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Original Article

A Study of the Bibliometry and Areas of the Research Groups of *Archivos de Bronconeumología* (2003–2007)

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ABSTRACT

Introduction: Scientific cooperation is essential for the advance of biomedical research. Scientists set up informal groups to work together on common issues, who are the main units in the research funding system. Bibliometric and Social Network Analysis methods allow informal groups in scientific papers to be identified and characterised. The objective of the study is to identify research groups in *Archivos de Bronconeumología* between 2003 and 2007 period with the aim of characterizing their scientific collaboration patterns and research areas.
Methods: Co-authorships, institutional collaboration relationships and the main research areas of papers published in *Archivos de Bronconeumología* have been identified. Co-authorship networks and institutional collaboration networks have been constructed by using Pajek software tool.
Results: A total of 41 research groups involving 171 investigators have been identified. The Collaboration Index for articles was 5.59 and the Transcience Index was 73.11%. There was institutional collaboration in 60.33% of papers. The collaboration between institutions of the same region prevails (41.03%), followed by collaborations between departments, services or units of the same institution (39.74%), inter-regional collaboration (14,97%) and international collaboration (6.83%). A total of 83.03% of articles were cited. The main research areas covered by groups were chronic obstructive pulmonary disease, asthma, lung neoplasm, bronchogenic carcinoma, smoking and pulmonary embolism.
Conclusions: The scientific production of a large number of Respiratory System Spanish research groups is published in *Archivos de Bronconeumología*. A notable collaboration and citation rate has been observed. Nevertheless, it is still essential to encourage inter-regional and international collaboration.

Caracterización bibliométrica y temática de los grupos de investigación de *Archivos de Bronconeumología* (2003–2007)

Palabras clave:
Bibliometría
Aparato respiratorio
Publicaciones científicas
Autorías
Colaboración
Redes cooperativas
Relaciones interinstitucionales
España

RESUMEN

Introducción: La colaboración científica es fundamental para el avance de la investigación biomédica. Los científicos conforman grupos informales en relación con sus áreas de interés, que constituyen las unidades de referencia en los procesos evaluativos. Los métodos bibliométricos y el análisis de redes sociales permiten la identificación y la caracterización de estos grupos a partir del análisis de las publicaciones científicas. Se identifican los grupos de investigación de *Archivos de Bronconeumología* en el período 2003–2007, y se caracterizan su grado de colaboración y sus ámbitos de investigación.

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Método: Se han identificado las coautorías, las relaciones de colaboración institucional y los temas de los trabajos publicados en *Archivos de Bronconeumología*, y se han construido las redes de coautoría y colaboración institucional con el programa Pajek.
Resultados: Se han identificado 41 grupos conformados por 171 investigadores. El índice de colaboración de los artículos fue de 5,59 y el índice de transitoriedad fue del 73,11%. El 60,33% de los trabajos se realizó en colaboración institucional, y predominó la colaboración entre instituciones de la misma comunidad autónoma (41,03%) frente a las colaboraciones entre diferentes departamentos, servicios o unidades de la misma institución (39,74%), las colaboraciones interautonómicas (14,97%) e internacionales (6,83%). Se citó el 83,03% de los trabajos. Las principales áreas de investigación de los grupos son enfermedad pulmonar obstructiva crónica, asma, neoplasias de pulmón, carcinoma broncogénico, tabaquismo y embolismo pulmonar.
Conclusiones: Archivos de Bronconeumología canaliza la producción científica de un importante número de grupos españoles del sistema respiratorio. Se ha observado un importante grado de colaboración y citación; no obstante, debe fomentarse la colaboración interregional e internacional.

Introduction

Biomedical research development is increasingly becoming a cooperative activity in which researchers form groups that go beyond the formal institutional boundaries of the centres to which they are affiliated.[1,2] The knowledge generated and passed around within these groups therefore constitutes one of the basic pillars for the progress of scientific activity, which is recognised by organisations that manage scientific policy in rounds of public financing. These organisations aim to promote scientific cooperation by creating more inclusive research groups and increasing the cohesion between them.[3]

Analysing the bibliographical information in scientific publications by analysing social networks enables us to identify existing groups in a certain discipline or area of knowledge. It also offers highly interesting information about how the scientific community is structured, such as group size, the researchers making up research groups, the degree of cohesion between the groups, who the main scientific agents are and the role played by each of them. This facilitates our understanding of the generation and diffusion process for scientific knowledge and contributes to more efficient management of resources dedicated to research.[4-6]

The purpose of this study is to identify both the research groups that form around Spain's leading respiratory system journal, *Archivos de Bronconeumología* (AB), and the thematic areas for each group, and to classify their scientific activity using bibliometric indicators.

