The management of scientific achievement in life sciences: a perspective from the complexity

Pablo Álvarez[1], Marta Reyes[2], Arturo Argüello[3]

[1] Foundation for the Biosanitary Research of Eastern Andalusia (FIBAO) and Granada Biohealth research institute (ibs.Granada), Granada, Spain

[2] Guest researcher, University of Granada, Spain

[3] Andalusian Public Progress and Health Foundation (FPS)

SUMMARY

In the area of biomedicine, there have been numerous scientific achievements that have resulted in a growing proliferation of therapeutic innovations, designed to improve life. The effectiveness of the transfer of scientific achievements is playing a vital role in health systems innovation. The expectations of quality of life due to the advances in the diagnosis and treatment of various pathologies have grown significantly. In this work, a review of trends and quantitative indicators has also been carried out by searching the databases of documents produced and published on scientific achievement in life sciences, analyzing the percentage of annual growth during the period 2010- 2021, showing that the increase in theoretical research and scientific innovation in health has increased exponentially and the interest of the scientific community in this area is clear, as evidenced by the predominance of the number of research articles. The number of articles of research has been 10,353 and 2,636 review articles. It is important to highlight that the percentage of document growth per year is very significant: in 2020 it was 14.28% while in 2010 it was 4.9%.

We analyze the conceptual framework of Innovation in biomedicine, which is based on scientific and technical advances and the panorama of intellectual property. This analysis allows life sciences researchers to expand the concept of innovation in this area, being useful for formulating health research policies capable of translating their scientific achievements, where possible, into health innovations and truly valuable for future advances in health.

Key words: Healthcare innovation – Innovation process – Scientific achievement

HISTORICAL REFERENCES AND A BRIEF DEFINITION OF INNOVATION IN HEALTH

In the last ten years, many works carried have been carried out in the field of characterization of the human talent of the bio-health sector, focusing

Corresponding author:
Pablo Álvarez. Biosanitary Research of Eastern Andalusia Foundation (FIBAO) and Granada BioHealth research institute (ibs.Granada), Avda de Madrid, 18014 Granada, Spain. Phone: 608376697. E-mail: palvarez@fibao.es

Submitted: April 27, 2021. **Accepted:** May 13, 2021

Not final proof's revision by the authors

lately on the analysis of key characteristics and problems of human talent in the field of life sciences. Primary and secondary information sources have been used with qualitative and quantitative methodology that identify the characteristics of scientific knowledge in the global context.

The current strategies of scientific knowledge are based on comprehensive actions that allow us to take advantage of innovation to address the fundamental scientific and social challenges of the third millennium. (Raymond et al., 2010; Kobylarek, 2019).

In the field of biomedicine, the different institutions are interested in promoting translational research in the biomedical research sector, and thereby promote innovation in health by improving the health of the population and the economy itself. The social utility of talent is the main driver of productivity and sustainable growth (Barile and Saviano, 2018). Governments and civil society itself have proposed a renewed focus on the social benefits of translational research. The preferred place for innovation, in the area of human health, is found in the context of new diagnostic and therapeutic molecules, as well as health technologies capable of being more efficient and effective.

Innovation is a concept that has emerged strongly in the health sector: it is defined as the potential that new scientific achievements present to be socially useful. In medicine, it appears as a fundamental challenge for the achievement of new therapeutic tools for the health sector and for the application of changes that add value to social problems (D'Alvano and Hidalgo, 2012). In the health sector, the impulse of innovation is being implemented, establishing lines of action aimed at promoting sustained innovation and oriented towards socially relevant objectives. This strategy implies the implementation of new ways of working and the adoption of new diagnostic and therapeutic tools (Bernardi and Exworthy, 2020).

The COVID-19 pandemic is being a clear example of the usefulness of innovations, derived from scientific achievements to solve health problems. The amount and speed of innovative therapeutic responses to the health crisis are being extraordinary. The COVID-19 genome was mapped with dizzying speed and diagnostic and treatment tests have been developed in record time; developments in clinical trials of therapies and vaccines are being more than remarkable (Saidi et al., 2020). The speed of these advances in the COVID-19 experience is demonstrative of the transformative effect of scientific and technological knowledge to achieve scientific and technological innovations necessary in a health crisis.

