Situation of Medical Sciences in 50 Top Countries from 1996 to 2010- Based on Quality and Quantity of Publications

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Received: 13 Apr. 2011; Received in revised form: 15 Jul. 2011 ; Accepted: 18 Jan. 2012

Abstract- In research outputs both quality and quantity are of critical value and evaluation of both aspects is required for best evaluation. Several studies have worked on single or two-dimensional methods that provide the assessment of quality, quantity or both simultaneously in different branches of sciences, but none of them have played a role in a particular area of medicine. This study has been conducted to compare countries worldwide in the field of medical researches. Measuring both quality and quantity of researches is performed separately. In order to evaluate countries from both aspects of quantity and quality of research outputs, a modified form of the citation per publication (CPPm) and publication per population (PPPm) were used to make these indices comparable through different years and nations by normalizing the values according to the world average standards. When countries are ranked by CPPm, Iceland ranks the 1st with the score of 1.98, Faroe Islands and Gambia rank the 2nd and the 3rd with scores of 1.84 and 1.63, respectively. In PPPm Switzerland, Sweden and Denmark ranked the top three with scores of 13.34, 11.67 and 10.32, respectively. Iran ranked 71 in CPPm and 141 in PPPm. Ranking countries makes it possible to identify countries which have performed better in research outcomes by means of quality and quantity; thus, reforming policies can be taken into action to lower the waste of money, higher quality and quantity of outputs while providing helpful tip(s) for institutions to improve.

Acta Medica Iranica, 2012; 50(4): 273-278.

Keywords: Medicine; Scientometric; Citation per publication; Publication per population

Introduction

To evaluate the performance of countries in the research domain as general and determine the highest rankings, several scientometric indices have been proposed e.g. a number of documents, total counts of citations, citation per publication (CPP), publication per population (PPP), and H index. Previous studies have referred to CPP as an index of quality, which can be used in large scales to evaluate the researches' outputs of a given nation (1-4). While citation can be used as a quality indicator, it plays a role as a multidimensional variable; it means while it impresses the relations of a study with previous researches, it also indicates the one that has had more effects on particular fields and are more important. In another end citation, frequency can display the disagreement of other researches on an argument of a paper. Thus, not necessarily all highly cited papers have more scientific value. In research outputs, both quality and quantity are of critical value; thus, considering both quality and quantity is necessary for making the best judgment. Although novel indicators such as H index have been proposed to overcome the difficulty of simultaneous measurement of quality and quantity, the problem still exists. Moreover, other questions have been evolved from this index itself. Recent studies have suggested to use a modified form of H index, to overcome the size dependency of H index. And in another study, the time factor of the H index has been argued (3,5). Relative scientometric indicators are preferred for comparative studies (6). The usage of relative scientometric indicators in national and

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international evaluation(s) has been suggested previously (6,7). The use of a relative index of CPP has been proposed previously in the form of dividing CPP to FCSm (Field-based world average Citation Score) (7) which is called the modified forms of CPP (CPPm) (8). PPPm is a modification of PPP, which is calculated by the division of PPP to average world PPP in each year. These modifications are useful for assessing the quality and quantity of researches. In addition, the modification is used to make these indices comparable between different years and countries by normalizing the values according to the world average standards (8). In a recent study, Arab nations were compared with other non-Arab Middle East countries during the years 2001-2005. Research quality and quantity were assessed by citation frequency and the original article publication number, respectively. Then, the results were normalized by GDP, GDP per capita and population (9). As issued by Kirigia and Wambebe (10), an improvement in health care of the general population can be assessed, improved and followed by the research strategies of a country in health sciences. These strategies can contain priorities in research topics, resource allocation and policies that can help them with providing better health care plans to achieve a higher quality of health in the society; in the other form, research policies can be used to provide therapeutic, preventive and diagnostic solutions for health issues in a nation (10). Several studies have worked on single or two-dimensional methods that provide the assessment of quality, quantity or both simultaneously in different branches of sciences (8, 11); however, none of them were applied in a particular field of medicine. This study has been conducted to compare countries worldwide just in medical researches.

