Global Dental Research Productivity and Its Association With Human Development, Gross National Income, and Political Stability

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Abstract

Objective: The objective of this study is to examine the associations between country level factors (such as human development, economic productivity, and political stability) and their dental research productivity.

Methods: This study is a cross-sectional analysis of bibliometric data from Scopus search engine. Human Development Index (HDI), Gross National Income per capita (GNI), and Failed State Index measures were the independent variables. Outcomes were "Total number of publications (articles or articles in press) in the field of dentistry" and "Total number of publications in the field of dentistry per million population." Non-parametric tests were used to examine the association between the independent and outcome variables.

Results: During the year 2013, a total of 11,952 dental research articles were published across the world. The top 5 publishing countries were United States, Brazil, India, Japan, and United Kingdom. "Very High" HDI countries had significantly higher number of total dental research articles and dental research articles per million population when compared to the "High HDI," "Medium HDI," and "Low HDI" countries ($p < 0.0001$). There was a significant linear relationship between the GNI quartile income levels and outcome metrics ($p \leq 0.007$). Countries which were highly politically stable were associated with significantly higher dental research productivity ($p < 0.0001$).

Conclusions: There appears to be a regional concentration of articles with just five countries contributing to over 50% of all articles. The human development and economic development of a country are linearly correlated with

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dental research productivity. Dental research productivity also increases with increasing political stability of a country.

Keywords: Journal metrics, Dental research, Global research, Bibliometrics, Journal publishing, Human development, Political stability.

INTRODUCTION

The number of research publications is one of the major parameters that are used to measure research productivity or output at the individual, institutional or even at the national level. Research funding, availability of qualified researchers, investment from private firms, influence of policy makers and the brain-drain to developed countries are some of the factors known to affect this parameter at the country level.[1] It is known that developing world contribute significantly less to the growing body of scientific evidence when compared to developed world thus raising serious concerns.[2,3] Lack of resources to conduct research, poor preparation of manuscripts, lack of access to scientific literature, lack of participation in publication-related decision making, inadequate representation in journal review boards, and bias of the journals are listed as some of the contributing factors for this under-representation of developing countries.[3]

Increasing the research output in all parts of the world is extremely important not only for the economic growth and well-being of the population in a country, but also for the reason that the results obtained from studies performed in developed countries cannot always be applied to developing nations.[1] This concern was further elevated by the transatlantic divide that was observed in medical publishing, with leading American medical journals publishing far fewer papers that are relevant to the developing world, compared to the European counterparts.[4]

There has been prior research examining metrics of medical research productivity in developing countries.[5–9] However, to date there are no published data on the distribution of global dental research productivity and factors at a country level that contribute to this productivity. Furthermore the impact of political stability of a country on its research productivity is unknown. The objective of the present study is to provide a snapshot of global dental research productivity and to examine the associations between country level factors (such as human development, economic productivity, and political stability) and their dental research productivity. We hypothesized that countries that are high in human development indices, have higher per capita income, and are politically stable also have high dental research productivity when compared to countries that are low in human development, are economically poor, and are politically unstable.

MATERIALS AND METHODS

Study Design, Database, and Institutional Review Board Approval

The present study is a cross-sectional analysis of bibliometric data from Scopus search engine for research publications.[10,11] Scopus is the largest abstract and citation database of peer-reviewed journals, books and conference proceedings.[10] It provides information on close to 53 million records (including scientific articles, abstracts, book chapters, conference proceedings, etc) and has 21,915 titles in its repository.[10] Scopus indexes articles in the fields of science, technology, medicine, social sciences, and arts and humanities. The present study was granted Institutional Review Board (IRB) "Exempt" status by the College of Dentistry – The University of Iowa Human Subjects Protection Office. IRB protocol number is 201410837.

Search Strategy

The Scopus database was queried using the following strategy: publication year = "2013"; document type = "Article" or "Article in Press"; and subject area = "Dentistry."[11] No restrictions were placed on language of publication, country of publication, affiliation, source title, or source type.

Outcome Measures

The two outcome measures examined in the present study were "Total number of publications (articles or articles in press) in the field of dentistry" and "Total number of publications in the field of dentistry per million population." The two outcome metrics were obtained for each country from the Scopus database.[11] The unit of analysis is the individual country.

