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Bibliometric and thematic characterization of the research on HIV–AIDS in Spain (2010–2019)



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ABSTRACT

Introduction: The establishment of the Spanish AIDS Research Network (RIS) was a milestone for the promotion of HIV research in Spain. We analyse Spanish HIV research, assessing the role that RIS has played in it.

Methods: We identified publications on HIV–AIDS with the participation of Spanish institutions in the Web of Science over the period 2010–2019, characterising research activity by means of bibliometrics and identifying the thematic areas of research through a cluster analysis.

Results: A total of 3960 documents have been identified (average of 396 documents/year), 42% of which have been signed in international collaboration. RIS researchers have participated in 60% of the documents, presenting a scientific production and citation significantly higher than authors not linked to the RIS. Five thematic clusters articulate the research, focusing on the clinical and therapeutic approach to people living with HIV, co-infection and co-morbidity with other diseases, the genetic characterisation of the virus, the development of vaccines and the study of its transmission in specific groups or associated with sexual behaviour.

Conclusion: Spanish HIV research, largely driven by RIS groups, has reached a stage of maturity, with a notable increase in scientific production, participation in international cooperative networks and an outstanding impact and visibility.

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Caracterización bibliométrica y temática de la investigación sobre VIH-sida en España (2010–2019)

RESUMEN

Introducción: La constitución de la Red de Investigación en Sida (RIS) constituyó un hito para el impulso de la investigación sobre el VIH en España. Se analiza la investigación española en el área, evaluando específicamente el papel que ha desempeñado la RIS en la misma.

Métodos: Se identificaron las publicaciones sobre VIH-sida con la participación de instituciones españolas en la *Web of Science* a lo largo del período 2010–2019, caracterizando bibliométricamente la actividad investigadora e identificando mediante un análisis de clústeres los ámbitos temáticos de investigación.

Resultados: Se han identificado 3.960 documentos (promedio de 396 documentos/año), el 42% de los cuales han sido firmados en colaboración internacional. Los investigadores de la RIS han participado en el 60% de los documentos, presentando una producción científica y citación sensiblemente superior a los autores no vinculados a la misma. Cinco clústeres temáticos articulan la investigación, centrados en

Palabras clave:

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el abordaje clínico y terapéutico de las personas que viven con el VIH, la coinfección y la comorbilidad con otras enfermedades, la caracterización genética del virus, el desarrollo de vacunas y el estudio de su transmisión en colectivos específicos o asociado a las conductas sexuales.

Conclusión: La investigación española sobre el VIH, impulsada en gran medida por los grupos de la RIS ha alcanzado un estadio de madurez, con un notable incremento de la producción científica, la participación en redes cooperativas internacionales y un destacado impacto y visibilidad.

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Introduction

Research on HIV–AIDS in Spain has addressed different challenges since the discovery of the virus in the 1980s. These have been centred around controlling the epidemic and improving the health of people living with HIV, focusing on areas such as prevention, early detection and how to approach the disease clinically.¹ Spanish research groups also carried out important work in the field of basic research to determine the genetic bases of the virus and its incidence, to contribute to the development of treatments and the creation of a vaccine while increasingly becoming integrated and connected with other international groups and networks in this area.²

Three creditable milestones marked the development of the research: a) the creation in 1997 of the Sociedad Española de Enfermedades Infecciosas y Microbiología Clínica [Spanish Society of Infectious Diseases and Clinical Microbiology] Grupo de Estudio de Sida (GeSIDA) [AIDS Study Group], which became an important reference for the promotion of research; b) the creation in 1999 of the Fundación para la Investigación y Prevención del Sida en España (FIPSE) [Foundation for AIDS Research and Prevention in Spain], which was the first specific funding agency for research in the area; and c) the creation in 2003 of the Redes Temáticas de Investigación Cooperativa (RETIC) [Thematic Networks on Collaborative Research], which enabled the setting up of the Red de Investigación en Sida (RIS) [AIDS Research Network].² The RIS has established itself as a major international benchmark, with a growing presence in large worldwide research consortiums, in parallel with the excellence of the research carried out by its groups.¹

There is extensive bibliometric literature analysing research on HIV, both worldwide,^{3–6} and on the scale of geographic areas^{7–9} or countries.^{10–12} More specifically, there are articles which analyse the extension of collaborative practices and scientific collaboration networks,^{13,14} identification of the thematic hubs of the most cited documents or research fronts in the area¹⁵ or the literature focusing on social, psycho-social or economic aspects, such as the stigmatisation and discrimination of people living with HIV,¹⁶ intervention programmes centred around children with HIV–AIDS¹⁷ or its incidence in demographic terms, or the impact of the financial resources dedicated to the research.¹⁸

