

Evolution of the scholar community in the area of informetrics in Mexico: 1971-2018

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ABSTRACT

We study the evolution of the Mexican community of researchers active in the field of informetrics studies in the period 1971-2018. Bibliometric data was retrieved from ten databases. 938 documents were registered with a total of 2121 authors affiliated to Mexican institutions. However, 42.2% of them have a scarce research production during this period. The production profiles of the full sample are organized according to the publications and citations by Mexican scholars, research lines of the authors, evolution of the number of local and foreign scholars, number

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of active and non-active scholars, and members of the National System of Researchers and scientific disciplines. Our findings indicate that a high proportion (54.5%) of the authors are members of the National System of Researchers. Our sample of authors include scholars from different areas of knowledge, and the most prolific corresponds to professionals of librarianship and information science. There is an increasing trend in their research production, specifically during the period 1990-2018, but the collaboration network is structured with a minimum set of dominant nodes.

Keywords: Informetrics-Mexico; Scientific Production and Impact; Informetrics-Graduate Studies; Researchers in Informetrics

Evolución de la comunidad académica en el área de informetría en México: 1971-2018

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RESUMEN

Se estudia la evolución de la comunidad mexicana de investigadores activos en el campo de los estudios de informetría en el periodo 1971-2018. Los datos bibliométricos se recuperaron de 10 bases de datos distintas. Se registraron 938 documentos con un total de 2 121 autores afiliados a instituciones mexicanas. Sin embargo, 42.2 % de ellos tiene una producción de investigación escasa durante este periodo. Los perfiles de producción de la muestra completa están organizados de acuerdo a las publicaciones y citas de académicos mexicanos, líneas de investigación de los autores, evolución del número de académicos locales y extranjeros, número de académicos activos y no activos, miembros del Sistema Nacional de Investigadores y disciplinas científicas. Nuestros hallazgos indican que una alta proporción de los autores (54.5 %) son miembros del Sistema Nacional de Investigadores. La muestra de autores incluye académicos de diferentes áreas del conocimiento, y la más prolífica corresponde a profesionales de la bibliotecología y las ciencias de la información. Existe una tendencia creciente en su producción investigadora, es-

pecíficamente en el periodo 1990-2018, pero la red de colaboración se estructura con un conjunto mínimo de nodos dominantes.

Palabras clave: Informetría-Mexico; Producción e Impacto Científico; Graduados en Informetría; Investigadores-Informetría

INTRODUCTION

Informetrics has been described by Egghe and Rousseau (1990) as all metric studies related to information science, including bibliometrics, scientometrics and webometrics. This term was originally introduced by Nacke, as well as Blackert and Siegel, in 1979. Informetrics has been considered as the most complete field (Tague-Sutcliffe, 1996) in the area of knowledge associated to the new disciplines in metric studies such as informetry, patentometry and altmetrics (Peters and Bar-Ilan, 2015; Jovanovic, 2012; Hood and Wilson, 2001). The evolution of all these metric disciplines has been studied in recent years (Hérubel, 1999; Gorbea-Portal, 2016; Ball, 2017).

On the other hand, Indranil N. Sengupta (1992) has stressed that this diversity is a natural consequence of the combination of bibliometry, information and library science, science and technology: all these terms may be considered as synonyms in their reach and applications.

Informetrics studies had a steady increase after they were addressed in 1994 by the International Society for Scientometrics and informetrics and of course, other metric disciplines influenced in this increase. Informetrics has been consolidated as a mature field of research with methods and theoretical models well defined to characterize the analysis associated to libraries, information centers and the scientific activity in general (Gorbea-Portal, 2016). These studies are complemented with the use of social sciences methods and data visualization, as well as network analysis and science maps (Wolfram, 2015).

We performed a data search on the informetrics (bibliometrics, scientometrics, informetrics, webometrics, patentometrics and altmetrics) subject in the WoS databases in the last five years of the period studied. We retrieved about 10,000 files on metric studies, 1.4% of them correspond to Mexican authors. A selection of this sample corresponds to collaborations, communication and scientific policies (Hanel and Mehler, 2019; Uddin, Choudhury, and Hossain, 2019); citation analysis and Hirsch index (Mingers and Leydesdorff,

2015); bibliometric methodologies (Mandelis, 2019); evaluation of scientific journals and impact factors (Collazo-Reyes, 2014); interdisciplinary and trans-disciplinary research (Youngblood and Lahti, 2018); bibliometric indicators, use of new databases and mathematical models (Fischhoff, 2019); theory applications, data visualization, science maps through Pajeck and VosViewer software (Ekanayake, Shen, and Kumaraswamy, 2019; Restrepo-Arango and Urbizagástegui-Alvarado, 2017) and finally cybermetrics, webmetrics and almetrics (Haunschild and Bornmann, 2017), which arised by the impulse of social networks. The almetrics has open the way to another type of indicators associated to the development of the Web 2.0, also known as the second generation of Web services (Peralta-González, Frías-Guzmán, and Gregorio-Chaviano, 2015). They pretend to identify the social processes reproduced in the web by the users and different civil organizations (Ayala, 2014).

In Latin America, the social studies on the scientific production were published in the 1970 decade (Krauskopf, Pessot, and Vicuña, 1986) using the regional databases of Clase and Periodica (Alonso-Gamboa, 2003). The evolution of the scientific activity was also analyzed (Pérez-Angón and Torres-Vega, 1998; Almeida-Filho et al., 2003; Herrero-Solana and Ríos-Gómez, 2006) as well as the quality of the local journals (Bonilla-Marín and Pérez-Angón, 1999).

Scientometrics published in 1995 a special volume on the Latin American studies on science and technology (Cortés-Vargas, 2007). In this volume we can appreciate the consolidation of the research groups from Argentina, Brazil and Mexico. The first Mexican publication on informetrics was published in 1971 by Jorge Robles Glenn from the National Autonomous University of Mexico (UNAM). In particular, the performance of some Mexican scientific communities has been analyzed in the areas of ecology (Castillo, 2000), physics (Contreras-Gómez et al., 2015), engineering (Rodríguez-Miramontes and González-Brambila, 2016), medicine (William, 2001), agriculture (Duarte-Malanski, Schiavi, and Dedieu, 2019) and social sciences (Gil-Antón and Contreras-Gómez, 2017; Contreras-Gómez et al., 2020).

