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Information literacy in social sciences and health sciences: a bibliometric study (1974–2011)

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Abstract We examine the international scientific productivity on information literacy since its inception in 1974 until late 2011, based on a bibliometric analysis of scientific articles included in the web of science and Scopus databases. The sample comprised two macro-domains—the most productive and the least productive. The former was the area of social sciences (SoS), covering such disciplines as information and documentation, communication, education, management, etc. The latter was the area of health sciences (HeS), covering such disciplines as medicine, nursing, etc. The objective of the study was to analyse the evolution of research activity during this period, taking into account the authors' production, the distribution and co-authorship of the works, the affiliation, and the most frequently used journals. A quantitative and qualitative methodological approach was taken, based on statistical, mathematical, and content analyses. The results showed exponential growth of the scientific publications in both domains ($R^2 = 0.9544$ for SoS, and $R^2 = 0.9393$ for HeS), with a predominance of Anglo-Saxon authors. Author productivity was low (1.29 and 1.12 papers/author), while the dispersion of articles by journal averaged 4.96 in SoS and 1.86 in HeS. Scientific collaboration exceeded 53 % in the SoS domain and 69 % in HeS. There was a major dispersion of the places of the authors' affiliation. In both domains, the author distributions fitted Lotka's law, and the journal distributions Bradford's Law.

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Introduction

A decade ago, Rader (2002) observed that "more than 5000 publications related to library user instruction and information literacy were published in the past thirty years". Since then, the volume of literature on information literacy (IL) has continued to increase, with the trend in the number of published papers being exponential.

The present research study was designed to quantify the world scientific output in the area of IL. The analyses used the web of science (WoS) and Scopus databases, restricting the search to publications containing the words 'information literacy', and 'social sciences' (SoS) or 'health sciences' (HeS). The aim of this communication is to present an overview of the research activity and the evolution of the bibliometric characteristics of the literature on IL in SoS and HeS over the last four decades.

The object of bibliometrics is to analyse a body of literature using quantitative methods (statistical and mathematical), to extract the possible relationships between the elements that compose it. The specific objective of the present study was to examine the following aspects of the literature on IL:

- Temporal evolution of the number of publications.
- Publication country.
- Number of authors contributing to each article, and the authorship pattern.
- Author productivity through the application of Lotka's law, and the most prominent authors in the area of IL.
- The distribution of documents by author, and the identification of the most productive authors.
- Output of different journals with their rank, and the application of Bradford's law as an indicator of the dispersion of the scientific information; the distribution of journal articles and core journals, and a zone analysis and graphical formulation from Bradford's law.
- The authors' institutional affiliations.
- A focus of the various analyses on the presentation of publications, frequencies, and percentages.

Literature review

It would be laborious to analyse the extensive international scientific production on IL since its inception in 1974 (with the first publication of Zurkosky) until the end of 2011 (closing date for the present study). Research in this field has grown exponentially in all the areas that it involves. There have been numerous, enriching research fronts in the areas of Information and Documentation, Education, Computer Science, and Business, for example. The area of Information and Documentation has accounted for the greatest number of papers, followed by Education and Computer Science. We would therefore concur with Virkus (2003) about the conceptual breadth of IL and the diversity of contexts in which it is being applied.

Based on the literature and our professional experience, we shall organize this selective review of the literature into three phases—initial, growth, and integrative. These phases are not meant to represent watertight compartments, but rather are interlinked in their sharing of concepts, processes, instruments, applications, etc.

Initial phase (1974–1989)

This phase corresponded to a predominantly librarianship focus on IL. It is characterized in 1974 by Zurkowski's first use of the term. This broke with the vision of instruction in the use of bibliographic resources as an essential component of the know-how undergraduates should acquire in university, to advocate the more general concept of preparation for the access and use of information. A series of works were published in this sense that highlighted the importance of knowing how to use and pre-digest information. These works corresponded to different domains—journalism (Burchinal 1976), politics and citizenship (Owens 1976; Hamelink 1976) organizations (Taylor 1979), and the university (Johnston 1985).

The major impulse that was given to IL research occurred in 1985, coinciding with the development of Information and Communication Technologies in libraries. Some authors (Breivik 1985; Kuhlthau 1985) focused their research on the integration of IL into undergraduate curricula, and on information resource centred learning. The publication in 1989 of the first "final" report by the ALA's Presidential Committee on IL laid the conceptual and strategic foundations for its development and implementation. In particular, it strengthened the role of information in problem solving and decision making.

Growth phase (1990–1999)

This phase was marked by a solidification of the concept of IL. The concept evolved towards a preferentially systemic and document-based focus, characterized by a major contextual component which stressed IL's cognitive, attitudinal, informational, and pragmatic aspects (Marcun 2002; Purdue 2003; Kapitzke 2003; Pawley 2003; Kuhlthau 2004; Swanson 2004; Lloyd 2006). This phase coincided with an exponential growth in the scientific production on IL, especially in the SoS in which we found a total of 208 articles compared with the 15 of the previous phase. Also significant was the ERIC database's incorporation in 1992 of IL in its list of descriptors.

The burgeoning growth and implementation of Information Technologies meant that the term IL co-habited with other similar terms of a clearly technological acceptance, such as computer literacy and digital literacy. This went together with a change in library practices to an orientation that included assessing the quality of their services and the library's social impact in the community as support for the work of teaching and learning. In 1998, the first IL standards were published in the USA (ALA 1998), followed by some key documents in Britain which involved clear innovations for their implementation and development (SCONUL 1999). There also stand out in this phase the works of such authors as Kuhlthau (1990, 1991, 1993), Behrens (1994), Doyle (1996), Bruce (1997), Snavely and Cooper (1997), Barry (1997), Davenport (1997), Spitzer et al. (1998), Bundy (1998), and Grassian and Clark (1999).

Integrative phase (2000–)

This phase is characterized by a preferentially socio-educational orientation. There is recognition of IL as a holistic process to be integrated into the different contexts of a

citizen's life—social, political, cultural, educational, economic, work, and health (Pierce 2000; Cheuk 2002; Candy 2002; Hancock 2004; Kapitzke 2003; Catts 2005a, 2007; Lau 2006; Ward 2006; Horton 2007; Clark and Catts 2007).

