

## Assessing the Scientific Research Productivity of Puerto Rican Cancer Researchers: Bibliometric Analysis from the Science Citation Index

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**Objective:** The analysis of cancer scientific production in Puerto Rico is largely unexplored. The objective of this study was to characterize trends in cancer-related research publications by authors affiliated to Puerto Rican institutions in recent decades.

**Methods:** Manuscripts were retrieved from the Science Citation Index (SCI) database from 1982 to 2009. Search criteria were that the author's affiliation field contained some institution located in Puerto Rico and that the manuscripts were related to cancer research (according to keywords from the National Cancer Institute's cancer definition). Indexes measured in our analysis included number and type of manuscript, scientific collaboration, author's affiliation, and journal visibility. All the analyses were conducted using ProCite for bibliographic information management and STATA and SEER Joinpoint for the statistical inquiry.

**Results:** From 1982-2009, cancer-related papers authored by scientists located in Puerto Rico came to 451. Over the last three decades the scientific production underwent significant growth (APC = 6.4%,  $p < 0.05$ ) with the highest peak between 2000 and 2009 (61.4% of all articles). Universities are the local institutional sector with the highest number of authors (81.4%), and the University of Puerto Rico is the most active center in this regard (68.5%). Forty-three percent of the manuscripts ( $n=195$ ) were published in 20 journals from which 14 are observed to have high visibility when compared to similar thematic journals.

**Conclusions:** Cancer-scientific production in Puerto Rico underwent constant growth during the last three decades. A complete understanding of citing, publishing, and collaboration patterns in Puerto Rico is critical to researchers, policy makers, and health-care professionals in order to make informed decisions about cancer research priorities. [*P R Health Sci J* 2010;3:250-255]

*Key words:* Science Citation Index, Bibliometric analysis, Cancer research, Puerto Rico

When assessing the scientific production of a country through bibliometric analyses, researchers can map the growth of a research discipline and the patterns of collaboration and funding (1). Thus, bibliometric indicators have become attractive to researchers and policy makers with its promise of some objective measure of output (2-4). Even though bibliometric approaches cannot be taken as an unequivocal measure of scientific quality, at higher aggregate levels, such as journals, bibliometric indicators give relevant information about the research activity conducted (5). Moreover, the application of bibliometric methods has been successful to understand cancer research outputs (6-14) and more specifically, to measure the impact of public policy and funding on cancer research worldwide (4, 15-18).

Because cancer is a public health problem in both industrialized and developing countries (19) and remains as one of the leading causes of morbidity and mortality worldwide (20); cancer research has become one of the most extensive biomedical

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research domains worldwide and cancer-related papers are published on a growing pace of over 2% per year (4). Recently, Ortiz and colleagues found a growth in the number of cancer-related manuscripts published in Puerto Rico's biomedical journals during the last century, although this increase did not parallel the increase in cancer mortality during the last five decades (14). Even though we have already successfully used descriptive bibliometric measures to map out cancer research in Puerto Rico's biomedical journals, we have not yet addressed the contribution of authors affiliated to Puerto Rican institutions publishing on national and international journals. Overall, the scientific activity for science and technology has increased in Puerto Rico as a measure of publications on non-Puerto Rican journals (21-22), but no evidence exists particularly for cancer research.

Understanding the cancer-related scientific activity conducted in Puerto Rico is essential to the development of its scientific policy in this area, as this analysis provides knowledge of progress in science, making it possible to identify the research community's strengths and weaknesses and establish criteria for planning and decision-making (14). As a result of the increase in the burden of cancer in Puerto Rico (23) and given the lack of comprehensive bibliometric analysis of cancer-related research in the Island (14), this study aimed to characterize trends in cancer-related research publications in Puerto Rico in the past decades.

