Analysis of Scientific Production published in the journals of the Ecuador collection in SciELO: Trends and Challenges (2014-2022)

Raidell Avello-Mártínez
Universidade da Coruña (España) ✉ ⓘD
Víctor Gómez Rodríguez
Instituto Superior Tecnológico Urdesa (Ecuador) ✉ ⓘD
Rosangela Caicedo Quiroz
Universidad Bolivariana del Ecuador (Ecuador) ✉ ⓘD
Roberto Tolozano-Benites
Universidad Bolivariana del Ecuador (Ecuador) ✉ ⓘD
Julio Barzola Monteses
Universidad de Guayaquil (Ecuador) ✉ ⓘD

ENG Abstrct. This study examines the scientific production of Ecuador in the SciELO network between 2014 and 2022. The main objective is to analyze the temporal evolution, areas of specialization, types of documents, language of publication, international collaboration, and access licenses open in Ecuadorian scientific production. The methodology is based on a cross-sectional descriptive design, using the SciELO Analytics and Analytics Visualizations web tools to collect and analyze data in September 2023. The results reveal a notable increase in the number of documents published over time, indicating a growth and consolidation of Ecuador's scientific production on the SciELO platform. The areas of Applied Social Sciences and Engineering stand out with a high representation, reflecting the thematic priorities in Ecuadorian research. Most documents are research articles and are published under open-access licenses, promoting the dissemination of research. Ecuador maintains significant international collaborations, which contributes to the visibility of its publications worldwide. Although Spanish is the predominant language, the presence of English and Portuguese demonstrates the openness to global collaboration. The findings highlight progress in Ecuador's scientific development but also point out the importance of diversifying research areas and further promoting international collaboration to strengthen the country's scientific presence in the global community

Keywords. Scientific production, Ecuador, SciELO, temporal evolution, international collaboration.

ES Análisis de la producción científica publicada en las revistas de la colección Ecuador en SciELO: tendencias y desafíos (2014-2022)

ES Resumen. Este estudio examina la producción científica del Ecuador en la red SciELO entre 2014 y 2022. El objetivo principal es analizar la evolución temporal, áreas de especialización, tipos de documentos, idioma de publicación, colaboración internacional y licencias de acceso abiertas en ecuatoriano. producción científica. La metodología se basa en un diseño descriptivo transversal, utilizando las herramientas web SciELO Analytics y Analytics Visualizations para recolectar y analizar datos en septiembre de 2023. Los resultados revelan un aumento notable en el número de documentos publicados en el tiempo, lo que indica un crecimiento y consolidación de la producción científica del Ecuador en la plataforma SciELO. Se destacan con alta representación las áreas de Ciencias Sociales Aplicadas e Ingenierías, reflejando las prioridades temáticas en la investigación ecuatoriana. La mayoría de los documentos son artículos de investigación y se publican bajo licencias de acceso abierto, lo que promueve la difusión de la investigación. Ecuador mantiene importantes colaboraciones internacionales, lo que contribuye a la visibilidad de sus publicaciones a nivel mundial. Aunque el español es el idioma predominante, la presencia del inglés y el portugués demuestra la apertura a la colaboración global. Los hallazgos resaltan el progreso en el desarrollo científico de Ecuador, pero también señalan la importancia de diversificar las áreas de investigación y promover aún más la colaboración internacional para fortalecer la presencia científica del país en la comunidad global.

Palabras clave. Producción científica, Ecuador, SciELO, evolución temporal, colaboración internacional.

1.Introduction

Bibliometric studies are tools that allow analyzing and evaluating the scientific production of researchers, institutions, and countries, as well as their impact, visibility, and collaboration. These studies are of great importance to know the state and devel-opment of science in different areas, regions, and contexts, as well as to identify strengths, weaknesses, and opportunities for improvement.

Latin America has had to face several challenges to adapt to the global dynamics of the generation of new scientific knowledge (Guerrero-Casado, 2017). Among these challenges are: adverse conditions, scarcity of economic resources, weakness of academic communities and delay in participation in the global knowledge competition (León Cano et al., 2022). Despite these factors and the low investment in research and development, which in 2019 only represented 2.6% of the world total and 57% of the financing was governmental (RICYT, 2021), the generation of new knowledge in Latin America depends largely on state initiatives. Several countries in the region have adopted strategies, public policies, and state institutions to promote and encourage scientific development. For example, Argentina, Brazil, Chile, Cuba, and Colombia have elevated Science and Technology to the ministerial level. Ecuador has implemented public policies such as Prometeo and SENESCYT (SENESCYT, 2018), which seek to pro-mote research and innovation.