The general aim of the present work is to study the evolution of the Mexican community active in research in the field of informetrics studies. We have studied recently (Luna-Morales, Luna-Morales, and Pérez-Angón, 2021) the effect of local and international collaborations on the research production of this community. Our interest in the present work is to characterize this set of scholars according to their institutional affiliation, their geographical distribution and academic formation. We have identified the authors

of 938 documents registered in 10 databases, which include Web of Science (WoS) and Scopus. A high fraction of them (54.5%) is member of the National System of Researchers. Our findings indicate that there is a positive trend of the research production in this area of knowledge, with a high degree of collaboration but that the respective research network is characterized by very few (less than ten) dominant nodes. Accordingly, our research questions can be summarized in two points:

1. How much mature is the research community of Mexican scholars involved in the area of informetrics studies?
2. What are the perspective of this community in terms of the training of new researchers and the generation of strong research networks?

METHODS

We were able to build a bibliometrics database using ten sources of information: Web of Science (WoS) in all Databases (Web of Science Core Collection, Derwent Innovations Index, KCI-Korean Journal Database, Russian Science Citation Index, SciELO Citation Index), Scopus, Google Scholar, Clase, Periodica, Humanindex, Infobila, PubMed, Scielo (<https://scielo.org/es/>) and Latindex. We expected to get a stronger data sample by including also local and regional databases in spite the diversity of fields they include and the normalization they require. We retrieved bibliometric data for the period 1971-2018 in the April-June 2019 window in such a way the our 2018 data was already complete. According to our data search, the first paper on informetrics studies was published by Robles-Glenn (1971). Our citation search was restricted only to WoS and Scopus. WoS included already a portion of the Scielo collection. The other databases do not include reliable citations data yet.

We have included in our data search the features “Topics” in the case of WoS, while for Scopus we used the search feature “all fields”. On the other hand, we used the advanced search in all other cases with two options: by fields and Boolean operators. In particular, for Scholar we saved the data in CVS.

The search strategy that was applied to retrieve publications in informetrics is shown in *Figure 1*, in both English and Spanish, both in singular and plural.

SPANISH TERMS	ENGLISH TERMS	SPANISH TERMS	ENGLISH TERMS
Acoplamiento bibliográfico	Bibliographic coupling	Índice H	Index H
Altimetría	Altimetrics	Informetría	Informetrics
Análisis bibliométrico	Bibliometric analysis	Investigación bibliotecológica	Library research
Arquimetría	Archivometrics	Journal Citation Reports	Journal Citation Reports
Bibliometría	Bibliometrics	Ley de Bradford	Bradford's Law
Ciencia de los datos	Data science	Ley de Lotka	Lotka's Law
Cienciometría	Scientometrics	Ley de Price	Price's Law
Co-citación	Co-citation	Ley de Zipf	Zipf's Law
Coefficiente de colaboración	Collaboration coefficient	Mapas científicos	Scientific maps
Colaboración científica	Scientific collaboration	Obsolescencia de la literatura	Obsolescence of literature
Colecciones, estudios	Collections, studies	Patentometría	Patentometrics
Colegios invisibles	Invisible schools	Producción científica	Scientific production
Comunicación científica	Scientific communication	Producción e impacto científico	Production and scientific impact
Crecimiento de la literatura	Literature growth	Producción e impacto redes autores	Production and impact on author networks
Estudios Métricos	Metric Studies	Redes bibliométricas	Bibliometric networks
Evaluación científica	Scientific evaluation	Redes de Colaboración	Collaboration Networks
Factor de impacto	Impact factor	Scientometrics	Scientometrics
Impacto científico	Scientific impact	Tecnometría	Technometrics
Indicadores bibliométricos	Bibliometric indicators	Vida media	Half life
Indicadores de la ciencia y tecnología	Science and technology indicators	Webmetría	Webmetrics

Figure 1. Terminology applied in the search for research publications in Mexico

Our search strategy was completed by identifying journals included in JCR-2018 that published articles on informetrics subjects, in particular those in the subject areas Information science and library science. We also included PLoS ONE and Interciencia. In both cases, we carried out direct searches in their web sites on information disciplines published by Mexican authors. The respective data was registered in Excel with the same WoS data structure.

In order to avoid duplicated papers, we used specific matches for author's names, titles, publication years and bibliographical data. Finally, our search strategy retrieved 938 publications, 542 of them written in Spanish, 381 in English, 11 in Portuguese and 4 in French.

WoS and Scopus data files were retrieved in Excel and CVS formats. In all other cases, the respective files were registered directly and with the same structure used for the WoS and Scopus files. We examined directly each file in order to keep just those associated to the subject area of informetrics studies. We went through the usual process of Normalization of authors names, institutions, scientific disciplines, journal titles and Federal entities. Finally, our data sample was arranged according to the ten general disciplines promoted by the project Atlas de la Ciencia Mexicana (ACM, 2013): biology, physics, chemistry, mathematics, medicine, engineering, humanities, social sciences, geosciences, and agrosociences.

These disciplines were classified according to the subject areas considered in the (SC) field of WoS. Our search was performed in the process of

selecting members and non-members of NSR in our data sample. This selection used a direct search in the NRS databases and the web pages of their respective institutions. This strategy was used also to identify the author's research areas. *Table 1* includes the indicators used in this search strategy. It was necessary to normalize the data on each institution before including it in an Access database.