SCIENCE AND TECHNOLOGY, GENERAL TRENDS OF INNOVATION IN BIOMEDICINE

Innovation in this area is in the process of exponential change and development; consequently, academic and other institutions are considering new creative strategies involving ways to manage and retain talent. (Thayer et al., 2018)

The current dynamics of biomedical research management is allowing the explosion of promising new fields of research and technology, whose scientific achievements make it possible to translate into transversal improvements in medical care. Knowledge management (KM) is an emerging field of expertise (Haider et al., 2018). In different scientific areas, especially in Medicine, knowledge management (KM) constitutes an area of specialization with potential, which allows for translating scientific achievements into transversal improvements in health in a more effective and efficient way.

Different analyses are influencing the development models of KM. However, KM's progress is growing in arithmetic progression and not as much as it should. It is necessary that the different academic and business institutions assume a more proactive and visible role in the advancement of the KM, demonstrating that it is an area of emphasis, whose time has come.

Knowledge management increases the exchange of knowledge with social organizations and is based on an adequate transfer of knowledge to society and industry (McInerne, 2002; Argüello and Álvarez, 2021). In this implementation, the

effort is aimed at the social utility of the knowledge generated in public or private institutions. Therefore, its effective management must be based on the understanding of the dynamic nature of knowledge as a dynamic process.

Management of biotechnological innovation in industry has had a direct impact on the productivity of pharmaceutical R&D. Biomedical research groups develop new ways of working, fostering scientific-technical collaboration and exchange, prioritizing the diversity of applications of new information technologies, enabling the convergence of scientific achievements in areas such as medicine, biotechnology, biology, engineering, computing or nanotechnology (Carmen et al., 2018).

THE CYCLE OF INNOVATION IN BIOMEDICINE: PANORAMIC OF THE FUTURE

State-of-the-art information technologies make it easy for researchers to interconnect flexibly, enabling efficient research.

Innovation in biomedicine is based on scientific and technical advances which involves both public and private sectors, which requires specific financial investments (Uhl-Bien et al., 2007; Álvarez et al., 2014).

The development of its future is conditioned to the creation of incentives for the promotion of R & D, providing shared research infrastructure of the latest generation; fostering interdisciplinary research and the translation of scientific achievement to society, as well as updating the regulatory environment.

In biomedicine, many of the research groups that generate translational knowledge are distributed in universities, opis or industries, so the ability to retain, manage and exploit knowledge comes from various public and private research organizations (Bolisani and Bratianu, 2018).

Therefore, the social utility of scientific achievement and innovation in health requires an expert management of assets, as well as a specific organization, adequate financing and a pertinent vision of the future (Ahern et al., 2014).

In the life sciences, scientific achievements must be accessible. The openness of knowledge is essential for the performance of innovation; so in the case of the human genome, for the progress of personalized medicine, it is necessary to establish and regularize the databases of genetic research and the maintenance and use of biobanks.

For high quality research, databases are fundamental, as they facilitate broad access to biomedical data and materials.

In the field of intellectual property, currently, different governments are designing relevant actions capable of improving the social use of intellectual assets (Cardona, 2013).

Intellectual property and patents are one of the best strategic tools to generate and commercialize new drugs, utility models and strategic intangible assets in the health sector. These benefits affect health in general as well as the generation of wealth in particular.

The intellectual property area is working to generate greater efficiencies in the exploitation of intellectual property. Collaborative innovation is an example of theseuses as a means to optimize innovation, the translation of knowledge to promote R&D by promoting the commercialization of new drugs and utility models.

In order to detect current trends in the management of scientific achievement in life sciences, a scientific-metric analysis based on the scientific and technical literature has been carried out to quantitatively analyze the bibliometric contributions of this specific area.

The bibliometric scientometry tools allow the identification of the existing information on a specific topic. With the new web tools, it is possible to carry out complete searches that make it possible to carry out better bibliometric analyses of the scientific literature published in a specific field.

To carry out the main purpose of this work, which is to provide an updated vision of scientific achievement in life sciences as well as its future perspective, a bibliometric analysis has been carried out to detect the trend of the subject in the field of the scientific community.

We have made a schematic flow diagram of the bibliographic search and selection and analysis of the documents produced in the analyzed temporal space (Fig. 1).

The objective of the bibliometric analysis carried out has been to scientometrically analyze the documents published, quantitatively and qualitatively analyzing the production of scientific documents in Scientific Achievement in Life Sciences.

