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Bibliometric analysis of the Spanish MR radiological production (2001–2007)

Alberto Miguel-Dasit [a,*], Luis Martí-Bonmatí [b], Pilar Sanfeliu [c]

[a] *Magnetic Resonance Section, La Plana de Vila-Real Hospital, Castellón, Spain*
[b] *Department of Radiology, MR Section, Dr. Peset University Hospital, Valencia, Spain*
[c] *Humanities Department, Cardenal Herrera-CEU University, Alfara, Valencia, Spain*

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Abstract

Objective: To evaluate the number and characteristics of papers on MR imaging written by radiologists in Spain and published in 2001–2007 Medline-indexed journals, including a comparison with the MR research output from German radiological departments.
Materials and methods: Specific search profiles were devised to retrieve items from the Medline database. Relationship with the topic and major thematic areas of the articles, publication year, journal, language of publication, and mean impact factors were analyzed. Spanish and the German institutions with the highest MR productivity were identified. Also, the number of articles from Spain and Germany published in their respective official journals (*Radiología* and *ROFO*) was recorded.
Results: There were 332 Spanish articles published in 101 different journals. The higher number of papers was published in Spanish radiology and non-radiology journals ($n = 105$, 32%, mean IF: 0.191). The journal with the higher number of articles was *Radiología* ($n = 51$, 15%). "Neuroradiology" was the most frequent topic ($n = 139$, 42%). The Spanish productivity on MR imaging was yearly stable ($p = 0.67$), with the higher percentage of papers (17%) published in 2006. The topic with the higher IF was "neuroradiology" (IF: 2.317). There were no yearly variations for the three major thematic areas ("Neuro imaging": $p = 0.64$; "Body imaging": $p = 0.91$; and "Non-clinical miscellanea": $p = 0.46$). The highest number of MR publications was found in two Spanish institutions (Dr. Peset University Hospital and Vall d'Hebron Hospital) (both, $n = 28$, 8%). In comparison, there were 1681 articles on MR imaging from Germany, having the two most productive institutions more than 150 papers in this period (University Hospital Essen and Eberhard-Karls University of Tübingen). The adjusted number of articles per million populations was 20.4 for Germany and 8.1 for Spain. A total of 395 (23%) articles originating from Germany were published in the official German radiological journal *ROFO*. The percentage of articles originating from Spain and Germany published in their respective official journals was statistically different.
Discussion: Spanish radiologists published approximately two-third of their MR articles in several non-Spanish journals, while the official Spanish radiological journal *Radiología* leads the ranking of Spanish journals. Spanish radiologists are mainly active in the "neuroradiology" topic. The Spanish healthcare sector is the most active. German institutions published more in their official journal *ROFO*.

Keywords: Radiology and radiologists; Research; Spain; Germany; Magnetic resonance imaging; Impact factor; Scientific journals

1. Introduction

Some bibliometric studies have been conducted in the field of radiology. Most of them determined the productivity in scientific papers of the radiology investigators originated from Europe, globally [1] and for specific countries such as Spain [2–5] or Italy [6]. On the other hand, the development, diffusion, access, and trends in the utilisation of magnetic resonance (MR) imaging technique in several different countries have been analyzed [7–12]. Nevertheless, few bibliometric studies regarding the productivity in articles focused on a specific diagnostic imaging technique were found in the literature [13–16].

The purpose of this work is to evaluate the scientific production of Spanish radiologists by calculating their papers on MR imaging published in 2001–2007 Medline-indexed journals, and the relationship to the topic of the articles, publication year, journal, and language of publication. The study is also aimed to analyze the Spanish output on MR imaging in journals included in Journal Citation Reports (JCR). The impact factor (IF) by

* Corresponding author at: C/Pintor Peris Aragó 35-12, Alboraya (Valencia) E-46120, Spain. Tel.: +34 961859924; fax: +34 964357697.
E-mail address: amdasit@hotmail.com (A. Miguel-Dasit).

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topic will be also calculated to identify the topics with the highest IF in which Spanish radiologists publish. A comparison will be made with their publications in the official Spanish radiological journal, *Radiología*; and with the publication of radiology departments in Germany, the leading country both in number of scientific papers in Europe during 1995–2000 [1] as well as in publications on cardiac MR imaging between 1999 and 2004 [14].