Indicators	Description	General objective
Production	Papers on metric studies	Identification of the production by authors, institutions, and federal entity
	Papers by research subject	Identification of the production by research subject / Papers by scientific area (ACM)
	Papers by scientific area (ACM)	Identification by scientific area
Citation impact	Number of citations by paper	Impact factor by author, institution and federal entity
	Number of citations by subject area	Impact factor by subject area
	Number of citations by scientific discipline (ACM)	Impact factor by scientific discipline
NSR/authors	Identification of NSR members	Determination of active/non-active NSR members Determination of active members by NSR level and academic area
	Identification of addresses of authors	Determination of NSR members by federal entity
	Identification of the NSR academic area of authors	Determination of the production by academic area

Table 1. Indicators used to retrieve bibliometric data

Finally, in order to get a well-organized data sample, it was necessary to tolerate double counting with integer values in the fields of name authors and institutions, as well in subject areas and scientific disciplines. We used TL.exe software for co-word mappings of texts (<https://www.leydesdorff.net/>). The author network was generated with Pajek software (<http://mrvar.fdv.uni-lj.si/pajek/>).

RESULTS

The databases of WoS, Scopus and Scholar were pioneer tools in the bibliometric studies published by Mexican scholars. However, some of the first published works in area of knowledge used Clase, Periodica and Latindex (Luna-Morales, Luna-Morales, and Pérez-Angón, 2021). They constituted the first databases with complete bibliometric information in Latin America.

In *Figure 2* we used the whole sample (938 documents) to depict the evolution of the number of documents, and the respective generated citations, published in the area of informetrics studies in the period 1971-2018. There is a scarce production during the first three decades with a positive trend in the most recent period 2000-2018. The number of citations is appreciable since 1990 and it is possible to identify five years with an impressive number of citations: 402 (2007), 281 (2014), 264 (2012), 244 (2013) and 210 (2011). They correspond mostly to four papers published in *Scientometrics*, *Inter-ciencia*, *Journal of the American Society for Information Science and Technology (JASIST)* and *Research Policy* as it is shown in *Appendix* with the list of the papers that generated the larger number of citations in this period.

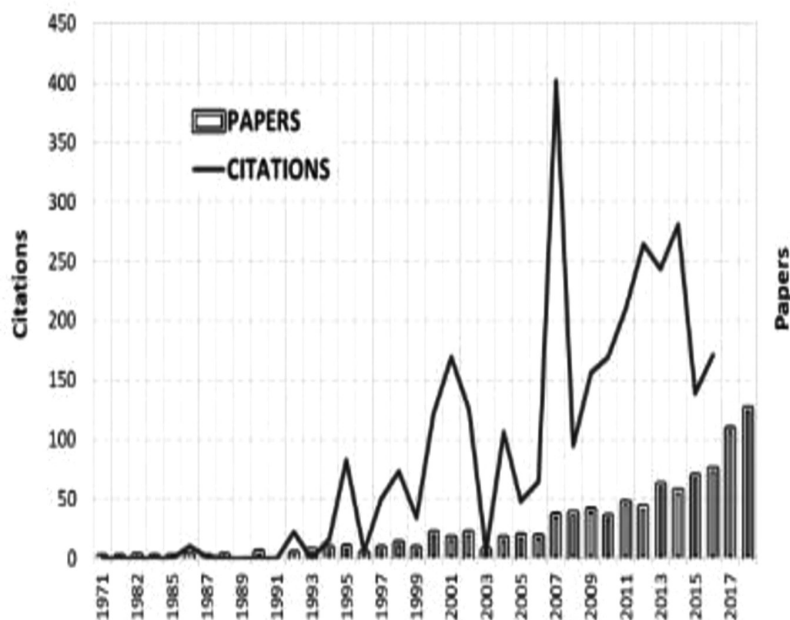


Figure 2. Evolution of the number of publications and citations by Mexican scholars in the field of informetrics (1971-2018)

In *Table 2* we have included the list of the more prolific authors in the field of metric studies of science and technology in Mexico. We were able to identify 1393 active authors in this area of knowledge. There are scholars with different research interests but the most active set of scholars in this field correspond to the area of librarianship.

Table 2 included the 41 most active authors with a minimum of five publications in mainstream journals. Their production corresponds to 22.7% of the total production in this area of knowledge. This set of authors are affiliated to 14 Mexican institutions which also reflects the fact that field of metric studies of science and technology is a very young area of research. There is other group of 187 scholars that published only 2 to 5 papers with 22.2% of the total research production. It is important to notice that the rest of the research production (55.1%) is associated to 1175 scholars with just one publication.

Num.	Authors	Institutions	Papers	Author's research áreas
1	Russell-Barnard, Jane Margaret	UNAM	56	Librarianship
2	Licea de Arenas, Judith	UNAM	46	Librarianship
3	Collazo-Reyes, Francisco	Cinvestav	33	Librarianship
4	Luna-Morales, Maria Elena	Cinvestav	28	Librarianship
5	Macias-Chapula, Cesar Augusto	Secretaría de Salud	24	Librarianship
6	Gorbea-Portal, Salvador	UNAM	23	Librarianship
7	Gonzalez-Brambila, Claudia Noemi	ITAM	21	Engineering
8	Aguado-Lopez, Eduardo	UAEMex	17	Sociology
9	Perez-Angon, Miguel Angel	Cinvestav	17	Physics
10	Valles-Valencia, Javier	UNAM	16	Librarianship
11	Arenas-Vargas, Miguel Angel	UAM	15	Biology
12	Michan-Aguirre, Layla	UNAM	15	Biology
13	Del Rio, Jose Antonio	UNAM	13	Physics
14	Musi-Lechuga, Bertha	UACJ	13	Librarianship
15	Olivas-Avila, Jose Alonso	UACJ	13	Medicine
16	Alonso-Gamboa, Jose Octavio	UNAM	12	Librarianship
17	Carrillo-Calvet, Humberto Andres	UNAM	12	Engineering