Subsequently, we focus on the results obtained from what has been published in Management of Scientific Achievement in Life Sciences using the ScienceDirect database in the 2010-2021 time-frame, both inclusive.

The choice of this database was made because ScienceDirect explores scientific and technical research in Engineering and Physical Sciences, Life Sciences, Health Sciences and Humanities and Social Sciences, including the number of publications, type of document, title of the journal and area in which the publication is included. This search engine allows researchers to access full-text documents and allows them to locate book citations, theses, reports, etc.

Subsequently, the publications were selected in accordance with the type of article (research, review, congress, book chapter and editorial) as well as the year of publication. As a next step, we develop guidelines for the analysis of the documents included in this study depending on the type of document, being classified as: Articles produced as research articles, review articles, short communications, and articles published in peer-reviewed journals.

On the other hand, the documents that include: Books in general. Included are books and encyclopedias, book chapters, editorials, and conference proceedings, editorials, practical guides, conferences, etc.

To analyze the quantitative evolution and show the qualitative mapping of trends, the number of articles published in journals with impact factor as indicators to measure the quality of scientific production was selected and analyzed, thus obtaining qualitative evidence from the published articles.

RESULTS AND COMMENTS

The scope of the research was carried out by collecting documents produced and selected from academic databases and using the keywords: Management of scientific achievement in Life Sciences.

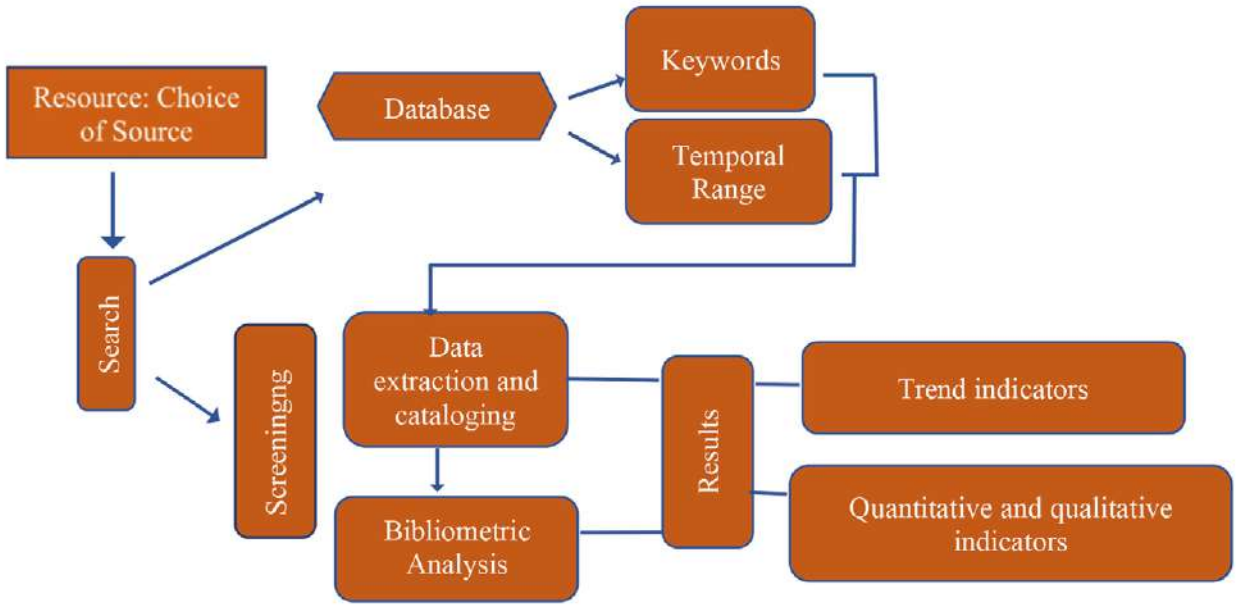

Fig. 1.- Diagram of the development of the work: Route of the bibliographic search and the respective selection of the analyzed documents.

We have used different search engines for free access to scientific and academic literature that allow us to locate references, full texts and the number of citations of an article.

To identify the largest number of documents produced, the academic databases used were: Search Engine, iSEEK Education, Springer Link, Google Scholar, RefSeek, World Wide Science and ScienceDirect.