Different bibliometric studies have also analysed the research on HIV–AIDS carried out in Spain,^{19–22} although they do not include the most recent research generated after the creation of the RIS. At an international level, only a small number of studies analysed scientific activity linked to the formal research networks created to promote research on HIV, despite the essential role they acquired as organisations setting the thematic lines for research and as instruments for organising interaction and collaborative practices among researchers. One of these studies, by Rosas et al.²³ analysed the publications generated by the different networks or research groups concerning clinical trials on HIV/AIDS linked to the National Institute of Allergy and Infectious Diseases (NIAID) in the period 2006–2008, concluding that their recognition and impact were outstanding and they involved a significant amount of interdisciplinary collaboration. Another was the contribution from Nye et al.²⁴ who conducted an overall evaluation of the production, influence and

collaboration involved in the scientific output of the HIV Vaccine Trials Network (HVTN) in relation to worldwide research on HIV vaccines. They remarked on the progressive growth in the network's scientific output, particularly the greater productivity of the researchers linked to it, more widespread collaborative practices, an impressive number of authors occupying leading positions in the network of scientific co-authors, and a significantly higher degree of citation and visibility of publications in relation to the rest of the scientific output in the area.

The aim of this study is to analyse Spanish research on HIV–AIDS, specifically characterising the contribution of the RIS. We aim to answer the following questions:

- What weight does the research that RIS researchers participated in carry in relation to all Spanish research generated in this area of knowledge, and how has it evolved?
- To what extent can being part of the RIS be associated with better scientific performance?
- What role do RIS researchers play in the co-authorship network and in relation to international collaboration?

Methods

The methodological process followed to address our objective and answer the research questions raised was as follows:

Identification of Spanish scientific output on HIV

To identify the document population under study, we opted to conduct a search taking the Medical Subject Headings (MeSH) thesaurus as a reference, as this controlled vocabulary tool enables accurate identification of documents in the area being analysed. The search was carried out using the databases of the Clarivate Analytics Web of Science (WoS) Core Collection, as this source has a record of all the institutional affiliations of the authors, as well as the citations of the documents, and is linked to the data on the impact and visibility of the journals the articles are published in from the ranking listed in the Journal Citation Reports.

The search equation was defined as follows:

MeSH:EXPLODE: HIV OR HIV Infections OR Acquired Immunodeficiency Syndrome OR AIDS Vaccines AND Address: Spain.

Subsequently, the results were limited to the article and review document types and the chronological period 2010–2019.

Review of the homogeneity and quality of the data and determination of the scientific output of the RIS

To ensure the data were representative, we manually checked the forms of authorship identification, correcting any problems detected, such as the different degrees of information provided (one or two surnames or initials of first names), typing errors or homonyms. We also checked the institutional affiliations to unify the different variants with which the same institution is identified and individualise the instances included in this bibliographic field, as it is very common for two or more institutions which are entities in their own right to be included under one signature. In

these cases, a full assignation was made, duplicating the signatures, for example, in the case of research institutes linked to hospitals, which may give an impression of redundancy in the results, but which we consider necessary in order not to lose relevant information on affiliations which have been recorded by the authors of the publications and which are sometimes presented under one single signature.

To measure the scientific output linked to the RIS, we identified the members of the network's research groups appearing on its website in September 2021 (<https://redris.es>), also including in our analysis certain groups which were part of the RIS throughout the period analysed. They have been linked with the authorship of the WoS scientific publications below.

Calculation of indicators and interpretation of results

Bibliometric characterisation of Spanish research on HIV–AIDS Scientific collaboration and output. To provide an overview of the research activity generated on HIV–AIDS in Spain throughout the period analysed and of scientific collaboration in the area, we calculated the following indicators:

- Number of documents published per year.
- Distribution of the number of documents published among the different scientific agents: authors, institutions, journals and thematic categories or areas of knowledge in which the manuscripts have been published.
- Transience rate. Refers to the percentage of authors with one single publication. Different studies have taken this indicator, related to the distribution of productivity, as a reference to analyse the degree of consolidation of a research community, depending on the greater or lesser proportion of “transient” authors.²⁵
- Average number of authors per document.
- Number of documents in national and international collaboration.

Impact and visibility. The evaluation of the scientific performance of the research activity was based on document citation indicators and indicators of visibility in terms of the journal or sources in which the studies were published:

- Number of citations received by the documents grouped by thematic category and journal.
- Average citations per document.
- Impact Factor and Journal Citation Indicator (JCI) of the publishing journals. The JCI is a normalised impact measure of the citations received by a journal's articles and reviews in its thematic category. The average value is 1, so a journal with a JCI higher than 1 has a citation impact above the average for its category.
- Relative position of the journals in their thematic categories and distribution by quartiles in relation to the Impact Factor and the JCI. The 2020 ranking on the Clarivate Analytics WoS platform has been taken as a reference for this.