Method

The study included four phases: a) establishing the set of documents to be examined in the study and the treatment method for bibliographical information; b) bibliometric description of the journal's scientific activity; c) identification of the research groups and d) bibliometric/thematic classification of the main research groups that were identified.

a) Establishing the set of documents to be examined in the study and the treatment method for bibliographical information. To carry out this study, we searched the Science Citation Index-Expanded (SCI-Expanded) database to select the articles, letters, editorials and reviews published in AB between 2003 and 2007. Next, we ran a meticulous manual search of names and institutional affiliations to combine different variations on the name of a single author or institution. The reasoning process we followed to normalise authors' names was based on analysis of the coincidence of the institutional affiliation with different name variants likely to correspond to the same author. The most complete forms were always considered (two surnames and a full given name). With regard to the institutions, we must highlight that two or more institutional affiliations were sometimes present for a single denomination. This required duplication of these entries in order to register the second affiliation under the same name. SCI-Expanded frequently produces an error by which it confuses hospitals with "university" in their name with universities in the cities in which they are located, so we proceeded to review all names manually, access the full text copies of all studies and make the appropriate corrections. Institutions were taken to mean high-level administrative or hierarchical groups that function as autonomous or independent organisations and which are listed according to the names found in the following documents: 2009 Spanish Catalogue of Hospitals and 2009 Catalogue of Primary Care Centres in the Spanish Health System, drawn up by the Spanish Ministry of Health and Social Policy; the National Registry of Universities, Centres and study programmes, drawn up by the Spanish Ministry of Science and Innovation; and official public directories of institutions. Where these tools were not available, we considered names listed on these centres' Web pages, or, as a last resort, the most frequently found form of the name of the institution.
b) Bibliometric description of the journal's scientific activity. We calculated different bibliometric indicators of productivity (number of documents and signatures), cooperation (list of signatures per study) and impact (mean number of citations per study). We chose a complete holistic inventory system assigning each document to every one of its authors and institutions since this was the most common inventory method. However, such a system has the disadvantage of generating duplicate values or producing too high a count of documents produced as collaborative efforts. In addition, we described institutional collaboration and identified the following cooperation types for each of the documents: Intra-institutional collaboration, for documents produced as a cooperative effort between two different units at the same institution; inter-institutional collaboration, for documents produced as a cooperative effort between two or more institutions (differentiating between documents signed by two or more institutions from the same autonomous community and documents signed by institutions from different autonomous communities); and international collaboration, for documents produced as a cooperative effort among one or more Spanish institutions and one or more foreign institutions. All indicators were calculated for all document types as well as for original articles only, since the latter is the document type which generally presents the main results from scientific research projects.
c) Identification of research groups. To identify research groups, we determined and quantified all co-authorships. Using this information, we ran an algorithm which evaluated the threshold or degree of collaboration and the minimum necessary number of interconnected authors that could be considered a research group.

These values were established for the presence of two or more interconnected authors with three or more co-authorship connections. This algorithm was run with different degrees of cooperation (≥ 3, ≥ 4 and ≥ 5) in order to perform comparative analyses of different thresholds, since there was no clearly established criterion enabling us to define the necessary degree of collaboration for a group to be considered a research group. The same methodology was used to build the network of institutional collaboration relationships.