Independent Variables

The independent variables of interest included: Human Development Index (HDI), Gross National Income per Capita (GNI), and Failed States Index for the year 2013. HDI was introduced by the United Nations to summarize the achievement of a particular country in key dimensions of human development.[12] This includes a long and healthy life, education, and standard of living. Based on the United Nations Development Programme – Human Development Report, different countries are divided into four groups based on HDI: Very High HDI, High HDI, Medium HDI, and Low HDI.[12,13]

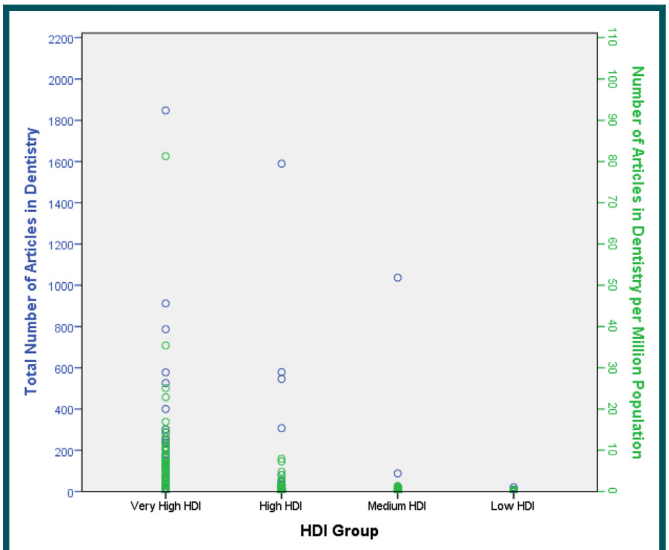

Figure 1. Total number of dental research articles and articles per million population by HDI.

The GNI is the "*aggregate income of an economy generated by its production and its ownership of factors of production, less the incomes paid for the use of factors of production owned by the rest of the world, converted to international dollars using Purchasing Power Parity rates, divided by midyear population.*"[14] The distribution of GNI per capita for each country was examined and the countries were ranked in descending order. The countries were then divided into four groups (quartiles) based on the GNI ranks. The cut-off GNI per capita values used to divide into quartiles was: >$23388; $10440 to $23388; $3662 to <$10440; and <$3662 groups. Data on HDI, GNI, and country population were obtained from United Nations Development Programme – Human Development Reports.[12–16]

The Failed States Index for the year 2013 was obtained from the Fund for Peace organization.[17] The Failed State Index is a composite score assigned to each country based on: demographic pressures, refugees and internally displaced people, group grievance, human flight, uneven development, poverty and economic decline, legitimacy of state, public services, human rights, security apparatus, factionalized elites, and external intervention. Higher scores indicate a failed state. During the year 2013, Somalia had the highest score (composite score of 113.9), while Finland had the lowest score (composite score of 18.0).

Statistical Analysis

Descriptive measures (mean, standard deviation, and percentile distributions) were used to summarize the data. Since the outcome data were highly skewed, non-parametric tests were used for statistical tests for association. The association between the HDI groups and outcomes was examined by Mann–Whitney *U* tests. Multiple pair-wise comparisons were made to examine "between group" differences in outcomes. A similar approach was used for comparing the outcomes "between" GNI quartile groups. A total of 6 pair-wise comparisons were used. In order to minimize Type 1 errors arising out of multiple pair-wise comparisons, Bonferroni corrections were applied to the *p*-values. For HDI and

TABLE 1. Distribution of dental research articles and dental research articles per million population by HDI.

HDI group	Total number of articles in dentistry	Number of articles in dentistry per million population
Very high HDI		
Mean	166.2	8.9
Std. deviation	310.3	12.3
Minimum	0.0	0.0
Maximum	1848.0	81.3
Percentiles		
25	10.0	3.0
50	55.0	6.3
75	178.0	10.4
High HDI		
Mean	63.8	0.9
Std. deviation	242.3	1.7
Minimum	0.0	0.0
Maximum	1590.0	7.9
Percentiles		
25	0.0	0.0
50	1.0	0.1
75	10.0	0.9
Medium HDI		
Mean	30.3	0.2
Std. deviation	161.8	0.4
Minimum	0.0	0.0
Maximum	1037.0	1.3
Percentiles		
25	0.0	0.0
50	0.0	0.0
75	5.0	0.3
Low HDI		
Mean	1.7	0.0
Std. deviation	3.9	0.1
Minimum	0.0	0.0
Maximum	21.0	0.4
Percentiles		
25	0.0	0.0
50	0.0	0.0
75	1.0	0.0

TABLE 2. Summary of pair-wise comparisons between HDI groups.