From the year 2000 onwards, one witnesses an exponential growth of publications on IL. This is especially notable in SoS, for which we found a total of 1,941 articles corresponding to different research areas such as documentation, education, management, and communication. The situation is somewhat similar in the area of computer sciences, with the development of such concepts as digital literacy, technological literacy, computer competence, etc. There has also been major growth in the HeS, with 304 publications. In general one observes that, first, the concept of IL has taken on an interdisciplinary cast as representing a collaboration between librarians, academics, and educators, and, second, its principles have become socialized with the recognition of the importance of IL for the access to and equitable use of information. The process seems to be leading to an integrated concept of IL as multiliteracy based on coexistence with other literacies, especially multimedia, digital, and intercultural literacies (Cope and Kalantzis 2000; Kellner 2000). The need for the establishment and publication of both general and specialized norms and standards has been recognized by such international organizations as UNESCO and by professional associations such as ALA (2000), CAUL (2001), and SCONUL (1999). These standards are aimed at providing IL with solid support, at defining its structure and components, and at fostering the paedagogical aspects of teaching IL with the proposal of active methodological approaches and the design of new models (Herring 1999; Webber and Johnston 2000; Eisenberg and Berkowitz 2000; Corrall 2007; Johnson 2008; Markless and Streatfield 2007; Pinto and Sales 2008b; Shenton and Fitzgibbons 2010). They are also aimed at promoting the incorporation of IL into the curricula of various levels of education (Lupton 2004; Shenton and Dixon 2004; Julien 2005; Limberg 2005; Webber and Johnston 2005; Gratch-Lindauer 2005; Andretta 2007; Saunders 2007; Basili 2008; Pinto and Sales 2008a).

In addition, there is an emerging development of applications for different types of libraries, especially university libraries (Julien 2000; Gómez and Pasadas 2003; Jehlik 2004; Gómez et al. 2004; Julien and Breu 2005; Somerville and Collins 2008; among others). There have been a growing number of publications on evaluating IL (e.g., O'Connor et al. 2002; Dunn 2002; Gratch-Lindauer 2002, 2003, 2004, 2005; Sontag and Meulemans 2003; Basili 2003, 2004; Owusu-Ansah 2004; Catts 2005a, b; Oakleaf 2006; Kurbanoglu et al. 2006; Gross and Latham 2007; Catts and Lau 2008; Oakleaf and Kaske 2009; Pinto et al. 2010; Pinto 2010, 2011) and on people-to-people Web ("Web 2.0") implementations based on such technologies as social software, RSS, mashups, cloud tagging, weblogs, wikis, e-portfolios, … (Zheng and Wang 2009; Partridge et al. 2010; Newell 2010).

In the case of Latin America, research in the field of IL and applications in the form of models, standards, and programs have appeared only relatively recently. The term information literacy itself only came into use in the Spanish speaking context (abbreviated as ALFIN) in the late nineties (Benito 1996; Ferreira 1995; Cortés and Lau 1999). At the beginning of the present century, scientific production on the topic began to grow significantly with the publication of the results of research projects and PhD dissertations, and of models, tools, applications, and programs in different fields of knowledge (higher education, translation, medicine, library science, communication, psychology, …). Three foci of research stand out. First, in Mexico, there is the work of Cortés and Lau (2000, 2004), Lau (2007), Licea de Arenas (2009), Sánchez Ambriz (2007), and Hernández (2012), among others. Second, in Spain there has been increasing visibility of work on IL in the country's overall scientific output, noteworthy among other authors being: Pinto (2010, 2011), Gómez and Pasadas (2003), Pinto and Sales (2007a, 2007b, 2008a), Pinto

and Garcia (2006), Ortoll (2004), Cuevas (2007), Calderón (2010), and Calzada and Marzal (2007). ALFIN research has also been gaining presence in Cuban universities with the work of Ponjuán (2010), Meneses (2009), Meneses and Pinto (2011), Quindemil (2008), Sánchez (2010), Fernández (2008), … There is a smaller presence of work on the topic in Brazil and Colombia, outstanding being such authors as Dudziak (2003, 2007, 2008), Lecardelli and Schoffen (2006), and Uribe (2010).

Despite this exponential growth of the global scientific literature, it appears that there have been few review studies of the scientific production in IL. These few include the works of Rader (2000, 2002) which already speak of the exponential growth of publications on this topic worldwide. As the author states: "New developments in education and technology during the last two decades have affected user instruction and have led to the emergence of information literacy. Based on needs related to the rapid development of information technology and the evolving information society, librarians have begun teaching information skills to all types of users to ensure that they gain information fluency so they can become productive and effective information users both in the education environment and in the work environment." The first research publications focused mostly on the USA, Canada, the UK, Australia, and New Zealand. Currently, these studies have become global in scope, extending to countries and regions such as China, Singapore, Spain, Mexico, South America, and South Africa, among others. One notes that a major part of the publications focus on IL in higher education, with emphasis on the complementary role of university libraries in the process of training students in IL competences.

Virkus (2003) analyses the evolution of IL in Europe, and provides an overview of the concepts used by European authors and the diversity of contexts in which IL is being used. Lau (2007), with the sponsorship of UNESCO, prepared a report on the global state of IL and IL initiatives, in order "to identify information literacy trends around the World in five broad subjects: resources for user education; publications devoted to the subject; organizations, such as associations, and other professional groups; training programs for IL facilitators; and communication events, such a conferences, and meetings." Calzada and Marzal (2007) analyse international IL production between 1990 and 2005 using the LISA, ERIC, and SSCI databases. The most productive authors and journals are identified, as also are emerging thematic lines. Pinto et al. (2010) make a terminological, conceptual, and statistical analysis of the evolution of terms used in IL over the last 30 years. They stress the different acceptance of terms related to library instruction, user education, IL, critical thinking, multimedia literacy, digital literacy, etc., according to the perspective and context in which they are being used. Dudziak (2010) examines world scientific production on IL over the previous 30 years, searching the WoS and Scopus databases to identify the principal research trends. The author notes that there are a number of emerging research topics related to education, information technology, free access to information, quality of life, e-government, citizenship, etc., all areas that have influenced people's activities related to information competences, and hence also the promotion of IL in different social contexts (e.g., education, the workplace, …). The study also finds, however, that despite the degree of institutionalization and consolidation that IL has reached in the USA, there still remain obstacles to the full understanding and acceptance of the concept.

