A Bibliometric Analysis of Global Research Production in Respiratory Medicine*

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Study objectives: To evaluate the contribution of different world regions in respiratory research productivity.

Methods: The world was divided into nine regions based on a combination of geographic, economic, and scientific criteria. Using the PubMed database, we retrieved information about the origin of articles from 30 journals included in the Respiratory System category of the Journal Citation Reports database for a 9-year period (1995 to 2003). We estimated the total number of publications, their mean impact factor, the product of these two parameters, and the research productivity per million of population of the world area divided by the gross national income per capita (GNIPC), for every year and the whole period of the study, for all defined world regions.

Measurements and results: Data on the country of origin of the publications was available for 48,614 of 49,382 retrieved articles (98.5%). The majority of articles published between 1995 and 2003 originated from Western Europe (40.4%) and the United States (35.4%). The research productivity compared to population and the GNIPC was found to be higher for Canada and Oceania compared to the United States and Western Europe. The rate of increase of the total published research product (number of published articles multiplied by the impact factor) was higher in the United States and Europe. The total research contribution of Asia, Eastern Europe, Central and Latin America, and Africa regarding the number of published articles was notably very low (approximately 8%).

Conclusions: The data suggest that there was a significant research activity in the field of respiratory medicine during the studied period. Although leaders of production of respiratory medicine research were from Western Europe and the United States, Canada, and Oceania had the best performance after adjustment for population and GNIPC.

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Key words: impact factor; medical journals; pulmonary medicine; research productivity; worldwide trends in research

Abbreviations: CAP = community-acquired pneumonia; GNIPC = gross national income per capita; JCR = Journal Citation Reports

Respiratory medicine includes a variety of extremely common diseases, such as COPD, bronchial asthma, respiratory tract infections, community-acquired pneumonia (CAP) or hospital-acquired pneumonia, lung cancer, ARDS, and pulmonary embolism. Because of the high prevalence of respiratory diseases and their associated morbidity and mortality, a considerable proportion of pulmonologists and thoracic surgeons all over the word are involved in research efforts.

The overall prevalence of COPD in adults appears to be between 4% and 10% in countries where it has been rigorously measured. An estimated 30 million individuals in the United States have COPD. COPD is estimated to affect 32 million persons in the United States and is the fourth-leading cause of death in the United States and in Europe.

In addition, the prevalence and severity of bronchial asthma cases are on the rise. Approximately 10% of children in the United States have asthma. Dramatic worldwide variations in asthma prevalence have been found, with the highest rates in the United Kingdom, Australia, and New Zealand. The percentage of children with asthma has increased in the last 20 years, and asthma is the leading serious chronic illness in children. Also increasing are the

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occurrences of asthma hospitalization and mortality resulting from status asthmaticus in both children and adults. Similar to the US data, asthma morbidity and mortality rates are increasing internationally. Internationally, asthma-related mortality rates vary widely by country.

CAP is a relatively common and potentially serious infection that affects both immunocompetent and immunosuppressive adults throughout the world. Pneumonia occurs in approximately 12 persons per 1,000 annually in the United States, and its incidence is highest among persons at the extremes of the age range. Pneumonia is the sixth-leading cause of death in the United States. The annual incidence of CAP in the United States is approximately 4 million cases.

The incidence of lung cancer, however, is approximately 60 cases per 100,000 population. The incidence of lung cancer in women has increased even faster than the overall incidence, reflecting their increased use of tobacco in the past 30 years. Smoking is the most important etiologic factor linked to lung cancer and is responsible for as many as 85% of cases. Lung cancer accounts for approximately 6% of all deaths in the United States each year and is the leading cause of cancer death for both men and women. Lung cancer is the leading cause of cancer-related deaths in both men and women worldwide. In the United States, approximately one third of cancer deaths occur as a consequence of lung cancer. The 5-year survival rate is 15%, and it has largely remained unchanged for decades.