d) Bibliometric and thematic description of the main research groups that were identified. Identified groups were called "aggregates", their scientific activity was described bibliometrically, and a thematic network was presented linking groups with a description of the documents in which they had participated. To this end, and faced with the difficulty of using keywords in the SCI-Expanded database since they are not subject to any terminological control, we resorted to descriptors assigned to the documents in the MEDLINE data base. This database uses a sophisticated thesaurus, Medical Subject Headings (MeSH), to index document content. The presented descriptor network takes its heuristic and analytic potential from the analysis of social networks. It enables us to view diagrams of relationships established between the different concepts, and the connections between the concepts and the groups. We opted for retaining descriptors referring to clinical symptoms, diagnoses, treatments, methods and research instruments along with the disease names and pathological processes. However, we did run the terminological network through a "pruning" algorithm to eliminate generic terms (such as diagnosis, aetiology or disease) or certain qualifiers (age group, sex, geographical location) that create a high relationship density and make a clear view of the network impossible, even though such terms are not trivial and do provide relevant information. Furthermore, we must point out that as with the case of co-authorship and institutional collaboration networks, it was necessary to measure the strength of the links between groups and topics in order to consider solidified thematic relationships only. Other attributes are also integrated in the thematic network: group and thematic area productivity, as reflected by increased node thickness, and the degree of connection between groups and areas, shown by different link thicknesses. Pajek software for analysing and viewing networks was used for all graphs (http://pajek.imfm.si/doku.php).

Results

We analysed 711 documents, of which 61.32% were original articles (n = 436), 19.97% were letters (n = 142), 11.53% were editorials (n = 82) and 7.17% were reviews (n = 51). Diachronic evolution shows stable productivity at a rate of 133 to 148 studies per year and a mean of 11.85 studies per issue. These values become 78 to 92 studies per year and 7.27 studies per issue when we consider original articles only. During the study period, 1180 authors and 288 different institutions participated in the journal, of which, 1536 authors and 237 institutions contributed original articles. For these articles, the number of signatures per study was 5.59 ± 2.13 and the single-hit index (percentage of authors who published only one study) was 73.11%. Participation in the journal is mainly Spanish. Spanish institutions left their names on 622 studies, while only 28 were signed by foreign institutions, and 23 were collaborative efforts between Spanish and foreign institutions. Of the 673 studies presenting an institutional affiliation, 60.33% (n = 406) were cooperative in some way, while 39.67% of the documents (n = 267) did not identify any type of collaborative effort. These values are noticeably higher when we consider only original articles, since 74.06% (n=297) of the 401 articles with an institutional affiliation were carried out collaboratively, while 25.93% (n = 104) were completed without collaboration. Of those articles in which Spanish institutions participated, the most common form of collaboration is that between institutions in the same autonomous community, which makes up 41.03% of the total collaborative efforts (n = 222). This number is closely followed by intra-institutional collaboration, which makes up 39.74% (n = 215). We then find collaboration among institutions in different autonomous communities at 14.97% (n = 81) and international collaboration, which makes up 4.25% (n = 23). With regard to the distribution of publications according to the institutional sector, hospitals lent their name to 89.75% of the studies (n = 604), universities to 24.66% (n = 166), research centres to 9.06% (n = 61), primary care centres to 5.2% (n = 35), government bodies to 3.26% (n = 3.27), non-profit organisations to 2.23% (n = 15) and corporations to 1.48% (n = 10). Regarding impact indicators, we must point out that 73.14% of the total studies (n = 520) and 83.03% of the original articles (n = 362) were cited at least once. Eighteen studies were cited more than nine times, 341 studies between two and nine times, and 161 studies a single time (data as of February 2009). Table 1 shows a summary of the main productivity, collaboration and citation indicator results.

We identified 7436 co-author relationships corresponding to 6125 different pairs of authors. Once this information was processed by using a threshold of three or more collaborative studies, we were able to identify 41 investigation groups made up by 171 authors, which means that 66.28% of the authors who published at least three studies form part of one of the groups, including the 14 most prolific authors (> 9 studies). We distinguish eight groups made up of between six and nineteen members (Fig. 1) and another 33 smaller groups made up of between two and five members (Fig. 2). In addition, by applying the same collaboration threshold, we identified nine institutional groups pertaining to 48 centres (fig. 3). Table 2 lists these values and those obtained by applying different thresholds or degrees of cooperation.