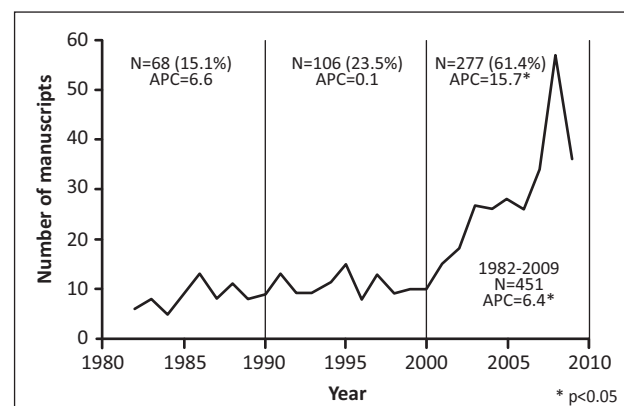
## Methods

The work discussed in this paper was based on published manuscripts retrieved from the Science Citation Index (SCI) Expanded database for the period 1982 to 2009, in which the search criterions were: 1) that the author's affiliation field contained some institution located in Puerto Rico and 2) that the article was related to cancer research. SCI is a citation index originally produced in 1960 by the Institute for Scientific Information in Philadelphia (24). The new SCI Expanded covers 6,400 of the world's leading journals of science and technology. It is made available online through the Web of Science database, a part of the Web of Knowledge Thomson Reuters collection of databases. Our analysis focuses on 1982-2009 given that those are the years for which our institution has access to the SCI Expanded. In accordance with the National Cancer Institute's (NCI) cancer and tumor definitions (25), cancer publications for this study were defined as those that considered the following key terms: cancer, carcinoma, sarcoma, leukemia, lymphoma, multiple myeloma, malignant or cancerous tumor, and neoplasm. The records were directly imported to ProCite using the conversion and file processing utilities provided by this bibliographic information management software (22). Data management and analysis were conducted following the methodology previously developed for bibliometric analysis by Sanz-Casado and colleagues (26).

The bibliometric indicators used for the analysis were: 1) number of papers, 2) author's institution (universities, hospitals, and governmental centers), 3) document typology (articles, congress minutes, notes, letters, editorials, and journal supplements containing published meeting abstracts), 4) journal visibility, and 5) author's collaboration. The annual percent change (APC) (27) was estimated to assess if the trends on the number of papers and co-authorship changed over the study period using the Joinpoint Regression Program from the NCI Surveillance, Epidemiology, and End Results Program (28). As described elsewhere, journal visibility was determined from the rank of each journal within the subject matter as classified by the Journal of Citation Report/SCI (22). Using this criteria, journals were grouped by quartiles (Q1, Q2, Q3, and Q4) to show the importance of each one within the discipline in question; journals in the first quartile (Q1) are the ones with greatest visibility for the scientific community. The journals most often used by local researchers were denoted as core journals if at least 4 papers were published in them. Author's collaboration was analyzed by identifying the number of researchers authoring the manuscripts. Any paper signed by only one author was classified under the heading no collaboration.

## Results

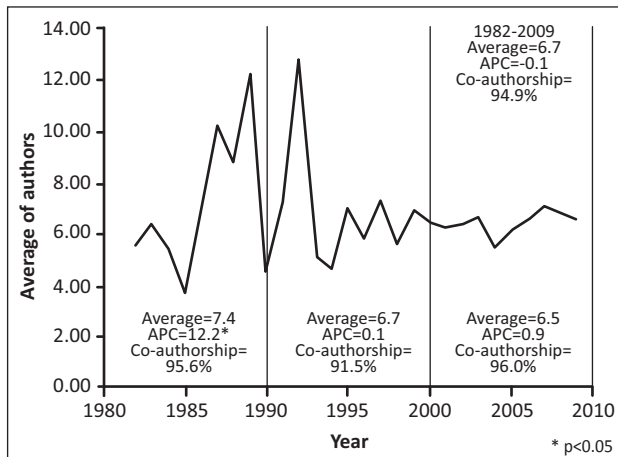
From 1982-2009, a total of 451 cancer-related articles authored by researchers affiliated to Puerto Rican institutions were identified. Figure 1 shows that cancer scientific production in Puerto Rico underwent significant growth during that period (APC = 6.4%,  $p < 0.05$ ). Scientific production has been consistently increasing through the last three decades with its peak in 2000-2009, when 277 papers (61.4% of total of articles) were published with an annual increase of 15.7% ( $p < 0.05$ ).



**Figure 1.** Trends of cancer-related manuscripts authored by researchers affiliated to Puerto Rican institutions, 1982-2009

Figure 2 shows that author's collaboration was relatively constant throughout the last three decades (APC = -0.1%,  $p > 0.05$ ). When analyzed by decade, the average number of

authors per paper fell from 7.5 in 1982-1989 to 6.5 in 2000-2009. Within decades, only during the 1980's did the collaboration between authors show an average annual increase (APC = 12.2%,  $p < 0.05$ ). Ninety-four percent of the papers were co-authored by at least two researchers during the complete study period (1982-2009).



