Sira Díaz-Morán[1]
Adolf Tobeña[1]

# Research contributions of Spanish Psychiatry (2004-2009): A bibliometric analysis of a University department

[1]Instituto de Neurociencias
Departamento de Psiquiatría y Medicina Legal
Universidad Autónoma de Barcelona

Psychiatric research in Spain went through a notorious increase in quality and quantity of peer-reviewed papers during the last decade of the previous century, in parallel with other medical disciplines. Although there have been systematic studies of scientific production, they are inadequate from the perspective of the research groups and particularly from university departments. We considered this bibliometric study, in order to analyze the scientific production of the Department of Psychiatry and Forensic Medicine, at the Autonomous University of Barcelona, UAB [DPsML].

**Methodology.** In a cross-sectional survey of independent groups (n = 57, 54% men), indicators were applied to production, quality, visibility/distribution and sustained popularity.

**Results.** DPsML research groups, published 314 articles and/or reviews (216 international) between 2004 – 2009, reaching a total of 974 quotations in the period (16 quots./basic researcher and 11.3 quots./clinical researcher). Contributions at the Thomson Scientific Index [TSI], come from clinical groups (56.48%), and basic groups: 43.52%. The basic groups showed on average impact factor of 5.12 and clinical groups of 2.

**Conclusions.** DPsML published 11.84% of most cited papers in Spanish psychiatry, 20% in the field of drug addiction and 20.84% in the field of behavioral science,1 the inconsistent results with other bibliometric studies2 on the same researchers, shows the need for more tight and demanding indicators and mapping of production encompassing, both research groups as molar units (university departments).

**Key words:**
Bibliometrics, Scientific output, Impact index, Citation analysis, Psychiatry

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Correspondence:
Sira Díaz Morán
Instituto de Neurociencias
Departamento de Psiquiatría y Medicina Legal
Universidad Autónoma de Barcelona
Dirección correo postal: Campus de Bellaterra s/n, Edificio M (Factulad de Medicina)
(Cerdañola del Vallès - Barcelona)
E-mail: Sira.Diaz@uab.cat

## Un lustro de investigación psiquiátrica (2004-2009): análisis de un departamento universitario

La investigación española en Psiquiatría se incrementó en cantidad y calidad a partir de la década de los noventa del siglo pasado. Aunque se han realizado estudios sistemáticos de producción científica, son insuficientes desde la perspectiva de los grupos de investigación y particularmente desde los departamentos universitarios. Con objetivo de analizar el rendimiento científico del Departamento de Psiquiatría y Medicina Legal UAB [DPsML], se planteó el presente estudio bibliométrico.

**Metodología.** Sondeo transversal sobre grupos independientes (n= 57, 54% hombres). Se aplicaron indicadores de producción, cualitativos, de visibilidad/difusión y popularidad sostenida.

**Resultados.** Los grupos de investigación del DPsML, publicaron 314 artículos y/o revisiones (216 internacionales) entre 2004 – 2009, alcanzando un total de 974 citas en el periodo (16 citas por investigador básico y 11,3 por investigador clínico). La producción indexada en el Thomson Scientific Index [TSI], proviene de grupos clínicos (56,48%) y de grupos básicos: 43,52%. Los grupos básicos presentaron un factor de impacto promedio de 5,12 y los grupos clínicos de 1,56.

**Conclusiones.** El DPsML publicó el 11,84% de los documentos más citados en Psiquiatría española, 20% en el ámbito de las drogodependencias y 20,84% en el ámbito de las ciencias del comportamiento[1]; la divergencia de resultados con otros estudios bibliométricos previos[2] sobre los mismos investigadores, muestra la necesidad de aplicar indicadores ajustados y exigentes, así como elaboración de mapas de producción que engloben tanto a grupos de investigación como a unidades molares (departamentos universitarios).