In their study, Pinto et al. (2011) take a qualitative and quantitative approach to examining the changes in the last three decades of two interdependent clusters of concepts—"information literacy", "information skills" and "library skills"/"computer literacy", "Internet literacy", "digital literacy", and "technological literacy". The data they use are taken from consulting three specialized databases (LISA, LISTA, ERIC) and three multidisciplinary databases (ISI, FRANCIS, CINDOC). They find that, although there have

been various studies that define and differentiate information competences and computer competences and conclude by presenting the latter cluster of concepts as complementary to and preceding the former, in many areas of knowledge such differentiation is less clear, and less emphasis is currently being given to the former, i.e., to information competences.

In sum, beginning at the close of the twentieth century, there has been increased international interest in IL research and scientific production. Understanding the phenomenon of IL and its implementation is a priority for such international organizations as IFLA and UNESCO which see it as an emerging paradigm for citizenship in the twenty-first century, and as a marker of quality in the processes of accreditation of higher education. It has also become a cross-discipline topic, having mobilized professionals from different areas—librarians, educators, computer systems specialists, doctors, biologists, psychologists, physicists, engineers, administrators, etc.—with a proliferation of studies that take a multi-focused approach.

Methods

We performed series of retrospective searches on IL in the databases of the WoS (Thomson Reuters) and Scopus (Elsevier) to retrieve the material of study of the present work, with a limitation in time from 1974 to 2011 (both years inclusive). The results were processed in the reference manager RefWorks (ProQuest).

The units for the analysis were publications on IL indexed in the those databases for the areas of SoS and HeS. The sub-areas selected as SoS were as Information and Documentation, Education, Law, Economics, and Sociology, and as HeS were Medicine, Nursing, and Psychology.

One major difficulty of trying to make the searches in WoS and Scopus as similar to each other as possible was that they each have their own specific query language and document structure. The main problem lay in setting the sensitivities of the two systems to the same level and then verifying that the results were as little biased as possible as a consequence of any differences in the searches, regardless of editorial policy or of the construction of the records in each database. The search equations executed both in the two databases were as follows:

Social sciences

In WoS

Topic = ("information* literacy" or "information* competenc*" or "information* skills")

Refined by: Document Type = (article or proceedings paper or review) and Subject Areas = (information science library science or education educational research or business economics or SoS other topics or communication or operations research management science or sociology or social issues or government law or public administration or social work or anthropology or women's studies)

In Scopus

title-abs-key("information* literacy" or "information* competence*" or "information* skills") and pubyear > 1973 and pubyear < 2012 and (limit-to(doctype, "ar") or limit-to

(doctype, "re") or limit-to(doctype, "cp")) and (limit-to(subjarea, "soci") or limit-to(subjarea, "busi") or limit-to(subjarea, "econ") or limit-to(subjarea, "mult"))

Health sciences

In WoS

Topic = ("information* literacy" or "information* competenc*" or "information* skills")

Refined by: Document Type = (article or proceedings paper or review) and Subject Areas = (nursing or health care sciences services or medical informatics or psychology or pharmacology pharmacy or public environmental occupational health or general internal medicine or neurosciences neurology or biomedical SoS or dentistry oral surgery medicine or paediatrics or psychiatry or anaesthesiology or geriatrics gerontology or infectious diseases or nutrition dietetics or research experimental medicine or rheumatology or surgery)

In Scopus

title-abs-key("information* literacy" or "information* competence*" or "information* skills") and pubyear > 1973 and pubyear < 2012 and (limit-to(subjarea, "medi") or limit-to(subjarea, "nurs") or limit-to(subjarea, "heal") or limit-to(subjarea, "psyc") or limit-to(subjarea, "dent") or limit-to(subjarea, "mult")) and (limit-to(doctype, "ar") or limit-to(doctype, "re") or limit-to(doctype, "cp"))

The results were exported to RefWorks, and stored in two folders, one for SoS and the other for HeS. As was to be expected, there was a major overlap between the two databases (Escalona et al. 2010), so that all duplicates were removed by means of the "see duplicates" tool of the reference manager. We then proceeded to export the analysed data: publication year, document type, author, affiliation, and keywords.

Results

Temporal evolution of the scientific production on information literacy

In the period of study (1974–2011), the scientific output on IL in SoS reached a total of 2,177 documents. In the case of HeS, the scientific output was much lower—367 documents in the same time period. Figures 1 and 2 show the evolution by 5-year periods of the number of papers in SoS and HeS, respectively.

In SoS, production was high in the last two 5-year periods—more than 100 documents per year in the period 2002–2006, and more than 200 documents per year in the period 2007–2011, i.e., an increase of 148 % between these two periods. In HeS, the production of papers was modest—about 15 documents per year in the period 2002–2006 and somewhat more than 40 per year in the 2007–2011, corresponding to a 195 % increase. In both cases, the growth was exponential, with coefficients of determination $R^2 = 0.9544$ for SoS and $R^2 = 0.9393$ for HeS.

