of departments and their researchers in academic institutions

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ABSTRACT

In general, scientific collaboration represents the quality of research work of co-researchers and the related research institutes. Knowledge exchange is known as one of the principle methods of spreading the science. Lack of collaboration leads to research institutional isolation and prevents science expansion. The previous indices that have been proposed for measurement of the degree of scientific collaboration do not base their assessment on the context of the main goal of the research groups and their scientists. As a scientist's maximum achievement will happen when he/she work as part of a team with a defined goal, and a team succeeds when it focuses on a defined subject, only the collaborations that are formed for promotion of the goals of the team would be considered constructive. Here, we propose two new indices entitled "collaboration h-index" and "collaborative researchers h-index", to assess the extent of collaboration activities focused on the main goals of a research team.

Keywords: Scientific collaboration; Evaluation indices; Scientometrics; Scientists; Research productivity

INTRODUCTION

Today, concepts such as knowledge exchange and scientific communication are common topics in scientific debates. Undoubtedly, scientific collaboration between researchers and academic institutions, in order to use facilities and skills of each, can cause these concepts practical. Scientific collaboration usually increases the quality of research outputs. The science is generated by researchers in academic institute. Any interactive collaboration between different institutes and their researchers increase the rate and quality of science production. Lack of scientific collaboration leads to institutional isolation and prevents "expansion of science". Many of the indices that have been created so far to measure the

scientific activities of researchers and the research institutes could be classified into three major groups: the first, represents the indices that are based on the science productivity in a certain period of time; the second, represents indices that are based on the citations to scientific outputs; and the last represents indices that are based on the ranking of the journals in which the results of a research is published (Costas and Bordons 2007).

h-Index is one of the widely used indices that was introduced in 2005 by Hirsh. According to this index, if h number of papers published by a researcher in a certain period receives at least h number of citations, then his or her index equals to *h* (Hirsch 2005). Simplicity of calculation, proper combination of quantity and quality, and the effect of production stability in *h*-index are the reasons for its acceptability. Disadvantages of this index include: (a) *h*-index is low in beginner researchers, regardless of how good they are; (b) it is not a good index to compare active researchers working in low productivity and late return areas with those working in high productivity and quick return areas; and (c) production half life is not considered in this index (Costas and Bordons 2007).

To solve the so-called disadvantages, other indices were introduced based on the subject in question. But most of these indices are used to assess the "researcher" or his/her scientific productivity. In addition, as the research centres and institutions are as important as the researchers themselves, several indices have been developed for assessment of institutions as well. One of the issues that have been considered in this category is "collaboration rate" of the "researcher" and his/her "institute" with other researchers and institutes. Nonetheless, previous indices that have been proposed for measurement of the degree of scientific collaboration do not base their assessment on the context of the main goal of the research groups and their scientists. As a scientist's maximum achievement will happen when he works as part of a team with a defined goal, and a team succeeds when it focuses on a defined subject, only the collaborations that are formed for promotion of the goals of the team would be considered constructive. Here, we propose two new indices entitled "collaboration *h*-index" and "collaborative researchers *h*-index", to assess the extent of collaboration activities focused on the main goals of a research team.

A REVIEW OF INDICES FOR MEASUREMENT OF COLLABORATION

In 1980, collaboration index (CI) is defined as the average number of authors per article (Lawani 1980). The disadvantage of this index is contribution of single-author articles to the calculation of CI, whereas these articles represent no collaboration. This problem is solved by modifying Lawani's index (Kumar and Kumar 2008; Lawani 1980). In 1983, a new formula presented for calculation of the so-called "degree of collaboration" (DC), which was defined as the ratio of single-author articles to the total number of articles (Subramanyam 1983). That concomitant use of both indices will draw a better picture of collaboration status. However, DC does not differentiate the multiple-author articles when the number of authors varies.