Scientific performance and output of the RIS groups

To specifically analyse the production and impact of the RIS, we present the above indicators referring to the subset of documents in which the researchers linked to this network participated, in addition to carrying out a detailed analysis of the activity carried out by these groups:

- Number of documents.
- Number of citations.
- Average citations/document.
- h-Index

A co-authorship network was generated, identifying the collaboration links established between the most productive authors (>9 documents) and those with a greater degree of collaboration with other researchers (>9 documents) to analyse the positioning of the RIS researchers. We calculated a measure of centrality (the degree of intermediation), also estimating the scientific output and the citations of the researchers in the above network.

Research thematic clusters

Lastly, we characterised the thematic areas addressed by the Spanish research on HIV–AIDS, generating a matrix with the co-occurrence of the MeSH descriptors assigned to the documents, on which we applied a cluster analysis to identify the different thematic lines and their visual representation.

To generate the network of topics, a process to homogenise the terminology was unnecessary, as we used the descriptors of the MeSH thesaurus. However, to help identify the clusters and optimal visualisation of the network, reducing the high density of links between the descriptors, we “pruned” excessively generic descriptors, such as those used in the search process, those referring to gender and age groups. The information provided by these descriptors was specifically analysed.

For the generation of the co-authorship network and the calculation of the intermediation of the researchers, we used the Pajek program, and the determination and representation of the thematic research clusters were carried out with VOSviewer.

Results

Spanish scientific output on HIV

We identified 3960 documents, with a stable scientific output of around 300–450 published documents per year (Table 1). Twenty-one thematic categories had documents making up more than 1%, including infectious diseases, with 46.04% of the documents and another five categories accounting for 15%–25% (immunology, virology, microbiology, pharmacology and pharmacy and multidisciplinary sciences). Although the disciplines related to basic research have a higher citation count, it should be noted that the publications of the different groups and researchers on HIV in general and internal medicine journals are those with the higher average number of citations per article (Appendix Table A1).

The multidisciplinary journal *PLoS One* published the largest number of documents. However, different journals specialising in HIV/AIDS were also among the most productive journals (such as *AIDS*, *HIV Medicine*, *JAIDS: Journal of Acquired Immune Deficiency Syndromes* and *Aids Research and Human Retroviruses*), in addition to the Spanish journals ENFERMEDADES INFECCIOSAS Y MICROBIOLOGÍA CLÍNICA [Infectious Diseases and Clinical Microbiology] and *Medicina Clínica* [Clinical Medicine]. It is also worth noting the presence in the ranking of the most productive journals of one specialised in reviews (*AIDS reviews*) and another in clinical trials (*HIV Clinical Trials*). Among the journals with the highest productivity, six stand out with a JCI higher than one, and eight are positioned in the first quartile of their thematic categories (Table 2).

Authorships and international collaboration

We identified 15,703 authors, 323 of whom were linked to the RIS. The rate of transience among the authors was found to be 64.56% (n = 10,140). Of the 753 authors with the highest scientific output (>9 documents), 186 are from the RIS. Appendix Table A2 shows the distribution of the authors by productivity thresholds. The high productivity of all the authors linked to the RIS is notable, as 57.58% (n = 186) had published more than nine documents. These

Table 1
Scientific output and international collaboration on HIV–AIDS in Spain (2010–2019).

Year	Number of documents	Number of documents in international collaboration	Percentage
2010	380	133	35
2011	450	166	36.89
2012	425	157	36.94
2013	411	160	38.93
2014	429	155	36.13
2015	444	197	44.37
2016	370	180	48.65
2017	390	187	47.95
2018	308	152	49.35
2019	353	178	50.42
Total	3960	1665	42.04

Table 2
Distribution by journal of publication by and participation of the RIS in the scientific output on HIV–AIDS in Spain (2000–2019).