Pair-wise comparison	*p*-value for total number of articles in dentistry	*p*-value for number of articles in dentistry per million population
Very high HDI versus high HDI	$p < 0.0001$[a]	$p < 0.0001$[a]
Very high HDI versus medium HDI	$p < 0.0001$[a]	$p < 0.0001$[a]
Very high HDI versus low HDI	$p < 0.0001$[a]	$p < 0.0001$[a]
High HDI versus medium HDI	$p = 0.06$	$p = 0.02$
High HDI versus low HDI	$p = 0.001$[a]	$p < 0.0001$[a]
Medium HDI versus low HDI	$p = 0.15$	$p = 0.08$

Mann–Whitney *U* tests were used for pair-wise comparison. Since 6 pair-wise comparisons were made a *p*-value of <0.008 was deemed to be statistically significant.
[a]Statistically significant at $p < 0.008$.

Income quartile comparisons, a *p*-value of <0.008 was deemed to be statistically significant. All tests were two-sided. A correlation analysis using the Spearman's Rho was used to examine the association between the outcomes and FSI. These associations were also plotted graphically. All statistical tests were two-sided. All statistical analyses were accomplished using SPSS Version 22.0 software (IBN Corp, NY).

RESULTS

During the year 2013, a total of 11,952 dental research articles were published or in press. In terms of the gross total number of dental research publications, the top five publishing countries were United States (number of articles = 1848), Brazil (1590), India (1037), Japan (912), and United Kingdom (787). Seventy-four countries did not publish a single dental research article. A total of 34 countries published at least 50 dental research articles in the year 2013. Amongst countries which published at least 50 articles in the year 2013, the top five countries with the highest dental articles per million population were: Switzerland (35.4 articles per million population), Sweden (25.1 articles per million population), Finland (22.8 articles per million population), Denmark (16.9 articles per million population), and Netherlands (15.2 articles per million population). United States was ranked 25th amongst this cohort with 5.8 articles per million population, while Brazil was ranked 17th (7.9 articles per million population), India was ranked 33rd (0.8 articles per million population), Japan was ranked 19th (7.2 articles per million population), and United Kingdom was ranked 8th (12.5 articles per million population).

During the year 2013, a total of 189 countries were assigned an HDI. Of these, 51 were designated as "Very High HDI," 53 were "High HDI," 42 were "Medium HDI," and 43 were "Low HDI." The distribution of total dental research articles and dental articles per million population by HDI is summarized in Figure 1 and Table 1. The mean number of articles published by countries in "Very High HDI" group was 166.2 (median is 55) compared to 63.8 for "High HDI" group (median is 1), 30.3 for "Medium HDI" group (median is 0), and 1.7 for "Low HDI group" (median is 0). The mean number of articles per million population published in the "Very High HDI" group was 8.9 (median is 6.3) compared to 0.9 for "High HDI" group (Median is 0.1), 0.2 for "Medium HDI" (median is 0), and 0 for "Low HDI" group (median is 0). The results of the multiple pair-wise comparisons between HDI groups from the Mann–Whitney *U* tests are summarized in Table 2. Overall, the "Very High" HDI group had significantly higher number of total dental research articles and dental research articles per million population when compared to the "High HDI," "Medium HDI," and "Low HDI" groups ($p < 0.0001$). The "High HDI" group had significantly higher number of total dental research articles and dental research articles per million population when compared to the "Low HDI" Group ($p \leq 0.001$).

The distribution of total dental research articles and dental articles per million population by GNI quartiles of different countries is presented in Table 3 and Figure 2. The mean number of articles published by countries with GNI >$23,388 was 177.7 (median is 66) compared to 79.2 (median is 5) for countries with GNI $10440 to $23388, 26.2 (median is 0.5) for countries with GNI $3662 to <$10440, and 0.8 (median is 0) for countries with GNI <$3662. The mean number of articles per million population published by countries with GNI >$23,388 was 9.4 (median is 6.7) compared to 1.6 (median is 0.5) for countries with GNI $10440 to $23388, 0.2 (median is 0) for countries with GNI $3662 to <$10440, and 0 (median is 0) for countries with GNI <$3662. The results of the multiple pair-wise comparisons between GNI quartiles from the Mann–Whitney *U* tests are summarized in Table 4. Overall, there was a significant linear relationship between the GNI quartile income levels and numbers of dental research articles and dental research articles per million population ($p \leq 0.007$).