2. Materials and methods

2.1. Study search and data collection

The Medline database (http://www.pubmed.gov/) was searched to determine the total number of publications on MR imaging, as original, reviews or case reports, originated from radiologists in Spain and published between 2001 and 2007. Given that there were not suitable terms focused on MR imaging in the "Medical Subject Headings" (MeSH) database (which includes only the terms "magnetic resonance imaging", "echo-planar imaging", "magnetic resonance angiography" and "magnetic resonance imaging, cine"), the search was performed in free language. Included articles were all those in which the following key words appeared in the title of the abstract: "magnetic resonance", "MR", "MRI", "MRS", "HMRS", "fMRI", "MRA", "MRCP", "magnetic cholangioresonance", "magnetic resonance voxel-based morphometry", and terms related to different sequences, such as "T2", "STIR" or "diffusion-weighted".

Articles submitted by Spanish radiology departments and MR imaging units were recovered using the "Affiliation" field of MEDLINE with the Spanish term "Espana" and their translations, both into English ("Spain") as well as other used languages from different Spanish regions (such as Catalonia, Galicia, Valencia and the Basque Country), and combinations of terms related to the magnetic resonance imaging technique, such as: "resonancia magnetica", "RM", "magnetic resonance", "MR", "MRI", "radiol*", "radiod*", "neuroradiol*", "diagnostic imaging", "diagnostico imagen", "diagnostic imatge" and "Ressonància magnetica". Last, articles focused on MR imaging but published from other specialties, such as cardiology, neurology or urology were excluded.

The JCR-indexed journals and their impact factor were identified by scanning the *ISI Web of Knowledge* (http://go5.isiknowledge.com/portal.cgi). The 2004 IF journal value was selected for this calculation because of its central position. All the identified JCR-indexed journals were stratified according to their 2004 IF.

Radiología is the only Spanish journal dedicated to diagnostic imaging, and the official journal of the Spanish Radiological Society. This journal was included in the Medline database in 2006. To assure that all the Spanish MR research was included in the study, an analysis of the bibliographical references included in the papers published between 2001 and 2005 in the Spanish journal *Radiología* was performed to record all those focused on MR imaging studies.

2.1.1. Variables evaluated

(a) The journals where the articles were published were classified as Spanish radiology and non-radiology journals, European non-Spanish radiology journals, USA radiology journals; worldwide MR topics journals; worldwide non-Spanish non-radiology journals; and worldwide non-European and non-USA radiology journals. The journals on MR topics included: *Journal of magnetic resonance imaging (JMRI); Magnetic resonance in medicine; Magnetic resonance imaging (MRI); Magnetic resonance materials in physics, biology and medicine (MAGMA), NMR in biomedicine; Journal of magnetic resonance; Journal of cardiovascular magnetic resonance; Topics in magnetic resonance imaging; and Magnetic resonance imaging clinics of north America*. Radiological journals were considered to be all those included both in the subject listing "diagnostic imaging" as well as in the subject listing "radiology" of the published *List of Journals Indexed for Medline* [17], excluding the above-mentioned journals on MR topics.

(b) The topic of the article: abdominal; breast; cardiac; chest; contrast media; genitourinary; head and neck; musculoskeletal; neuroradiology; pediatric; vascular; computer applications; and miscellaneous.

(c) The year in which the article was published.

(d) The temporal distribution of the articles according to topic. The year-by-year Spanish productivity in MR papers was statistically analyzed to identify trends in the temporal evolution of the number of publications in the studied period, as well as possible tendencies in the temporal publication patterns according to the topic. To facilitate the analysis, the above-mentioned topics ("variable" *b*) were grouped into three major thematic areas, including "Neuro imaging" ("neuroradiology", "pediatric neuroradiology" and "head and neck" topics), "Body imaging" ("abdominal", "breast", "cardiac", "chest", "genitourinary", "musculoskeletal", "pediatric body" and "vascular" topics), and "Non-clinical miscellanea" ("contrast media", "computer applications" and "miscellaneous" topics).

(e) The mean IF per topic, estimated as, for example: if there were three papers on a determinate topic published in three different journals, and the first journal was not indexed in the JCR, the second journal had a IF value of 2, and the third journal had a IF of 4, the mean IF of the topic was calculated as: $((1 \times 0) + (1 \times 2) + (1 \times 4))/3 = 2$.

(f) The mean IF per country of edition of the journal (Spanish radiology and non-radiology journals; European non-Spanish radiology journals, USA radiology journals; worldwide MR topics journals; worldwide non-Spanish non-radiology journals; and worldwide non-European and non-USA radiology journals).

(g) The documentary type of the article, classified as original articles, review articles or case reports.

(h) The language of the publication.