The 41 identified groups are responsible for 47.54% of the documents (n = 338) and 56.4% of the citations (n = 894); 79.88% of the documents signed by these groups were cited (n = 270). Figure 4 presents the thematic research areas for the research groups previously identified through co-author analysis and designated by the name of the investigator who participated in the most studies. Each group's productivity is indicated by the size of the nodes, and the degree of connection between different topics is shown using thinner or thicker links. Only those thematic areas covered by 25 of the 41 groups were classified due to the fact that some of them – mainly those with the lowest productivity – do not have established

Table 1
Main productivity, cooperation and impact indicators for Archivos de Bronconeumología (2003–2007)

Measurement or indicator	All documents	Original articles
Number of documents	711	436
Number of signatures	3087	2438
Number of authors,	1810	1536
Number of prolific authors	14	6
Number of single-hit authors	1275	1123
Rate of signatures per study ± SD (95% CI)	4.34 ± 2.53 (4.15-4.52)	5.59 ± 2.13 (5.39-5.79)
Single-hit authorship index	70.44	73.11
Authors per study index	2.54	3.52
Number of institutions	288	237
Number of institutional names	1217	852
Mean institutional names per study	1.81	2.12
Number of citations (February 2009)	1585	1222
Number of cited works	520	362
Mean citations per work	2.23	2.8
Percentage of works cited	73.14	83.03

SD: standard deviation; CI: confidence interval.

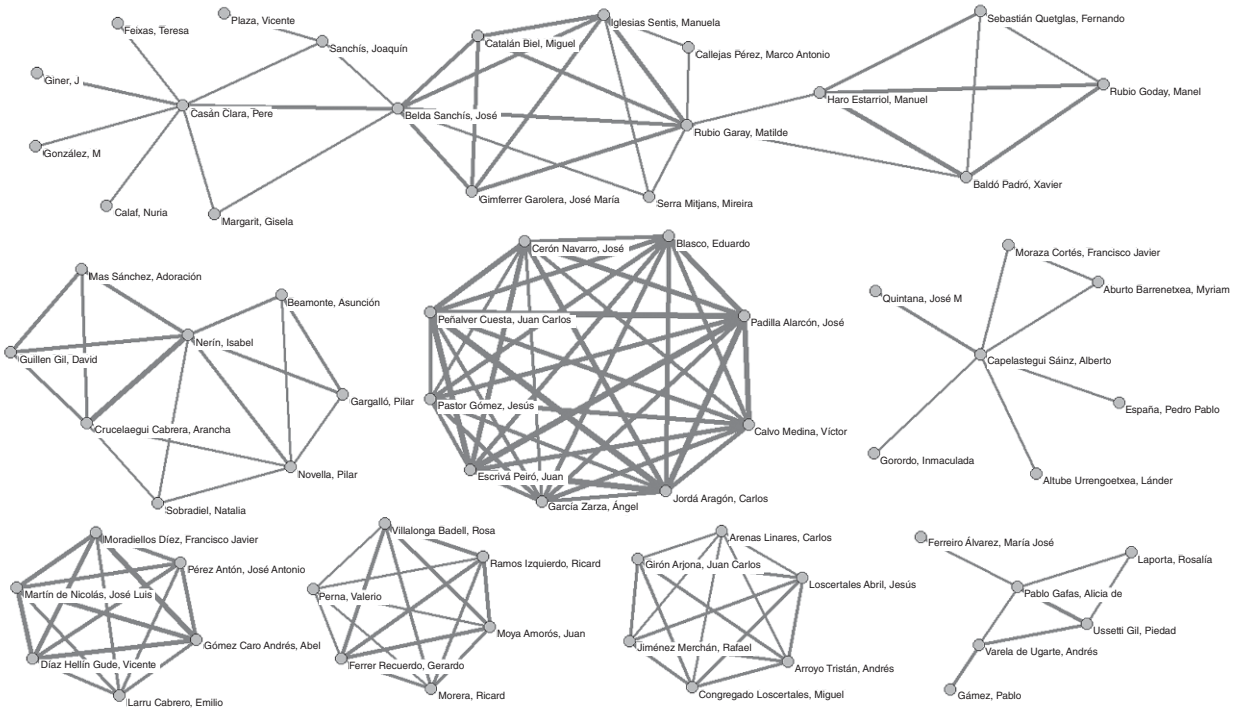

Figure 1. Groups of researchers (> 5 members, degree of collaboration ≥ 3) identified in *Archivos de Bronconeumología* (2003-2007).