**Figure 2.** Trends of author's collaboration by researchers affiliated to Puerto Rican institutions, 1982-2009

Table 1 shows that articles were the document type most often used by Puerto Rican scientists to publish their findings (68.5%), followed by meeting abstracts (14.6%) and proceedings papers (7.8%). Reviews, notes, letters, and editorials accounted for 8.9% of the remaining total. Table 2 shows that the university is the local institutional sector with the highest number of authors (81.4%), and the University of Puerto Rico is the most active center in this regard (68.5%). Table 3 shows the journals most often used (with at least 4 publications) by Puerto Rican researchers (core journals) and their standing in comparison with same-theme journals. Forty-three percent of the manuscripts ( $n=195$ ) retrieved during the study period were published in a core of 20 journals while the rest 256 papers (57%) were published in 190 different journals. With regard to the standing of those core journals, 14 (70%) are observed to be in the Q1 and 3 (15%) between Q1/Q2 of their respective areas of research.

**Table 1.** Types of documents published, 1982-2009

Type of manuscript	Number	Percentage (%)
Original Article	309	68.5
Meeting Abstract	66	14.6
Proceedings Paper	35	7.8
Review Article	21	4.7
Editorial Material	9	2.0
Note	7	1.6
Letter	4	0.9

**Table 2.** Cancer scientific production by institutional sector, 1982-2009.

Institution	Number	Percentage (%)
Universities	364	81.4
University of Puerto Rico	306	68.5
Private	58	13.0
Non-university hospitals	78	17.4
Governmental centers	5	1.1

**Table 3.** Visibility of cancer scientific production by core journals, 1982-2009\*

Journal Title	Number of papers	Percentage (%)**	Quartile***
Cancer	33	7.3	Q1
Int J Radiat Oncol			
Biol Phys	32	7.1	Q1
J Clin Oncol	19	4.2	Q1
PR Health Sci J	16	3.6	ND
Blood	16	3.6	Q1
Am J Clin Oncol	10	2.2	Q4
Ann Oncol	7	1.6	Q1
Cancer Treat Rep	7	1.6	ND
J Natl Prod	6	1.3	Q1/Q2
Breast Cancer Res Treat	5	1.1	Q1
Cancer Epidemiol			
Biomarkers Prev	5	1.1	Q1
Int J Cancer	5	1.1	Q1
J Nucl Med	5	1.1	Q1
Semin Oncol	5	1.1	Q2
Am J Epidemiol	4	0.9	Q1
Am J Gastroenterol	4	0.9	Q1
FASEB J	4	0.9	Q1
Invest New Drugs	4	0.9	Q1/Q2
J Natl Cancer Inst	4	0.9	Q1
N Engl J Med	4	0.9	Q1

\*The journals most often used by local researchers were denoted as core journals if at least 4 papers were published in them. Core journals represent 20 journals where 43% of the manuscripts ( $n=195$ ) were published.

\*\* Percentages were computed using the 451 total journals as the denominator.

\*\*\*ND = not determined yet, Q1/Q2 = Journals were classified in 2 different research disciplines getting different visibility values in both.

## Discussion

Scientific publications are the most objective and unambiguous product of global research activity (15). In fact, scientific research is primarily geared towards the production of knowledge through publications (15). This study expands our previous knowledge of cancer scientific production in Puerto Rico (14), as this work also includes for the first time a bibliometric analysis for non-Puerto Rican journals and considers journal visibility. Our findings suggest a growing interest for cancer research in Puerto Rico, as shown by the increase observed in the number of cancer related articles during the study period of 1982-2009 (APC=6.4%). This result is consistent with other studies that have demonstrated an increase in cancer research publications worldwide (6, 13, 29).

Also, the increase observed in the number of publications found in our study is higher than the historic increase previously reported for cancer-related publications in Puerto Rican biomedical journals from 1903-2005 (APC = 2.7%) (14).