**Palabras clave:**
Bibliometría, Producción científica, Índice de impacto, Análisis de citas, Psiquiatría

## INTRODUCTION

Systematic analyses of medical research output in Spain started at the eighties of the last century, centered on the National Health System and coinciding with general reports on biomedicine and health ciences.[3] The whole Spanish production rates (international peer-reviewed papers) rose from 1.83% in 1996, to 2.44 in 2002 became the ninth, and fifteenth in rankings including the European Union, USA and Japan. This jump of more than 35%, was much higher than increases of global international publications (3.5%) or at the European Union (12%). Although these results are characteristic of R+D+I structures during expansion periods as they start from lower levels in comparison with more advanced countries.[4] Between 1996 and 2002 the total number of biomedicine articles had a smaller increase (from 2,128 to 2,505) compared with scientific disciplines in general (from 1,983 to 2,390).

This trend of augmenting international publications had no parallel in national journals, depicting a clear inclination of Spanish researchers to publish internationally, especially in basic areas.[5] Spanish scientific output increased globally by 9% compared to a world increase of 3%, between 2002 and 2008, according to the figures of articles published in journals indexed in the Journal Citation Reports [JCR][7, 8] and the Thomson Scientific Database (formerly Institute for Scientific Information [ISI])[6]. Spain attained thus the fifth place in the European Union [EU] and the ninth in the world. Growth in science output was remarkable in medical fields (clinical and basic) going from 18,200 documents as 1995 to 39,115 in 2006.[9]

Nowadays, there are public access databases that alow to know detailed volumes of scientific activity within a discipline from specialized literature[2] with some limitations, howewer. The heterogeneity in institutional addresses, centers names and the name of authors, the ambiguous criteria and inadequate debuggind tools complicate the searches compromising reliabilities. Consequently, scientific production studies require a very accurate process at checking and refining raw data, with clearly specified treatment criteria and specialist searchs.

Scientific output assessment is carried out at different grouping levels and bibliometric indicators, but the level depends on the area covered:[7] macro level (countries and scientific disciplines), meso level (research centers, university departments and scientific subdisciplines) and micro level (research groups and individual researchers). In bilbiometric analysis the number of citations per published article is accepted by the majority of analysts, as the best impact or production value indicator. There are howewer several factors that can influence this indicator depending on the subject or the place of publication. Two distinctive effects have been highlighted: *Sleeping Beauties*[11] (fewer citations in the first years of publication with exponential increase in subsequent years) and *Flash in the pans*[12] (highly cited papers in the early years of publication, but without much success later); so, a low or non-citation of an article does not necessarily mean lower quality. The H index is another indicator that started to be applied rather recently, representing the level of sustained popularity of each researcher production along his career.[13, 14] In relation to indicators of journal visibility (Impact Factor), is important to highlight the subject classification of journals provided by Thomson-ISI, shown in the JCR classifications.

A relevant point in biomedical sciences is the distinction and synergies between basic and clinical research. University medical departments often gravitate upon hospital services and the leading basic and clinical research groups are based there. On the other hand, scientific collaboration which emerged in part by the increasing complexity and specialization of research, requires the joint effort of researchers from very different methodologies and skill traditions. These fruitful combinations have been associated with increased scientific outputs and has been reflected on the prestige of the journals were reports appear and citations received.[15, 16] The most active reseach frontiers have opened many ways for collaboration between clinical services and basic reseach laboratories. Psychiatry is not an exception of that trend, because in Neuroscience, Genetics, Biometrics and at the Diagnostc Imaging Centers, there are research groups which coexist and compete with eminentely clinical groups.

The Psychiatry and Legal Medicine Department, UAB [DPsML], is an example of competition and coexistence among groups of clinical and basic research, with complementariety and restrictions, that may illustrate tendencies which probably are becoming routine in many Departments of Psychiatry in the Spanish University system. The present study aims to release and analyze the scientific production of DPsML research groups, applying bibliometric indicators at the Departamental level. The analyses were made both at meso and micro levels with the goal of comparing with a previous analysis of Psychiatry research production in Spain during a preceding period,[2] overcoming some of its methodological limitations through application of sensitive indicators and correcting masked data.

## METHODOLOGY

This research applied a cross-sectional surrey. The design consisted of independent groups with different hierarchical

levels of grouping. The sample was composed by nine research groups, who are members of DPsML (57 researchers, 54% men). These groups have heterogeneous profiles in terms of years, researcher members, methodologies and research lines.