Journal	Number of documents	Percentage	Number of RIS documents	Percentage	Impact Factor (2020)	JCI (2020)	Position-ranking Impact Factor	Position-JCI
<i>PLoS One</i>	281	7.10	205	72.95	3240	0.57	26/72–multi-Q2	29/128 Q1
<i>AIDS</i>	267	6.74	213	79.77	4.177	1.09	32/93-ID-Q2 Immunology 84/62 Q3 Virology 14/67 Q2	26/118-ID-Q1 Immunology 41/177 Q1 Virology 9/39 Q1
ENFERMEADES INF ECCIOSAS Y MICROBIOLOGÍA CLÍNICA	210	5.30	115	54.76	1.731	0.45	82/93-ID-Q4	83/118-ID-Q3
<i>Journal of Antimicrobial Chemotherapy</i>	148	3.74	124	83.78	5.790	1.51	Microbiology 124/136 Q4 14/93-ID-Q1	Microbiology 120/151 Q4 8/118-ID-Q1
<i>HIV Medicine</i>	138	3.48	107	77.54	3.180	0.97	Microbiology 26/136 Q1 P&P 43/276 Q1	Microbiology 16/151 Q1 P&P 25/357 Q1
<i>JAIDS: Journal of Acquired Immune Deficiency Syndromes</i>	125	3.16	101	80.80	3.731	0.94	54/93-ID-Q3 40/93-ID-Q2	35/118-ID-Q2 39/118-ID-Q2
<i>Clinical Infectious Diseases</i>	100	2.53	77	77.00	9.079	2.13	Immunology 95/162 Q3 3/93-ID-Q1	Immunology 56/177 Q2 3/118-ID-Q1
<i>Aids Research and Human Retroviruses</i>	90	2.27	72	80.00	2.205	0.52	Microbiology 18/162 Q1 Immunology 12/136 Q1 75/93-ID-Q4	Microbiology 11/177 Q1 Immunology 7/151 Q1 78/118-ID-Q3
<i>Antiviral Therapy</i>	83	2.10	70	84.34	2.400	0.64	Virology 31/37 Q4 Immunology 142/162 Q4 70/93-ID-Q4	Virology 32/39 Q4 Immunology 134/177 Q4 68/118-ID-Q3
<i>AIDS Reviews</i>	72	1.82	53	73.61	2.500	0.37	P&P 204/276 Q3 Virology 27/37 Q3 67/93-ID-Q3	P&P 195/357 Q3 Virology 24/39 Q3 94/118-ID-Q4
<i>Journal of Virology</i>	72	1.82	58	80.56	5.103	1.24	Immunology 131/162 Q4 9/37-Virology-Q1	Immunology 150/177Q4 7/39 Q1
<i>Journal of Infectious Diseases</i>	58	1.46	41	65.52	5.226	1.40	18/93-ID-Q1	13/118-ID-Q1
<i>Antiviral Research</i>	57	1.44	42	73.68	5.970	1.49	Immunology 56/162 Q2 Microbiology 38/136 Q2 8/37-Virology-Q1	Immunology 29/177 Q1 Microbiology 18/151 Q1 6/39 Virology-Q1
<i>BMC Infectious Diseases</i>	51	1.29	34	66.67	3.090	0.82	P&P 35/276 Q1 57/93-ID-Q3	P&P 26/357Q1 50/118-ID-Q2
<i>Medicina Clínica</i>	48	1.21	17	35.42	1.725	0.40	105/167-General and Internal Medicine-Q3	131/315-Q2
<i>HIV Clinical Trials</i>	45	1.14	33	73.33	1.821	N/A	75/92-ID-Q4-2019 P&P 210/271 Q4-2019	N/A
<i>Scientific Reports</i>	41	1.04	27	65.85	4.380	0.80	17/72–multi-Q1	19/128 Q1
<i>Pediatric Infectious Disease Journal</i>	41	1.04	24	58.54	2.129	0.73	79/93-ID-Q4	59/118-ID-Q2
							Paediatrics 69/129 Q3 Immunology 143/162 Q4	Paediatrics 76/177 Q2 Immunology 85/177 Q2

ID: Infectious Diseases; JCI: Journal Citation Indicator; Multi: multidisciplinary; P&P: Pharmacology & Pharmacy; RIS: Red de Investigación en Sida [AIDS Research Network]; HIV: human immunodeficiency virus.

Table 3
Participation of institutions (>99 documents) in the scientific output on HIV–AIDS in Spain (2010–2019).