With regard to the standing of the journals used by scientists, most (70%) of the core journals in which local scientists are publishing their work are observed to be in the first quartile (Q1) of their respective areas of research. This is an indication that the visibility of Puerto Rican cancer research throughout the period was high, a finding also reported for research in science and technology in the Island (22). One possible reason to explain the increment of publications in well-recognized national and international journals by local researchers (an indicator of research quality) is due to the availability of local funding, US grants, and partnerships. As an example, in the last decades, the National Institutes of Health (NIH) and other federal agencies have been funding local researchers through highly competitive grants for research, training, education and outreach as documented by the NIH Research Portfolio Online Reporting Tools Expenditures and Results (30). Also, in 2004, the local government approved legislation to create a Comprehensive Cancer Center with an appropriation bill of more than 100 million dollars for the next ten years with the aim of strengthening research infrastructure in Puerto Rico (31).

Universities were the institutional sector with the largest amount of cancer-related articles published and specifically, the University of Puerto Rico, was the most active center in this regard. A similar pattern has been observed for scientific production in science and technology in Puerto Rico (22) and in cancer-related papers published in local biomedical journals (14). This finding is in keeping with the institutional goal of making the University of Puerto Rico the leading science and technology institution and its researchers more active and competitive at both local and international levels (32-33). It should be borne in mind in this connection that the executive and legislative branches of the government in Puerto Rico perceive scientific research as an activity characteristic of the university, therefore, the infrastructure of governmental agencies has not ideally been designed for scientific research (34). Our results also showed that research articles were the publication type most commonly used by Puerto Rican scientist to publish their findings. This result coincides with trends observed in previous studies conducted in Puerto Rico in the area of science and technology (22, 35) and in cancer (14).

With respect to scientific collaboration, the relatively constant average number of authors per article during the last three decades (APC = -0.1%) does not coincide with previous bibliometric studies conducted in Puerto Rico that documented an increase in collaboration, between local and international researchers (14, 21). Nevertheless, the average number of authors per cancer-related paper observed in this study (6.7 authors per manuscript) is higher than the previously reported for cancer papers published in Puerto Rican biomedical journals

(4.7 authors per manuscript) (14). Scientific collaboration is rising in most disciplines due, among other factors, to the growing complexity of research projects, for which increasingly large numbers of researchers specializing in different areas are required (22). The cost-effectiveness of available resources is directly related to the size of research groups, with the quantity and quality of papers published increasing with the number of authors (35-36). The rising tendency in the number of authors within scientific papers is a development identified in other studies as characteristic of research in the last decades internationally (37-38), since scientific research today calls for more and better human and material resources (22).

In order to fully understand the total spectrum of cancer research in Puerto Rico, it is essential that future bibliometric studies also evaluate other scientific materials such as monographs, books, and dissertation thesis. We also recommend that future bibliometric studies of cancer publications include citation analysis for authors affiliated to Puerto Rican institution. This indicator would help us to understand the extent to which a local researcher has been cited by other authors, an indicator of research quality (22). A complete understanding of citing, publishing, and collaboration patterns in Puerto Rico is critical to researchers, policy makers, and health-care professionals in order to make informed decisions about research priorities (39), public health interventions, and to, overall, guide Puerto Rico's Cancer Control Plan (currently in its implementation phase) (40). Finally, the characteristics and publication rates of the cancer scientific production in Puerto Rico should be compared to that of other countries, to further understand our level of development in the area of cancer research.

## Conclusions

In conclusion, our study expands the knowledge of cancer-related scientific production in Puerto Rico and showed that cancer-related papers authored by scientists located in Puerto Rico underwent significant growth from 1982 to 2009 (with the highest productivity peak observed in the last decades) and that a high journal visibility was observed for the selected journals where local researchers published their scientific findings. Thus, our results support a growth in cancer-related scientific productivity in Puerto Rico.

## Resumen

Objetivo: La producción científica relacionada a la investigación en cáncer en Puerto Rico no ha sido explorada a plenitud. El objetivo de este estudio es analizar las tendencias de publicaciones de cáncer realizadas por autores afiliados a instituciones en Puerto Rico en las últimas décadas. Métodos: Las publicaciones analizadas fueron obtenidas del Science Citation Index (SCI) para el periodo de 1982 a 2009. La