Ecuador is a country with great scientific potential and growing development in recent years. According to the International Monetary Fund, its gross domestic product (GDP) grew by 2.9% in 2023 (https://www.imf.org/en/Countries/ECU), and according to the World Bank, its human development index (HDI) stood at 0.759 in 2020 (https://www.worldbank.org/en/country/ecuador), ranking it 84th out of 189 countries. These indicators reflect the country's effort to improve its economic, social, and envi-ronmental conditions, as well as to promote innovation and the generation of knowledge.

Ecuador's scientific production has experienced a notable increase in the Latin American context. Its contribution went from representing 0.49% in 2007 to 2.27% of regional scientific production in 2017 (Froilán Méndez et al., 2016; Moreira-Mieles et al., 2020). This increase could be attributed, in part, to public policies in Higher Education through the Organic Law of Higher Education (LOES) and regulations in the university context, which put pressure on the teaching staff of universities and research institutes in the country. In addition, the incorporation of accreditation indicators for Superior education institutions that they consider as scientific production metrics from Scimago or ISI Web of Knowledge, which have greater weight than regional databases such as Latindex, Scielo, and Redalyc, among others (CEAACES, 2015). In addition, publications are essential requirements to access merit and op-position competitions for teaching and research positions in Higher Education Institu-tions (HEI) of Ecuador, as well as to obtain accreditation as a researcher at the national level (SENESCYT, 2018).

Scientific production is an indicator of the progress of knowledge in a country or region. However, Latin American countries face several challenges in publishing and making their research visible internationally, such as lack of resources, limited collab-oration, low quality or language. To overcome these obstacles, initiatives such as SciELO have been created, a network of electronic libraries that gathers scientific journals from Latin America, the Caribbean, Spain, and Portugal (Bojo-Canales & Sanz-Valero, 2019; Maz-Machado et al., 2016). Scielo offers free and open ac-cess to more than 1,400 journals and more than 700,000 articles in various areas of knowledge. Scielo is one of the main Ibero-American initiatives aimed at registering and giving visibility to scientific journals in the region. Scielo was created in Brazil more than 20 years ago as an innovative response to the limited coverage of international in-dices, which ignored a large number of serial publications published in developing and/or non-English speaking countries. Scielo is based on the open access model, which allows free access and use of scientific information and has become a large scientific information network and one of the most recognized academic communication projects worldwide (https://scielo.org).

In this sense, Ecuador joined SciELO in 2018 after a series of meetings and prepa-rations by the SciELO-Ecuador Consultative Committee 2018-2019 (SciELO-Ecuador, 2017), which also established the process and requirements for the application of journals to SciELO-Ecuador. As a result, Figure 1 shows the distribution of Ecuadorian journals contained in SciELO by year of inclusion, from 2018 to 2023, Ecuadorian case. It is observed that the number of journals has increased considerably in recent years, which indicates greater interest and recognition of scientific publications from Ecuador. This increase in the number of journals included in Scielo also reflects the efforts of Ecuadorian editors, authors, and institutions to improve the quality and visibility of their publications. However, it also poses new challenges and opportunities for the country's scientific development.

Journals distribution by the inclusion year at SciELO
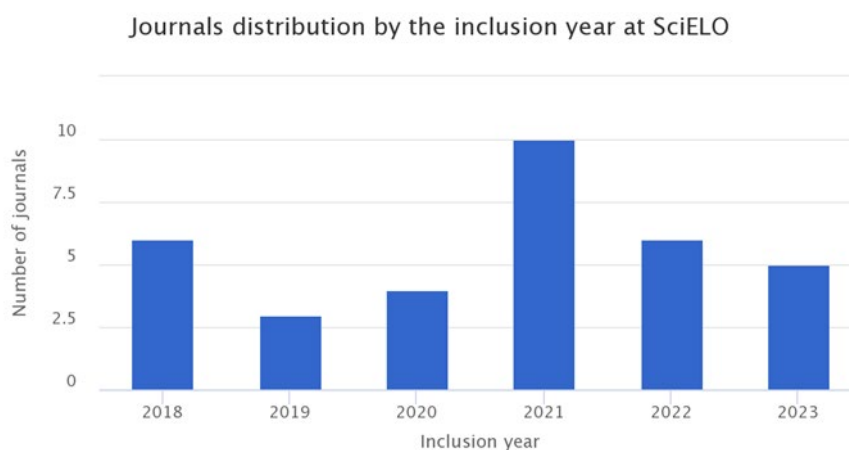
(figure.1) Distribution by year of academic journals included in SciELO.

In the meantime, Scielo has developed two tools called SciELO Analytics (SciELO, 2024b) and Analytics Visualizations (SciELO, 2024a), which allow analyzing the scientific production indexed in Scielo from different perspectives: by year, by topic, by type of document, by language, by country of affiliation of the authors, by number of authors per article, by number of references per article, by type of open access license, among other metrics. These tools, although they are currently in their beta-testing versions, offer an oppor-tunity to study the evolution and impact of Latin American science. However, few studies analyze Ecuador's scientific production in Scielo.