Institutional affiliation	Number of documents	h-Index	Number of citations	Average citations/document
Univ Autònoma de Barcelona.	669	46	11,142	16.65
Univ. de Barcelona	638	45	11,181	17.53
HC de Barcelona	628	48	11,143	17.74
HU Germans Trias i Pujol	623	50	11,973	19.22
Instituto de Salud Carlos III	502	38	6807	13.56
IrsiCaixa: Institut de Recerca de la Sida	475	49	10,589	22.29
HGU Gregorio Marañón	416	31	5248	12.62
HU Ramon y Cajal	385	32	5056	13.13
Institut d'Investigacions Biomèdiques August Pi i Sunyer	365	35	6169	16.90
HU La Paz	331	36	5764	17.41
CIBER de Epidemiología y Salud Pública	274	25	3243	11.84
H Carlos III ^a	254	36	5812	22.88
Univ. College London ^b	232	42	8018	34.56
HU Vall d'Hebron	223	25	2894	12.98
Fundació Lluita Contra la Sida	215	29	3595	16.72
HU 12 de Octubre	214	27	3110	14.53
H de la Santa Creu i Sant Pau	207	25	3043	14.70
HU Virgen del Rocío	194	25	2406	12.40
HU Virgen de Valme	186	19	1782	9.58
HU de Bellvitge	183	26	3088	16.87
Institució Catalana de Recerca i Estudis Avançats	178	35	4638	26.06
Univ de Vic - Univ Central de Catalunya	166	22	1998	12.04
Instituto Ramón y Cajal de Investigación Sanitaria	160	20	1755	10.97
HC San Carlos	143	21	1757	12.29
Instituto de Biomedicina de Sevilla	141	19	1378	9.77
Instituto de Investigación Sanitaria del Hospital Universitario La Paz	140	26	2612	18.66
Instituto de Investigación Sanitaria Gregorio Marañón	137	21	1271	9.28
Univ Sevilla	127	20	1515	11.93
HU Reina Sofía	124	21	1611	12.99
Univ Complutense de Madrid	119	19	1554	13.06
Centre de Recerca en Salut Internacional de Barcelona	117	20	1771	15.14
Univ Autónoma de Madrid	116	19	1268	10.93
HU Virgen de la Victoria	116	15	939	8.09
HU y Politécnico de La Fe	112	22	1602	14.30
Copenhagen Univ ^b	111	28	4162	37.50
Institut d'Investigació en Ciències de la Salut Germans Trias i Pujol	109	20	1447	13.28
HU de Donostia	105	18	1076	10.25
Univ Miguel Hernández de Elche	105	21	1988	18.93
Consejo Superior de Investigaciones Científicas	105	24	2066	19.68
Amsterdam Univ	104	32	4503	43.30
HGU de Elche	103	24	2223	21.58
Univ Alcalá de Henares	102	20	1426	13.98

H: hospital; HC: clinical hospital; HGU: university general hospital; HU: university hospital; Univ: university.

^a Although it has formed part of HU La Paz since 2013, this institution has kept its separate status, insofar as it continues to be listed as an institutional affiliation in scientific publications.

^b Foreign institutions appear in the table because authors from them have frequently collaborated with authors from Spanish institutions.

authors also have a much higher average number of published documents (41.56) than the large producers (>9 documents) not linked to the RIS (15.37).

Regarding collaboration, the average number of authors per document stood at 11.29 ± 17.8 , but this rose from 9.74 ± 14.62 to ± 14.62 in the period 2010–2014 to 13.04 ± 20.67 in 2015–2019. These figures show a considerable increase in the number of multi-author papers involving a very large number of authors; for example, papers with more than 20 authors represented 4.5% of the documents in the period 2010–2014 ($n = 95$), but 10.72% of the documents from 2015 to 2019 ($n = 200$). Table 3 shows the list with the most productive institutions (>100 documents). The proportion of documents in international collaboration climbed from 35% of the total in 2010 to 50.42% in 2019 (Table 1).

Participation of the RIS in Spanish research on HIV

The 38 research groups in the RIS analysed are divided into 19 groups linked to basic research, 21 to clinical research and another 18 groups which carry out epidemiological research. However, it should be noted that many groups participate simultaneously in more than one type of research (Appendix Table A3).

Overall, RIS researchers participated in 60.43% ($n = 2393$) of the Spanish scientific output on HIV, with a slightly higher average number of citations per document (15.92 compared to 14.15 for scientific output not linked to these groups) and with a lower rate of uncited documents (only 7.19% of the documents compared to 13.34% for scientific output with no RIS researcher participation).

The rate of participation of RIS researchers in the most productive journals with high impact and visibility is, in almost all cases, well above the overall participation of all researchers in the scientific output analysed (Table 2).

Although, in general, basic research is ranked with the highest output and citation values, it should be noted that the groups whose research can be defined as crossover (basic and clinical/epidemiological or clinical and epidemiological) have a higher citation count than groups specialising in one single type of research (Appendix Table A3).

Two groups with high productivity and citation counts stand out significantly above the rest (with an average of 19–21 citations per document and h-indexes of 45–48), followed by another 17 groups with more than 100 published documents and also a very high citation count (Table 4).

Table 4
Activity and scientific output of the RIS groups in the *Web of Science* (2010–2019).