búsqueda bibliográfica incluyó la afiliación del autor a alguna institución localizada en Puerto Rico y que los manuscritos estuvieran relacionados a investigaciones sobre cáncer (de acuerdo a palabras claves de la definición de cáncer del Instituto Nacional de Cáncer). Los índices analizados incluyen la cantidad y el tipo de manuscrito, colaboración científica, afiliación del autor y visibilidad de la revista. Para el manejo de la información bibliográfica se utilizó ProCite y para el análisis estadístico STATA y SEER Joinpoint. Resultados: De 1892 a 2009, un total de 451 manuscritos fueron escritos por autores afiliados a instituciones en Puerto Rico. Durante las pasadas tres décadas la producción científica tuvo un crecimiento significativo ( $APC = 6.4, p < 0.05$ ), con el mayor de publicaciones entre los años 2000 y 2009 (61.4% de todos los artículos). Aunque el 94% de los manuscritos fueron escritos por al menos dos autores, el promedio de autores bajo de 7.5 entre los años 1982-1989 a 6.5 para el período de 2000-2009. El 43 % de los manuscritos ( $n=195$ ) fueron publicados en 20 revistas científicas, de las cuales 14 tienen alta visibilidad, en comparación con otras revistas de temática similar. Conclusiones: La producción científica sobre cáncer en Puerto Rico tuvo un crecimiento significativo durante las pasadas tres décadas. Un mejor entendimiento sobre los patrones de citación, publicaciones y colaboración en Puerto Rico es necesario para que investigadores, creadores de política pública y profesionales de la salud puedan tomar decisiones informadas sobre las prioridades en la investigación de cáncer.

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### References

1. Traynor M, Rafferty AM. Bibliometrics and a culture of measurement. *J Adv Nurs*. 2001;36:167-8.
2. Smith K, Marinova D. Use of bibliometric modelling for policy making. *Math Comput Simul*. 2005;69:177-87.
3. Montes GS. Distribution of financial resources according to the productivity (determined by bibliometry) in the Medical Research Laboratories of the Hospital das Clinicas da Faculdade de Medicina de Universidad de Sao Paulo (Brasil). *Rev Med Chil*. 2000;128:431-6.
4. Lewison G, Purushotham A, Mason M, et al. Understanding the impact of public policy on cancer research: A bibliometric approach. *Eur J Cancer*. 2010;46:912-9.
5. Seglen PO. Why the impact factor of journals should not be used for evaluating research. *BMJ*. 1997;314:497-502.
6. Rodrigues PS, Fonseca L, Chaimovich H. Mapping cancer, cardiovascular and malaria in Brazil. *Braz J Med Biol Res*. 2000;33:853-67.
7. Grossi F, Belvedere O, Rosso R. Geography of clinical cancer research publications from 1995 to 1999. *Eur J Cancer*. 2003;39:106-11.
8. Parodi S, Parodi A, Lombardo C, et al. Cancer research in the European community and other non-EC countries. *Tumori*. 1993;79:9-15.
9. Mela GS, Cimmino MA, Ugolini D. Impact assessment of oncology research in the European Union. *Eur J Cancer*. 1999;35:1182-6.
10. Ugolini D, Casilli C, Mela GS. Assessing oncological productivity: is one method sufficient? *Eur J Cancer*. 2002;38:1121-5.
11. Mahoney MC, Michalek AM. A bibliometric analysis of cancer among American Indians & Alaska Natives, 1966-1993. *Alaska Med*. 1995;37:59-62, 77.
12. Lichtman MA, Oakes D. The productivity and impact of the Leukemia & Lymphoma Society Scholar Program: The apparent positive effect of peer review. *Blood Cells Mol Dis*. 2001;27:1020-7.
13. Ugolini D, Puntoni R, Perera FP, et al. A bibliometric analysis of scientific production in cancer molecular epidemiology. *Carcinogenesis*. 2007;28:1774-9.
14. Ortiz AP, Calo WA, Suárez-Balseiro C, et al. Bibliometric assessment of cancer research in Puerto Rico, 1903-2005. *Rev Panam Salud Publica*. 2009;25:353-61.
15. Eckhouse S, Lewison G, Sullivan R. Trends in the global funding and activity of cancer research. *Mol Oncol*. 2008;2:20-32.
16. Hitt E. The flat-funding years and the National Cancer Institute: Consequences for cancer research. *Mol Oncol*. 2008;2:290-2.
17. Cambrosio A, Keating P, Mercier S, et al. Mapping the emergence and development of translational cancer research. *Eur J Cancer*. 2006;42:3140-8.
18. Lewison G, Sullivan R. The impact of cancer research: How publications influence UK cancer clinical guidelines. *Br J Cancer*. 2008;98:1944-50.
19. Kamangar F, Dores GM, Anderson WF. Patterns of cancer incidence, mortality, and prevalence across five continents: Defining priorities to reduce cancer disparities in different geographic regions of the world. *J Clin Oncol*. 2006;24:2137-50.
20. Kanavos P. The rising burden of cancer in the developing world. *Ann Oncol*. 2006;17:viii15-23.
21. Suárez-Balseiro C, Sanz-Casado E, Ortiz-Rivera L. Patterns of international scientific co-operation in Puerto Rico. *Scientometrics*. 2006;67:335-50.
22. Ortiz-Rivera L, Sanz-Casado E, Suarez-Balseiro CA. Scientific production in Puerto Rico in science and technology during the period 1990 to 1998. *Scientometrics*. 2000;49:403-18.
23. Soto-Salgado M, Suárez E, Calo WA, et al. Incidence and Mortality Rates for Colorectal Cancer in Puerto Rico and among Hispanics, Non-Hispanic Whites, and Non-Hispanic Blacks in the United States, 1998-2002. *Cancer*. 2009, 115:3016-23.
24. Thomson Reuters. Web of Knowledge. Philadelphia, PA: Thomson Reuters. Available from: URL: <http://isiwebofknowledge.com>. Accessed 17 February 2010.
25. National Cancer Institute. Dictionary of cancer terms. Bethesda, MD: National Institutes of Health. Available from: URL: <http://www.cancer.gov/dictionary>. Accessed 17 February 2010.
26. Sanz-Casado E, Suárez-Balseiro C, García C, et al. Metric studies of information: an approach towards a practical teaching method. *Education for Information*. 2002;20:133-44.
27. Kim HJ, Fay MP, Feuer EJ, et al. Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med* 2000;19:335-51.
28. National Cancer Institute's Surveillance, Epidemiology, and End Results Program. Joinpoint Regression Program. Bethesda, MD: National Cancer Institute. Available from: URL: <http://srab.cancer.gov/joinpoint/>. Accessed 8 April 2010.
29. Ben Abdelaziz A, Harrabi I, Aouf S, et al. Typology of Tunisian medical research indexed in MEDLINE from 1965 to 1999. *Tunis Med*. 2002;80:548-55.
30. National Institutes of Health. Research Portfolio Online Reporting Tools Expenditures and Results. Bethesda, MD: National Institutes of Health. Available from: <http://projectreporter.nih.gov> Accessed 8 April 2010.
31. Puerto Rico Public Law No. 230 of 2004.
32. Maldonado N. Education on the road to excellence, all one system. Arlington, VA: The National Science Foundation Available from: URL:

- <http://www.nsf.gov/nsb/meetings/1999/oct/oct7.htm>. Accessed 25 October 2006.
33. Universidad de Puerto Rico. X para la década, agenda para la planificación de la Universidad de Puerto Rico: 2006–2016. San Juan, Puerto Rico: Universidad de Puerto Rico; 2005.
  34. Fernández JR. Política pública para la ciencia en Puerto Rico. Ciencia y política en Puerto Rico. San Juan, Puerto Rico: Ateneo Puertorriqueño; 1990.
  35. Sanz E. Bibliometric study of the scientific production of the University of Puerto Rico, Río Piedras Campus, Department of Chemistry from 1989 to 1994. San Juan, Puerto Rico: University of Puerto Rico; 1995.
  36. Gordon MD. A critical assessment of inferred relations between multiple authorship, scientific collaboration, the production of papers and their acceptance for publication. *Scientometrics*. 1980;2:193–201.
  37. Glanzel W, De Lange C. Modelling and measuring multilateral co-authorship in international scientific collaboration. Part II. A comparative study on the extent and change of international scientific collaboration links. *Scientometrics*. 1997;40:605–26.
  38. Glanzel W, Schubert A, Czerwon HJ. A bibliometric analysis of international scientific cooperation of the European Union (1985–1995). *Scientometrics*. 1999;45:185–202.
  39. Burright MA, Hahn TB, Antonisse MJ. Understanding information use in a multidisciplinary field: A local citation analysis of neuroscience research. *Coll Res Libr*. 2005;66:198–210.
  40. Puerto Rico Cancer Control Coalition. Puerto Rico Comprehensive Cancer Control Plan 2008-2012. A blue-print for cancer control in Puerto Rico. San Juan, Puerto Rico: Puerto Rico Cancer Control Program; 2008.
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