TABLE 3. Distribution of dental research articles and dental research articles per million population by gross national income.

Gross national income quartiles	Total number of articles in dentistry	Number of articles in dentistry per million population
>$23388		
Mean	177.7	9.4
Std. deviation	328.7	13.1
Minimum	0.0	0.0
Maximum	1848.0	81.3
Percentiles		
25	3.0	2.7
50	66.0	6.7
75	219.0	10.7
$10440 to $23388		
Mean	79.2	1.6
Std. deviation	250.5	2.3
Minimum	0.0	0.0
Maximum	1590.0	8.6
Percentiles		
25	0.0	0.0
50	5.0	0.5
75	35.0	2.8
$3662 to <$10440		
Mean	26.2	0.2
Std. deviation	149.6	0.4
Minimum	0.0	0.0
Maximum	1037.0	1.6
Percentiles		
25	0.0	0.0
50	0.5	0.0
75	6.0	0.3
<$3662		
Mean	0.8	0.0
Std. deviation	1.9	0.1
Minimum	0.0	0.0
Maximum	8.0	0.3
Percentiles		
25	0.0	0.0
50	0.0	0.0
75	1.0	0.0

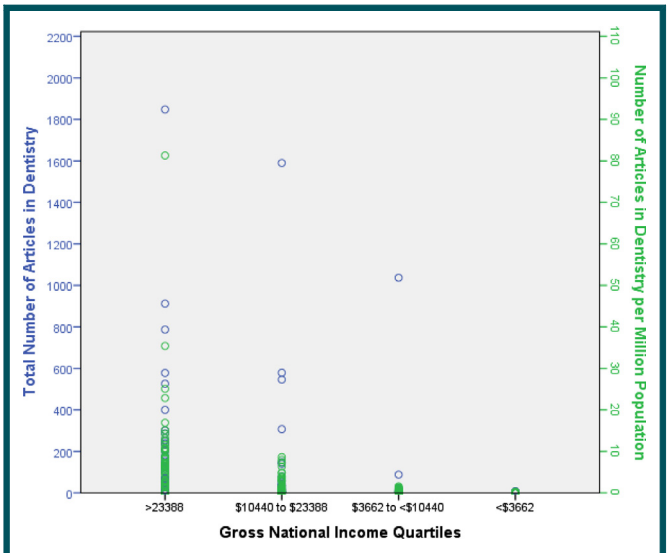

Figure 2. Total number of dental research articles and articles per million population by income quartiles.

Data on Failed States Index were available for 175 countries. The plots of total dental research articles and dental research articles per million population by FSI are presented in Figure 3. In summary, countries which were highly politically stable (lower FSI scores) were associated with significantly higher numbers of total dental research articles (Spearman's rho = −0.469, $p < 0.0001$) and dental research articles per million population (Spearman's rho = −0.593, $p < 0.0001$).

DISCUSSION

Our first of its kind analysis in dentistry clearly points to the significant influence that a country's HDI, GNI, or FSI have on the dental research productivity as measured by the number of publications and publications per million population. It is clear that only a handful of countries (United States of America, Brazil, India, Japan and United Kingdom) published slightly more than 50% of the global dental research publications in the year 2013. And 74 countries did not publish even a single dental research article in 2013, clearly pointing to the existing disparity in dental research publishing. This disparity in publishing scientific articles was known to exist in several medical areas including medical education, virology and cardiovascular disease research.[5,6,18]

Scientific research and publications still remain an important factor pushing the economy of a country forward. This is more visible in developed countries. This momentum for scientific research and publishing is gaining in the developing nations as well.[19] Though we observed a linear relationship between a country's development and research output, we noticed some outlier countries such as India or Brazil, who are not in the top tier of any of the variables of interest but are publishing a higher volume of dental articles. This is highly encouraging and we speculate that these fast-growing economies recognized the importance of research and are prioritizing scientific research within their political agenda. In addition, it is also feasible that a number of

TABLE 4. Summary of pair-wise comparisons between gross national income quartiles.