The justification for using these search engines have been established: Springer link provides researchers with access to millions of scientific journal papers, books, series, protocols, and reference works.

iSEEK Education is a dedicated search engine that collates hundreds of thousands of authority resources from universities, governments and established non-commercial vendors. It provides smart search and a web-based personal library to help locate the most relevant results immediately, thereby saving time by finding information quickly.

RefSeek is a web search engine for students and researchers that aims to make academic information easily accessible. RefSeek searches over a billion documents, including web pages, books, encyclopedias, magazines, and newspapers. It offers students extensive coverage of topics without overloading the information of a general search engine, increasing the visibility of academic information and compelling ideas that are often lost in a tangle of sponsored links and business results.

WorldWideScience.org is a global science portal made up of national and international science portals and databases. WorldWideScience.org accelerates scientific discovery and progress by providing a comprehensive search of databases around the world.

Google Scholar is a search engine that allows us to locate academic documents such as articles, theses, books, patents, conference-related documents, and abstracts. It feeds on information from various sources: university publishers, professional colleges, preprint repositories, universities, and other academic organizations. It provides an easy way to search academic literature. One can search many disciplines and sources: articles, theses, books, abstracts and opinions from academic publishers, professional societies, online repositories, universities and other websites. Google Scholar helps us find relevant jobs within the world of academic research.

Dialnet is one of the largest databases of scientific content in Latin-American languages and has various documentary resources: journal articles, articles of collective works, books, conference proceedings, bibliographic reviews, doctoral theses

ScienceDirect is a website that provides access to a comprehensive medical and scientific search database, with more than 12 million content from 3,500 academic journals and 34,000 electronic books, allowing access to scientific and technical research in Engineering and Physical Sciences, Life Sciences, Health Sciences and Humanities and Social Sciences, including the number of publications, type of document, title of the journal and the scope in which the publication is made.

ANALYSIS OF DOCUMENTS PRODUCED

We have detected that the number of documents displayed by the different selected search engines is diverse.

The search engines that show the greatest similarity in the number of documents found have been Google Scholar with 37,600 documents, RefSeek with 32,800 and ScienceDirect. with 32093. Table 1 shows the number of documents in the analyzed databases.

Table 1. Number of documents in the analyzed databases.

Search engine	Nº Documents
iSEEK Education	56597
Springer Link	46843
Google Scholar	37600
RefSeek	32800
World Wide Science	1354
ScienceDirect.	32093

Subsequently we focus on the results obtained from what has been published in Management of Scientific Achievement in Life Sciences using the ScienceDirect database in the 2010-2021 time-frame, both inclusive,

The choice of this database was made because ScienceDirect explores scientific and technical research in Engineering and Physical Sciences, Life Sciences, Health Sciences and Humanities and Social Sciences, including the number of publications, type of document, title of the journal and area in which the publication is included. This search engine allows researchers to access full-text documents and allows them to locate book citations, theses, reports, etc.

Subsequently, the publications were selected on the basis of the type of article (research, review, congress, book chapter and editorial) as well as the year of publication.

As a next step, we develop guidelines for the analysis of the documents included in this study depending on the type of document, being classified as: Research articles produced as research articles, review articles, short communications, and articles published in peer-reviewed journals.

On the other hand, the documents that include: Books in general. Included are books and encyclopedias, book chapters, editorials, and conference proceedings, Editorials, practical guides, conferences, etc.

To analyze the quantitative evolution and show the qualitative mapping of trends, the number of articles published in journals with impact factor as indicators to measure the quality of scientific production was selected and analyzed, thus obtaining qualitative evidence from the published articles.

Trend review: quantitative indicators

Once the search in the indicated databases was completed, we obtained the documents produced and published. Fig. 2 shows the numerical values of the documents published by year and their evolution in the analyzed temporal space, and Fig. 3 shows the percentage of them according to the databases used.

We have also analyzed the percentage of annual growth (Fig. 4) and the Number of documents produced by year, annual percentage and inter-annual increase.

Analysis of documents produced depending on the year analyzed

In general, the growth in the number of documents published in the area of Scientific Achievement Management in Life Sciences is progressive throughout all the years analyzed.