In this bibliometric analysis, we sought to examine the quantity and quality of research produced in the area of respiratory medicine, around the world, as it is represented by the published articles included in the electronic database PubMed and the Journal Citation Reports (JCR) database of the Institute for Scientific Information between 1995 and 2003. We also evaluated the relationship of research productivity of world areas with their population and gross national income per capita (GNIPC).

**Materials and Methods**

**World Division**

The methodology that we used has been reported previously. For the purpose of our study, the world was divided into nine regions based on a combination of geographic, economic and scientific criteria. The nine regions are Western Europe, the United States, Japan, Canada, Asia, Eastern Europe, Oceania, Latin America and the Caribbean, and Africa. All former socialist countries of Europe and Turkey were included in the category of Eastern Europe. Greenland was designated as Western Europe. Japan was studied as a separate region compared to the rest of Asia. Puerto Rico and Virgin Islands were combined with the United States.

**Journals**

All journals that were in the Respiratory System category of the JCR within the period 1995 to 2003 were included in our study. To identify whether these journals were also included in PubMed during the study period, we performed a detailed computerized search of each journal in the PubMed database for each year of the study period. Journals included in the Respiratory System category of the JCR but were not indexed by PubMed were excluded from our study. We did not include articles published prior to 1995 because the full address of the authors was frequently not registered in PubMed prior to this year. Furthermore, the JCR had data available up to year 2003 at the time of our data collection. A total of 30 journals were included in our study.

**Search Procedures**

A phrase consisting of four parts joined together by the Boolean operators (ie, “AND,” “OR,” and “NOT”) was used in our search in the PubMed database. Each search was limited to a specific year using the “limits” function, which is incorporated in the search engine. We only analyzed data on original articles and reviews, excluding publication types such as letters, editorials, and news reports. This was accomplished by selecting publications with the characterization “journal article [pt]” in the search fields of the database (“pt” designates publication type). For example, in order to search for articles published in Thorax, whose first author’s address was in Europe, we used the following text: Thorax[journal] AND journal article[pt] AND (Andorra[AD] OR Austria[AD] OR... Wales[AD]) NOT (Australia[AD] OR Canada[AD] OR...). All countries of each region were included in the first parenthesis of the search phrase. In the second parenthesis, after the word NOT, certain addresses were excluded in order to avoid double counting.

Subsequently, the results of our search (the number of articles produced by each world region in a specific journal within a year) were summed up. Further confirmation was accomplished by summing up the articles retrieved from our search for all different world regions in a specific journal and comparing them to the actual total number of articles published in the same journal for a specific year. The total number was obtained from PubMed without using address limits. Using the above methodology, we were able to cross-examine missed or unretrieved addresses. The above scenario occurred occasionally, in cases of articles with no address registered, or articles in which only the affiliation institution or the city (not the country) was recorded.

If < 5% of the total articles of a specific journal during a year had missing addresses, those articles were excluded. However, if > 5% of the total articles of a specific journal during a year had missing addresses, we performed searches for the author’s address by checking other articles of the same author within the same year. In order to include addresses where only cities or areas were registered, we expanded our search criteria, including search phrases with big cities or capitals (eg, Munich, London, or Moscow) and all the individual states of America.

Using the retrieval system described above, we identified a few addresses that were double counted in two different regions (eg, if “Beth Israel”—the name of several hospitals in the United States—appears in the address field of the article, then this...
individual article could be counted, for example, in both the United States and Asia). To avoid such problems, we manually checked many of our search results and we added exclusion criteria in the second parenthesis of our search string: when searching for Asia, we added the following: NOT [Beth Israel (AD) OR United States (AD)]. Two investigators performed independent searches to further strengthen our methodologic validity. In cases of disagreement between the two investigators, the findings were discussed until final decisions were taken.

The number of published articles was considered as an index of quantity of research productivity. The mean impact factor of the published articles was considered as a quality indicator. Finally, the product of the number of articles published in a journal multiplied by the impact factor of the journal, for each year studied, was considered as a combined indicator of the quantity and quality of research productivity. The sum of the above products from all journals, for each world region within a year, was considered a “total product” for that region.