For this reason, in this article, we will focus on the case of SciELO-Ecuador, where the scientific production published in the journals of the SciELO-Ecuador collection can be found. In addition, we will complement the study with an analysis of the general bibliography indexed from the year 2014 (years from where the data is available in SciELO) until 2022, to identify the trends, patterns, and challenges that the country faces to consolidate its scientific development.

2. Materials and methods

The methodology of this study is based on a cross-sectional descriptive design, which seeks to characterize the scientific production published in the journals of the SciELO-Ecuador collection. In addition, the study is complemented with an analysis of the general bibliography indexed in SciELO with the participation of Ecuadorian au-thors from 2014 to 2022. The main unit of analysis is the scientific documents published in the 33 Ecuadorian journals that are part of the SciELO-Ecuador collection, which in-cludes a total of 501 issues, 5,183 documents, and 150,505 bibliographic references.

To analyze the data, the SciELO Analytics and Analytics Visualizations web tools were used, available on the SciELO server, which allows access to different indicators and metrics on the scientific production indexed in SciELO. The data was obtained in September 2023, by selecting the "Ecuador" option in the top menu of the website.

It is important to highlight certain limitations in SciELO Analytics, such as the need to enrich its data presentation through more intuitive graphs and advanced bibliometric analyses. Currently, crucial analyses such as the H-index require manual calculation from available tabulated data, which can be cumbersome. Furthermore, it is observed that the updating of this data is not always constant. Another point to consider is that, in the general bibliometric analyses of SciELO Analytics (https://analytics.scielo.org/w/reports), the representation of some countries, such as Ecuador, is not yet included, which highlights a gap in inclusion in the global analysis. Likewise, the Analytics Visualizations tool does not yet include the Ecuador collection, so for this study, it could only be used for visual analysis of author affiliation where Ecuador does appear in the visualizations.

The main study indicators were the following:

- Documents per year: the temporal evolution of the number of documents published per year was analyzed, from 2014 to 2022.
- Access to documents by year of publication. Window of the last 3 years.
- Documents and journals by area: the percentage distribution of the number of documents was analyzed according to the thematic areas defined by SciELO: Agricultural Sciences, Biological Sciences, Health Sciences, Exact and Earth Sciences, Human Sciences, Social Sciences, Engineering, Linguistics, Letters and Arts, and Multidisciplinary.
- Document types: the percentage distribution of the number of documents was analyzed according to the document types defined by SciELO: Original article, Review article, Brief communication, Editorial, Letter to the editor, Bibliographic review, and Others.
- Publication Language: the percentage distribution of the number of documents was analyzed according to the language in which they were published: Spanish, English, Portuguese, and Others.
- Number of authors per article: the frequency and average of authors per article were analyzed, as well as the proportion of articles with one, two, three, or more authors.
- Number of references per article: the frequency and average of bibliographic references cited per article were analyzed, as well as the proportion of articles with less than 10, between 10 and 20, between 21 and 30, or more than 30 references.
- International collaboration: the proportion of articles with at least one author affiliated with a foreign institution was analyzed, as well as the countries with the greatest collaboration with Ecuador.
- List of co-authorship by country of affiliation.
- Publication license: the percentage distribution of the number of documents was analyzed according to the type of free access license under which they were published: Creative Commons Attribution (CC BY), Creative Commons Attribution NonCommercial (CC BY-NC), Creative Commons Attribution NonCommercial NoDerivatives (CC BY-NC-ND), Creative Commons Attribution NonCommercial ShareAlike (CC BY-NC-SA), Creative Commons Attribution NoDerivatives (CC BY-ND), Creative Commons Attribution ShareAlike (CC BY-SA) and Others

3. Results

Documents per year

One of the indicators that was analyzed was the temporal evolution of the number of documents published per year, from 2014 to 2022. Figure 2 shows a bar graph with the distribution of documents by year of publication. It is observed that the number of documents has increased considerably in recent years, going from less than 250 documents in 2016 to more than 750 documents as of 2022. This reflects the growth and consolidation of Ecuador's scientific production in the SciELO network.