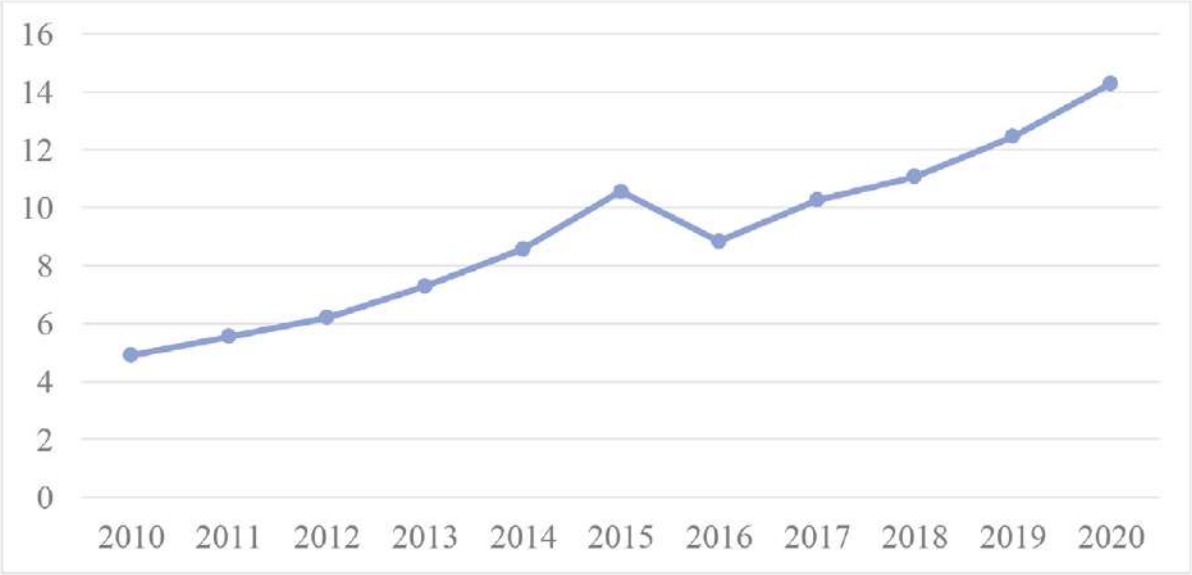

Fig. 2.- Number of of the documents published by year.

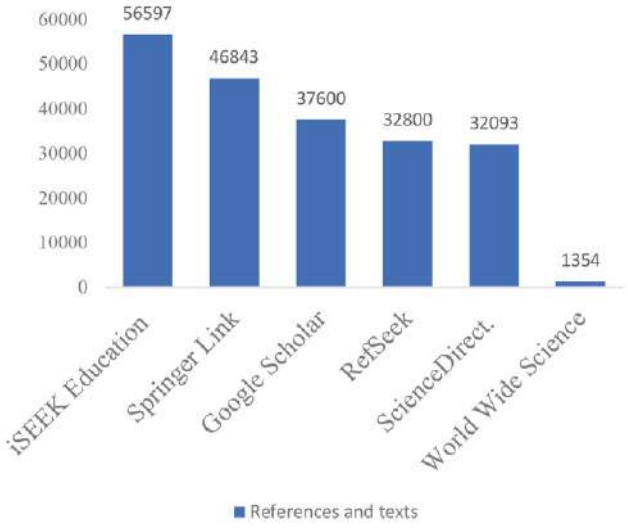

Fig. 3.- Total numerical values Documents according to the databases used.

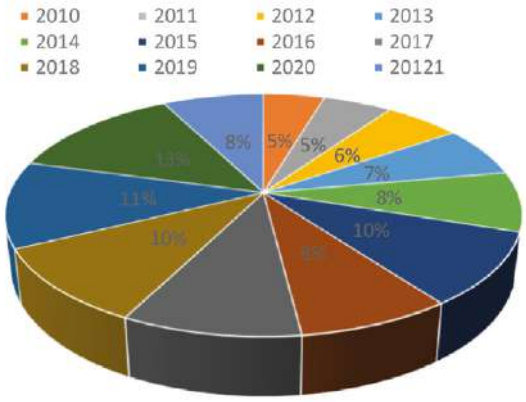

Fig. 4.- Percentage of annual growth of documents produced.

These results constitute a clear indicator of a quantitative trend, and is a demonstration of the growing and progressive interest of the scientific community in this topic. It is important to highlight that the percentage of document growth with respect to the total is very significant: in 2020 it was 14.28% while in 2010 it was 4.9% (Table 2).