18	Tarango-Ortiz, Javier	UACH	11	Librarianship
19	Luna-Morales, Evelia	Cinvestav	10	Librarianship
20	Rogel-Salazar, Rosario	UAEMex	10	Sociology
21	Narvaez-Bertheleot, Nora	UNAM	10	Librarianship
22	Cortes, Hector Daniel	UNAM	9	Physics
23	Ainsworth, Shirley	UNAM	7	Librarianship
24	Cocho, Germinal	UNAM	7	Physics
25	Fuentes-Navarro, Raúl	ITESO	7	Sociology
26	Machin-Mastromatteo, Juan D.	UACH	7	Studies Information
27	Restrepo-Arango, Cristina	ColMex	7	Librarianship
28	Rodríguez-Salvador, Marisela	ITESM	7	Engineering
29	Cetto-Kramis, Ana María	UNAM	7	Physics
30	Becerril-García, Arianna	UAEMex	6	Engineering
31	Roldan-Valadez, Ernesto	Secretaría de Salud	6	Medicine
32	Ayala-Picazo, Micaela	ColMex	5	Librarianship
33	Cantú-Ortiz, Francisco J.	ITESM	5	Engineering
34	García-Mandujano, Esther Ofilia	UNAM	5	Physics
35	García-Gómez, Francisco	IMSS	5	Medicine
36	Gonzalez, Eric	UNAM	5	Librarianship
37	Lieberman, Sofia	UNAM	5	Psychology
38	Mercado-Martínez, Francisco Javier	UDG	5	Medicine
39	Miramontes, Pedro	UNAM	5	Mathematics
40	Reyna-Espinosa, Felipe Rafael	UNAM	5	Librarianship
41	Ríos-Castañeda, Camilo	Instituto Nacional de Neurología y Neurocirugía	5	Medicine

Table 2. List of the most productive authors by institution and research area

Figure 3 also shows that the most recent increase in the Mexican output can be associated with a large number of new journals registered in the WoS and Scopus databases (Collazo-Reyes, 2014), as well as to an increase in the number of scholars active in this research field.

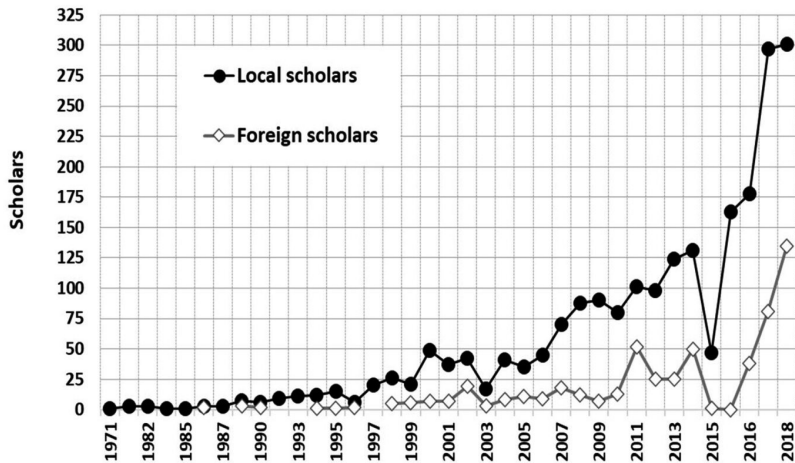


Figure 3. Evolution and comparison of the number of local and foreign scholars in the field of informetrics (1971-2018)

The same figure shows the evolution of the number of local vs. foreign authors in our data sample. It is impressive the dynamics of the number of local authors in this field of research, with an increasing factor of two or three in recent years. However, we found that 42.2% of the whole set of local authors (951) has a scarce research production with just one or two papers published in the analyzed period. We call inactive authors to the scholars identified with this very low research production (Figure 4).

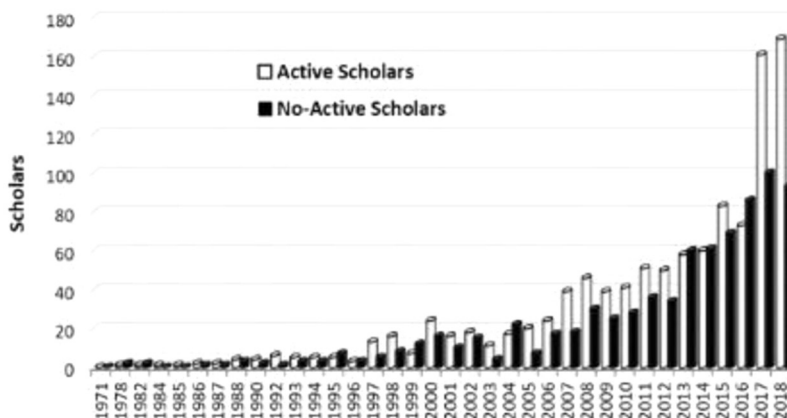


Figure 4. Evolution of the number of active and no-active scholars in informetrics (1971-2018)

In *Figure 5* we present the evolution of the number of authors that are members of the National System of Researchers. We were able to identify a relatively low percentage (54.1%) of NSR members in our data sample, which contribute with 43.7% of the whole production and with 43.4% of the respective number of citations (*Table 2*).

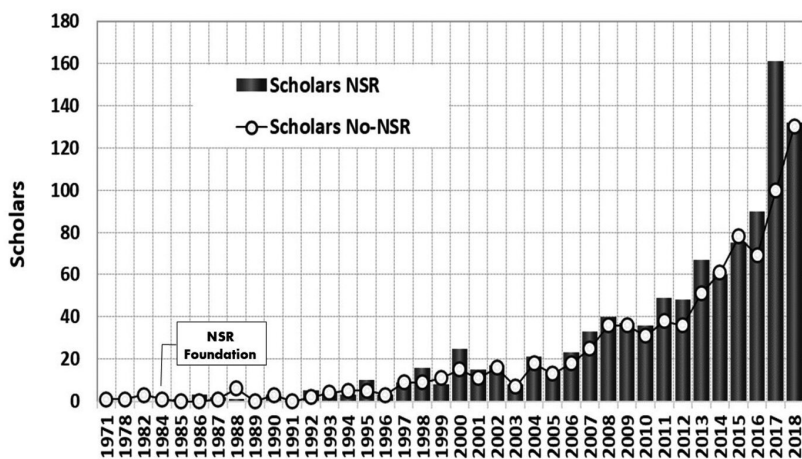


Figure 5. Evolution of the number of scholars which are members or no-members of the National System Research (NSR) in the field of informetrics (1971-2018)

These results are consistent with similar percentages obtained by NSR members in the area of social sciences with respect to the whole research production in this area of knowledge (Contreras-Gómez et al., 2020). We can appreciate that the number of NSR members in our data sample had a strong increase in period 2016-2018. However, this group of NSR authors do not have yet a strong contribution on the whole sample of documents published in the area of informetrics studies. Since NSR was funded in 1984, their first papers appeared in 1985 (*Table 3*). It is important to notice that there is double counting in *Table 2* due to the large number of documents published in collaboration by NSR members and no-members.