Another index called "collaborative coefficient" (CC), was introduced in 1988 (Ajiferuke et al. 1988). For calculation of this index, a score, which is equal to 1/*j* is conferred to each paper with *j* number of authors. Subtraction of the sum of the scores of all articles from 1 makes the CC index (Subramanyam 1983). CC has the advantages of both previous indices. This index differentiates various levels of multiple authorships. When single-author articles are in majority, this index will trend toward zero.

One of the other collaboration indices is "co-authorship index" (CAI), that was presented in 2001 (Garg and Padhi 2001; Guan and Gao 2008). This index represents the degree of collaboration in a subset to its whole set. The set and subsets could be defined by the locations (countries) in which the studies are performed. For example, the published articles in a set of countries are grouped based on number of authors and the ratio of articles in each group to the whole set is determined. These values are calculated for each individual country (subset) as well. Ratio of the value calculated for each group of each subset (country) to its similar value in the whole set of countries determines the CAI.

In addition to the above indices, some *h*-index-derived indices were formulated for assessment of co-authorship and active authorship. For example $h_{1,}$ which is calculated by dividing the square of Hirsch index to the average number of co-authors in Hirsch related papers (Batista et al. 2006); or corresponding author *h*-index (*hKA*-index) that calculates *h*-index only by taking into account those papers in which the scientist in question is the corresponding author (Krauskopf 2008; Krauskopf 2009). However, none of these indices consider the role of institutional collaboration and their researchers.

OBJECTIVES AND METHOD

One of the issues that promote the academic institutions' advancement, parallel to the global science, is the scientific collaboration and exchange of knowledge with other research institutes. Scientific collaboration is the most effective way to increase science production. In this paper, we put forward two new indices entitled "collaboration *h*-index" and "collaborative researchers *h*-index", to assess the extent of collaboration activities focused on the main goals of a research team.

Collaboration *h*-index

In order to measure the scientific collaboration of an institute, the number of published articles and registered patents produced in collaboration with other institutes could be sorted by the production quantity. If *h* number of institutes receives at least *h* number of collaborative productions, the collaboration *h*-index (*hc*-index) will be equal to *h*. To validate *hc*-index, an exercise was performed to measure the *hc*-index of Department of Pharmacology of Iran University of Medical Sciences, which is one of the prolific departments at this university. Meanwhile, pharmacologic research has shown to be the major theme of Iranian medical research system, which has enjoyed the highest rate of growth in recent years (Mohammadhassanzadeh et al. 2010). The bibliometric data were collected from "All Databases" section of ISI Web of Knowledge^{SM} provided by the Institute for Scientific Information (www.isiwebofknowledge.com). The database was accessed online on 28 October 2010. The advanced search was performed with the address tags for "Iran University of Medical Sciences" (Iran Univ Med Sci) and "Department of Pharmacology" (Dept Pharmacol) and the time span tag of "All Years". The retrieved documents were individually checked to exclude any incorrect retrievals and single authored documents. A total of 75 documents were included in this exercise.

The authors' affiliations recorded in each document were used as the basis for counting of collaborating institutes. In case where multiple affiliations were recorded for a single author, only the main affiliation of that author was counted. The main affiliation could be recognized because of professional acquaintanceship with the authors. But, if in a general setting the main affiliation cannot be determined, the authors or their heads of departments could be contacted for clarification. The reason only one affiliation was

counted for each author is the indices proposed in this paper base their measurements on human collaboration. If a single author who is affiliated to several institutes only benefits from those institutes' equipments, not researchers, the purpose of these proposed indices would not be fulfilled.

The retrieved documents showed that Department of Pharmacology has collaborated with 50 other institutes. As collaboration between members of the department (intra-institutional collaboration) is also very important, the publications resulted from this type of collaboration have been counted as well. Overall, Department of Pharmacology has established collaboration with 51 institutes (Table 1). As indicated, only 4 institutes have produced at least 4 collaborative products. Therefore, the *hc*-index for this department is 4. This index determines the effective levels of collaborations established by an academic institute. For instance, the example in Table 1 shows that the level of collaboration established with only four institutes is justified by the main research goals of Department of Pharmacology. Collaboration with other institutes can be considered as "occasional". For example, there is only one output for each collaboration established with the 30 institutes that were ranked 6. It shows that collaborations with these institutes were not based on the main research focus of Department of Pharmacology; otherwise, it would continue and produce more research output.