The study established the following inclusion criteria: 1. Articles published between January 2004 and December 2010. 2. All documents had to have an authorship department indication (DPsML). The study excluded all scientific documents that had no article format (originals and reviews).

Procedure: we used a Top-Down strategy in the analysis selection of scientific production for grouping levels. This strategy went from higher amplitude levels (DPsML) to lower levels (research groups and sets of researchers). TSI[6] and Pubmed[17] databases were used to find the articles as well as information from the curriculum vitae of the researchers. The production of each researcher was revised in several adjustment rounds, due to the large number of synonyms/homonyms author's names.

Quantitative and qualitative indicators were applied. Quantitative indicators were based on publications and citations numbers according to JCR 2008 (scientific production visibility). With regard to qualitative indicators, the type of research (clinical vs. basic) was taken into account, in addition of research subject and international reach (international publications). We used the Impact Factor[8] (IF) and H Factor[13, 14], as indicators of visibility and dissemination of findings.

Due to lack of agreement on the definition of basic or clinical branches of medicine research,[18] for the present study we adopted an arbitrary classification appropriate to the aims pursued. Basic research was understood as outputs coming from research groups belonging to the Bellaterra Campus laboratories of DPdML (School of Medicine, UAB) and to the Unit of Cognitive Neuroscience Research (URN); and as clinic research, all studies coming from research groups of Psychiatry Services at the University Hospitals. To delimit the concept of "research group" we applied the following definition: the nucleus of authors who regularly signed jointly scientific papers in a particular topic.[2]

## RESULTS

As shown in table 1, DPsML research groups published 314 total articles and/or revisions between 2004 and 2009, papers which received a total of 974 citations (16 citations per basic researcher and 11.3 per clinical researcher). 216 of all publications had an international scope (journal articles in TSI index). 55.48% of total output published in journals in TSI index (original articles and reviews), came from clinical research groups, highlighting the team: "*Neurogenetics and epidemiology of anxious pathologies*", which accumulated a 47.59% of total citations of the clinical groups.

Among basic groups (36.85% of total production), two groups had the higher percentage of publications: "*Animal models of mental and neural disorders*" (36.07%) and "*Human lab: psychobiology of temperament*" (45.90%); accumulating respectively 33.36% and 51.43% of the total cites (table 1). In terms of Impact Factor, the basic groups had a 5.12 average (range: 0.333-28.103), while in the clinical groups was 2 (range: 0.147-12.537).

Figure 1 shows the differences between basic and clinical research groups regarding the visibility of papers published between 2004 and 2009: basic groups obtained 455 citations and the clinical groups 519.

Figure 2 shows the evolution across the period studied in quotations numbers achieved by all groups. Regarding the visibility of publications, it is worth emphasizing the volume of citations achieved by two basic groups: 234 by the "*Human-lab: Psychobiology of temperament*" group and 153 to the "*Animal models of mental and neural disorders*" group. Among the clinical groups 247 for the "*Neurogenetics and epidemiology of anxious pathologies*" group and, 195 for "*Neurobiology and neurogenetics of affective disorders*" group.

Seven of the nine research groups of DPsML had researchers with H Factors higher than 15, and the rest had researchers within the range 3-10 (groups of more recent onset).

Is important to specify the focus of biometric analysis in order to do the process in a consistent way and interpret the findings properly. Table 2 shows the data from a previous nationwide analysis,[2] which reflected the production of five groups of the DPsML. In this analysis, three of these five groups were only included under the Autonomous University of Barcelona figures (without detailing the Department to which they belonged).

Among the eight groups with highest scientific production and visibility across Spain, three were adscribed to DPsML. 21% of papers published in scientific disciplines related to the field were assigned to these three research groups.[2] Although the comparisons of two different periods (1996-2004 and 2004-2009) are misleading due to methodological and rank differences, there is a coincidence