(i) The comparison of the MR papers productivity between Spain and Germany during 2001–2007. Germany was selected because it is the European leading country in number of scientific papers during 1995–2000 [1] and

also because German radiological departments showed the highest productivity in cardiac MR imaging research studies [14]. Germany MR papers productivity was estimated by combining the terms "Radiology" and "Germany" in the "affiliation" field of Medline, and the term "ROFO" in the "journal" field of this database, excluding all papers published by radiologists from other German-speaking countries, like Austria. As the productivity in scientific papers according to the country of authors' origin is largely influenced by the number of inhabitants in the country, the number of papers was adjusted for the population in both countries for 2002 by consulting the *UN World population division website* (http://w.w.w.un.org/esa/population/publications/wpp2002/wpp2002wc.htm).

Moreover, the percentage of papers published by German radiologists in the official organ of the Radiological Society of Germany, the journal *ROFO-Fortschritte auf dem Gebiet der Rontgenstrahlen und der bildgebenden Verfahren*, was estimated and compared with the percentage of published articles by Spanish radiologists in the official Spanish radiological journal, *Radiología*, to evaluate a possible tendency to publish the studies in the official journals of their respective societies.

2.2. Statistical analysis

Contingency tables were analyzed with the chi-square test to evaluate differences in publication tendencies for Spanish radiologists and for German radiology departments in their respective official journals. The chi-square test for lineal trend in proportions was used to evaluate the variations in year-by-year Spanish productivity and in the temporal evolution of the number of publications according to the three major thematic areas of "Neuro imaging", "Body imaging" and "Non-clinical miscellanea". Any $p \leq 0.05$ was considered to be statistically significant.

3. Results

3.1. Article distribution according to publishing journal

Between January 2001 and September 2007, a total of 332 articles were published in 101 different journals. Of these papers, 105 were published in Spanish radiology and non-radiology journals (32%), 84 in USA radiology journals (25%), 73 in worldwide non-Spanish non-radiology journals (22%), 52 in European non-Spanish radiology journals (16%) and 17 in worldwide MR topics journals (5%).

Tables 1–5 show the distribution of articles and the IF of the publishing journals. The only paper which was published in worldwide non-European and non-USA radiology journals was in *Australasian Radiology*. Stratified by number, journals with more than 10 papers in this period ($n = 132$) were *Radiología* ($n = 51$), *Revista de Neurología* ($n = 27$), *European Radiology* ($n = 26$), *American Journal of Neuroradiology* ($n = 14$), and *American Journal of Roentgenology* ($n = 14$). Seventeen articles were published in seven different worldwide MR topics journals

Table 1
Number of papers in Spanish radiology and non-radiology journals in decreasing order of impact factor (IF)

Journals	No. of articles	2004 IF
Revista Española de Cardiología	4	1.802
Medicina Clínica (Barc)	1	1.005
Neurología	7	0.752
Nefrología	1	0.390
Neurocirugía	1	0.299
Revista Clínica Española	1	0.287
Revista de Neurología	27	0.210
Anales del Sistema Sanitario de Navarra	1	–
Anales españoles de pediatría	1	–
Anales de Pediatría (Barc)	1	–
Archivos Españoles de Urología	6	–
Gastroenterología y Hepatología	1	–
Radiología	51	–
Revista Española de Anestesiología y Reanimación	1	–
Psicothema	1	–
Total no. of articles in these 15 journals and mean IF	105	0.191

Table 2
Number of papers in European non-Spanish radiology journals in decreasing order of impact factor (IF)

Journals	No. of articles	2004 IF
European radiology	26	2.364
Ultrasound in Obstetrics and Gynecology	1	2.167
European Journal of Radiology	8	1.745
Neuroradiology	5	1.515
Clinical Radiology	3	1.514
British Journal of Radiology	4	1.232
Acta Radiologica	2	1.178
Dentomaxillofacial radiology	1	0.924
International Journal of Cardiovascular Imaging	1	0.789
European Journal of Echocardiography	1	–
Total no. of articles in these 10 journals and mean IF	52	1.898

Table 3
Number of papers in USA radiology journals in decreasing order of impact factor (IF)

Journals	No. of articles	2004 IF
Radiology	6	5.076
Neuroimage	4	4.869
Medical Image Analysis	1	3.212
Radiographics	7	2.494
American Journal of Neuroradiology	14	2.406
American Journal of Roentgenology	14	2.384
Radiologic Clinics of North America	2	1.869
Academic Radiology	5	1.470
Journal of Computed assisted Tomography	9	1.357
Journal of Neuroimaging	1	1.068
Pediatric Radiology	2	1.052
Abdominal Imaging	4	0.884
Skeletal radiology	6	0.880
Seminars in Ultrasound, CT and MR	2	0.688
Current Problems in Diagnostic Radiology	6	–
Emergency Radiology	1	–
Total no. of articles in these 16 journals and mean IF	84	2.075

Table 4
Number of papers in worldwide MR topics journals in decreasing order of impact factor (IF)