It should be noted that the publications made in 2021 are not yet fully compiled by the different scientific search engines.

Qualitative data

Analysis of the distribution and evolution of publications according to the type of article:

a.- Articles published in journals with impact factor and peer evaluation.

b.- The rest of the research documents published on this matter without the criteria of "a" section.

Table 2. Analysis of documents produced depending on the year analyzed. Number of documents produced by year, annual percentage and interannual increase.

Year	Nº of documents	Percentage documents	Year-on-Year increase
2010	814	4,9 %	1,09
2011	914	5,55 %	1,13
2012	1021	6,2 %	1,11
2013	1198	7,28 %	1,17
2014	1410	8,57 %	1,18
2015	1736	10,55 %	1,23
2016	1453	8,83 %	0,84
2017	1687	10,25 %	1,16
2018	1822	11,07 %	1,08
2019	2049	12,45 %	1,06
2020	2350	14,28 %	1,15

The selected research articles were grouped by type of article: research articles and review articles. Fig. 5 shows the evident predominance of research articles published in journals with an impact factor.

Research articles are always the majority over documents in general, this preponderance being a constant in the selected period. In the years analyzed, the research articles produced are significantly higher in number with respect to the rest of the types of documents produced: they constitute 74% of the total (Fig. 5). These data demonstrate that in the scientific community there is a predominant interest in the research articles: the number of research articles has been 10,353 and the number of review articles is 2,636 (Fig. 6).

Therefore, these results represent a clear qualitative trend indicator, since the increase in research articles published in indexed journals,

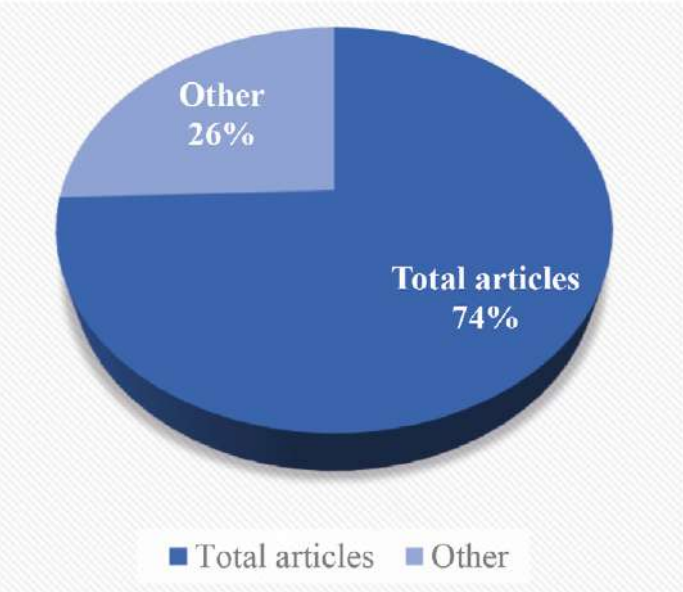

Fig. 5.- Percentage of total documents: research articles and others.

with an impact factor and with peer evaluation, constitutes a quality indicator, being a constant in the years analyzed.

The proportion of types of articles remains in a constant rhythm throughout the period analyzed.

THE MANAGEMENT OF INTELLECTUAL PROPERTY IN THE CURRENT CONTEXT

Patents in the concept of open innovation, different from the traditional technology transfer, need regulatory updates. In the area of life sciences, scientific and technological advances occur with an exponential progression (Armitage et al., 2011; Alvarez et al., 2019). Its scientific achievements are carried out with the participation of different areas of knowledge and its social transfer and innovation in health integrates multiple scientific and clinical achievements, which with the necessary interoperability, make an efficient use of the scientific achievement acquired.

For example, the technologies involved in diagnostic biomarkers and synthetic biology involve different multidisciplinary scientific achievements in different areas such as molecular biology, nanotechnology, BigData database, advanced computing, mathematical models, algorithms, utility models, biomarkers, etc.