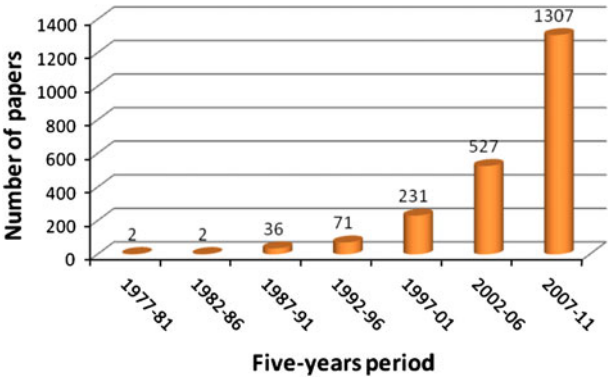

Fig. 1 Five-yearly evolution of the number of papers in social sciences

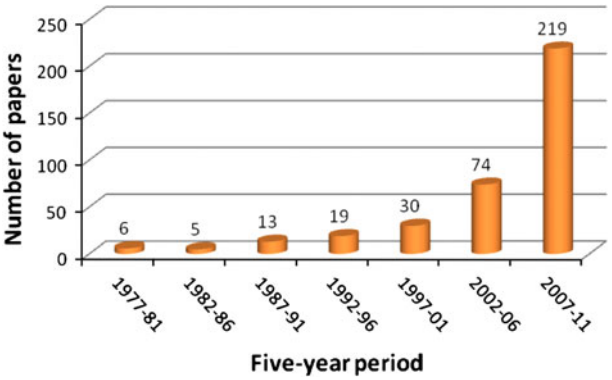

Fig. 2 Five-yearly evolution of the number of papers in health sciences

Co-authorship

The 2,177 papers published in SoS are signed by 4,071 authors, for a collaboration index of 1.87 authors per paper. In HeS, the 367 papers are signed by 963 authors, for a collaboration index of 2.62 authors per document. Tables 1 and 2 present the distribution of the number of authors per document for SoS and HeS, respectively.

In SoS, there is one document signed by 13 authors, a second by 12, and a third by 11, with 1,009 documents signed by a single author. There is thus collaboration in 1,168 papers, i.e., 53.6 % of the documents are signed by two or more authors. In HeS, there is one document signed by 12 authors and two by 11, with 113 documents signed by a single author. There are thus 254 papers in collaboration, i.e., 69.2 % of the documents are signed by two or more authors.

The scientific production of the authors

Tables 3 and 4 show the distribution of author productivity in SoS and HeS, in decreasing order of productivity. In SoS, 2,653 authors have a single paper and 317 have two, up to a

Table 1 Collaboration index per paper in social sciences

N° authors (*a*)	N° papers (*b*)	*a* × *b*
13	1	13
12	1	12
11	1	11
10	0	0
9	0	0
8	6	48
7	5	35
6	20	120
5	34	170
4	84	336
3	285	855
2	731	1,462
1	1,009	1,009
	2,177	4,071
Collaboration index per paper		1.87

Table 2 Collaboration index per paper in health sciences

N° authors (*a*)	N° papers (*b*)	*a* × *b*
12	1	12
11	2	22
10	1	10
9	2	18
8	2	16
7	5	35
6	14	84
5	15	75
4	39	156
3	76	228
2	97	194
1	113	113
$\sum$	367	963
Collaboration index per paper		2.62

single author with 20 published papers. In the case of HeS, 784 authors have a single paper and 52 have two, up to a single author with 6 published papers. The average productivity in SoS was 1.29 papers/author, and in HeS 1.12 papers/author.

In order to verify that the distribution of the observed productivity of the authors fits the theoretical distribution of Lotka's law (Lotka 1926), we subjected the data to the non-parametric Kolmogorov–Smirnov goodness-of-fit test, following the approach of Pao (1985). In particular, if x and y follow an inverse power law, the resulting log–log plot will be a straight line of negative slope n. The slopes of the two distributions of authors, obtained with the best fit of the coefficient of determination R^2 (the first 10 pairs of data for SoS and uncut distribution for HeS), were: $n = 2.99$ ($R^2 = 0.9914$) for SoS, and $n = 3.79$ ($R^2 = 0.9805$) for HeS.

Table 3 Kolmogorov–Smirnov test in social sciences

x = papers	y = authors	$x \times y$	$y/\sum y$	$\sum(y/\sum y)$	Ef	$\sum$Ef	D_{max}
1	2,653	2,653	0.8444	0.8444	0.8300	0.8300	0.0144
2	317	634	0.1009	0.9453	0.1045	0.9345	0.0108
3	80	240	0.0255	0.9707	0.0311	0.9655	0.0052
4	43	172	0.0137	0.9844	0.0131	0.9787	0.0057
5	15	75	0.0048	0.9892	0.0067	0.9854	0.0037
6	10	60	0.0032	0.9924	0.0039	0.9894	0.0030
7	7	49	0.0022	0.9946	0.0025	0.9918	0.0028
8	6	48	0.0019	0.9965	0.0017	0.9935	0.0030
9	5	45	0.0016	0.9981	0.0012	0.9946	0.0035
10	2	20	0.0006	0.9987	0.0008	0.9955	0.0032
11	1	11	0.0003	0.9990	0.0006	0.9961	0.0029
13	1	13	0.0003	0.9994	0.0005	0.9966	0.0027
16	1	16	0.0003	0.9997	0.0004	0.9970	0.0027
20	1	20	0.0003	1.0000	0.0003	0.9973	0.0027
$\sum$	3,142	4,056	1				
Average productivity 1.29							

x number of works, y number of authors, $y/\sum y$ frequency of authors with 1, 2, 3, etc. works (the frequencies observed in the distribution of authors in social sciences), $\sum(y/\sum y)$ cumulative frequency of authors with 1, 2, 3, etc. works, *Ef* expected frequencies, calculated by Lotka's formula (the value of the first cell corresponds to the value of "*C*"), $\sum Ef$ cumulative expected frequencies, $D = D_{max}$ differences between the column of the observed and expected cumulated frequencies