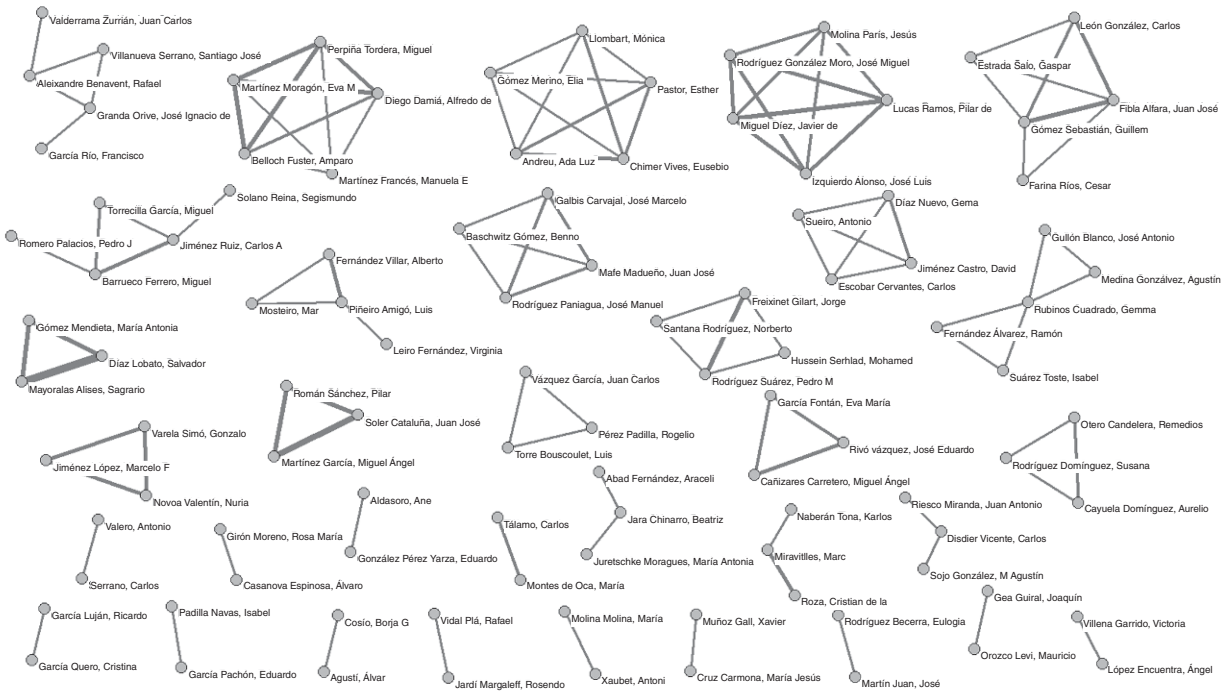

Figure 2. Groups of researchers (2 to 5 members, degree of collaboration ≥ 3) identified in *Archivos de Bronconeumología* (2003-2007).

solidified links that would have permitted them to define their research fields. Chronic obstructive pulmonary disease, lung cancer and lung neoplasias, asthma and smoking stood out in the centre of the network as the thematic areas linked to the largest number of groups.

Discussion

The main methodological limitation of this study is that the database in use tends to have significant defects in quality. This may be because the authors themselves do not always sign their studies