Journals	No. of articles	2004 IF
Magnetic Resonance in Medicine	1	3.468
NMR in Biomedicine	5	3.414
Journal of Magnetic Resonance Imaging (JMRI)	1	2.935
Journal of Magnetic Resonance	1	2.461
Magnetic Resonance Imaging (MRI)	1	1.469
Magnetic resonance materials in physics, biology and medicine (MAGMA)	6	1.431
Magnetic Resonance Imaging Clinics of North America	2	–
Total no. of articles in these seven journals and mean IF	17	2.117

(Table 4). A total of 73 papers were published in 52 different worldwide non-Spanish non-radiology journals, the journals *Stroke* ($n=8$) and *Neurology* ($n=5$) having the higher number of papers (Table 5).

3.2. Article distribution according to topic

The highest number of articles were found in the topics "neuroradiology" ($n=139$, 42%); "musculoskeletal" ($n=67$, 20%), "abdominal" ($n=29$, 9%) and "cardiac ($n=21$, 6%). On the contrary, "chest" ($n=4$, 1%), "head and neck" ($n=4$, 1%) and "computer applications" ($n=3$, 1%) had the lowest number of papers (Tables 6 and 7).

3.3. Article distribution according to year of publication

The productivity on MR diagnostic imaging papers published by Spanish radiologists between 2001 and 2007 was stable with slight variations (Table 7). The higher number and percentage of articles ($n=57$, 17%) was found in 2006, whereas the lowest number and percentage of articles were found in the first ($n=41$) and last ($n=42$) years of the analyzed period (12%, both). No differences were found in the year-by-year Spanish productivity in MR research papers during 2001–2007 ($p=0.67$).

3.4. Temporal distribution of the articles according to topic

Table 7 shows the year-by-year distribution of the number and percentages of papers according to topic. "Head and neck" (75%) and "genitourinary" (31%) were the topics with the higher percentage of published articles in the first year (2001) of the analyzed period. "Vascular" (37%) was the topic with the higher percentage of published papers for 2004, whereas articles on MR "chest" imaging studies were published mostly in 2006 (75%). Regarding the "contrast media" topic, 49% of the papers were found published in 2003. In the following topics: "abdominal", "cardiac", "genitourinary", "musculoskeletal", and "neuroradiology", published articles in each year of the analyzed period (2001–2007) were found. No changes in proportions of the number of papers were found for any of the three major thematic areas in which the number of papers per topic was subsequently classified ("Neuro imaging": $p=0.64$; "Body imaging": $p=0.91$; "Non-clinical miscellanea": $p=0.46$).

Table 5
Number of papers in worldwide non-Spanish non-radiology journals in decreasing order of impact factor (IF)

Revistas	No. of articles	2004 IF
Hepatology	2	10.416
Journal of the American College of Cardiology	1	9.133
Lancet Neurology	2	8.340
Brain	1	8.201
American Journal of Psychiatry	1	7.614
Neurology	5	5.973
European Heart Journal	1	6.247
Stroke	8	5.748
Neurobiology of Aging	1	5.516
American Journal of Gastroenterology	2	4.716
Central Nervous System Drugs	1	4.180
American Journal of Medicine	1	4.179
Rheumatology (Oxford)	1	4.102
Anesthesiology	1	4.055
Current Opinion in Neurology	1	4.017
Liver Transplantation	1	3.984
Schizophrenia Research	1	3.889
Multiple Sclerosis	2	2.849
Epilepsia	1	3.329
Cephalalgia	1	3.133
American Journal of Cardiology	2	3.140
Journal of Neurology	3	3.140
Journal of Neurology, Neurosurgery and Psychiatry	1	3.110
Journal of Psychiatry Research	1	3.078
Journal of Neurosurgery	2	2.577
Neurosurgery	1	2.517
Brain Research	1	2.389
Neuropsychology	1	2.357
Neuroreport	1	2.351
European Journal of Neurology	1	2.225
Cerebrovascular Diseases	1	2.150
International Journal of Cardiology	1	2.095
Neuroscience Letters	1	2.019
Metabolic Brain Disease	1	1.973
Journal of neuro-oncology	1	1.968
European Spine Journal	1	1.458
Digestive and Liver Disease	1	1.429
Knee Surgery Sports Traumatology Arthroscopy	2	1.182
Artificial Intelligence in Medicine	1	1.124
Acta Neurochirurgica (Suppl)	1	1.080
Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology & Endodontics	1	0.973
Journal of Shoulder and Elbow Surgery	1	0.861
Journal of Cardiovascular Surgery (Torino)	1	0.800
Advances in Experimental Medicine and Biology	1	0.642
Transplantation Proceedings	2	0.511
Journal of Cardiac Surgery	1	0.181
Six non-JCR indexed journals	6	–
Total no. of articles in these 52 journals and mean IF	73	3.564