The administrations must carry out the drafting of the pertinent legislation that regulates the promotion of the social utility of scientific achievements, especially those financed with public funds (Argüello et al., 2020). Currently in the universities, there has been a rapid growth of its regional economic development influence, and this has generated an increasingly complex network in the field of university technology transfer, which has resulted in the academy, the industry, the regional government and users of innovation based on knowledge constitute a functional unit, is the so-called fourth Helix (Miller et al., 2018; Blackler, 1993) The empowerment of the translation of scientific knowledge produced in the academic environment to the industry (Pahl-Wostl, 2007) is directly related to the increase in the development options of personalized medicine. The consideration of the patient individually enables the design for its treatment with precision, facilitated by the massive use of biomarkers in the initial decision-making.

NEW POLITICAL CHALLENGES BASED ON ADVANCES IN BIOMEDICINE

The management of organizations: a perspective from the complexity.

The rhythms of evolution and growth of the scientific achievements of the university and industrial institutions have demonstrated that there are many concepts that must be re-

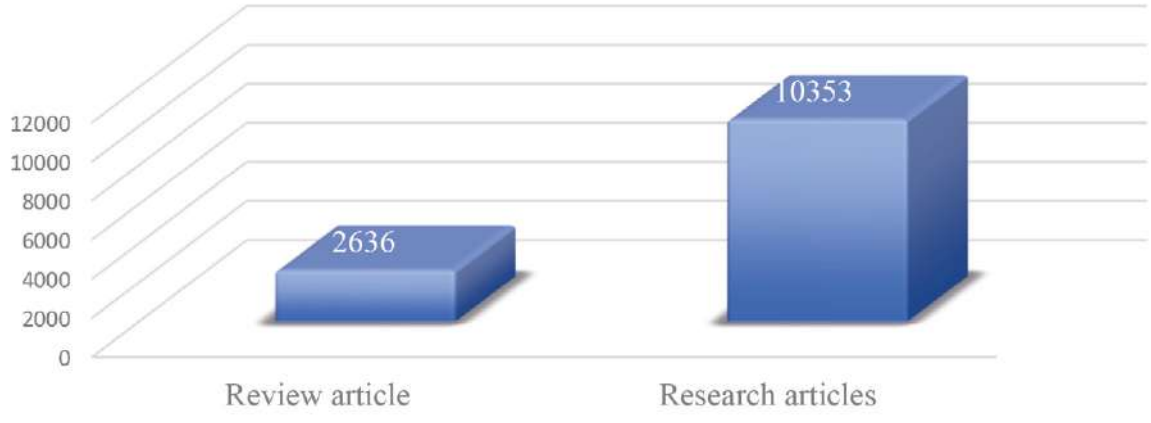

Fig. 6.- Number of research articles and review articles.

evaluated. The strategic plans and structures have a certain obsolescence, conditioning the appearance of new ones that are configured as a tendency for the new generations (Álvarez et al., 2014). In the field of Science and Technology, there have been profound transformations. New spaces of understanding appear with the target of the importance and social legitimacy of scientific achievement, Collings et al. (2018) incardinated this in the Global Ethics and Bioethics. Basically, current dynamics condition new forms of governance of R & D & I that adapt to new social and economic realities. We think that the organization of the management of scientific achievements is ordered as an integrating system in which social and industrial utility are highly interrelated. Technicians of scientific and technical transfer are the main instruments that organizations have in order to make translational research tangible: they generate and offer the social utility of knowledge, and they induce changes and transformations in the productive system.

REFERENCES

AHERN T, LEAVY B, BYRNE PJ (2014) Complex project management as complex problem solving: A distributed knowledge management perspective. *Int J Project Manag*, 32(8): 1371-1381.

ÁLVAREZ P, MARCHAL J, BOULAIZ H, CARRILLO E, VÉLEZ C, RODRÍGUEZ-SERRANO F, MELGUIZO C, PRADOS J, MADEDDU R, ARANEGA A (2012) 5-Fluorouracil derivatives: a patent review. *Expert Opin Ther Pat*, 22: 107-123.

ÁLVAREZ P, BOULAIZ H, VÉLEZ C, RODRÍGUEZ-SERRANO F, ORTIZ R, MELGUIZO C, PRADOS J (2014) Qualitative and quantitative analyses of anatomists' research: evaluation of multidisciplinarity and trends in scientific production. *Scientometrics*, 98(1): 447-456.

ÁLVAREZ P, REYES M, SÁNCHEZ-CANTALEJO J, ARGÜELLO A (2019) Analysis of factors associated with Grant for PCT national phase entries patent: a mathematical model. *Eur J Anat*, 23(5): 333-340.