Members NSR				No-Members NSR			
Years	Num. Scholars	Num. Papers	Num. Citations	Years	Num. Scholars	Num. Papers	Num. Citations
1971-1975	0	0	0	1971-1975	1	1	1
1976-1980	0	0	0	1976-1980	1	1	0
1981-1985	1	1	0	1981-1985	4	4	0

1986-1990	9	9	11	1986-1990	10	10	43
1991-1995	22	30	93	1991-1995	16	17	71
1996-2000	61	73	257	1996-2000	47	49	77
2001-2005	75	95	494	2001-2005	65	73	241
2006-2010	169	201	733	2006-2010	146	161	651
2011-2015	299	330	873	2011-2015	264	287	778
2016-2018	386	455	295	2016-2018	299	325	256
TOTAL	1022	1194	2756	TOTAL	853	928	2118

Table 3. Relation of the number of publications and citations by members and no-members of NSR in the field of informetrics (1971-2018)

In *Table 4* we included the distribution of the number of documents registered in our data sample according to author's research areas. The most frequent areas included in our data sample correspond to librarianship and medicine, with 27.2% (17.6%) and 21.6% (28.7%) of the documents (citations), respectively. In the following places we found also that engineering and physics have a substantial contribution to our data sample, with 7.4% (10.0%) and 5.4% (10.8%) of the documents (citations).

The large number of documents published by scholars with specialties different from librarianship is associated to their interest in the development of their own research communities, and to the interest in applying some methodologies generated by members of their communities like network analysis, visualization systems and mining data.

Num.	Authors' research areas	Papers	Citations	% Papers	% Citations
1	Librarianship	555	1564	27.2	17.6
2	Medicine	441	2557	21.6	28.7
3	Engineering	151	894	7.4	10.0
4	Physics	110	962	5.4	10.8
5	Biology	76	424	3.7	4.8
6	Psicology	51	154	2.5	1.7
7	Sociology	51	143	2.5	1.6
8	Mathematics	49	383	2.4	4.3
9	Education	48	62	2.4	0.7
10	Economy	47	217	2.3	2.4
11	Ecology	43	90	2.1	1.0

12	Social Studies	43	124	2.1	1.4
13	Administration	42	160	2.1	1.8
14	Agronomy	39	102	1.9	1.1
15	Chemistry	29	223	1.4	2.5
16	Nursing	27	18	1.3	0.2
17	Veterinary and zootechnics	24	9	1.2	0.1
18	Artificial intelligence	21	169	1.0	1.9
19	Anthropology	16	133	0.8	1.5
20	Vegetal biology	16	107	0.8	1.2
21	Science Studies	15	32	0.7	0.4
22	Aquaculture	14	18	0.7	0.2
23	Social communication	13	31	0.6	0.3
24	Ecosystems	13	6	0.6	0.1
25	Astronomy	12	4	0.6	0.0
26	Technologies	11	79	0.5	0.9
27	Geophysics	11	64	0.5	0.7
28	Political Sciences	11	5	0.5	0.1
29	Journal editors	11	5	0.5	0.1
30	Manufacture	10	73	0.5	0.8
31	Design	10	43	0.5	0.5
32	Scientific communication	10	28	0.5	0.3
33	Science, Technology and Society	10	11	0.5	0.1
34	Pedagogy	10	2	0.5	0.0

Table 4. Distribution of the research areas involved in the production of Mexican scholars in the field of informetrics (1971-2018)

In *Table 5*, there are some scientific disciplines, like physics, medicine and engineering, that have higher percentages of citations as compared with their respective contributions to the number of publications and scholars.

The case of humanities deserves a special comment. This area of knowledge has contributed to the Mexican scientific production with a low number of publications and citations (ACM, 2013). Some of the leading researchers in librarianship are members of NSR in the área V (humanities); as a consequence, they have contributed with an extraordinary number of publications and citations.

Num. Scholars	Scientific Discipline	Papers	Cita-tions	% Papers	% Citations
8	Earth sciences	8	17	0.3	0.2
11	Humanities	12	151	0.4	1.7
21	Chemical sciences	29	223	1.1	2.5
40	Agriculture	43	122	1.6	1.4
41	Mathematics	50	291	1.9	3.3
102	Physical sciences	172	1135	6.4	12.9
190	Biological Sciences	212	512	7.9	5.8
222	Engineering	315	1289	11.8	14.6
551	Medicine and Health Sciences	641	2595	24.0	29.5
661	Social Sciences and Behavioral Sciences	1193	2474	44.6	28.1
TOTAL		2675	8809	100.0	100.0

Table 5. Distributions of the number of scholars, publications and citations, according to the scientific disciplines (1971-2018)

The geographical distribution of authors is presented in *Tables 6* and *7*. There is a very high concentration of scholars in Mexico City (CDMX): 52.2% that produce 59.4% (55.3%) of the published documents (citations). Only four of the other federal entities (Jalisco, Edo. de México, Nuevo León, Morelos) have percentages higher than 4%. This is a rather dramatic concentration of the research activity in CDMX which has been also observed by other studies in social sciences and humanities (Contreras-Gómez et al., 2020). The same situation is reflected in *Table 7* for the authors data in terms of NSR membership.