Table 4 Kolmogorov–Smirnov test in health sciences

x = papers	y = authors	$x \times y$	$y/\sum y$	$\sum(y/\sum y)$	Ef	$\sum$Ef	D_{max}
1	784	784	0.9148	0.9148	0.9100	0.9100	0.0048
2	52	104	0.0606	0.9754	0.0657	0.9757	−0.0002
3	12	36	0.0140	0.9894	0.0141	0.9899	−0.0004
4	7	28	0.0081	0.9976	0.0047	0.9946	0.0029
5	1	5	0.0011	0.9988	0.0020	0.9967	0.0020
6	1	6	0.0011	1		0.9967	0.0032
$\sum$	857	963	1				
Average productivity 1.12							

x number of works, y number of authors, $y/\sum y$ frequency of authors with 1, 2, 3, etc. works (the frequencies observed in the distribution of authors in health sciences), $\sum(y/\sum y)$ cumulative frequency of authors with 1, 2, 3, etc. works, *Ef* expected frequencies, calculated by Lotka's formula (the value of the first cell corresponds to the value of "*C*"), $\sum Ef$ cumulative expected frequencies, D_{max} differences between the column of the observed and expected cumulated frequencies

The second parameter of Lotka's law (the constant *C*, equal to the percentage of authors with a single published work in the theoretical distribution, i.e., in the expected frequencies), was calculated from the previously determined value of the slope. The results were 0.83 for SoS, and 0.91 for HeS.

The calculation of 'C' starts from Lotka's law, $y_x = c \times x^{-n}$.

Dividing both terms by $\sum y_x$, the number of authors, $y_x/\sum y_x = (c/\sum y_x)(1/x^n)$ and writing $C/\sum y_x = C$, the fraction of the total sample of authors, one has $y_x/\sum y_x = C/(1/x^n)$, and hence $\sum y_x/\sum y_x = C(\sum 1/x^n) = 1$.

Finally, $C = 1/(\sum 1/x^n)$.

For fractional non-negative values of n, the sum of the series in its general form $\sum 1/x^n$ can be approximated by a function that calculates the sum of the first P(20) terms. The result, according to Pao (1985), is due to Professor David Singer

$$\sum_{x=1}^{\infty} \frac{1}{x^n} = \left[\sum_{x=1}^{P-1} \frac{1}{x^n} + \frac{1}{(n-1)(P^{n-1})} + \frac{1}{2P^n} + \frac{n}{24(P-1)^{n+1}} \right]$$

For the case SoS, using the slope calculated (2.99), one has

$$\sum_{x=1}^{\infty} \frac{1}{x^{2.99}} = \left[\sum_{x=1}^{19} \frac{1}{x^{2.99}} + \frac{1}{(2.99-1)(P^{2.99-1})} + \frac{1}{2 \times 20^{2.99}} + \frac{2.99}{24 \times 19^{2.99+1}} = 1.204 \right] \quad \text{and}$$

$C = 1/1.204 = 0.83$.

For the case HeS, using the slope calculated (3.79), one has

$$\sum_{x=1}^{\infty} \frac{1}{x3.79} = \left[\sum_{x=1}^{19} \frac{1}{x^{3.79}} + \frac{1}{(3.79-1)(P^{3.79-1})} + \frac{1}{2 \times 20^{3.79}} + \frac{3.79}{24 \times 19^{3.79+1}} = 1.098 \right] \quad \text{and}$$

$C = 1/1.098 = 0.91$.

Finally, we used the data of the last column of Tables 3 and 4 ($D_{\max}$), obtained as the absolute value of the difference between columns 5 and 7 of those tables. The greatest value of this column ($D_{\max}$) was taken as the referent for comparison with the "critical value" (c.v.) obtained by the asymptotic formula proposed by Nicholls (1986).

$$\text{v.c.} = \frac{1.63}{\left(\sum y_x + (\sum y_x/10)^{1/2} \right)^{1/2}}$$

For the present case, we used a significance level of 0.01, so that the numerator in the above expression was 1.63. The results gave a value of $D_{\max} = 0.0145$ and c.v. $= 0.0288$ for SoS, and $D_{\max} = 0.0048$ and c.v. $= 0.054$ for HeS. Since, for a significance level of $\alpha = 0.01$, the value in both distributions is smaller than the critical value, the null hypothesis that the data fit a Lotka distribution is accepted.

Authors with the greatest scientific production

In general, productivity was low—an average of 1.29 papers/author in SoS, and 1.12 papers/author in HeS. In SoS, only 1.56 % of the authors published more than four papers, and in HeS only 2.45 % of the authors published more than two papers.

Tables 5 and 6 list, for SoS and HeS, respectively, the authors with the greatest scientific production, together with the site of their affiliation.

Table 5 Authors with the greatest scientific production in social sciences (≥5)