**Table 1** Department of Psychiatry and Legal Medicine volume scientific output (articles and reviews) and visibility (UAB)

| | Principal Investigator | I/G[1] | Total articles (2004-2009) | | Total articles TSI[2] | | Total number citation[3] | | Impact Factor mean[4] | H Factor (I.P)[5] |
|---|---|---|---|---|---|---|---|---|---|---|
| Animal models of mental and neural disorders | Albert Fernández-Teruel | 10 | 44 | 36.07% | 36 | 38.30% | 153 | 33.63% | 7.37 | 26 |
| Cognitive Neuroscience | Óscar Vilarroya | 9 | 18 | 14.75% | 16 | 17.02% | 52 | 11.43% | 5.00 | 4 |
| Human lab. | Rafael Torrubia | 8 | 56 | 45.90% | 38 | 40.43% | 234 | 51.43% | 3.80 | 13 |
| Environmental variables and mental health | Rosa Maria Escorihuela | 6 | 4 | 3.28% | 4 | 4.17% | 16 | 3.52% | 5.30 | 26 |
| **BASIC TOTAL GROUPS** | | 33 | 122 | 38.85% | 94 | 43.52% | 455 | 47.05% | **5.12** | |
| Neurobiology and neurogenetics of affective disorders | Enric Álvarez | 4 | 43 | 21.94% | 35 | 28.69% | 195 | 37.57% | 1.02 | 23 |
| Neurogenetics and epidemiology of anxious pathologies | Antonio Bulbena | 6 | 67 | 34.18% | 50 | 40.98% | 247 | 47.59% | 0.14 | 12 |
| Neuropathology of mental disorders with impulsiveness | Miquel Casas | 6 | 64 | 32.65% | 26 | 21.31% | 64 | 12.33% | 2.74 | 14 |
| Psychiatric complications in eating disorders | Luís Sánchez-Planell | 3 | 11 | 5.61% | 4 | 3.28% | 11 | 2.12% | 1.26 | 4 |
| Neuropsychology of Behaviour | Jordi Peña-Casanova | 5 | 7 | 3.57% | 7 | 5.74% | 2 | 0.39% | 2.64 | 10 |
| **CLÍNICAL TOTAL GROUPS** | | 24 | 192 | 61.15% | 122 | 56.48% | 519 | 53.29% | **1.6** | |
| **DPSML TOTAL** | | 57 | 314 | | 216 | | 974 | | | |

[1]I/G: number of researcher members for each group. [2]Articles total: Thomson Scientific Index. [3]Citation Total number: Journal Citation Index. [4]Average impact factor: average impact factor of the journals in which the articles were published. Data extracted from the Thomson Scientific Index. [5]I.P.: Journal Citation Index.

in the positive growth of the total yield and the percentage of international productions. The table also reflects the relative increase in DPsML research output compared with UAB totals, across neuroscience disciplines.

## DISCUSSION

This analyses or the research output of a Psychiatry department was carried out as a single case study, with the

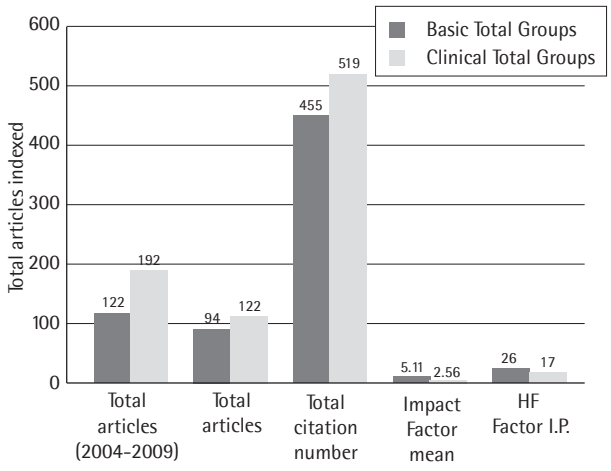


*Figure 1* Comparative data production according research methodology

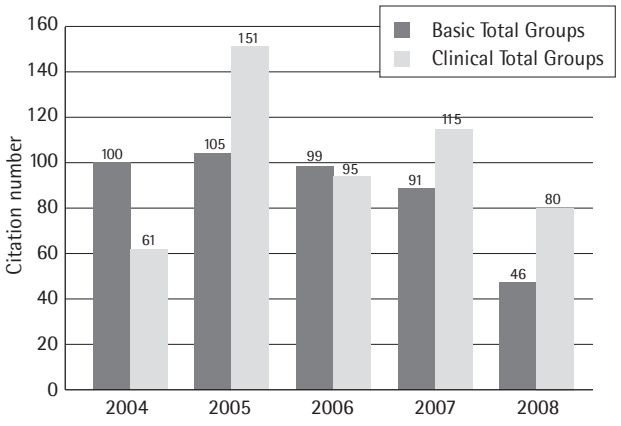


*Figure 2* DPsML scientific production visibility (2004-2009). Clinical and Basic total groups data (JCR, 2009)