Geographical entity	Num. Scholars	% Scholars	Papers	% Papers	Citations	% Citations
CDMX	724	52.2	1257	59.4	3913	55.3
Jalisco	91	6.6	106	5.0	538	7.6
Estado de México	82	5.9	107	5.1	160	2.3
Nuevo León	58	4.2	80	3.8	477	6.7

Morelos	57	4.1	101	4.8	559	7.9
Baja California	50	3.6	52	2.5	157	2.2
Puebla	49	3.5	63	3.0	140	2.0
Chihuahua	37	2.7	88	4.2	404	5.7
Tamaulipas	24	1.7	26	1.2	22	0.3
Veracruz	22	1.6	25	1.2	85	1.2
Yucatán	21	1.5	21	1.0	27	0.4
Michoacán	20	1.4	24	1.1	308	4.3
Guanajuato	17	1.2	17	0.8	39	0.6
Sinaloa	17	1.2	17	0.8	28	0.4
Sonora	16	1.2	18	0.9	27	0.4
Querétaro	15	1.1	15	0.7	34	0.5
San Luis Potosí	12	0.9	18	0.9	17	0.2
Tabasco	10	0.7	10	0.5	3	0.0
Zacatecas	10	0.7	16	0.8	19	0.3
Chiapas	9	0.6	9	0.4	2	0.0
Colima	9	0.6	9	0.4	22	0.3
Coahuila	7	0.5	7	0.3	6	0.1
Hidalgo	7	0.5	7	0.3	14	0.2
Durango	5	0.4	5	0.2	29	0.4
Quintana Roo	4	0.3	4	0.2	24	0.3
Tlaxcala	3	0.2	4	0.2	19	0.3
Nayarit	3	0.2	3	0.1	1	0.0
Aguascalientes	2	0.1	2	0.1	3	0.0
Baja California Sur	2	0.1	2	0.1	0	0.0
Campeche	2	0.1	2	0.1	1	0.0
Guerrero	2	0.1	2	0.1	3	0.0
TOTAL	1387	100	2117	100	7081	100

Table 6. Distribution of the scholars by geographical entity in the field of metric studies (1971-2018)

Members NSR			No-Members NSR		
Geographical entity	Papers	% Papers	Geographical entity	Papers	% Papers
CDMX	672	56.4	CDMX	585	63.2
Estado de México	63	5.3	Jalisco	47	5.1
Nuevo León	61	5.1	Morelos	43	4.6
Jalisco	60	5.0	Chihuahua	40	4.3
Baja California	50	4.2	Puebla	38	4.1
Chihuahua	47	3.9	Estado de México	33	3.6
Puebla	45	3.8	Nuevo León	20	2.2
Morelos	32	2.7	Baja California	18	1.9
Michoacán	16	1.3	Guanajuato	10	1.1
Veracruz	15	1.3	Querétaro	10	1.1
Yucatán	15	1.3	Tamaulipas	10	1.1
Querétaro	13	1.1	Veracruz	9	1.0
San Luis Potosí	12	1.0	Sinaloa	8	0.9
Tabasco	12	1.0	Tabasco	8	0.9
Tamaulipas	12	1.0	Michoacán	5	0.5
Sonora	11	0.9	San Luis Potosí	5	0.5
Sinaloa	10	0.8	Zacatecas	5	0.5
Zacatecas	10	0.8	Chiapas	4	0.4
Chiapas	6	0.5	Yucatán	4	0.4
Coahuila	5	0.4	Durango	3	0.3
Hidalgo	5	0.4	Hidalgo	3	0.3
Colima	4	0.3	Nayarit	3	0.3
Guanajuato	4	0.3	Quintana Roo	3	0.3
Aguascalientes	2	0.2	Campeche	2	0.2
Campeche	2	0.2	Coahuila	2	0.2
Durango	2	0.2	Colima	2	0.2
Quintana Roo	2	0.2	Guerrero	2	0.2
Tlaxcala	2	0.2	Sonora	2	0.2
Baja California Sur	1	0.1	Aguascalientes	1	0.1

			Baja California Sur	1	0.1
TOTAL	1191	100	TOTAL	926	100

Table 7. Geographical distribution of the number of publications by NSR members in the field of metric studies (1971-2018)

In *Figure 6* we have depicted the collaboration network obtained from our data sample in the informetrics studies. We can appreciate two main sub-networks associated to Jane Margaret Russell Barnard and Judith Licea de Arenas, two of the pioneers in this research field. They are affiliated to the National University of Mexico (UNAM). Most of their collaborations shown in *Figure 6* involve their own graduate students. Another aspect of interest in *Figure 6* is the very low (less than ten) dominant nodes, which induce a large vulnerability of the network. We used the Leydesdorff and Pajeck softwares in order to construct this collaboration network.

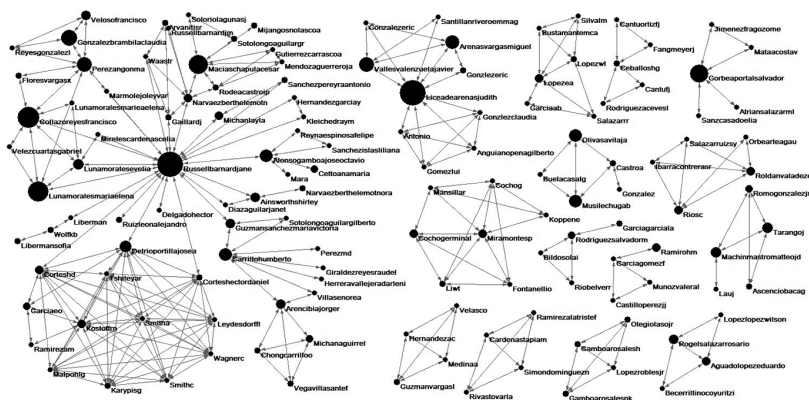


Figure 6. Co-authorship network of Mexican scholars in the field of informetrics (1971-2018)

There are eight training institutions with graduate programs in the field of informetrics (*Table 8*). Most of these programas require presencial participation of students. UNAM was the pioneer institution in these graduate programs in Mexico with both master and PhD programs. For this reason, three of the dominant nodes in the collaboration network shown in *Figure 6* correspond to UNAM faculty members (Russell Barnard, Licea de Arenas, and Gorbea Portal). It has been pointed out also that the training of new researchers has a positive effect on the development of strong research groups.