Authors	N° papers	%	∑%	Affiliation
Pinto M.	20	0.92	0.92	University of Granada (Spain)
Julien H.	16	0.73	1.65	Univ. Alberta (Canada)
Shenton A. K.	13	0.60	2.25	Boston University (USA)
Lloyd A.	11	0.51	2.76	Charles Sturt Univ, Wagga (Australia)
O'Connor L.	10	0.46	3.22	University of Kentucky, Lexington (USA)
Majid S.	10	0.46	3.68	Nanyang Technological University, Singapore
Arp L.	9	0.41	4.09	Univ. Illinois (USA)
Koltay T.	9	0.41	4.50	Szent István University, Jászberény (Hungary)
Mokhtar I.A.	9	0.41	4.91	Technological University (Singapore)
Somerville M.M.	9	0.41	5.32	San José State University (USA)
Woodard B.S.	9	0.41	5.73	University of Illinois (USA)
Blummer B.	8	0.37	6.10	Center for Computing Sciences, Bowie (USA)
Corrall S.	8	0.37	6.47	University of Sheffield (UK)
Fourie I.	8	0.37	6.84	University of Pretoria (South Africa)
Oakleaf M.	8	0.37	7.21	Syracuse University (USA)
Sales D.	8	0.37	7.58	University Jaume I, Castellón (Spain)
Urquhart C.	8	0.37	7.95	University Hospitals of Leicester (UK)
Foo S.	7	0.32	8.27	National Institute of Education (Singapore)
Kim K.-S.	7	0.32	8.59	University of Wisconsin-Madison (USA)
Kwon N.	7	0.32	8.91	Myongji University, Seoul (South Korea)
Nassimbeni M.	7	0.32	9.23	University of Cape Town (South Africa)
Swanson T.	7	0.32	9.55	Moraine Valley Community College (USA)
Webber S.	7	0.32	9.87	The University of Sheffield (UK)
Bruce C.	7	0.32	10.19	Queensland University of Technology (Australia)
Crawford J.	6	0.28	10.47	Glasgow Caledonian University, Glasgow (UK)
Dabbour K.S.	6	0.28	10.75	California State University, Northridge (USA)
Ford N.	6	0.28	11.03	University of Sheffield, Sheffield (UK)
Harris B.R.	6	0.28	11.31	Trinity University, San Antonio (USA)
Hepworth M.	6	0.28	11.59	Loughborough University (UK)
Joint N.	6	0.28	11.87	University of Strathclyde, Glasgow (UK)
Mansourian Y.	6	0.28	12.15	Tarbiat Moallem University, Tehran (Iran)
Marzal M.A.	6	0.28	12.43	Universidad Carlos III de Madrid (Spain)
Owusu-Ansah E.K.	6	0.28	12.71	City University of New York (USA)
Sundin O.	6	0.28	12.99	University of Borås, Borås and Lund University (Sw)
Doucet A.V.	5	0.23	13.22	University of Granada (Spain)
Green R.	5	0.23	13.45	Shenandoah University, Winchester (USA)
Gross M.	5	0.23	13.68	Florida State University (USA)
Johnson A.M.	5	0.23	13.91	University of Louisville, Louisville (USA)
Johnson C.M.	5	0.23	14.14	Washington State University Carol (USA)
Kong S.C.	5	0.23	14.37	The Hong Kong Institute of Education (Hong Kong)
Korobili S.	5	0.23	14.60	Technological Educational Instit. Thessaloniki (Greece)
Limberg L.	5	0.23	14.83	Högskolan I Borås, Borås (Sweden)
Malliari A.	5	0.23	15.06	Technological Educational Instit. Thessaloniki (Greece)

Table 5 continued

Authors	N° papers	%	∑%	Affiliation
Snavely L.	5	0.23	15.29	Penn State University Libraries (USA)
Spring H.	5	0.23	15.52	York St John University, Lord Mayor's Walk (UK)
Underwood P.	5	0.23	15.75	University of Cape Town (South Africa)
Williams D.	5	0.23	15.98	Robert Gordon University, Aberdeen (UK)
Williamson K.	5	0.23	16.21	Charles Sturt University (Australia)
Zainab A.N.	5	0.23	16.44	University of Malaya, Kuala Lumpur (Malaysia)

Table 6 Authors with the greatest scientific production in health sciences (≥3)

Authors	N° papers	%	∑%	Affiliation
Pierce S.T.	6	1.63	1.63	Northwestern State University, Shreveport (USA)
Gustafson D.H.	5	1.36	3.00	University of Wisconsin-Madison (USA)
Brettle A.	4	1.09	4.09	University of Salford (UK)
Elfrink V.L.	4	1.09	5.18	Ohio State University (USA)
Ivanitskaya L.	4	1.09	6.27	Central Michigan University (USA)
McNeil B.J.	4	1.09	7.36	Division of Nursing and Health Science, Lewiston (USA)
Spring H.	4	1.09	8.45	York St John University (UK)
Hawkins R.	4	1.09	9.54	University of Wisconsin, Madison (USA)
Kingsley K.V.	4	1.09	10.63	University of New Mexico, Albuquerque (USA)
Beyea S.C.	3	0.82	11.44	Northwestern State University, Shreveport (USA)
Bickford C.J.	3	0.82	12.26	American Nurses Association, Silver Spring (USA)
Brennan P.	3	0.82	13.08	University of Sydney (Australia)
Crookes P.A.	3	0.82	13.90	University of Wollongong (Australia)
Fetter M.S.	3	0.82	14.71	Villanova University (USA)
Hulme C.	3	0.82	15.53	University of Salford (UK)
Jacobs S.K.	3	0.82	16.35	New York University College of Nursing (USA)
McTavish F.	3	0.82	17.17	University of Wisconsin-Madison (USA)
Meerah T.S.M.	3	0.82	17.98	Universiti Kebangsaan Malaysia (Malaisia)
Pravikoff D.	3	0.82	18.80	Louisiana Dept Hlth &Hosp, Alexandria (USA)
Shorten A.	3	0.82	19.62	University of Wollongong (Australia)
Wallace M.C.	3	0.82	20.44	University of Wollongong (Australia)

The dispersion of the scientific literature

In SoS, a total of 1969 papers were retrieved distributed among a total of 397 journals, for an average of 4.96 papers per journal. Table 7 lists the 47 journals with a productivity ≥10 articles. One observes in the table that the most productive journals were *Reference Services Review*, with 109 returns for articles published throughout the period of study, followed by the *Journal of Academic Librarianship* with 91 articles, and *College and Undergraduate Libraries* with 57 articles on IL. Only 22 of the 47 journals in the table were included in the 2010 Journal Citation Reports (JCR).

Table 7 Distribution of social sciences journals, ordered by productivity (≥10)

Journals	N° papers	IF2010
Reference Services Review	109	
Journal of Academic Librarianship	91	0.870
College and Undergraduate Libraries	57	
Research Strategies	56	
Portal	49	
College and Research Libraries	43	0.683
Information Research	43	0.822
Health Information and Libraries Journal	40	0.761
Journal of Library Administration	39	
Library Review	39	
Journal of Librarianship and Information Science	37	0.636
New Library World	36	
Journal of Documentation	34	1.447
International Information and Library Review	33	
Library Trends	33	0.667
Libri	32	0.365
Public Services Quarterly	31	
Science and Technology Libraries	29	
Electronic Library	26	0.489
Reference and User Services Quarterly	26	0.338
College and Research Libraries News	24	
Communications in Information Literacy	23	
Library and Information Science Research	21	1.362
Library Philosophy and Practice	21	
Program	20	0.596
Community and Junior College Libraries	19	
Education for Information	18	
Journal of Information Science	17	1.406
Journal of Library and Information Services in Distance Learning	17	
Aslib Proceedings: New Information Perspectives	16	0.600
Canadian Journal of Information and Library Science	15	0.000
Journal of Educational Media and Library Science	14	
School Library Media Research	13	
Behavioral and Social Sciences Librarian	12	
Computers and Education	12	0.635
Library Hi Tech	12	0.413
Profesional de la Informacion	12	0.375
Journal of Business and Finance Librarianship	11	
Journal of the American Society for Information Science and Tech	11	2.137
International Journal of Information Management	10	1.564
Internet Reference Services Quarterly	10	
Library Management	10	
Library Quarterly	10	0.651