Table 1: Institutes Collaborating with Department of Pharmacology, Iran University of Medical Sciences

Rank	Collaborating Institute	No. of Collaborative Output
1	Dept. of Pharmacology, Iran University of Medical Sciences (intra-institutional collaboration)	45
2	Endocrinology & Metabolism Research Center, Tehran University of Medical Sciences	7
2	University of Tehran, Institute of Biochemistry & Biophysics	7
3	Dept. of Pathology, Iran University of Medical Sciences	4
3	Dept. of Medicinal Chemistry, Tehran University of Medical Sciences	4
4	Dept. of Physiology, Iran University of Medical Sciences	3
4	Cellular and Molecular Research Center, Iran University of Medical Sciences	3
4	Dept. of Anatomical Sciences, Iran University of Medical Sciences	3
4	Dept. of Pharmacology, Mashhad University of Medical Sciences	3
4	Dept. of Pharmacology, Shaheed Beheshti University of Medical Sciences	3
4	Dept. of Pharmaceutics, Tehran University of Medical Sciences	3
5	Dept. of Nephrology, Iran University of Medical Sciences	2
5	Dept. of Cardiovascular Surgery, Iran University of Medical Sciences	2
5	Dept. of Nutrition, Iran University of Medical Sciences	2
5	Dept. of Pharmacodynamics & Toxicology, Mashhad University of Medical Sciences	2
5	Dept. of Microbiology, Azad University, Karaj Branch	2
5	Dept. of Chemistry, Azad University, Tehran Science & Research Branch	2
5	Dept. of Pharmacology, Iranian Academic Center for Education, Culture & Research	2
5	Qazvin University of Medical Sciences	2
5	Dept. of Chemistry, Shahid Bahonar University of Kerman	2
5	Dept. of Neurology, Iran University of Medical Sciences	2
6	Dept. of Basic Sciences, Iran University of Medical Sciences	1
6	Dept. of Microbiology, Iran University of Medical Sciences	1
6	Dept. of Parasitology, Iran University of Medical Sciences	1

6	Dept. of Epidemiology, Iran University of Medical Sciences	1
6	Dept. of Immunology, Iran University of Medical Sciences	1
6	Dept. of Pathology, Shahid Beheshti University of Medical Sciences	1
6	Dept. of Epidemiology, Shahid Beheshti University of Medical Sciences	1
6	Dept. of Immunology, Shahid Beheshti University of Medical Sciences	1
6	Dept. of Rheumatology, Tehran University of Medical Sciences	1
6	Dept. of Dermatology, Tehran University of Medical Sciences	1
6	Center for Research and Training in Skin Diseases and Leprosy, Tehran University of Medical Sciences	1
6	Dept. of Gynecology, Tehran University of Medical Sciences	1
6	Dept. of Pathology, Shiraz University of Medical Sciences	1
6	Tri-State Institute of Pharmaceutical Sciences	1
6	Dept. of Biology, Azad University, Kazeroon Branch	1
6	Dept. of Ophthalmology, Baqiatallah University of Medical Sciences	1
6	Dept. of Physiology, Baqiatallah University of Medical Sciences	1
6	Dept. of Anatomical Sciences, Semnan University of Medical Sciences	1
6	Dept. of Pharmacology, Semnan University of Medical Sciences	1
6	Neuroscience Research Center, Kerman University of Medical Sciences	1
6	Dept. of Medicinal Chemistry, Tabriz University of Medical Sciences	1
6	Dept. of Anatomical Sciences, Ardebil University of Medical Sciences	1
6	Dept. of Anatomical Sciences, Yasouj University of Medical Sciences	1
6	Dept. of Biostatistics, Tarbiat Modares University	1
6	Dept. of Medicinal Chemistry, Mazandaran University of Medical Sciences	1
6	Dept. of Physiology & Pharmacology, Pasteur Institute of Iran	1
6	Darou Pakhsh Company	1
6	Dept. of Pathology, Milad Hospital	1
6	Kowsar Pharmaceutical Company	1
6	Isfahan Laboratory of Khatam-ol Anbia	1

Collaborative Researchers *h*-index

In each research institute, the researchers who established active collaboration are sorted according to the number of their collaborative productions (published articles and patents), which contributed to the *hc*-index. If *h* number of researchers receive at least *h* number of collaborative productions, the collaborative researchers *h*-index (*hcr*-index) will be equal to *h*.