RIS group ^a	Type of research	Number of documents	Number of citations	Average citations/document	h-Index
Groups from IrsiCaixa Instituto de Investigación del sida	Basic	489	10,200	20.86	48
Hospital Clínic-IDIBAPS	Basic/clinical	489	9312	19.04	45
Hospital Universitario Ramón y Cajal, Infectious Diseases Department	Basic/clinical	289	4386	15.18	32
Instituto de Investigación del Hospital Sanitario La Paz (IdiPAZ), HIV Unit	Basic/clinical	155	3784	24.41	32
Hospital General Universitario de Elche	Clinical/epidemiology	150	2868	19.12	27
Hospital Universitario 12 de Octubre, Virology-HIV/AIDS Research Group	Basic/clinical	184	2703	14.69	26
Hospital General Universitario Gregorio Marañón, HIV BioBank	Basic	191	2553	13.37	25
Hospital Universitario Vall d'Hebron, HIV/AIDS Research Unit	Basic/clinical	181	2633	14.55	25
Hospital Universitario Ramón y Cajal, Infectious Diseases Department, HIV and STD Unit	Clinical/epidemiology	157	2820	17.96	25
Instituto de Investigación Sanitaria Galicia Sur	Clinical/epidemiology	190	2251	11.85	24
Hospital de la Santa Creu i Sant Pau Research Institute, HIV and AIDS Research Group	Basic/clinical	186	2848	15.31	24
Centro Nacional de Epidemiología (ISCIII)/Centro Sanitario Sandoval, AIDS Research Network Cohort Unit (CoRIS)	Clinical/epidemiology	151	2065	13.67	24
Hospital General Universitario Gregorio Marañón, Clinical and Epidemiological Aspects of HIV and Associated Conditions Group	Basic/clinical	215	2340	10.88	23
Hospital Universitario Reina Sofía, Infectious Diseases Unit	Clinical/epidemiology	159	1918	12.06	23
Hospital Universitario Virgen del Rocío, HIV Research Group	Basic/epidemiology	172	1920	11.16	20
Centro Nacional de Microbiología (Instituto de Salud Carlos III), AIDS Immunopathology Unit	Basic	101	1314	13.01	20
Hospital Universitario de Valme, Infectious Diseases and Microbiology Unit	Clinical	141	1558	11.05	19
Hospital Universitario San Cecilio	Clinical/epidemiology	84	1157	13.77	19
Centro Nacional de Biotecnología, Poxviruses and Vaccines	Basic	50	990	19.8	19
Hospital General Universitario de Alicante, HIV Infectious Diseases Research Group	Clinical/epidemiology	114	1083	9.5	18
Instituto de Investigación Sanitaria-Fundación Jiménez Díaz	Basic	90	1056	11.73	17
Centro Nacional de Microbiología (Instituto de Salud Carlos III), Viral Infection and Immunity Unit	Basic	115	972	8.45	16
Hospital Universitario Joan XXIII de Tarragona, Infection and Immunity Research Group	Basic/clinical	95	837	8.81	16
Hospital Universitario de La Princesa, Department of Internal Medicine-Infectious Diseases	Clinical	75	814	10.85	16
Hospital Universitario Donostia	Clinical/epidemiology	71	690	9.72	14
Hospital Universitario Virgen de la Victoria	Epidemiological	77	557	7.23	11
Hospital Universitario y Politécnico de La Fe	Epidemiological	51	478	9.37	11
Hospital San Pedro, HIV Unit	Epidemiological	51	403	7.9	10
Hospital Universitario Son Espases	Clinical/epidemiology	49	491	10.02	10
Hospital Universitario Mútua Terrassa, HIV*/AIDS Research Group	Clinical/epidemiology	31	307	9.9	10
Centro Nacional de Microbiología (Instituto de Salud Carlos III), HIV Biology and Variability Unit	Basic/epidemiology	30	255	8.5	9
Hospital Universitario Parc Taulí, Retrovirus Research Group	Epidemiological	28	230	8.21	8
Centro Nacional de Microbiología (Instituto de Salud Carlos III), Molecular Virology Unit	Basic	25	265	10.6	8
Instituto de Salud Carlos III, Digital Health Research Unit	Basic/clinical	11	272	24.73	8
Hospital General Universitario Reina Sofía	Epidemiological	28	185	6.61	7
Hospital Universitario de Canarias	Epidemiological	27	163	6.04	6
Universidad de La Laguna, Cellular and Viral Immunology	Basic	8	81	10.12	6
Complejo Hospitalario de Navarra, HIV Infection Research Group	Epidemiological	11	63	5.73	4

RIS: Red de Investigación en Sida [AIDS Research Network].