3.5. Mean impact factor distribution according to topic

The journal IF values were obtained from Tables 1–5. On the other hand, for each topic the publishing journals were obtained

Table 6
Distribution of journals and number of articles according to topic

Topic	Journals and no. of articles
Abdominal ($n=29$)	*Radiología (n = 7); AJR (n = 5); Eur Radiol (n = 5); Abdom Imaging (n = 2); Am J Gastroenterol (n = 2); Acad Radiol (n = 1); Dig Liver Dis (n = 1); Gastr Hepatol (n = 1); Hepatology (n = 1); Med Clin (n = 1); NMR Biomed (n = 1); Radiology (n = 1); Transplant Proc (n = 1)*
Breast ($n=9$)	*Radiología (n = 4); JCAT (n = 2); AJR (n = 1); Br J Radiol (n = 1); Curr Probl Diagn Radiol (n = 1)*
Cardiac ($n=21$)	*JCAT (n = 5); Am J Cardiol (n = 2); Radiología (n = 2); Rev Esp Cardiol (n = 2); An Sist Sanit Navar (n = 1); Clin Radiol (n = 1); Eur Heart J (n = 1); Eur Radiol (n = 1); Eur J Echocardiogr (n = 1); Int J Cardiol (n = 1); Int J Cardiovasc Imaging (n = 1); J Am Coll Cardiol (n = 1); Radiology (n = 1); Transplant Proc (n = 1)*
Chest ($n=4$)	*AJR (n = 1); J Card Surg (n = 1); J Cardiovasc Surg (n = 1); Radiología (n = 1)*
Contrast media ($n=6$)	*Radiología (n = 2); Eur Radiol (n = 1); Liver Transpl (n = 1). Radiology (n = 1); Semin Ultrasound CT MR (n = 1)*
Genitourinary ($n=17$)	*Arch Esp Urol (n = 6); Br J Radiol (n = 3); Radiología (n = 3); Abdom Imaging (n = 2); Eur Radiol (n = 2); AJR (n = 1); Clin Transl Oncol (n = 1)*
Head and neck ($n=4$)	*AJNR (n = 1); JCAT (n = 1); Radiología (n = 1); Rev Neurol (n = 1)*
Musculoskeletal ($n=67$)	*Eur Radiol (n = 13); Radiología (n = 8); Skeletal Radiol (n = 6); AJR (n = 4); Eur J Radiol (n = 5); Radiographics (n = 4); Curr Probl Diagn Radiol (n = 3); MAGMA (n = 3); Knee Surg Sports Traumatol Arthrosc (n = 2); Acta Radiol (n = 2); Clin Radiol (n = 2); Magn Reson Imaging Clin North Am (n = 2); Radiol Clin North Am (n = 2); Australias Radiol (n = 1); Dentomaxillofac Radiol (n = 1); Emerg Radiol (n = 1); Eur Spine J (n = 1); JCAT (n = 1); J Plast Reconstr Aesthet Surg (n = 1); J Shoulder Elbow Surg (n = 1); Oral Surg Oral Med Oral Pathol Oral Radiol Endod (n = 1); Rev Clin Esp (n = 1); Rheumatology (Oxford) (n = 1); Semin Ultrasound CT MR (n = 1)*
Neuroradiology ($n=139$)	*Rev Neurol (n = 26); Radiología (n = 13); AJNR (n = 11); Stroke (n = 8); Neurologia (n = 7); Neurology (n = 5); Neuroradiology (n = 5); Acad Radiol (n = 4); Neuroimage (n = 4); NMR Biomed (n = 4); Eur J Radiol (n = 3); J Neurol (n = 3); MAGMA (n = 3); Radiology (n = 3); Eur Radiol (n = 2); J Neurosurg (n = 2); Lancet Neurol (n = 2); Mult Scler (n = 2); Acta Neurochir Suppl (n = 1); Am J Med (n = 1); Am J Psychiatry (n = 1); Artif Intell Med (n = 1); Brain (n = 1); Brain Res (n = 1); Cerebrovasc Dis (n = 1); Cephalalgia (n = 1); CNS Drugs (n = 1); Curr Opin Neurol (n = 1); Epilepsia (n = 1); Eur J neurol (n = 1); Hepatology (n = 1); J Magn Reson (n = 1); J Neuroimaging (n = 1); J Neurol Neurosurg Psychiatry (n = 1); J Neurooncol (n = 1); J Psychiatr Res (n = 1); Magn Reson Med (n = 1); Medinfo (n = 1); Metab Brain Dis (n = 1); Neurobiol Aging (n = 1); Neurocirugía (Astur) (n = 1); Neuropsychology (n = 1); Neuroreport (n = 1); Neurosci Lett (n = 1); Neurosurgery (n = 1); Progr Neuropsychopharmacol Biol. Psichiatry (n = 1); Psicothema (n = 1); Rev Esp Anestesiol Reanim (n = 1); Schizophr Res (n = 1); Ultrasound Obstet Gynecol (n = 1)*
Pediatrics ($n=11$)	*Pediatr Radiol (n = 2), Radiología (n = 2); AJR (n = 1); AJNR (n = 1); An Esp Pediatr (n = 1); An Pediatr (Barc) (n = 1); Curr Probl Diagn radiol (n = 1); Radiographics (n = 1); Semin Pediatr Surg (n = 1).*
Vascular ($n=10$)	*Radiología (n = 2); Rev Esp Cardiol (n = 2); AJR (n = 1); AJNR (n = 1); Curr Probl Diagn Radiol (n = 1); Eur Radiol (n = 1); J Magn Reson Imaging (n = 1);R adiographics (n = 1)*
Computer appl. ($n=3$)	*Magn reson Imaging (n = 1); Med Image Anal (n = 1); Stud Health Technol Inform (n = 1)*
Miscellaneous ($n=11$)	*Radiología (n = 6); Adv Exp Med Biol. (n = 1); Anesthesiology (n = 1); Eur Radiol (n = 1); Nefrología (n = 1); Radiographics (n = 1)*