Pair-wise comparison	*p*-value for total number of articles in dentistry	*p*-value for number of articles in dentistry per million population
>$23388 versus $10440 to $23388	$p = 0.001$[a]	$p < 0.0001$[a]
>$23388 versus $3662 to <$10440	$p < 0.0001$[a]	$p < 0.0001$[a]
>$23388 versus <$3662	$p < 0.0001$[a]	$p < 0.0001$[a]
$10440 to $23388 versus $3662 to <$10440	$p = 0.001$[a]	$p < 0.0001$[a]
$10440 to $23388 versus <$3662	$p < 0.0001$[a]	$p < 0.0001$[a]
$3662 to <$10440 versus <$3662	$p = 0.007$[a]	$p = 0.003$[a]

Mann–Whitney *U* tests were used for pair-wise comparison. Since 6 pair-wise comparisons were made a *p*-value of <0.008 was deemed to be statistically significant.
[a]Statistically significant at $p < 0.008$.

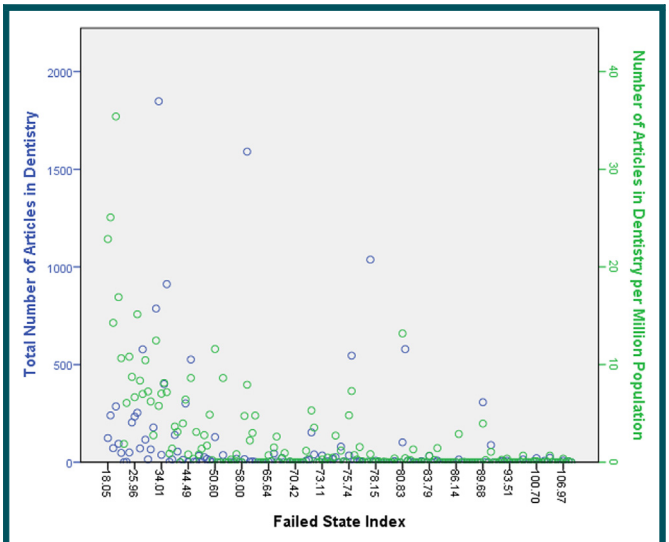

Figure 3. Total number of dental research articles and articles per million population by Failed States Index.

stakeholders in these countries must have developed strategies to improve research, by creating research centers within training institutions and by enhancing training for research personnel.[20] Langer and colleagues pointed out the following steps to address this unequal representation of countries: Make possible the access to biomedical information via easy access to journals and translating journal articles to local languages; fostering research collaboration between developing countries and developed countries; encouraging active regional representation in journals' editorial boards, and introducing special issues of international journals with regional focus.[3]

There are inherent limitations in the present study. The present study examined only research productivity in terms of number of dental research publications and publications per million population. Indicators of research productivity other than number of publications include multiple variables such as patent submissions and approvals or acquiring grant funding. These were not considered in the analysis. Since it is a cross-sectional analysis of 1 year's data, it may not truly represent the past trend as both the employed variables and assessed outcomes vary each year. Due to practical difficulty, the quantity of publications but not their quality was assessed in the present study. Since we relied on indexed published articles for our analysis, published but not indexed articles or non-published articles (grey literature) were not included. Finally, the cross-sectional nature of the study design precludes us from clearly establishing a cause and effect relationship.[21] It should be kept in perspective that it would be practically impossible to conduct a randomized controlled study or a prospectively controlled clinical trials to address our hypotheses.

In summary, it is evident that there exists a significant amount of disparity in the dental research publishing between countries and it is also clear that in the year 2013, only a few countries combined contributed to half of the indexed dental research literature, literature. Some of the developing countries published more dental articles than developed countries, clearly pointing to the ongoing strategizing and prioritizing for dental research and publishing in these fast-growing economies.

CONCLUSIONS

During the year 2013, a total of 11,952 dental research articles were published across the world. There appears to be a regional concentration of articles with just five countries contributing to over 50% of all articles. Furthermore, the human development and economic development of a country are linearly correlated with dental research productivity. Dental research productivity also increases with increasing political stability of a country.

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