Documents distribution by publishing years

Source: SciELO.org
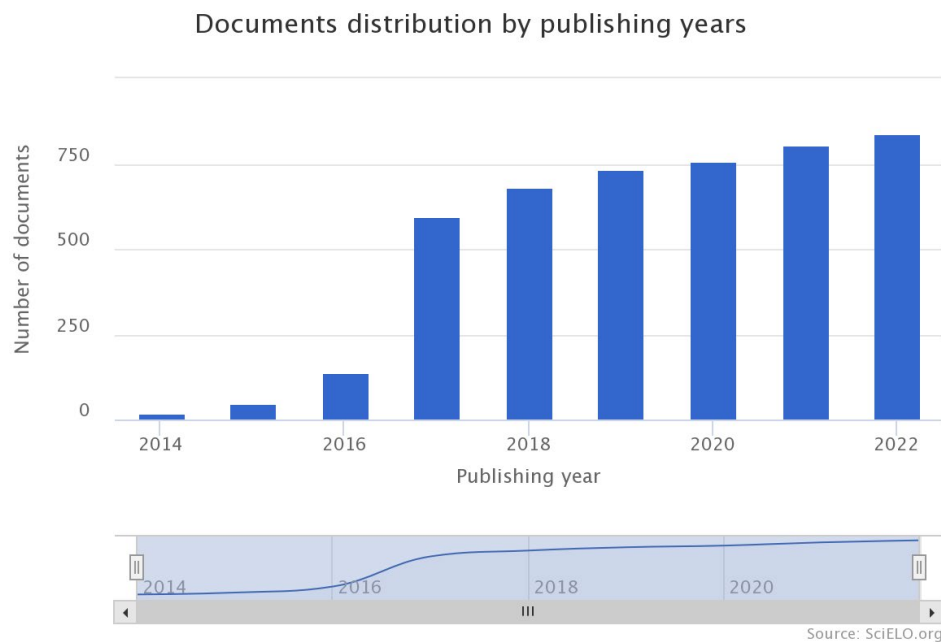
(figure.2) Distribution of documents by year of publication.

Figure 3 shows a bar graph detailing the number of document accesses from 2014 to 2022, over the last 3 years. The general trend indicates a significant increase in the number of accesses, with a notable peak in the years 2021 and 2022, reflecting a growing interest in research produced in Ecuador. This ascending pattern underlines the importance and growing relevance of Ecuadorian scientific production in the global academic sphere.

Source: SciELO.org
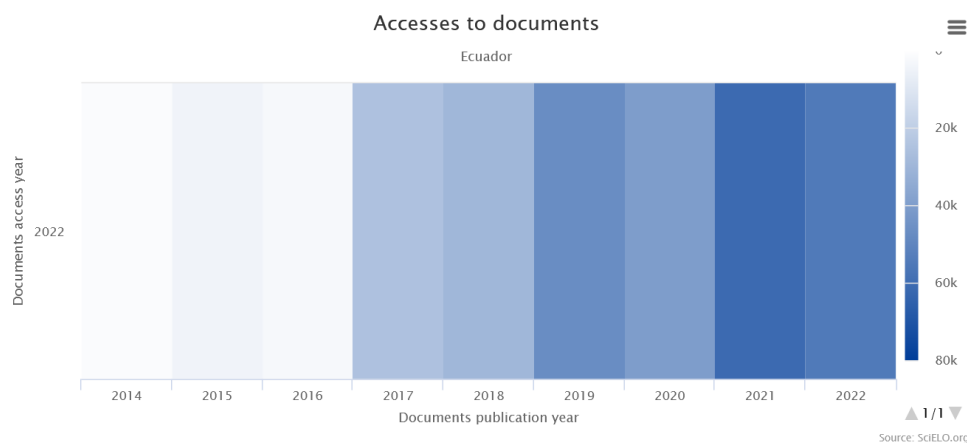
(figure.3) Access to articles in the last 3 years, distributed by year of publication.

Documents and magazines by area

Another indicator that was analyzed was the distribution of documents by areas of specialization, according to the major areas of the CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico, http://memoria.cnpq.br/english/cnpq/index.htm), which is an organization of the Brazilian federal government dedicated to the promotion of scientific and technological research and the training of human resources for research in the country. CNPq areas are periodically assigned to each of the SciELO journals, and, in turn, these can be related to more than one area of specialization. Figure 4 shows a bar graph with the number of documents published in this regard. It is observed that the areas with the greatest number of documents are Applied Social Sciences with more than 2000 documents, and Engineering with about 1000 documents. The areas with the lowest number of documents are Agriculture with less than 250 documents, and documents from other areas with less than 100 documents. These data reflect the priorities and strengths of Ecuador's scientific production in the SciELO network.