from Table 6. Finally, corresponding journal's IF values were multiplied by the number of articles published in each journal and divided by the total number of papers on the topic.

Table 7 shows the IF value according to the topic. The topics with the highest IF values were "neuroradiology" (IF: 2.317), "cardiac imaging" (IF: 2.114), "contrast media" (IF: 2.018) and "abdominal" (IF: 2.008). On the contrary, the topics with the lower IF values were "genitourinary" (IF: 0.698), "breast" (IF: 0.703), and "chest" (IF: 0.841).

3.6. Mean impact factor distribution according to country of edition of the journal

The worldwide non-Spanish non-radiology journals showed the highest mean IF value (IF: 3.564), followed by worldwide MR topics journals (IF: 2.117), the USA radiology journals (IF: 2.075) and the European non-Spanish radiology journals (IF: 1.898). The lowest mean IF value (IF: 0.191) was found in the Spanish radiology and non-radiology journals.

3.6.1. Article distribution according to documentary type and language of publication

With respect to the documentary type, most papers were "original articles" ($n=228$, 69%). The remaining ones were "reviews" ($n=68$, 20%) and case reports ($n=36$, 11%). Regarding the language of publication, 227 articles (68%) were published in English, and the remaining ($n=105$, 32%) in Spanish.

3.7. Comparison in MR research productivity between Spain and Germany

The German productivity on MR imaging papers ($n=1681$) was much higher than that of the Spanish radiologists ($n=332$).

Table 7
Temporal distribution of the papers and mean impact factor according to topic

Topic	No. of papers published in 2001	No. of papers published in 2002	No. of papers published in 2003	No. of papers published in 2004	No. of papers published in 2005	No. of papers published in 2006	No. of papers published in 2007	Total no. of papers per topic	Mean Impact factor per topic
Abdominal	4 (17%)	1 (3%)	7 (27%)	3 (7%)	7 (17%)	5 (17%)	2 (3%)	29 (100%)	2.008
Breast	–	1 (11%)	–	2 (22%)	3 (33%)	2 (22%)	1 (11%)	9 (100%)	0.703
Cardiac	1 (5%)	3 (14%)	3 (14%)	1 (5%)	6 (28%)	4 (19%)	3 (14%)	21 (100%)	2.114
Chest	–	1 (25%)	–	–	–	3 (75%)	–	4 (100%)	0.841
Contrast media	1 (17%)	1 (17%)	3(49%)	1 (17%)	–	–	–	6 (100%)	2.018
Genitourinary	5 (31%)	2 (6%)	1 (6%)	4 (19%)	2 (12%)	3 (19%)	1 (6%)	17 (100%)	0.698
Head and neck	3 (75%)	–	–	1 (25%)	–	–	–	4 (100%)	0.993
Musculoskeletal	8 (13%)	10 (12%)	12 (20%)	11 (16%)	8 (14%)	8 (14%)	10 (13%)	67 (100%)	1.373
Neuroradiology	18 (13%)	27 (19%)	15 (11%)	18 (13%)	14 (9%)	25 (19%)	22 (14%)	139 (100%)	2.317
Pediatrics	–	2 (22%)	2 (22%)	2 (22%)	2 (22%)	1 (11%)	2 (11%)	11 (100%)	0.853
Vascular	1 (12%)	2 (12%)	–	4 (37%)	1 (12%)	2 (25%)	–	10 (100%)	1.618
Computer applications	–	–	–	1 (33%)	–	1 (33%)	1 (34%)	3 (100%)	1.560
Miscellaneous	–	–	3 (27%)	2 (18%)	1 (9%)	3 (27%)	2 (18%)	11 (100%)	0.904
Total no. of papers and mean IF of MR publications	41 (12%)	50 (15%)	47 (14%)	51 (15%)	44 (13%)	57 (17%)	42 (12%)	332 (100%)	1.384