aim of exposing the importance of using molar units on clustering, as well as qualitative and longitudinal bibliometric indicators to obtain a map of scientific production overcoming the constraints and distortions found in earlier bibliometric analysis.[2] From the definition of research group according to a nationwide analysis of the 1996-2004 periods by the team BAC from Barcelona, we selected DPsML as a unit of molar analysis encompassing smaller units such as the different research groups and individual investigators.

As shown in Figure 1, from the 314 total output of papers 69.4% reached international scope, published in journals indexed in TSI database;[3] obtaining in addition a total of 974 citations in international literature from 2004 to 2009. In terms of differential outcomes although clinical groups reported a higher amount of articles and reviews, the basic groups achieved higher rates of international publications and citations (Figure 1). Basic groups published 122 total documents, 77% being of international scope and they got the 47.05% of citations. Clinical groups produced a total of 192 articles/reviews, being 63.54% international. As shown in table 1, most of the DPsML articles/reviews were within-groups as less than 5% of the cases involved various groups in their development.

This study only included the number of citations appearing in the TSI[6] databases (69% of all articles published). It is important to mention the difficulty of obtaining reliable data on the number of citations and its interpretation as international databases do not yet provide unanimous sand reliable data; for this reason we have considered only the originals and reviews, identified as pertaining to DPsML , excluding proceedings, abstracts and notes which were included in previous bibliometric analysis[2].

We compared the present DPsML findings with figures coming from Spanish biomedicine production, including research institutions, universities or hospitals with research groups with a well established track record. In a bibliometric analysis in Catalonian region between 1996 to 2006, DPsML research groups DPsML published the 11.84% of the most cited papers in Psychiatry, 20% in the field of drug addiction and 20.84% in the field of behavioural sciences. These ratios are relevant because Catalonia is a Spanish area with the largest number of published documents and the highest number of citations in the field of Psychiatry and Psychology, from 0.43% to 0.57% international publications. Differential outputs among clinical and basic groups moderate the gap found in nationwide data, particularly in the field of Psychiatry, Clinical Psychology and Drug Addiction where there is a clear superiority for basic research in research groups number (health services total: 30 and university total: 87), in the scientific output (health services total: 822 and university total: 1,718) and total citations (health services total: 24.9 and university total: 27.2).

Although the analysis conducted by Méndez-Vázquez y cols. (2007) was useful and covered a different period for the output of psychiatric research groups in Spain,[2] it is important to note the methodological differences with the present work. The documents studied in this previous analysis (1996-2004) included an exhaustive list of all publications, although the

**Table 2** DPsML groups at national level and UAB representativeness, comparions between 1996-2004 y 2004-2009 volume productions (data from 1996-2004, Méndez-Vázquez, 2007)

| Principal investigator for each group | Research center attached | | Total D. (1996-2004) | Total articles (2004-2009) | Total citation number (1996-2004) | Total C. (2004-2009) | Int% (1996-2004) | Int% (2004-2009) |
|---|---|---|---|---|---|---|---|---|
| Miguel Casas | Autonomous University of Barcelona | Scientific Disciplines (JCR)[6] | 26 | 25 | 437 | 56 | 11.50% | 37.31% |
| Alberto Fernández-Teruel | | | 21 | 38 | 507 | 152 | 61.90% | 79.20% |
| Rafael Torrubia | | | 21 | 38 | 186 | 234 | 19% | 67.90% |
| DPsML groups data[7] | | | Total D.% | Total C.% | Groups% | | | |
| | | | 21% | 27.50% | 37.5 | | | |
| **UAB research groups comparisons (1996 – 2004)** | | | Group profile according to documents in all science areas | | | | | |
| | | | **Total D.[1]** | **Total C. [2]** | **Int% [3]** | **FI [4]** | **Grupos** | |
| Autonomous University of Barcelona scientific production | | Scientific Disciplines (JCR)[6] | 416 | 4.896 | 23.80% | 2.518 | 8 | |
| Spanish Total (Neurosciences and Psychiatry) | | | 7,613 | 72,285 | 25.10% | 2.063 | 123 | |
| UAB groups data[8] | | | **Docs%** | **Citations%** | **Groups%** | | | |
| | | | | 8.67% | 6.50% | | | |