For example, the 75 documents collected for the Department of Pharmacology have been used to calculate the *hcr*-index of this department. For this purpose, the collaborative products that have contributed to the *hc*-index (the first five rows [as rows four and five have equal counts] in Table 1) were considered. The researchers from Department of Pharmacology of Iran University of Medical Sciences who have contributed to these products, together with the number of products they have contributed to, are listed in Table 2. Other researchers in the department who have not contributed to the products counted in the first five rows of Table 1 and researchers from collaborating institutes are not listed. Table 2 shows that only 5 researchers have produced at least 5 collaborative products. Therefore, the *hcr*-index for this department is 5, meaning that the level of collaboration established by only 5 researchers is justifiable by the overall collaborative activity and goals of Department of Pharmacology.

Table 2: Measurement of *hcr*-index for Department of Pharmacology

Rank	Collaborating Researcher*	No. of Collaborating Output
1	Massoud Mahmoudian	40
2	Ali Mohammad Sharifi	13
3	Parvaneh Rahimi-Moghaddam	10
4	Massoumeh Shafiei	8
5	Nasrin Akbarloo	6
6	Fariborz Keyhanfar	5
6	Iraj Milanian	5
6	Radbod Darabi	5
6	Soltan Ahmed Ebrahimi	5
7	Hossein Mirkhani	4
7	Manijeh Motevallian	4
7	Saeid Ghiaee	4
7	Seyed Ali Ziai	4
8	Seyed Hadi Mousavi	3
8	Shahab Bohlooli	3
9	Babak Gholamine	2
9	Nahid Rahbar-Roshandel	2
10	Ali Rassouli	1
10	Ali Rouzrokh	1
10	Anahita Torkaman-Boutorabi	1
10	Armin Madadkar-Sobhani	1
10	Bahareh Tavakoli-Far	1
10	Behnam Heshmatian	1
10	Behnoush Zare	1
10	Habib Eslami	1
10	Hoda Fotovat Eskandari	1
10	M. Demankeshideh	1
10	Mahmood Hoormand	1
10	Majid Chalian	1
10	Maryam Noubarani	1
10	Massoumeh Amanlou	1
10	Negin Zand	1
10	S. Beigly	1
10	T. Mobasheri	1
10	Z. Nehradani	1
10	Zahra Kiani	1

* Only those researchers from Department of Pharmacology who have contributed to the products counted in the first five rows (rows four and five have equal counts) of table 1 are listed.

CONCLUSION

In this paper two new indices called collaboration *h*-index (*hc*-index) and collaborative researchers *h*-index (*hcr*-index) are proposed. Collaborative *h*-index determines those institutes which form the core of collaborative research activity. Naturally, this core is

formed based on the research that is directed to the main goal of the institute in question. A new goal will only be taken into account when it becomes equally important for the institute. This will be indicated by increase of the output in the areas which are studied in collaboration with other institutes, which in turn, increases the *hc*-index. The concept of "main research activity" has not been dealt with in any preceding indices.

The collaborative researchers *h*-index assesses the researcher in the context of its institute. Generally speaking, seminal and ground breaking research is performed in groups which have a research focus. Therefore, collaboration can promote an institute only when it is established for development of the main goals of the institute. This concept has not been considered in any previous indices.

These indices are based on the concept of "main research theme" and assess the degree of collaboration of each institute and its researchers according to this theme. This is a fundamental concept that contributes to the success of a research institute and again has not been considered in any previous indices.

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