Documents distribution by suject areas
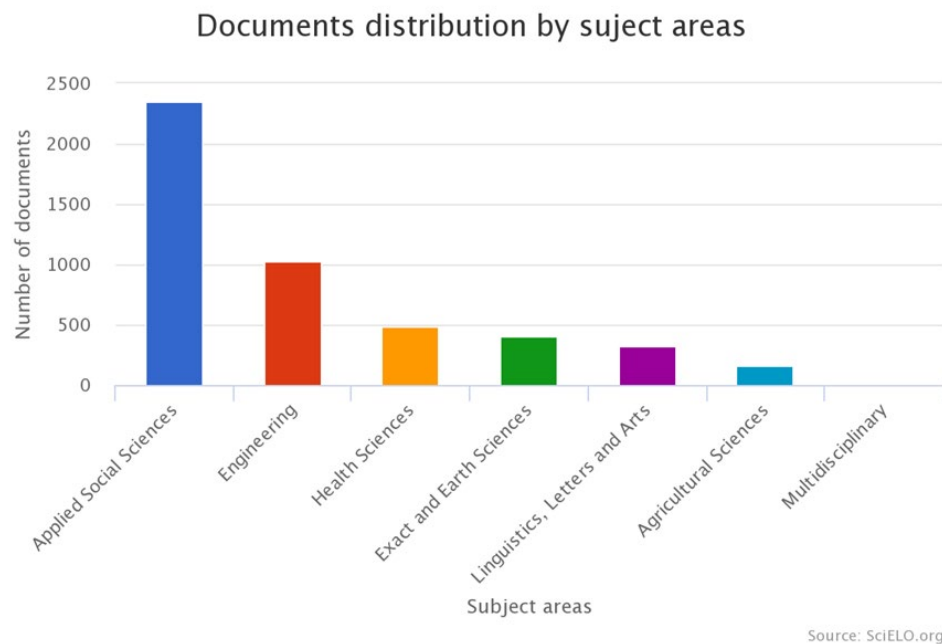
(figure.4) Documents distribution by subject areas.

Figure 5 illustrates the distribution of the 33 Ecuadorian scientific journals by subject areas in SciELO, although the total count is 35 because two journals are classified in two different areas. Applied Social Sciences dominates with 19 journals. This is followed by Engineering with 7, Exact and Earth Sciences with 3, and Health Sciences, Linguistics, Letters, and Arts with 2 each. Agricultural Sciences and Multidisciplinary disciplines are represented by one journal each. This distribution underlines the diversity and multidisciplinary approach of the research published in Ecuador.

Distribution by subject areas
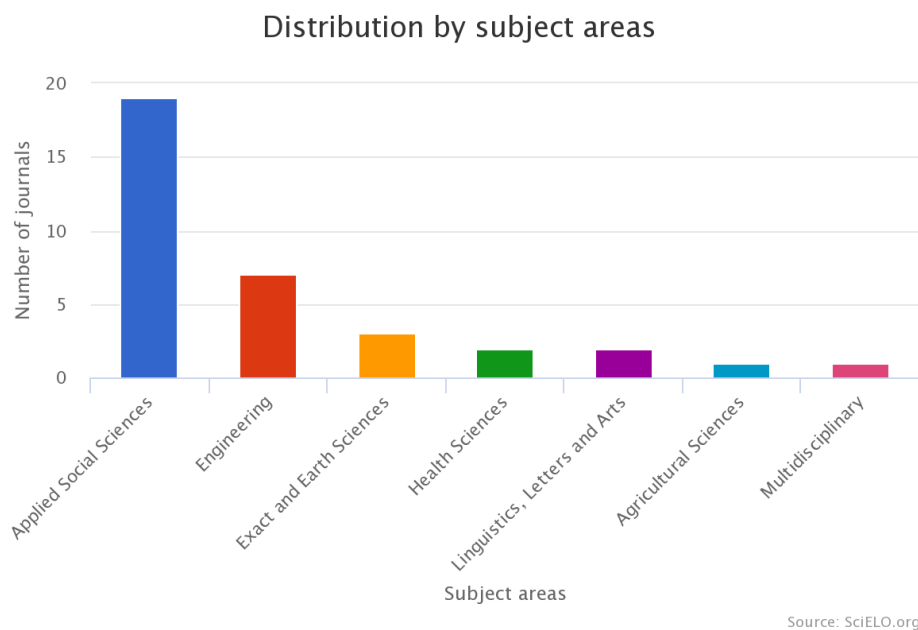
(figure.5) Magazines per area.