Num.	Institutions	Graduate programs	Begin Year	Learning Unit Character
1	Universidad Nacional Autónoma de México (UNAM)	Master in librarianship and Information Science	1998	Virtual
		Master in librarianship and Information Science	2000	Presential
		PhD in librarianship and Information Science	2006	Virutal
2	Universidad Autónoma Metropolitana (UAM-X) – Universidad de la Habana – Universidad de Murcia, España	Master/PhD in Information Magnagement	2006	Virtual
3	Instituto Tecnológico de Estudios Superiores Monterrey (Campus Hidalgo)	Master, Information Science and Knowledge Management	1999	Virtual
4	Centro de Investigación y de Estudios Avanzados (Cinvestav)	Transdisciplinary PhD, Science, Technology and Society	2009	Presential
5	El Colegio de México (COLMEX)	Master in librarianship	2010	Presential
6	Universidad Autónoma de Ciudad Juárez (UACJ)	Master/PhD in Information Magnagement	2010	Virtual
7	Universidad Autónoma de Chihuahua (UACH)	Master, librarianship and Information Science	2013	Presential
8	Universidad Autónoma de San Luis Potosí (UASLP)	Master in Information Science and Documentation	2015	Presential

Table 8. Relation of graduate programs in the field of informetrics

DISCUSSION AND CONCLUDING REMARKS

The present analysis of the research production in informetrics in Mexico finds a young community of scholars with about 40 years of activity. This community originated in the first training programs on bibliothecology and information science. UNAM was pioneer in both training programs and research projects. Our analysis identified a strong research network of collaboration but with rather few dominant nodes (Luna-Morales, Luna-Morales, and Pérez-Angón, 2021). We were able to identify five scholars which had a clear influence in the development of this community: Jane

Margaret Russell Barnard y Salvador Gorbea-Portal (Instituto de Investigaciones Bibliotecológicas, UNAM), Judith Licea de Arenas (Facultad de Filosofía y Letras, UNAM), and Eduardo Aguado López and Rosario Rogel Salazar (Universidad Autónoma del Estado de México).

While most of the research production in this area of knowledge is published in mainstream journals involving collaborations of several authors (Dorta-González and Santana-Jiménez, 2019), in the Mexican case most of the research production is published in regional journals in Spanish with few international collaborations, with just 17% of the publications involving collaborations with authors beyond the Latin American region (Luna-Morales, Luna-Morales, and Pérez-Angón, 2021). This fact is also a consequence of the large number of local authors in the production of this area of knowledge.

The maturity of a research community depends on the effective implementation of several factors: academic and experimental infrastructure, active leadership, collaborative work and the formation of new researchers through qualified graduate programs (Durand-Villalobos, 2017). Even though the field of informetrics in Latin America and Mexico has been active for about 50 years (Kreimer and Vessuri, 2018), we could identify a positive trend of the Mexican research production starting the period 2000-2018.

Our findings indicate that this research trend is a consequence of three facts: (1) an increasing number of institutions with undergraduate programs in librarianship; (2) an increase in the number of scholars involved in this area of knowledge, which were trained mostly in foreign institutions; (3) the consolidation of several research groups with experienced members of NSR. The formal requirement established for NSR members to maintain a continuous research activity has also contributed to the steady increase in the research production in the field of metric studies of science and technology.

In the present work, we have characterized the scholar community that is active in research in the field of informetrics in Mexico. Its research output was retrieved from ten bibliometric databases. Our findings indicate a positive trend in this research production just in the period 2000-2018 in both in published documents and the respective number of generated citations. The scholars working in the area of librarianship have the largest contribution in the number of published documents (27.2%) but not in the number of generated citations (17.6%). The scholars working in the area of medicine had the largest fraction of generated citations (28.7%) with a lower number of published papers (21.6%). It is natural that the librarianship community is the most active in this research area since its work is directly related to the metric studies of science and technology. Salvador Gorbea-Portal (2013) has pointed out that metric studies of the scientific information constitute a

new research field: librarianship. It is a multidisciplinary discipline that has involved scholars with different research interests, like engineers, physicists, mathematicians and others.

This area of knowledge has still an intense concentration of research activity in the Mexico City metropolitan area: 52.2% of the researchers, 59.4% of the Mexican production and 55.3% of the total number of citations.

On the other hand, there a substantial number of NSR members in our data sample (54.5%), the active researchers in this area of knowledge represent a healthy variety of scientific disciplines. We were able to identify a strong network of collaboration among the members of this community. However, there is weak point in the structure of this network: there is a very few dominant nodes (less then ten).

We would like to stress that, as far we know, the present work is the first study that addresses the evolution and characterization of a local community of scholars in Latin America involved in research and training in the area of informetrics studies. Finally, we hope that the present study will be continued in future work by taking into account the following pints: analysis of the performance of new researchers coming out from the seven graduate programs identified in the present work; and the age distribution of the members of this community in order to determine the perspective of new research groups located outside the Mexico City metropolitan area. It will be interesting also to search for the production in other databases and journals in this research field which are not included in the databases analyzed.