Numbers in parentheses are percentages of articles per topic according to year of publication.

Table 8 shows that a number of published articles equal or higher than 25 was found in a total of 19 different German institutions. Regarding Spain, only radiologists from two institutions (Hospital Universitario Dr. Peset and Hospital Vall d'Hebron) had a productivity higher than 25 papers ($n = 28$, both). Since the number of inhabitants in 2002 was 82,282,000 for Germany, and 40,752,000 for Spain, the adjusted number of articles per million populations was 20.4 for Germany and 8.1 for Spain.

Regarding the journal of publication, 395 (23%) of the 1681 articles originating from Germany were published in *ROFO*, the Official Radiology German journal, while 51 (15%) of the 332 articles originating from Spain were published in the Official Radiology Spanish Journal *Radiología*. These differences in proportion where statistically significant (chi-square, $p = 0.001$).

4. Discussion

Published papers play a vital role in all stages of scientific research. They are the starting point for research projects and the preferred channel through which the results of completed research are made known [18]. Based on these premises, bibliometric studies – or studies on scientific production – are essential tools in the analysis and assessment of the research performed in different countries. Their data successfully complement other types of indicators such as the economic investment made in research, or the human resources involved in research activities [18]. Despite their relevance, and in our knowledge, only two bibliometric studies focused on MR imaging research in the field of radiology [14,15] have been identified since 1991 in the literature.

The present study shows some differences in the journals where radiologists in Spain publicate. During 2001–2007, the leading journal in number of articles was *Radiología*, despite not being currently included in the JCR, and only recently (since 2006) covered by the Medline database. Reasons that may justify this tendency include giving priority to diffuse knowledge between their fellow and a desire to become known at the Spanish radiological environment, given that *Radiología* is the main voice of the Spanish Radiological Society. Furthermore, publications on diagnostic radiology in Spanish are limited by the fact that no other Spanish journals are dedicated exclusively to radiology. The Spanish radiologist must therefore choose between non-radiological Spanish journals or foreign radiology journals [4].

In this respect, the Spanish non-radiological journal *Revista de Neurología* was the second journal in MR research productivity, being also the leading journal in number of papers focused on the "neuroradiology" topic. This is related to the higher neuroradiological activity of the Spanish radiologists as compared to other topics (42% of all the published papers focused on this topic). Another reason for this is the coverage of *Revista de Neurología* by the JCR database, despite their low 2004 IF value (IF: 0.210). In this sense, in 2005 there were only 17 biomedical Spanish journals included in the JCR, and just three of them on the field of neurosciences (*Revista de Neurología, Neurología* and *Neurocirugía*). As *Neurología* is the third Spanish journal in

Table 8
Comparison between Spanish and German radiology departments according to the institution's productivity on MR papers (in decreasing order of number of articles)