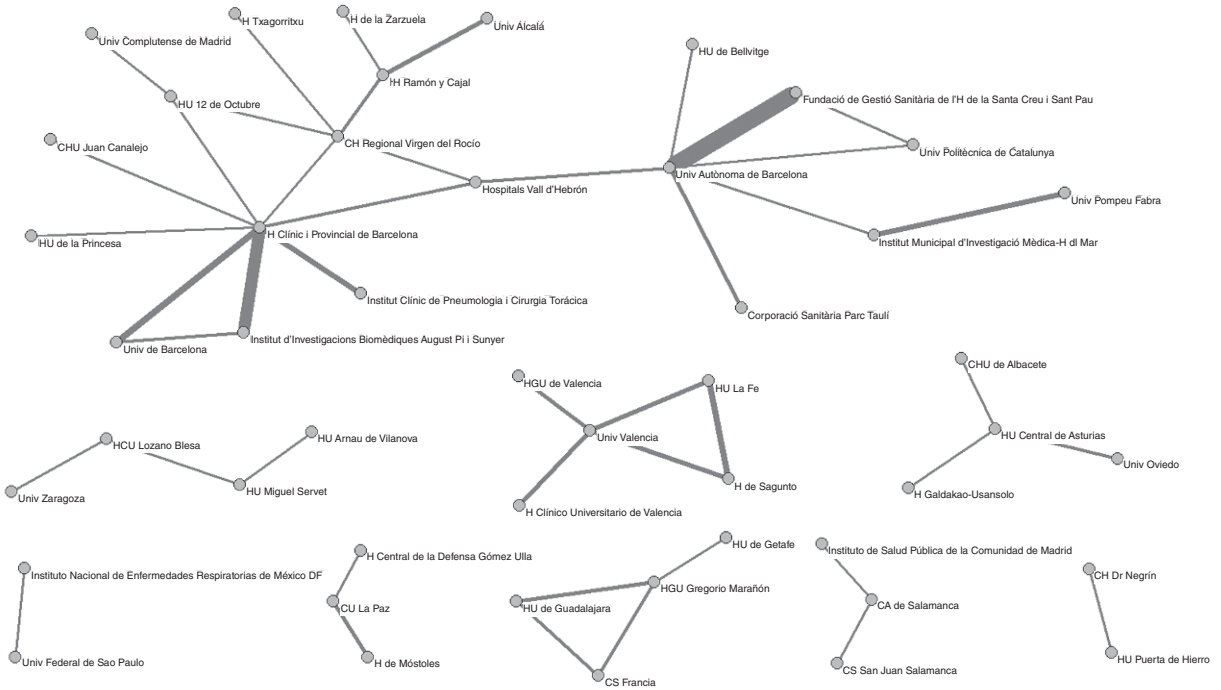

Figure 3. Institutional collaboration networks (degree of collaboration ≥ 3) identified in *Archivos de Bronconeumología* (2003-2007).

Table 2
Co-authorship and institutional collaboration groups identified in *Archivos de Bronconeumología* (2003–2007)

Measurement or indicator	Degree of collaboration ≥ 3		Degree of collaboration ≥ 4		Degree of collaboration ≥ 5	
	Authors	Institutions	Authors	Institutions	Authors	Institutions
No. of groups	41	9	25	7	19	7
No. authors/institutions per group	171	48	95	25	65	20
Percentage of authors/institutions forming part of a group	66.28	47.52	57.93	31.25	61.32	29.41
No. members in largest group	19	21	9	8	9	5

in the same way, or it may be due to errors or lack of uniformity when the information is processed. As a result, we may not have detected some instances of synonymy (two or more signatures corresponding to the same author) or homonymy (a single signature referring to the scientific works of two or more authors), although we tried to minimise this problem through an exhaustive and meticulous examination of all of the signatures, as stated in the "methods" section. Furthermore, we must be aware that an exhaustive, complete vision of the groups and Spanish research on the respiratory system in general must consider studies published in all scientific journals, as well as studies found in multidisciplinary publications or those belonging to other specialties. However, since this journal is the official publication of SEPAR (the Spanish Society of Pneumology and Thoracic Surgery) and the only Spanish journal in that field with an impact factor listed in the Journal Citation Reports (JCR), the study performed using AB is a good model of the characteristics of Spanish research in that area.[7,8] This publication includes 41.67% of the studies in the respiratory system category that were signed by at least one Spanish institution during the study period. With regard to thematic analysis of research groups' scientific activity, although using a controlled document thesaurus or vocabulary list does not exclude the possibility of errors arising due to the documentalist's poor interpretation of document content, it does offer more uniformity and consistency than using free language to describe subject matter. Therefore, a study of keywords used by authors of documents published in AB between 1994 and 2001 found a correspondence between author-selected keywords and descriptors used in MeSH that varied by 39 to 65%, depending on the different thematic areas. This calls attention to the fact that the words and acronyms most frequently misused by authors were listed in the MeSH vocabulary as one of the most common motives for a lack of correspondence. These factors were corrected in the present study, which used MeSH descriptors.[9]