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Appendix

Relation of the most cited papers by Mexican scholars in the field of metric studies (1971-2018)

Year	Authors	Title	Source	Document Type	Citations	*Database
2007	Gonzalez-Brambila, C.; Veloso, F. M.	"The determinants of research output and impact: A study of Mexican researchers"	<i>Research Policy</i> 36 (7): 1035-1051	Article	105	WoS
2013	Nagata, J. M.; Hernández-Ramos, I.; Kurup, A. S.; Albrecht, D.; Vivas-Torrealba, C.; Franco-Paredes, C.	"Social determinants of health and seasonal influenza vaccination in adults ≥ 65 years: A systematic review of qualitative and quantitative data"	<i>BMC Public Health</i> 13 (388)	Review	99	Scopus
2012	Barreto, S. M.; Miranda, J. J.; Figueroa, J. P.; Schmidt, M. I.; Munoz, S.; Kuri-Morales, P. P.; Silva, J. B.	"Epidemiology in Latin America and the Caribbean: current situation and challenges"	<i>International Journal of Epidemiology</i> 41 (2): 557-571	Article	84	WoS
2007	Hamel, R. E.	"The dominance of English in the international scientific periodical literature and the future of language use in science"	<i>Aila Review</i> 20 (1): 53-71	Article	83	Scopus
2007	Lowe, R. A.; Gonzalez-Brambila, C.	"Faculty entrepreneurs and research productivity"	<i>Journal of Technology Transfer</i> 32: 173-194	Article	77	WoS
2009	Martínez-Mekler, G.; Martínez, R. A.; Del Río, M.-B.; Mansilla, R.; Miramontes, P.; Cocho, G.	"Universality of rank-ordering distributions in the arts and sciences"	<i>Plos One</i> 4 (3): e4791	Article	73	Scopus

2007	Mansilla, R.; Koppen, E.; Cocho, G.; Miramontes, P.	"On the behavior of journal impact factor rank-order distribution"	<i>Journal of Informetrics</i> 1 (2): 155- 160	Article	63	WoS
2014	Aleman-Nava, G. S.; Casiano-Flores, V. H.; Carde- nas-Chavez, D. L.; Diaz-Chavez, R.; Scarlet, N.; Mahlknecht, J.; Dallemand, J. F.; Parra, R.	"Renewable energy research progress in Mexi- co: A review" (ITESM, estudio de la producción Tecnología del agua)	<i>Renewable & Sustainable Energy Reviews</i> 32: 140-153	Review	62	WoS
2004	Morales-Gonzales, J. M.; Benito-Leon, J.; Rivera-Navarro, J.; Mitchell, A. J.	"A systematic approach to analyse heal- th-related quality of life in multiple sclerosis: the GEDMA study" (Universidad de Veracruz, Estudio de esclerosis múltiple, metodo- logía cuantitativa y cualitativa)	<i>Multiple Sclerosis Journal</i> 10 (1): 47-54	Article	62	WoS
2001	Kostoff, R. N.; Del Rio, J. A.; Humenik, J. A.; Garcia, E. O.; Ramirez, A. M.	"Citation mining: Integrating text mining and bibliometrics for research user profiling"	<i>JASIST</i> 52 (13): 1148-1156	Article	57	WoS
2011	Arechavala Vargas, R.	"Las univer- sidades y el desarrollo de la investigación científica y tecno- lógica en México: Una agenda de investigación"	<i>Revista de la Educacion Superior</i> 40 (158): 41-57	Article	54	Scielo
2000	Ramirez, A. M.; Garcia, E. O.; Del Rio, J. A.	"Renormalized impact factor"	<i>Scientome- trics</i> 47 (3-9): 7	Article	49	WoS

2012	Kaplan, W. A.; Ritz, L. S.; Vitello, M.; Wirtz, V. J.	"Policies to promote use of generic medicines in low and middle income countries: A review of published literature, 2000-2010"	<i>Health Policy</i> 106 (3): 211-224	Review	47	WoS
2001	Ingwersen, P.; Larsen, B.; Rousseau, R.; Russell, J.	"The publication-citation matrix and its derived quantities"	<i>Chinese Science Bulletin</i> 46: 524-528	Editorial Material	46	WoS
2014	Vessuri, H.; Guédon, J.-C.; Cetto, A. M.	"Excellence or quality? Impact of the current competition regime on science and scientific publishing in Latin America and its implications for development"	<i>Current Sociology</i> 62 (5): 647-665	Article	41	Scopus
2016	Cadenas, E.; Rivera, W.; Campos-Amezcuca, R.; Heard, C.	"Wind speed prediction using a univariate ARIMA model and a multivariate NARX model" (Es un estudio de impacto de variables, varias instituciones de México)	<i>Energies</i> 9 (2):109-	Article	40	Scopus
2013	Gonzalez-Brambila, C. N.; Veloso, F. M.; Krackhardt, D.	"The impact of network embeddedness on research output"	<i>Research Policy</i> 42 (9): 1555-1567	Article	39	WoS
2010	Olivas-Avila, J. A.; Musi-Lechuga, B.	"Analysis of the production of psychology professors in Spain in journal articles of the Web of Science"	<i>Psicothema</i> 23 (2): 267-273	Article	36	WoS

2009	Musi-Lechuga B., Olivas-Ávila J.A., Buela-Casal G.	"Producción científica de los programas de Doctorado en Psicología Clínica y de la Salud de España"	<i>International Journal of Clinical and Health Psychology</i> 9 (1): 161-173	Article	36	Scopus
2000	Urzua, C. M.	"A simple and efficient test for Zipf's law"	<i>Economics Letters</i> 66 (3): 257-260	Article	35	WoS
2014	Collazo-Reyes, F.	"Growth of the number of indexed journals of Latin America and the Caribbean: the effect on the impact of each country"	<i>Scientometrics</i> 98: 197-209	Article	34	WoS
1995	Lozoya, X.; Rivera-Arce, E.; Dominguez, F.; Arellano, M. L.; Muñoz, O.	"Archives of medical research: An historical and subject coverage overview"	<i>Archives of Medical Research</i> 26: S1-S5	Article	33	WoS
2010	Li, W. T.; Miramontes, P.; Cocho, G.	"Fitting Ranked Linguistic Data with Two-Parameter Functions"	<i>Entropy</i> 12 (7): 1743-1764	Article	31	WoS
2008	Naumis G. G.; Cocho G.	"Tail universalities in rank distributions as an algebraic problem: The beta-like function"	<i>Physica A</i> 387 (1): 84-96	Article	30	Scopus

* This column includes the databases that were used to retrieve articles and number of citations