[1]**Total D.:** scientific total documents published. [2]**Total C.:** total citations of the selection documents. [3]**Int%:** international documents percent. [4]**FI:** Impact Factor. [5]**HF:** H Factor mean. [6]**Scientific Disciplines (JCR)**: Neurosciencies, Social Psychology, Psychiatry and Clinical Pychology clínica (Journal Citation Reports). [7]**DPsML groups data:** DPsML groups /UAB selected disciplines of total scientific production. [8]**UAB groups data:** UAB groups / National level selected disciplines of total scientific production.

overall figures did not differentiate by the number of quotations, document types and without establishing impact hierarchies for peer reviewed papers. We considered more valid to include only the original articles and reviews, assuming a greater degree of requirement compared to the inclusion of abstracts proceedings and notes as it was done in that previous work. At the unit of analysis used (research groups), the sample encompassed 123 Spanish groups with five of the nine DPsML groups occupying positions between 29 and 60. Among the ten most productive teams, the research group "*Animal models of mental and neural disorders*" was considered one of the upper eight at state-level in relation to scientific visibility and degree of findings dissemination.[1] However, as Table 2 shows, the previous analysis contains several DPsML research groups not included in any university department[2], thus giving a distorted view of the Spanish scientific network. These groups were in particular: "*Neurobiology and neurogenetics of affective disorders*" and "*Neurogenetics and epidemiology of anxious pathologies*". Moreover, three DPsML teams were not included in the general list although they generated scientific papers regularly from before 2004 (URNC, Psychiatric complications in eating disorders and Neuropsychology of Behaviour). Total outputs and quotations from these research groups were not included within the U.A.B. figures, neglecting the link between the University and their respective hospitals. Therefore, the application of molecular analysis may facilitate debugging errors in assignment of research groups, which can also affect co-authorship of scientific articles, as well as the analysis of joint work between different research groups and/or research centers.

Although that previous nationwide analysis[2] used an H Factor average for all researchers within a group, we believe it is methodologically more correct to specify the H factor of each researcher separately, thus avoiding interferences or collusion between career paths of research group members (year career/quality of published papers).

We hope that the implementation of approaches similar to the one used in this study, can be useful for other Spanish University Departments towards the goal of establishing a network to get reliable outputs comparisons. Is crucial to detect real relationships among research groups as well as differences between journals with different levels of impact in order to perform qualitative analysis and assess the quality of articles in addition to quantity. By comparing the present study with previous analysis we have tried to show that depending on the selected units of analysis the results can be greatly modified and the interpretations also, factors which can give an inaccurate view of the scientific landscape. However, applying indicators simultaneously throught a hierarchy of levels of grouping including: researchers, research groups and university department/ hospital services, it is possible to gain an insight on several dimensions with tight demands. Perhaps institutions such as the Spanish Society of Psychiatry should lead such initiatives.

In conclusion, the objective of this study was the application of bibliometric indicators using molecular units in clustering, selecting a University Department as a molar unit, to try to give a more accurate vision of scientific production in Psychiatry from a single case details. To ascertain whether differences in interpretation of data, might depend on the analysis unit used the volume of research output by DPsML groups, between 2004-2009, was contrasted with the analysis of nationwide study covering the period 1996-2004, which used the "research group" as a grouping variable.

We detailed the performance of DPsML research groups between 2004-2009, assessing the degree of international visibility and the impact factor achieved in specialty journals. According to global data, the DPsML is positioned as a center of biomedical research with a significant volume production, in the Spanish and Catalan context, with both international visibility and impact sowing positive growth. This is a reflection of the amount of work coming from two different but compatible fronts, such as basic and clinical research in Psychiatry, although it would be desirable to increase the interaction between boths sides in order to augment the quality and incisiveness of scientific production of the DPsML.