^a Although they are not listed on the RIS website, the groups of the Instituto de Investigación del Hospital Sanitario La Paz (IdiPAZ) [Hospital Sanitario La Paz Research Institute] and the group of Instituto de Investigación del Hospital de la Santa Creu i Sant Pau [Hospital de la Santa Creu i Sant Pau Research Institute] have been included in the analysis, given their links with the network. Meanwhile, the group "La Doctora Álvarez" has not been considered, as it is focused on carrying out scientific communication activities.

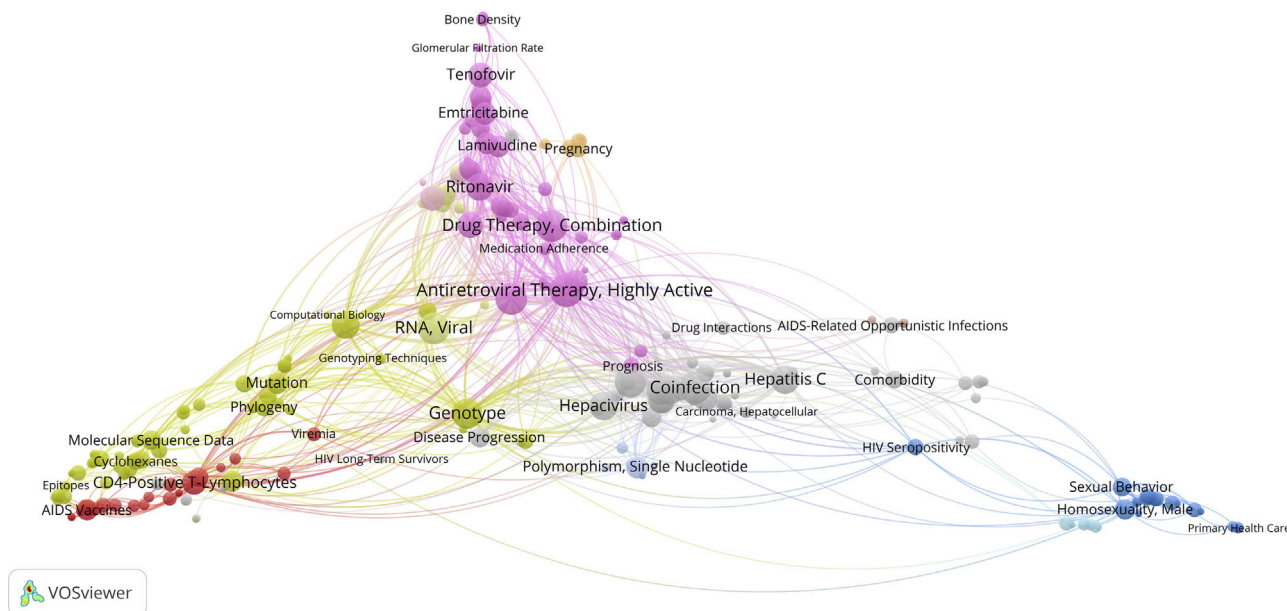


Fig. 2. Map of the thematic clusters of Spanish research on HIV–AIDS (2010–2019) generated from the co-occurrence of the MeSH descriptors assigned to the documents.

count than the average for their categories, confirming the positive growth in the degree of visibility and impact of Spanish research on HIV–AIDS.

We also found a significant increase in scientific collaboration. From an author's point of view, Lakeh and Ghaffarzadegan³ highlighted that the average number of authors per document in HIV publications worldwide increased progressively from 4.2 in the 1980s and 1990s to around 6.2 in 2012. Those figures were far exceeded in our study (11,29), with considerable growth in multiple authorship studies with many authors. The high percentage of documents in international collaboration was also remarkable and well above other areas of biomedical research. Scientific collaboration and participation in international networks are particularly important in a complex multidisciplinary area like HIV–AIDS research, as it helps improve the sharing of knowledge, expertise, resources and data.²⁴ The prominent participation of Spanish researchers, and members of the RIS in particular, in initiatives such as cohorts, biobanks and the promotion of multi-centre studies may partly explain the high levels of collaboration observed.²⁹ In total, Spain has various important cohorts of patients infected with HIV and AIDS, such as the CoRIS, the Cohorte Nacional de Pacientes Pediátricos con Infección VIH (CoRISPe) [Spanish Cohort of Paediatric Patients with HIV Infection] and the Proyecto para la Informatización del Seguimiento Clínico-epidemiológico de la Infección por VIH y Sida (PISCIS) [Project for the Computerisation of the Clinical-epidemiological Follow-up of HIV Infection and AIDS], all of them coordinated with other international cohorts such as COHERE, ART-CC and EuroCOORD.^{1,29,30}

There is no question of the importance of the RIS, as its researchers were behind 60% of the scientific output analysed. The groups and researchers linked to this network had significantly higher scientific output and citation values than authors and published documents outside the network. These aspects have also been confirmed by other studies which bibliometrically characterised the networks linked to HIV research, such as the one by Nye et al.,²⁴ analysing the HIV Vaccine Trials Network (HVTN); they showed that the researchers linked to the HVTN doubled their scientific output in a decade, and their publications obtained a significantly higher citation count, with

many of their contributions being among those with the highest visibility.