Since biomedical research is becoming increasingly characterised by cooperative work, individual author and institution inventories are not a faithful representation of the developmental dynamic of scientific research, and it makes more sense to speak of studies using "research groups" as the unit of reference. The research group concept used in the present study was developed based on ideas contributed by scientific policy management organisations. In the 2009 round conceding Strategic Health Action grants within the framework of the 2008-2011 Spanish R&D & innovation plan, the research group was defined as a "set of researchers grouped around a lead researcher who collaborate in the study of a homogeneous topic and who complete research projects financed by national or international financing rounds, and who have contrasted quality and/or patent development publications".[3] In addition, we consider the bibliometric concept of the group, meaning the co-authorship of scientific studies,[10-12] as well as contributions from network theory, according to which any social system can be broken down into the different subgroups that make it up; the subgroups are determined based on the cohesion between their own components. The

Figure 4. Thematic areas for research groups identified in *Archivos de Bronconeumología* (2003-2007). *Only three authors in addition to the cited author presented an equal number of studies: Juan Moya Amorós, Ricard Ramos Izquierdo and Rosa Villalonga Badell.

collaboration threshold or degree in the case of scientific co-authorship networks is a reflection of the existence of solidified collaboration connections.[13]

The completed analysis highlights many of the keys to AB's success as the Spanish-language journal with the second highest impact factor in the JCR. On this subject, we must first refer to the significant increase in the absolute number of citations received, which has grown from 280 in the 1997–2000 period to 1585 in the present study.[8] Most important, however, is the fact that most of the compiled contents are of interest to the scientific community, as shown by the high percentage of cited studies (83.03% of the original articles). This places the journal at the forefront of the Spanish-language biomedical journals listed in SCI-Expanded for the 2003–2007 period, significantly ahead of the *Revista Española de Cardiología* (72.6%) or *Enfermedades Infecciosas y Microbiología Clínica* and *Medicina Clínica,* which have a 67.52% and 67.11% citation rate, respectively. We must also point out the large degree of cooperation both among authors, as the number of signatures per work is increasing continuously,[14] and on an institutional level, as the percentage of collaborative documents (60.33%) is higher than that observed in other publications. For example, the *Revista Española de Cardiología* produced 51.43% of its articles through institutional collaboration between 2000 and 2005, and the *Revista de Neurología* produced 56.54% of its articles through institutional collaboration between 2002 and 2006.[6] In addition, numerous research groups and an expansive view of the field of research, as shown by the thematic diversity of the topics that were addressed, are factors that help explain the journal's success. On the other hand, the analysis also enables us to identify some of the weak points which should be examined, such as the need for integrating the largest possible number of authors participating in the magazine in some of the research groups, and for favouring increased cohesion and integration of the numerous researcher groups or nuclei we identified as having a low number of members. It has been noted that studies signed by research groups receive more citations (79.88% of the cited studies) than those in which no research group members participated (66.93%). In addition, studies by groups containing high numbers of researchers (> 5 members) receive the most citations (84.76%). It is also crucial to strengthen collaboration by Spanish researchers on the interregional and international levels, as the positive effect of this type of action on citation rates has been shown by various studies.[15] We must also foster university and research centre participation in collaborative efforts with health centres, and take steps to increase the number of studies that attract high citation rates. This may be done through several studies, such as preferential attention to hot topics, which attract the attention of international-level research projects.[16]

The groups' areas of investigation are related to the research areas prioritised by SEPAR during the last few years. Scientific contributions to AB in the following areas have been examined in exhaustive reviews[17-21]: chronic obstructive pulmonary disease, which is the main thematic area in terms of both productivity and citations;[22,23] asthma;[24,25] smoking,[26] which once played a marginal role in AB, but is now one of the key areas of research,[15,27] and lung cancer.[28] All of these topics had a remarkable presence in the research presented in AB in the 1990s.[27] SEPAR directives designated each of them as the topic of reference in 2002, 2003, 2007 and 2005 respectively, and different groups were formed to address each of these topics. Likewise, we must also indicate another three areas receiving attention that have been well-covered by AB: sleep apnoea,[29] pneumonia[30,31] and tuberculosis,[32] the SEPAR topics of reference in 2006, 2004 and 2008 respectively, although no well-formed groups related to the last two thematic areas could be identified in AB.

Conflict of interest

The authors affirm that they have no conflicts of interest.

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