ARMITAGE D, BERKES F, DALE A, KOCHO-SCHELLENBERG E, PATTON E (2011) Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environ Change*, 21(3): 995-1004.

ARGÜELLO A, SOLANA VH, JÜRGENS B, ARÁNEGA P (2020) Análisis de patentes y desarrollo territorial: Ejemplo en el ámbito Biosanitario. *J Econ Bus Intellig*, 2: 13-19.

ARGÜELLO A, ORUEZABAL RI, ÁLVAREZ P (2021) Las unidades de inteligencia competitiva y prospectiva como motor director de la innovación tecnológica en los sistemas sanitarios. *J Econ Bus Intellig*, 3(5): 43-49.

ARRIZABALAGA J (2021) The challenge of (re)emerging diseases, the limits of the biomedical response and the new paradigm of global health. *História, Ciências, Saúde- Manguinhos*, 28(1): 255-281.

BARILE S, SAVIANO M (2018) Complexity and sustainability in management: insights from a systems perspective. In: *Social dynamics in a systems perspective*. Springer, Cham, pp 39-63.

BERNARDI R, EXWORTHY M (2020) Clinical managers' identity at the crossroad of multiple institutional logics in its innovation: The case study of a health care organization in England. *Information Systems J*, 30(3): 566-595.

BLACKLER F (1993) Knowledge and the theory of organizations: Organizations as activity systems and the reframing of management. *J Manag Studies*, 30(6): 863-884.

BOLISANI E, BRATIANU C (2018) The emergence of knowledge management. In: *Emergent knowledge strategies*. Springer, Cham, pp 23-47.

CARDONA OD (2013) The need for rethinking the concepts of vulnerability and risk from a holistic perspective: a necessary review and criticism for effective risk management. In: *Mapping vulnerability*. Routledge, pp 56-70.

CARMEN E, WATT A, CARVALHO L, DICK J, FAZEY I, GARCÍA-BLANCO G, LIQUETE C (2018) Knowledge needs for the operationalization of the concept of ecosystem services. *Ecosystem Services*, 29: 441-451.

COLLINGS DG, WOOD GT, SZAMOSI LT (2018) Human resource management: A critical approach. Routledge, pp 1-23.

D'ALVANO L, HIDALGO A (2012) Innovation management techniques and development degree of innovation process in service organizations. *R&D Management*, 42(1): 60-70.

DOELLO K, ORTIZ R, ÁLVAREZ PJ, MELGUIZO C, CABEZA L, PRADOS J (2018) Latest in vitro and in vivo assay, clinical trials and patents in cancer treatment using curcumin: a literature review. *Nutr Canc*, 70(4): 569-578.

HAIDER LJ, HENTATI-SUNDBERG J, GIUSTI M, GOODNESS J, HAMANN M, MASTERSON VA, SINARE H (2018) The indisciplinary journey: early career prospects in sustainability science. *Sustainability Science*, 13(1): 191-204.

KOBYLAREK A (2019) Social responsibility of science. *J Educ Culture Soc*, 10(2): 5-11.

MCINERNEY C (2002) Knowledge management and dynamic nature of knowledge. *J Am Inform Sci Technol Soc*, 53(12):1009-1018.

MILLER K, MCADAM R, MCADAM M (2018) A systematic literature review of university technology transfer from a quadruple helix perspective: toward a research agenda. *R&D Management*, 48(1): 7-24.

PAHL-WOSTL C (2007) The implications of complexity for integrated resources management. *Environ Modeling Software*, 22(5): 561-569.

RAYMOND CM, FAZEY I, REED MS, STRINGER LC, ROBINSON GM, EVELY AC (2010) Integrating local and scientific knowledge for environmental management. *J Environ Manag*, 91(8): 1766-1777.

SAIDI T, THUNE TM, BUGGE M (2020) Making 'hidden innovation'visible? A case study of an innovation management system in health care. *Technol Analysis Strategic Manag*, 1-13.

THAYER AL, PETRUZZELLI A, MCCLURG CE (2018) Addressing the paradox of the team innovation process: A review and practical considerations. *Am Psychologist*, 73(4): 363.

UHL-BIEN M, MARION R, MCKELVEY B (2007) Complexity leadership theory: Shifting leadership from the industrial age to the knowledge era. *Leadership Quarterly*, 18(4): 298-318.