Table 7 continued

Journals	N° papers	IF2010
Malaysian Journal of Library and Information Science	10	0.353
Procedia—Social and Behavioral Sciences	10	
Reference Librarian	10	
Slavic and East European Information Resources	10	

Table 8 Distribution of health sciences journals, ordered by productivity (≥3)

Journals	N° papers	FI2010
Health Information and Libraries Journal	32	
ACIMED	19	
Medical reference services quarterly	13	
Journal of Nursing Education	10	0.790
Procedia—Social and Behavioral Sciences	10	
Bulletin of the Medical Library Association	9	
Nurse education today	9	1.113
Journal of Hospital Librarianship	7	
Studies in health technology and informatics	6	
American Journal of Pharmaceutical Education	5	1.265
International journal of medical informatics	5	2.244
Journal of Medical Internet Research	5	4.663
Journal of Professional Nursing	5	0.970
Nurse educator	5	0.684
Journal of the Medical Library Association	4	
American Journal of Health Education	3	
CIN-Computers Informatics Nursing	3	0.957
Computers in Human Behavior	3	
Drug information journal	3	0.433
European Journal of Dental Education	3	1.237
Journal of nursing management	3	1.452
Journal of the American Medical Informatics Association	3	3.088
Medical teacher	3	1.494
Patient education and counseling	3	2.237

In HeS, the 367 retrieved papers were published in 197 journals, for an average of 1.86 papers per journal. Table 8 lists the 24 journals with productivity ≥3 articles. *Health Information and Library Journal* was the most productive journal, with 32 published articles. It was followed by *ACIMED* with 19, and *Medical Reference Services Quarterly* with 13. Only 14 of the 24 journals were included in the 2010 JCR.

The two distributions fit the Bradford Law (Bradford 1948) for three zones. In SoS, the core (or first zone) comprises the 10 most productive journals with a total of 560 articles, the second zone a total of 57 journals, and the third zone the remaining 330 journals. In HeS, the core zone also comprises 10 journals with a total of 120 articles, the second zone a total of 39 journals, and the third zone the remaining 148 journals.

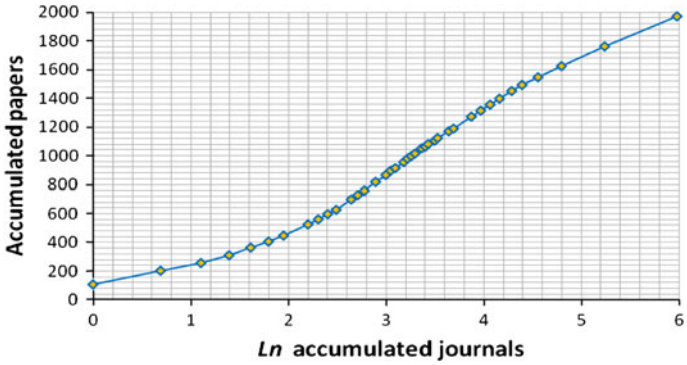

Fig. 3 Bradford plot (accumulated papers vs. Ln accumulated journals) in social sciences

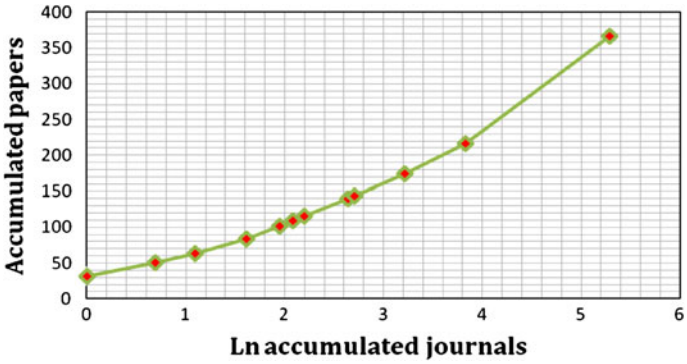

Fig. 4 Bradford plot (accumulated papers vs. Ln accumulated journals) in health sciences

When we arrange the journals in order decreasing productivity, then we can form zones or groups, starting with the most productive journals, containing the same number of articles, but with a number of journals, respectively.

$$r_{0,} r_0 k, r_0 k^2, \ldots, r_0 k^{i-1}, \ldots$$

where r_0 is the number of journals in the first Bradford zone (core) and k the Bradford's multiplier (Bradford 1948).

In Egghe (1986) it is shown mathematically that $k = (e^{\gamma} \times y_m)^{1/p}$ where γ is Euler's number (0.5772), γ_{m} is the number of articles in the most productive journal and p the number of Bradford zones.

In SoS, the Bradford's multiplier is $k = (1.781 \times 109)^{1/3} = 5.79$.

In HeS, the Bradford's multiplier is $k = (1.781 \times 32)^{1/3} = 3.85$.

Figures 3 and 4 show the Bradford plots for the two areas. In SoS, the core zone extends from the beginning of the curve up to the point of coordinates (2.30, 560), the second zone from there until (4.20, 1,416), and the third zone from there until the end of the curve.