Spanish institutions	City of the institution	No. of papers	German institutions	City of the institution	No. of papers
Hospital Universitario Dr. Peset	Valencia	28	Universitätsklinikum Essen	Essen	162
Hospital Universitari Vall d'Hebron	Barcelona	28	Eberhard-Karls-Universität Tübingen	Tübingen	153
Ciutat Sanitària i Universitària de Bellvitge	Barcelona	21	Klinikum Großhadern der Ludwig-Maximilians-Universität München	Munich	138
Hospital Clinic i Provincial	Barcelona	20	Deutsches Krebsforschungszentrum (DKFZ) Heidelberg	Heidelberg	117
Hospital Quirón Valencia	Valencia	12	Klinikum der Albert-Ludwigs-Universität, Freiburg	Freiburg	108
Hospital Juan Canalejo	A Coruña	12	Universitätsklinikum Aachen	Aachen	97
Clínica Girona	Girona	12	Universitätsklinikum Bonn	Bonn	83
Hospital Ruber Internacional	Madrid	12	Charité Campus Mitte, Humboldt-Universität zu Berlin	Berlin	79
Centre Diagnòstic Pedralbes	Barcelona	10	Universitätsklinikum Münster	Münster	70
Hospital Universitari de Tarragona Joan XXIII	Tarragona	10	Campus Virchow Klinikum-Charité Universitätsmedizin Berlin	Berlin	62
Hospital Quirón Zaragoza	Zaragoza	9	Klinikum der Johann Wolfgang Goethe-Universität Frankfurt	Frankfurt am Main	58
Instituto Radiológico Cántabro-Clínica Mompía	Mompía	9	Universitätsklinikum Hamburg-Eppendorf	Hamburg	57
Consorci Sanitari Parc Taulí	Barcelona	8	Klinikum der Johannes-Gutenberg-Universität, Mainz	Mainz	49
Hospital Josep Trueta	Girona	8	Technische Universität München-Klinikum rechts der Isar	Munich	49
Hospital La Paz	Madrid	8	Universitätsklinikum Regensburg	Regensburg	49
Hospital Miguel Servet	Zaragoza	8	Klinikum der Friedrich-Schiller-Universität, Jena	Jena	39
Hospital de Basurto	Bilbao	7	Universität Heidelberg	Heidelberg	32
Hospital 12 de Octubre	Madrid	6	Christian-Albrechts-Universität zu Kiel	Kiel	29
–			Heinrich-Heine-Universität Düsseldorf	Düsseldorf	25
Other 26 Spanish institutions with a no. of papers lower than 6		104	Other 36 German institutions with lower than 25 articles	–	225
Total no. of articles		332			1681

productivity on MR imaging studies, the current status of neurological journals in the bibliometric context of Spain can be considered appropriate [19].

Regarding the importance of the IF in publication tendencies, investigators try to gain prestige in the scientific world publishing their papers in the journals in which they can reach an ample diffusion and impact. Although Anglo-American publishers countries and English-language journals prevail in JCR with respect to IF levels, researchers normally check the lists of JCR-indexed journals to obtain the necessary dissemination of their work [5].

The results of this study are in agreement with these publication tendencies, according that, from the Spanish output in MR publications during 2001–2007, approximately a two-third (68%) of the articles were published in several worldwide non-Spanish radiology, non-radiology and MR topics journals.

Noteworthy, the mean IF of the Spanish radiology and non-radiology journals was very low (0.2). Even worst, more than half of the selected Spanish journals are not currently included in the JCR, as is the case of the leading journal in total productivity, *Radiología*.

Of interest, approximately one-fifth of articles on MR imaging were published in worldwide non-Spanish non-radiology journals, surely benefiting of their high impact factors (mean IF: 3.6) of them. This tendency of publication in journals not devoted on a determinate medical specialty has been found in some specialties distinct to radiology, as is the case of nephrology [20].

The Spanish healthcare sector is the most active, having the Dr. Peset University Hospital and the Vall d'Hebron Hospital the higher number of MR publications. The percentage of articles originating both from Spain as well as from Germany, which were published in their respective official journals (*Radiología* and *ROFO*) was different (15% vs. 23%), being the majority of papers originated from these two countries (68% from Spain and 77% from Germany) published in English-language journals. To be considered, in most German institutions MR imaging research is performed by both physicians and radiologists, whereas research in Spain is performed mainly by clinical radiologists. Thus the different conception and professional environment of the radiology departments in these countries is also responsible of the gap in research outcome.

Finally, because the relatively small number of articles focused on "chest radiology", "head and neck imaging" and "computer applications" topics, an opportunity exists for Spanish radiologists to become more involved on MR research on these topics.

4.1. Study limitations

As the database search was performed during September 2007, articles published from October to December 2007 are not included in the study. Moreover, the search was restricted to Medline-indexed journals (with the exception of the Spanish journal *Radiología* for the 2001–2005-year-period), and published articles during 2001–2007 in other journals not indexed in this database are surely missed. Published articles in collaboration between radiologists and clinicians from other medical specialties in which the first author was not a radiologist were also surely missed, as the Medline database includes only the institutional affiliation of the first author of the article. Last, as the articles included in the analysis were those in which terms related to the MR imaging technique appeared in the title of the paper, all the remaining ones in which this technique was possibly mentioned in the text of the abstract were not included in this study.

In summary, Spanish radiologists published approximately two-third of their MR articles in non-Spanish journals. Spanish radiologists are shown to be very active in MR studies focused on the "neuroradiology" topic. The Spanish healthcare sector is the most active. The percentage of articles originating both from Spain and Germany which were published in their respective official journals (*Radiología* and *ROFO*) (15% vs. 23%) was statistically different.

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