Materials and Methods

Data for each country contains the number of citable documents, citations and population that have been collected from 1996 to 2010. Data regarding the population of countries were collected from the World Development Indicators database (12) and data containing publications and citations were collected from SCImago Journal & Country Rank portal (13), which provides Scopus® data (13). SJR assigns journals to 27 major thematic categories as well as to 313 specific subject categories according to Scopus® Classification. In this classification, medicine is a major subject and entails 48 subgroups. To collect data regarding the number of citable documents and citation counts, search was limited to subject of medicine, including all subgroups, and time interval of a single year, *e.g.* 1997 in SJR web based tool, and the results were saved into an excel workbook. SJR provides the search output as of country name, in this way SJR uses affiliation(s) of articles to allocate papers to countries; incase of documents whose affiliations contain more than a single country, all affiliated countries will receive the count of document. Data regarding each year for the 15-year interval were composed into an excel workbook, then countries which had data for all 15 years were selected; in this step, 21 countries were excluded from the study because of insufficient data of citation counts, number of documents or population.

In order to evaluate countries from both aspects of quantity and quality of research outputs, CPPm and PPPm, as described by Nejati and Jenab (8), were used. CPPm is an indicator of quality and is described as CPP divided by the world average CPP of that year (Equation 1), and PPPm is an indicator of quantity described as PPP divided by the world average PPP of that year (Equation 1).

$$CPPm = \frac{\frac{Citaions}{Documents}}{\frac{Total\ \ World\ \ Citations}{Total\ \ World\ \ Documents}}$$

The CPP of each country for every year has been calculated by dividing the number of citations by the country's population. The average CPP of the world in a year has been calculated by diving the total number of citations of studied countries by the total population of the studied countries. Then CPP of each country has been divided by the average CPP of the world for fourteen years. Hence, CPPm has been computed for every country. The PPPm has been calculated in the same way of CPPm, but instead of citations the number of citable documents has been used. The average CPPm and PPPm have been calculated for fourteen years and the countries were ranked. This 15-year interval seems to be significant to evaluate past and present research outputs of countries. At last, 50 top countries were obtained and listed (Tables 1 and 2). Mathematical formulations were performed by Excel 2011 Mac.

Results

When the ranking is sorted according to PPPm, Switzerland, Sweden and Denmark ranked the top three with scores of 13.34, 11.67 and 10.32, respectively. The 50^{th} rank is taken by United Arab Emirates with the score of 0.94 (Table 1).

Table 1. Countries ranked by PPPm.

Rank	Country	Average PPPm	Rank	Country	Average PPPm
1	Switzerland	13.34	26	Japan	3.30
2	Sweden	11.67	27	The Czech Republic	3.04
3	Denmark	10.32	28	Taiwan	3.02
4	Netherlands	9.99	29	Croatia	2.95
5	Israel	9.68	30	Grenada	2.84
6	Finland	9.18	31	Luxembourg	2.05
7	Iceland	8.99	32	Hungary	1.91
8	Norway	8.77	33	Greenland	1.83
9	United Kingdom	8.08	34	Estonia	1.73
10	Australia	7.96	35	Kuwait	1.65
11	Monaco	7.83	36	Portugal	1.63
12	Belgium	7.66	37	Poland	1.60
13	Austria	7.30	38	Bahrain	1.59
14	Canada	6.88	39	Turkey	1.52
15	New Zealand	6.82	40	Slovakia	1.49
16	United States	6.03	41	Qatar	1.44
17	Ireland	5.68	42	Venezuela	1.44
18	Germany	5.19	43	South Korea	1.44
19	France	4.75	44	Malta	1.43
20	Italy	4.63	45	Faroe Islands	1.29
21	Singapore	4.48	46	Barbados	1.23
22	Greece	4.45	47	Cyprus	1.21
23	Spain	4.31	48	Lebanon	1.17
24	Hong Kong	4.23	49	Bulgaria	1.04
25	Slovenia	3.44	50	United Arab Emirates	0.94

Table 2. Countries ranked by CPPm.