Additionally, a detailed analysis is incorporated that combines the relationship between the thematic area and the affiliation of the authors, using the Analytics Visualizations tool (see Figure 6). Notably, non-Ecuadorian authors contribute to Linguistics within Ecuadorian journals, and some Ecuadorian researchers tend to publish in fields such as Biological Sciences in foreign journals. This complex network confirms the multidisciplinary and transnational dynamics of scientific collaboration in Ecuador.
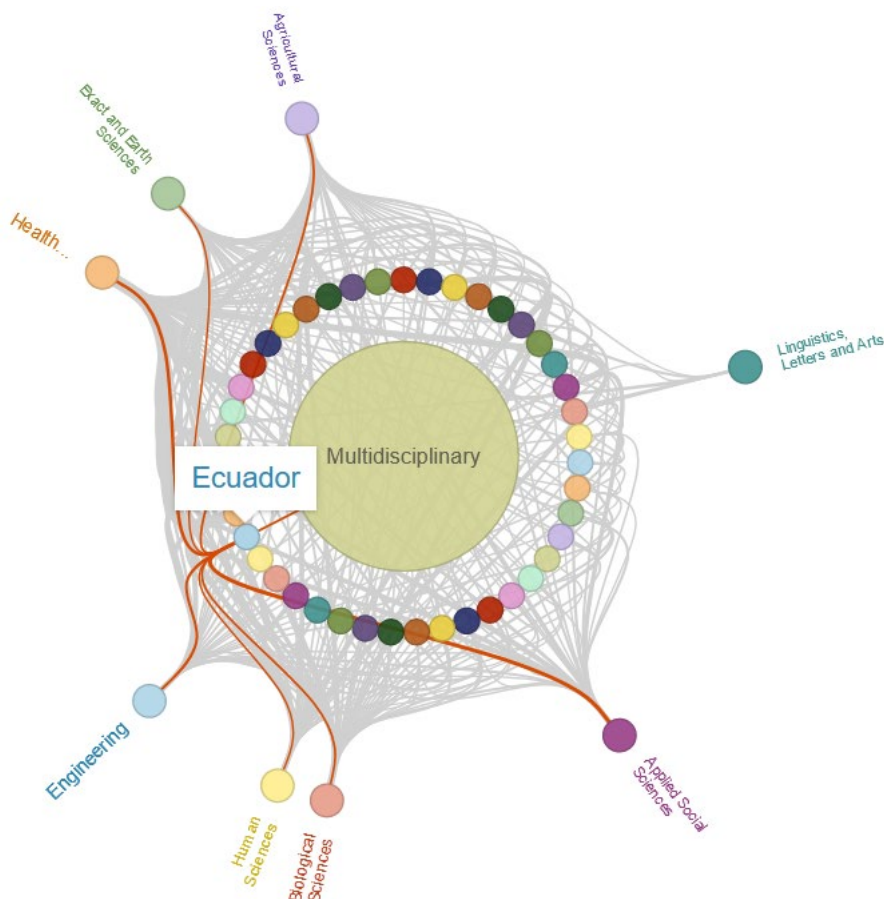
(figure.6) Relationship of the area of specialization with the author's affiliation.

Figure 7 shows a bar graph with the distribution of documents by document type. The types of documents are research articles, review articles, case reports, book reviews, letters, rapid communication, and article comments. The largest number of documents are research articles, with more than 4000 documents. The smallest number of documents are article comments, with only 1 document.
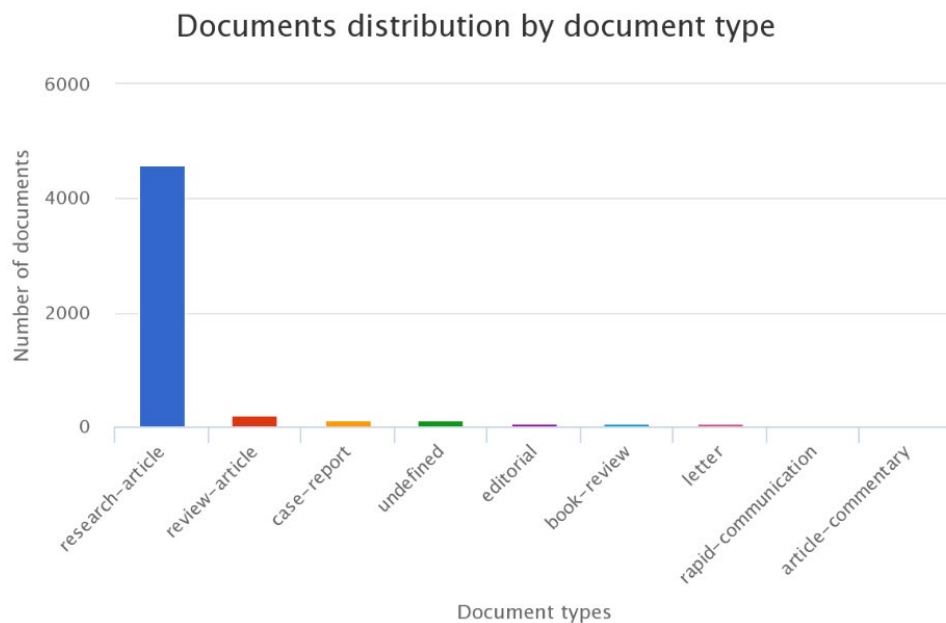
(figure.7) Documents distribution by document type.

Publication language

Figure 8 shows a bar graph with the distribution of documents by language in the Scielo Ecuador collection. The most used language is Spanish, with 4,436 documents, which represents 95.8% of the total. The second most used language is English, with 173 documents, which represents 3.7% of the total and the third most used language is Portuguese, with 9 documents, which represents only 0.2% of the total.