The equation representing the Bradford plot for this area (SoS) is:

$$R(r) = a \times \ln(1 + b \times r) = 373.729 \times \ln(1 + 0.486 \times 397) = 1,969$$

Table 9 Affiliation of authors in social sciences ($n \geq 9$)

Sites of author affiliations	City/state, country	*n*
California State University	CA, USA	49
Purdue University	IN, USA	44
University of Illinois	IL, USA	33
University of Sheffield	Sheffield, UK	26
Universidad de Granada	Granada, Spain	25
Charles Sturt University	Wagga Wagga, Australia	23
Queensland University	Brisbane, Australia	23
University of Alberta	Alberta, Canada	22
Pennsylvania State University	PA, USA	21
Iowa State University	IA, USA	20
Northumbria University	Newcastle, UK	18
San Jose State University	CA, USA	18
Loughborough University	Loughborough, UK	18
University of Arizona	AZ, USA	18
Nanyang Technological University	Nanyang, Singapore	17
Ohio State University	OH, USA	16
University of Strathclyde	Glasgow, UK	16
University of Cape Town	Cape Town, South Africa	16
University of Colorado at Boulder	CO, USA	16
Florida State University	FL, USA	14
University of Pretoria	Pretoria, South Africa	14
Trinity University	TX, USA	13
University of Maryland	MD, USA	13
University of Wisconsin	WI, USA	13
Syracuse University	NY, USA	12
University of Botswana	Gaborone, Botswana	12
University of Sydney	Sydney, Australia	12
Auburn University	AL, USA	11
College of Staten Island	NY, USA	11
Manchester Metropolitan University	Manchester, UK	11
Robert Gordon University	Aberdeen, UK	11
Universiti Kebangsaan Malaysia	Selangor, Malaysia	11
University of Wales Aberystwyth	Aberystwyth, UK	11
Victoria University of Wellington	Wellington, Australia	11
Hacettepe Üniversitesi	Ankara, Turkey	10
University of Auckland	Auckland, New Zealand	10
University of Kentucky	KY, USA	10
University of Malaya	Kuala Lumpur, Malaysia	10
Universidad Carlos III de Madrid	Madrid, Spain	9

In HeS, the corresponding points distinguishing the different zones are: the core is from the beginning of the curve to the point of coordinates (2.30, 120), the second zone from there until (3.90, 220), and the third zone from there until the end.

Table 10 Affiliation of authors in health sciences ($n \geq 3$)

Sites of author affiliations	City/state, Country	*n*
University of Wisconsin	WI, USA	8
Centro Nacional de Información de Ciencias Médicas	La Habana, Cuba	7
University of Sydney	Sydney, Australia	7
Columbia University in the City of New York	NY, USA	5
University of California	CA, USA	5
Indiana University School of Medicine	IN, USA	4
Lewis-Clark State College	ID, USA	4
New York University	NY, USA	4
Northwestern State University	LA, USA	4
Universiti Kebangsaan Malaysia	Selangor, Malaysia	4
University of New Mexico	NM, USA	4
University of Salford	Salford, UK	4
Villanova University	PA, USA	4
Central Michigan University	MI, USA	3
Dartmouth-Hitchcock Medical Center	NH, USA	3
Kent State University	OH, USA	3
Nanyang Technological University	Nanyang, Singapore	3
Ohio State University	OH, USA	3
Unidad de Análisis y Tendencias en Salud	La Habana, Cuba	3
University of Auckland	Auckland, New Zealand	3
University of Maryland	MD, USA	3
University of Missouri	MO, USA	3
University of Queensland	Brisbane, Australia	3
University of South Australia	Underdale, Australia	3
University of Tennessee Health Science Center	TN, USA	3
University of Wollongong	Wollongong, Australia	3
York St John University	York, UK	3

For this area (HeS), the equation representing the Bradford plot is:

$$R(r) = a \times \ln(1 + b \times r) = 90.77 \times \ln(1 + 0.284 \times 197) = 367.$$

Author affiliations

The sites of the authors' affiliations were widely distributed (Tables 9, 10).

In SoS for instance, the 2,177 works were created in places all over the world. In total, there were over 538 different sites of the authors' affiliations, with an average of more than 4 works per site. The USA and the UK were the countries with most sites of affiliation. The top-ranked institutions in this sense were: California State University, Purdue University, and the University of Illinois, with many published documents. Spain, with the University of Granada, was ranked 4th with 25 records (Table 9). Australia was one of the countries with a high production of both documents and sites.

Table 9 lists the institutions with a production ≥9. In Spain, there were 20 institutions figuring as authors' affiliations. They had a total production of 64 documents.

In HeS, there was also a notable diversity of affiliation sites, with over 300 institutions. The countries which most stand out were the USA, Cuba, and Australia (Table 10). For Spain, there appeared only one record—for the University of Murcia, published in the journal ACIMED. Table 10 lists the sites of affiliations with ≥3 documents.

Conclusion

In SoS, 2,177 documents were retrieved, and in HeS, 367. In both cases, the temporal evolution presented an exponential trend, with coefficients of determination >0.92.

With respect to the numbers of authors, there were more than 4,000 in SoS, and more than 900 in HeS. Their average productivities were 1.29 and 1.12 publications per author, respectively. Only 1.56 % of the SoS authors published more than four works, and only 2.45 % of the HeS authors published more than two works. Both author distributions fitted the Lotka model. The fraction of papers published in collaboration was >50 % in SoS, and >70 % in HeS.

The papers were published in 397 journals in SoS (for an average of 4.9 articles per journal), and in 197 journals in HeS (for an average of 1.8 articles per journal). Both journal distributions fitted the Bradford Law of three zones.

The sites of the authors' affiliations were both numerous and widespread, exceeding 500 in the case of SoS and 300 in the case of HeS. The countries with the most frequent affiliations in SoS were the USA and the UK, and in HeS were the USA, Cuba, and Australia.

As a final consideration, one can distinguish a number of characteristics of these last 40 years' of IL research:

- A high scientific production, although it is quite sparsely scattered among a large number of authors, who present, therefore, a low average productivity.
- A high rate of collaboration in HeS, and somewhat lower in SoS.
- A major dispersion of the scientific literature in HeS, but less so in SoS. Approximately 50 % of the most productive journals have the visibility of being listed in the 2010 JCR.
- Also, there is a major dispersion of the sites of origin of the works, more so in HeS than in SoS. A large proportion of these sites correspond to the USA and the UK.

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