Rank	Country	Average CPPm	Rank	Country	Average CPPm
1	Iceland	1.98	26	Australia	1.09
2	Faroe Islands	1.84	27	Luxembourg	1.08
3	Gambia	1.63	28	Botswana	1.07
4	Panama	1.48	29	Tanzania	1.07
5	Puerto Rico	1.46	30	Ireland	1.07
6	Guinea-Bissau	1.42	31	New Zealand	1.06
7	Finland	1.40	32	Mongolia	1.04
8	Denmark	1.39	33	Estonia	1.04
9	Netherlands	1.37	34	Austria	1.04
10	Uganda	1.35	35	Peru	1.03
11	Costa Rica	1.33	36	Malta	0.99
12	Canada	1.31	37	Italy	0.97
13	Latvia	1.31	38	Philippines	0.96
14	Sweden	1.30	39	Germany	0.95
15	United States	1.27	40	France	0.94
16	Kenya	1.25	41	Israel	0.93
17	Switzerland	1.25	42	Hong Kong	0.92
18	Belgium	1.24	43	Myanmar	0.92
19	Cambodia	1.20	44	Rwanda	0.91
20	United Kingdom	1.19	45	Paraguay	0.90
21	Norway	1.18	46	Gabon	0.88
22	Malawi	1.16	47	South Africa	0.87
23	Viet Nam	1.14	48	Lithuania	0.87
24	Zambia	1.14	49	Uruguay	0.87
25	Mozambique	1.11	50	Dominican Republic	0.87

This is of particular interest that 45 countries out of the total of 50 countries have high-income economies and the other 5 are in the upper-middle-income economies class with no country in the low-income group. However, when countries are ranked by CPPm (Table 2), Iceland ranks the 1st with the score of 1.98, Faroe Islands and Gambia rank the 2nd and the 3rd with scores of 1.84 and 1.63, respectively. In CPPm, the 50th rank is replaced by Dominican Republic with the score of 087. Out of 50 countries ranked by CPPm, 10 countries are in low-income, 15 in the middle-income (9 upper-middle and 6 lower-middle) and 25 in the high-income economy groups according to the World Bank category of countries based on their Gross National Index per capita (14). Countries like the United States and the United Kingdom, which are the two first countries in H index ranking (13), are the 15th and the 20th in CPPm and the 16th and the 9th in the PPPm list, respectively. There are 28 European, 14 Asian, 5 American, 1 African and 2 Oceania countries in PPPm list. However, 20 European, 12 African, 10 American, 6 Asian and 2 Oceania countries are in CPPm ranking. European countries are the leading countries in both lists. Nevertheless, when it comes to the role of economy in a variable, it is not unexpected to have few African and Asian countries at the top of the list as it is shown in PPPm ranking list. . Iran, with a score of 0.35, ranked 141 in CPPm and score of 0.34 placed Iran in rank of 71 in PPPm.

When the product of CPPm and PPPm is used to rank countries as a simultaneous method of evaluation of quality and quantity (Figure 1), PPPm has a more powerful effect in ranking than CPPm, mostly because CPPm scores are less than one which lowers the product of a multiply. Thus, the results mostly depend on the score of PPPm; as it is seen the top 20 countries in the PPPm list are the top 20 countries when the product of PPPm and CPPm is used. On the other hand, only 8 out of top 20 countries of the CPPm list are within the top 20. Thus, when the simultaneous measurement of quality and quantity is considered, the results are in favor of countries with high published papers.

The rankings for countries in CPPm might be unexpected because of the observation of some low-income American and African countries at the top of the list. This high CPPm can be explained by the following reasons: self-citation(s) (2), industry funding along with industry favorable results, publication in higher impact factor (IF) journals, group authorship, field of research such as pharmacology, oncology or cardiovascular and sample size (15). However, it should not be assumed that these countries publish less important articles until a research provides such informative findings. The finding disturbances also can be a result of methodological problems, which large-scale studies are faced with. In addition, there is a shortage of data in the field of scientometric analysis in comparing medical sciences in different countries. Thus, to inspect the results of countries ranked by CPPm another study should be performed to evaluate the above-mentioned variables in medical research ranking of countries.