Distribution by languages
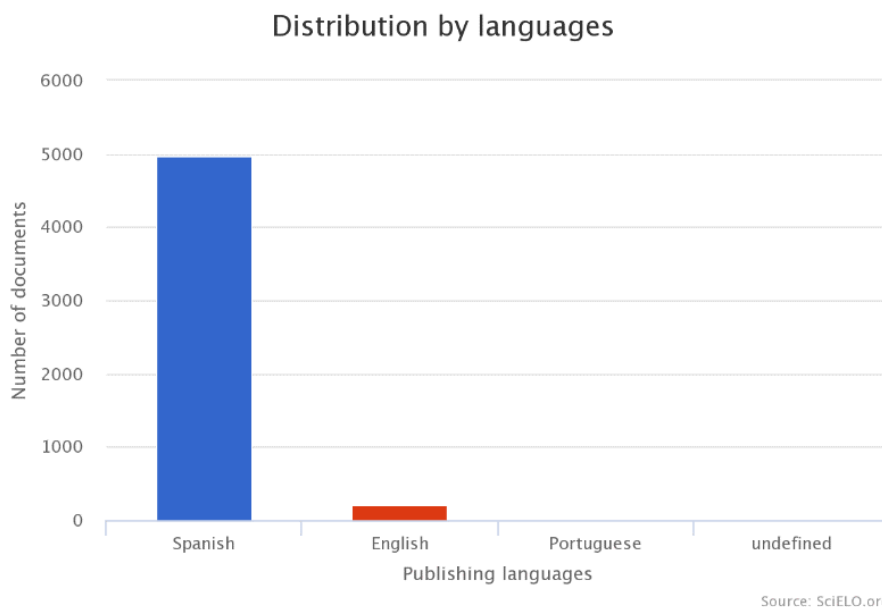
(figure.8) Distribution of documents by language in the Scielo Ecuador collection.

Number of authors per article

Figure 9 shows the distribution of documents by several authors, where it highlights that the majority of the documents (1563) have a single author, followed by documents with two authors (1132). As the number of authors increases, the number of documents decreases, the minimum being documents with 12 and 14 authors with 1 and 2 documents respectively.

Documents distribution by number of author
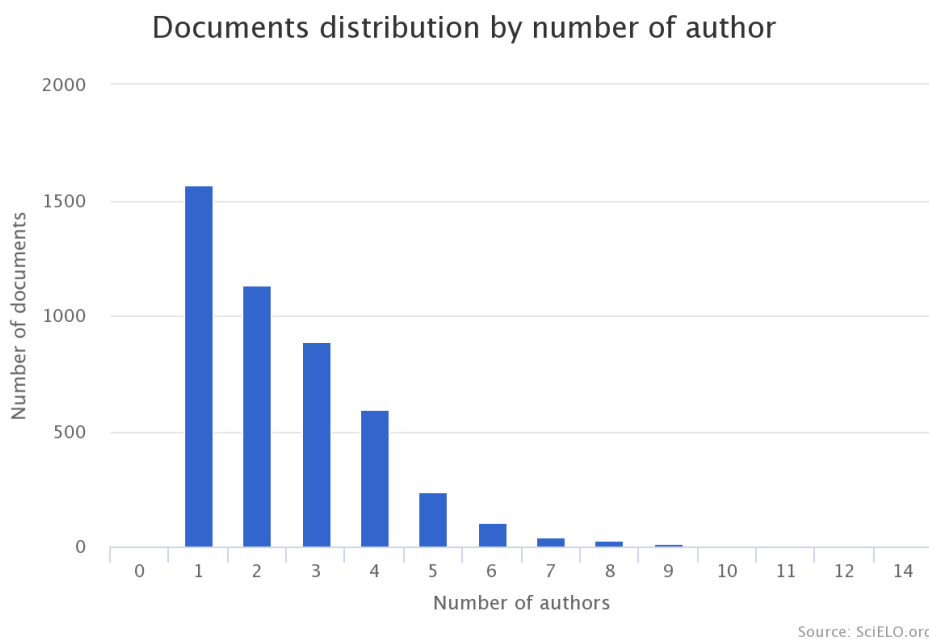
(figure.9) Documents distribution by the number of authors.

Number of references per article

Figure 10 presents a histogram that shows the distribution of scientific documents in Ecuadorian journals according to the number of bibliographic references they contain. It is observed that the largest number of documents (142) has 17 references, followed closely by those with 20 references (140 documents). Documents with no bibliographical references are the most numerous (129), which could indicate a significant proportion of primary literature or short reports. The number of documents tends to decrease as the number of references increases, with a notable drop after 30 references. This distribution provides an overview of citation practices within scientific production in the SciELO-Ecuador collection.