Relationships of Research Productivity With Economic and Scientific Resources

To further evaluate associations between the research productivity of each region and other factors, we used relevant “world development indicators” from the online databases of the World Bank. The research productivity of different world regions (estimated by the total product) was evaluated in relation to the total population and GNIPC in standard 1995 US dollars (Atlas method). Data analysis was performed using statistical software (SPSS version 10.0; SPSS; Chicago, IL).

Results

A total of 49,382 articles indexed in PubMed that were in the Respiratory System category of the JCR for the period from 1995 to 2003 were included in our study. We were able to retrieve data for the origin of 48,614 articles (98.5%) and categorized them according to the country of origin based on the methodology described earlier.

In Table 1, we present the total production of articles by world region and the relative contribution of each region to the total number of articles from all 30 journals that were included in our study. The majority of articles published between 1995 and 2003 originated from Western Europe and the United States (75.8%). Western Europe published more articles than the United States in most years, especially the last years. The United States ranks second, except in the year 1995, when US production exceeded that of Western Europe. Japan ranks third, Canada ranks fourth, Asia ranks fifth, Oceania ranks sixth (except in 2002 and 2003 when it ranked seventh), Eastern Europe ranks seventh, Latin America and the Caribbean ranks eighth, and Africa ranks last. We also observed a significant increase in the number of articles produced by each region mainly during the last 4 years of the study.

Figure 1 displays the worldwide trends of total research product (number of articles published mul-

### Table 1—Number of Articles Published in Journals Included in the Respiratory System JCR Database Category and Indexed By PubMed From Different World Regions for the Period 1995 to 2003

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<tbody>
<tr>
<td>Western Europe</td>
<td>1,749</td>
<td>1,889</td>
<td>2,041</td>
<td>2,224</td>
<td>2,327</td>
<td>2,258</td>
<td>2,506</td>
<td>2,298</td>
<td>2,354</td>
<td>19,646</td>
</tr>
<tr>
<td>United States</td>
<td>1,858</td>
<td>1,656</td>
<td>1,777</td>
<td>1,868</td>
<td>1,926</td>
<td>2,072</td>
<td>2,203</td>
<td>1,832</td>
<td>2,031</td>
<td>17,223</td>
</tr>
<tr>
<td>Japan</td>
<td>313</td>
<td>369</td>
<td>343</td>
<td>415</td>
<td>432</td>
<td>499</td>
<td>520</td>
<td>508</td>
<td>499</td>
<td>3,898</td>
</tr>
<tr>
<td>Canada</td>
<td>365</td>
<td>388</td>
<td>253</td>
<td>205</td>
<td>207</td>
<td>234</td>
<td>250</td>
<td>273</td>
<td>300</td>
<td>2,666</td>
</tr>
<tr>
<td>Asia</td>
<td>26</td>
<td>28</td>
<td>24</td>
<td>21</td>
<td>19</td>
<td>17</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>1,164</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>13</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>64</td>
</tr>
<tr>
<td>Latin America and Caribbean</td>
<td>28</td>
<td>25</td>
<td>22</td>
<td>19</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td>85</td>
</tr>
<tr>
<td>Africa</td>
<td>18</td>
<td>15</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>84</td>
</tr>
<tr>
<td>Total</td>
<td>4,590</td>
<td>4,860</td>
<td>5,213</td>
<td>5,589</td>
<td>5,906</td>
<td>6,286</td>
<td>6,569</td>
<td>6,036</td>
<td>6,315</td>
<td>58,614</td>
</tr>
</tbody>
</table>

*Data are presented as No. of articles (% within a calendar year).

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multiplied by the impact factor of journals) for different world regions from 1995 to 2003. The United States was first followed by Europe, while Japan ranks third in a great distance from the first two areas, followed by Canada and Asia. Eastern Europe, Central and Latin America, and Africa had a little contribution regarding this indicator of research productivity also. The United States and Western Europe had the most significant relative growth in the total product of research between 1995 and 2003.