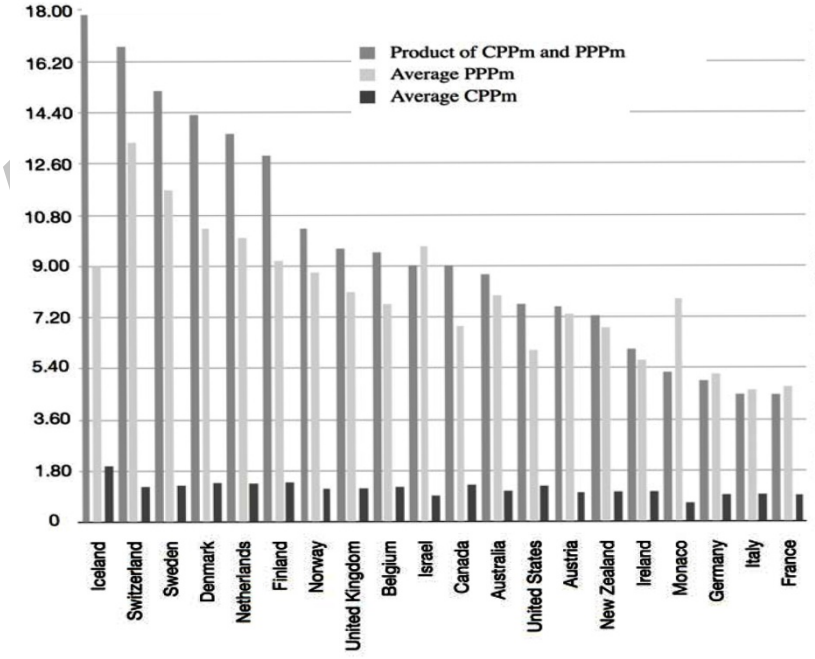

Figure 1. Country ranking by product of CPPm and PPPm.

Discussion

Quality evaluation is much better in descriptive form. There are numerous problems in the quantification of quality, basically because there is no appropriate definition for quality. However, the numerical explanation of quality is available but has its own advantages and disadvantages.

A perfect method to evaluate the quality of research is peer review analysis of articles (4), but it is not actually possible in large scales, where, for example, just USA has published over 113,000 documents in year 2008. A comparison of peer review and citation count has been performed and a coefficient factor has been proposed, but other studies are essential to make an accurate coefficient value in each field of science, and subfields consequently (16).

A study has assessed the use of H index in top quality selection of research (17). Although H index seems to be a standard indicator which considers both quality and quantity of research outcomes simultaneously, data regarding H index is not widely available for previous years, making the importance of further work on this subject in years beyond. Another recent study has argued the issue of logical measuring of H index in comparison to other derivatives of H index (the so called P index) which shows that the use of new mathematical formulas, which are comparable with dynamic energy rule and are more in favor of judicious ranking method of journals. However, it is not used in universal scales which is considered to be necessary (11).

For journals, the use of IF has been proposed to determine the quality of a journal. IF has its own difficulties regarding the size and field of the journal. In comparison to citation counts, IF has the advantage of showing the reputation of an individual journal rather than citation counts because there is a gap of few years through which an article receives its cumulative citation counts. Strike Rate Index (SRI), as introduced by Barendse (3), has the benefit of comparability in years and different fields; so journals with high SRI publish documents which gain citations in a few years while IF represents the citation rates just in 2 years (3). Thus, this is of particular value to evaluate countries in a time interval that represents recent articles and previous articles in the same manner.

Ranking countries makes it possible to identify countries, which have done better in research outcomes by means of quality and quantity. As shown in Poland, financing for institutions in spite of being in high or low quality group is the same while output is different (18) Thus, reforming policies can be taken into action to lower the waste of money, and increase the output while providing helpful tip(s) for institutions to improve in quality.

In our study, the accuracy of data collection had a few limitations. There was no accurate data for population in Afghanistan, Andorra, Aruba, Cape verd, Cayman, Cook island, Cayman island, French guiana, Guadeloupe, Iraq, Lichtenstein, Martinique, Northern Merina Island, Palau, Palestine, Reunion, Sao tome and principles, Timor leste, US minor outlaying islands, Virgin island UK, and Virgin island US for years between 1996 and 2010. Thus, these countries were excluded from the study. In the field of citations, the effect of self-citation was not assessed.

A single method that simultaneously considers the quality and quantity is not suggested yet, although efforts have been done in this field. CPPm and PPPm are valuable variables that can be used to rank countries in order to get and learn policies from high-rank countries and help them with providing better strategies for developing countries in which health care systems are not constructed or guided in a good way, to facilitate using resources and to minimize the squander of time, manpower and funds.

Acknowledgement

Special thanks to Dr. K. Sedig and Dr. A. Pilc for their generosity to help us with providing their researches.

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