This study has identified, and bibliometrically characterised the entire Spanish scientific output on HIV–AIDS from 2010 to 2019. However, in the specific analysis of the RIS groups, we have to consider their dynamic nature, as some groups and researchers were part of the network for the entire period and others for only part of the time. Nonetheless, our evaluation provides important information about the research activity carried out by these groups during a time of reformulation of the research structures in this area.

Another limitation of our study is that by carrying out the search process using the MeSH thesaurus, the view we have provided is fundamentally of the biomedical research on HIV–AIDS, and this might be complemented by an analysis of research focused on psycho-social aspects, highlighting areas such as prevention and educational measures. Lakeh and Ghaffarzadegan³ confirmed the greater biomedical orientation of research on HIV–AIDS in countries with a lower incidence of the disease and lower mortality rates, estimating that in the case of Spain, less than 30% of the research focuses on social and behavioural aspects. In the current context of globalisation, without neglecting biomedical, basic and clinical research, in which Spain, with the leadership of the RIS, has become a major international benchmark, we need to include social and behavioural aspects and give greater weight to areas such as the analysis of perception and risk behaviours (for example, drug users and sexual practices), the identification of infected people, mental health, social support and initiatives that help reduce discrimination and stigmatisation of infected people.

The main conclusion of our study is that Spanish research on HIV–AIDS has reached a stage of maturity, with an impressive level of scientific output and integration into international collaboration networks. Spain, particularly the RIS initiative analysed in this study, can stand tall as a leading reference for other countries whose research in the area is less well-developed.^{10–12}

Conflicts of interest

The authors declare that they have no conflicts of interest.

Appendix A.

Table A1

Number of documents published on HIV–AIDS in Spain (2010–2019) distributed according to the thematic affiliation of the publication journals.

Category	Number of documents	Percentage	Number of citations	Average citations/doc.
Infectious Diseases	1823	46.04	25,947	14.23
Immunology	987	24.92	17,383	17.61
Virology	744	18.79	12,054	16.20
Microbiology	699	17.65	9916	14.19
Pharmacology & Pharmacy	577	14.57	6890	11.94
Multidisciplinary Sciences	346	8.74	4884	14.12
Public, Environmental & Occupational Health	253	6.39	2417	9.55
Medicine, General & Internal	198	5.00	7813	39.46
Biochemistry & Molecular Biology	133	3.36	2534	19.05
Gastroenterology & Hepatology	102	2.58	1806	17.71
Respiratory System	82	2.07	872	10.63
Medicine, Research & Experimental	81	2.05	1711	21.12
Social Sciences, Biomedical	78	1.97	785	10.06
Chemistry, Medicinal	74	1.87	1039	14.04
Paediatrics	67	1.69	416	6.21
Health Policy & Services	57	1.44	428	7.51
Health Care Sciences & Services	55	1.39	368	6.69
Biotechnology & Applied Microbiology	54	1.36	532	9.85
Cell Biology	49	1.24	1140	23.27
Tropical Medicine	48	1.21	445	9.27
Psychology, Multidisciplinary	42	1.06	391	9.31

Table A2

Distribution of the number of authors with the number of documents in Spanish research on HIV–AIDS (2010–2019).

Number of documents	Number of authors	Percentage	Number of authors linked to the RIS	Percentage
1	10,096	64.29	15	4.64
2	2378	15.14	13	4.02
3	1022	6.51	24	7.43
4	518	3.30	22	6.81
5	340	2.16	20	6.19
6	224	1.43	10	3.09
7	154	0.98	10	3.09
8	128	0.81	9	2.79
9	90	0.57	14	4.33
>9	753	4.79	186	57.58
Total	15,703	100	323	100

Table A3

Distribution of the research into the scientific activity and citation according to the orientation of the research by the RIS groups (2010–2019).

Type of research	Number of groups	Number of authors	Number of documents	Number of citations	Average citations/document
Basic	8	72	945	16,096	17.03
Basic/clinical	9	104	1234	20,673	16.75
Basic/epidemiology	2	18	202	2175	10.77
Clinical	3	24	302	4526	14.99
Clinical/epidemiology	9	75	716	9658	13.49
Epidemiology	7	30	206	1730	8.4
Total	38	323	2393	38,089	15.92

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