Table 2 shows the number of publications multiplied by the impact factor of journals per million of population divided by the GNIPC (in 10,000 1995 US dollars per capita). Canada had the best performance after adjustment for these variables within the whole study period. Oceania, although was the origin of few research studies regarding the absolute number of publications, ranked second after adjustment for population and GNIPC were made. Europe ranked fourth.

**Discussion**

To our knowledge, this is the first study that evaluated the relative contribution of all world regions in research productivity in the field of respiratory diseases during the period between 1995 and 2003. Although Western Europe published more articles than the United States, it ranked after the United States with regard to the total product of research productivity (number of articles multiplied by their impact factor). Japan, Canada, and Asia had modest research productivity in absolute numbers. On the contrary, Oceania, Eastern Europe, Central and Latin America, as well as Africa had a small contribution (< 7%) of the total research productivity.

During this 9-year period, the United States and Western Europe had the best trends of total product of research productivity and ranked at the top of quantity and quality of published articles. Although it should come as no surprise that Western Europe and the United States lead the world in research production in respiratory medicine, it is surprising that Western Europe leads the United States. At a great distance are Japan, Canada, and Oceania. Japan and Asia had increased considerably their productivity during the last 4 years and 2 years, respectively. Oceania, Eastern Europe, Central and Latin America, as well as Africa fell short considerably.

![Figure 1. Graph displaying the worldwide trends of the total product of research productivity (number of articles published multiplied by their impact factor [IF]) in the Respiratory System category in different world regions in the period from 1995 to 2003. West_Eu = Western Europe; USA = United States; East_Eu = Eastern Europe; C_L_Am = Central and Latin America.](image)

**Table 2—Research Output of Different World Areas Published in Journals Included in the Respiratory System Category of the Institute for Scientific Information, Adjusted for Population and GNIPC**

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<tbody>
<tr>
<td>Canada</td>
<td>10.3</td>
<td>13.2</td>
<td>11.5</td>
<td>12.1</td>
<td>13.3</td>
<td>12.8</td>
<td>13.6</td>
<td>11.8</td>
<td>13.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Oceania</td>
<td>5.5</td>
<td>4.6</td>
<td>6.2</td>
<td>7.8</td>
<td>6.7</td>
<td>8.6</td>
<td>10.2</td>
<td>7.8</td>
<td>7.7</td>
<td>7.2</td>
</tr>
<tr>
<td>United States</td>
<td>5.3</td>
<td>5.2</td>
<td>5.3</td>
<td>5.6</td>
<td>5.8</td>
<td>6.3</td>
<td>6.9</td>
<td>5.9</td>
<td>6.7</td>
<td>5.9</td>
</tr>
<tr>
<td>Western Europe</td>
<td>3.6</td>
<td>4.3</td>
<td>4.3</td>
<td>4.8</td>
<td>5.0</td>
<td>5.4</td>
<td>6.1</td>
<td>5.5</td>
<td>5.6</td>
<td>5.0</td>
</tr>
<tr>
<td>Japan</td>
<td>1.2</td>
<td>1.4</td>
<td>1.4</td>
<td>1.7</td>
<td>1.8</td>
<td>2.1</td>
<td>2.2</td>
<td>2.2</td>
<td>2.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>0.6</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td>1.4</td>
<td>1.6</td>
<td>2.9</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Africa</td>
<td>0.6</td>
<td>0.9</td>
<td>0.9</td>
<td>1.2</td>
<td>1.6</td>
<td>1.6</td>
<td>2.0</td>
<td>1.8</td>
<td>2.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Asia (excluding Japan)</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
<td>1.1</td>
<td>1.2</td>
<td>1.4</td>
<td>1.4</td>
<td>1.6</td>
<td>2.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Latin America and the Caribbean</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.7</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.1</td>
<td>1.1</td>
<td>0.7</td>
</tr>
</tbody>
</table>

*Data are presented as No. of publications multiplied by the impact factor per million of population divided by the GNIPC (in 10,000 1995 US dollars per capita).*
Taking into consideration the population of each world area and their GNIPC, although Canada and Oceania fell short in absolute numbers compared to Western Europe and the United States, both of them had better records, with Canada being the protagonist. The United States ranked third, and Europe ranked fourth on this list. On the contrary, Japan, Eastern Europe, Africa, Asia, as well as Latin America and the Caribbean did not have strong records of productivity.