Finally, the comparison between this work and the previous nationwide study repeatedly quoted revealed differences departing from the focus of the analysis which were extended to the selection of bibliometric indicators and adscription of groups to University Departments or Hospital Services, resulting in notorious discrepancies at total figures. Thus, this work can serve as a warning in a sensitive area for science policy decisions.

## REFERENCES


1. Rovira LI, Méndez-Vázquez RI, Suñén-Pinyol E, Camí J. Caracterització bibliomètrica de la producció científica a Catalunya, 1996-2006. Informe AGAUR-PRBB. 2007. Disponible en: http://bibliometria.prbb.org/ncrcat06.
2. Méndez-Vázquez RI, Suñén-Pinyol E, Torrens M, Castro-Fornielles J, Camí J. Caracterización bibliométrica de grupos de investigación en psiquiatría, psicología clínica y drogodependencias. España. Fundación Alicia Koplowitz y Parque de Investigación Biomédica de Barcelona. 2007. Disponible en: www.prbb.org/psiquiatria.
3. Méndez-Vázquez R, Suñén-Pinyol E, Cervelló R, Camí J. Mapa bibliométrico de España 1996-2004: Biomedicina y Ciencias de la salud. Med Clin. 2008;130(7):246-53. Disponible en: http://www.isciii.es/mapabiomedico
4. Science Citation Index (SCI): http://science.thomsonreuters.com/cgibin/jrnlst/jloptions.cgi?PC=K
5. Bordons M. Hacia el reconocimiento internacional de las publicaciones científicas españolas. Rev Esp Cardiol. 2004 57(4):799-802.
6. Base de datos ISI of Knowledge: http://www.accesowok.fecyt.es/login/
7. Vinkler P. An attempt of surveying and classifying bibliometric indicators for scientometric purposes. Scientometrics 1988;13(5-6):239-59.
8. Journal citation reports: http://www.accesowok.fecyt.es/jcr/
9. Van Leeuwen TN. Modelling of bibliometric approaches and importance of output verification in research performance assessment. Research Evaluation 2007;16(2):93-105.
10. Luukkonen-Gronow T. Scientific research evaluation: a review of methods and various contexts of their application. R&D Management 1987;17(3):207-20.
11. Van Raan A FJ. (2004) Measuring Science. En: Moed H F y Glänzel W, eds. Handbook of Quantitative Science and Technology Research. Netherland: Kluwer Academic Publishers, 2004; p. 19-50.
12. Costas R. Análisis bibliométrico de la actividad científica de os investigadores del CSIC en tres áreas: Biología y Biomedicina, Ciencia de Materiales y Recursos Naturales. Una aproximación metodológica a nivel micro (Web of Science, 1994-2004). Tesis doctoral, Departamento de Biblioteconomía y Documentación 2009. Disponible en: http://e-archivo.uc3m.es/bitstream/10016/4947/1/Rodrigo%20Costas%20Tesis.pdf
13. Hirsch JE. An index to quantify an individual's scientific research output. Proceedings of the National Academy of Sciences USA 2005;102:16569-72.
14. Hirsch JE. Does the H index have predictive power? Proc Natl Acad Sci USA 2007;104(49):19193-8. Disponible en: www.pnas.org/cgi/doi/10.1073/pnas.0707962104)
15. Narin F, Stevens K, Whitlow ES. Scientific co-operation in Europe and the citation of multinationally authored papers. Scientometrics 1991;21(3):313-23.
16. Katz JS, Hicks D. How Much Is a Collaboration Worth? A

Calibrated Bibliometric Model. Scientometrics 1997;40(3):541-54.
17. Base de datos Pubmed: http://www.ncbi.nlm.nih.gov/pubmed/
18. Narin F, Pinski G, Gee, H. Structure of the Biomedical Literature. J. Am Soc Inform SC 1976;27(1):25-45.
19. Lane, J. Let's make science metrics more scientific. Nature 2010;464:488-9.