Scientific publications in respiratory disease research increased from 1995 through 2003 in both absolute numbers and quality especially in the United States and Europe. Western Europe, the United States, Japan, and Canada produced approximately 90% of the total number of articles published in this field of research during this period. On the contrary, the contribution of developing world in research productivity was rather disappointing. Similarly to this finding, the total share of all biomedical publications decreased for low-income countries in the period from 1990 to 2000.14 On the contrary, the better the economic ranking of a country, the higher the quantity and quality of its biomedical publications.15

The increased number of published articles in the respiratory disease research journals is mainly attributed to the introduction of new titles of journals as well as to an increase of the number of articles published in some of the journals in the field. The average number of references allowed in the published papers has also increased during the last few years of the study.16 One explanation for this could be that the electronic on-line submission systems during last years made easier for international authors to submit their studies. In addition, the compensation and efforts for contribution in research and international recognition of pulmonary and critical care doctors increased the quantity of publications in this field. It should also be noted that the average impact factor of all biomedical journals show increasing trends.17 All these factors most likely represent the result of increased demand for publishing due to increased production of research.

We would like to acknowledge several limitations of our study.12 First, we used JCR criteria to include medical journals in the study. Articles published in non-JCR-cited journals were not included, although we recognize that they contribute to scientific production.18 This pertains especially to regions with authors who are not native speakers of English (ie, Eastern Europe and Japan), where researchers tend to publish their findings in regional journals of their own language.19 In addition, one should take into account that the impact factor has often been criticized as a tool for measuring quality of scientific research by several investigators.20,21 This is because there are several variables that may influence the impact factor of a journal besides its quality and impact of its publications, such as the proportion of review articles compared to original articles, self-citation practices, and promotion of journal by publishing companies. Yet, thus far, it has not been replaced by any other worldwide-accepted method.23 We also used PubMed, which is an easily accessible and widely used database. Nevertheless some scientific articles are not included in this database and consequently were not analyzed in our study. It should be also emphasized that, in PubMed, only the address of the first author is presented; thus, the fact that a study may be the result of a multinational cooperation is not taken into account. Another problem with the collection of data were associated with the fact that our search criteria were not perfect in retrieving the addresses from all articles. However, we managed to retrieve 95.5% of all published articles by performing meticulous searches for the address of the first author.

Furthermore, the division of the world into different regions could be done in several alternative ways, based on various criteria, (eg, Canada could be grouped together with the United States, while Japan could be studied together with the rest of Asia). We believe that our categorization takes into account geographic, economic, and, most importantly, scientific criteria (ie, Canada and Japan represent powerful scientific world regions of their own). Finally, when interpreting the results, one should take into account that many articles regarding respiratory diseases are published in journals other than those included in the respiratory system category. However, we believe that there is no systematic bias in the analysis of our data because there is no reason to believe that research articles on respiratory diseases from some world regions are preferentially published in journals included in other JCR categories.

In conclusion, we evaluated the worldwide trends of research productivity in the field of respiratory disease research during a 9-year period. The results of our study showed that leaders in quantity and quality of research productivity in the respiratory disease research were Western Europe and the United States. Western Europe and the United States had the majority of publications in the respiratory medicine field. As expected, developed world regions rank first in quantity and quality of published articles and have higher productivity adjusted for their population. However, Canada and Oceania had the best performance based on population and GNIPC.
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REFERENCES
10 Index Medicus database (PubMed). Bethesda, MD: National Library of Medicine, 2004
16 Gensini GF, Conti AA. The impact factor: a factor of impact or the impact of a (sole) factor? The limits of a bibliometric indicator as a candidate for an instrument to evaluate scientific production. Ann Ital Med Int 1999; 14:130–133
20 Seglen PO. Why the impact factor of journals should not be used for evaluating research. BMJ 1997; 314:498–502