Documents distribution by number of bibliographic references
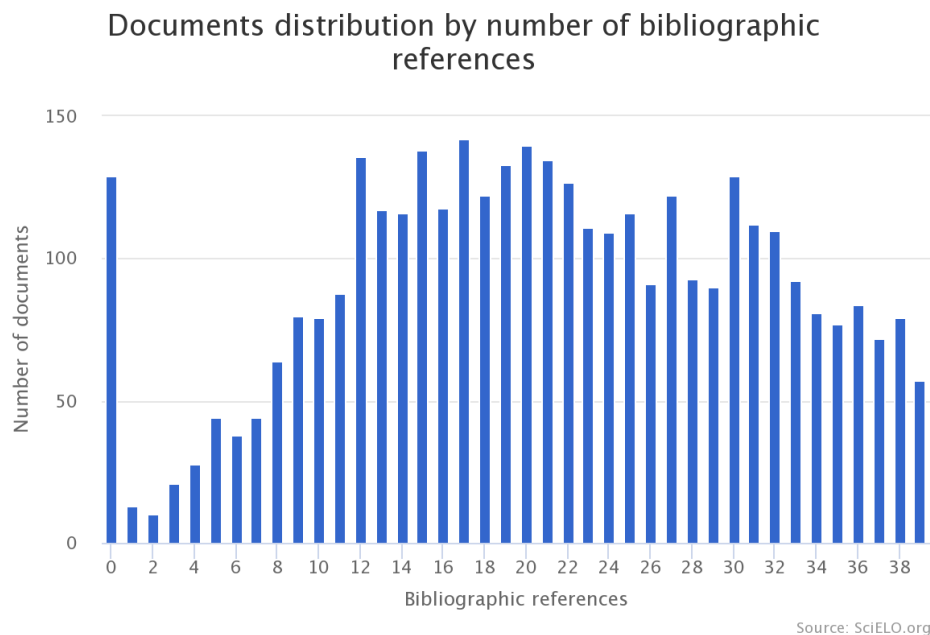
(figure.10) Documents distribution by number of bibliographic references.

International Collaboration

Figure 11 shows the number of documents by country of affiliation of the authors who have published in the journals of the SciELO-Ecuador collection between 2014 and 2022. The country with the most documents, of course, is Ecuador, with 2610 documents, followed by countries that are not defined in the data, with 745 documents. The other countries have less than 500 documents each, with Argentina being the country with the most documents, with 319, and Canada the country with the fewest documents, with 7 documents. These data do not reflect the total number of publications in the collection, since the documents may have more than one country of affiliation, but it could reflect the degree of international collaboration of the Ecuadorian authors, as well as the impact and visibility of their journals.
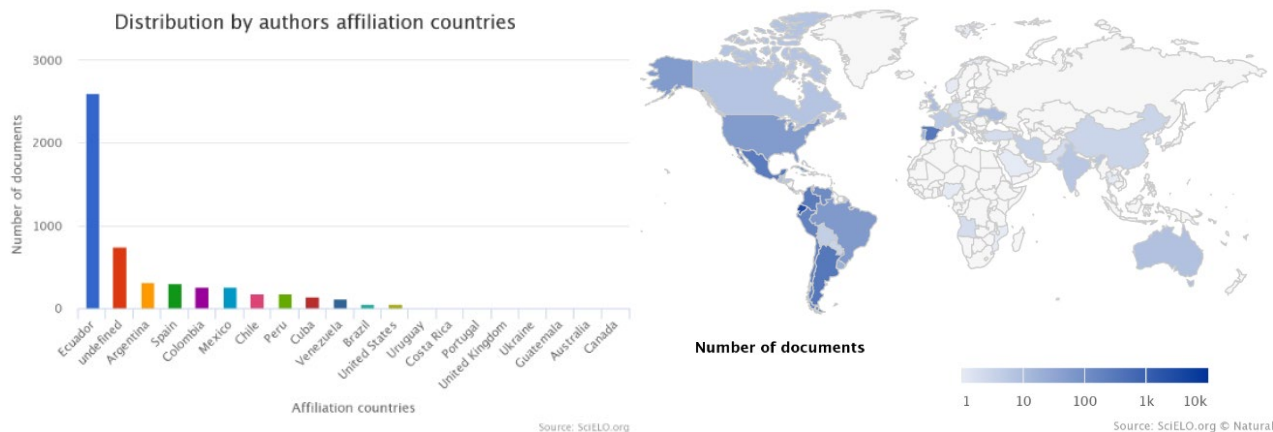
(figure.11) Number of documents by country of affiliation of authors.

Co-authorship relationship by country of affiliation.

Figure 12 visualizes Ecuador's scientific co-authorship network with other countries. Each node represents a country, with the node size proportional to the number of collaborations (degree), and the lines between them represent co-authorships. Ecuador has outstanding connections with Brazil, Colombia, Chile, Peru, Cuba, Venezuela, Angola, and Sint Eustatius, which evidences interdisciplinary collaboration and the extension of Ecuadorian research across geographical and academic borders. Thicker lines indicate a greater number of co-authorships, highlighting a robust and diverse scientific collaboration network.
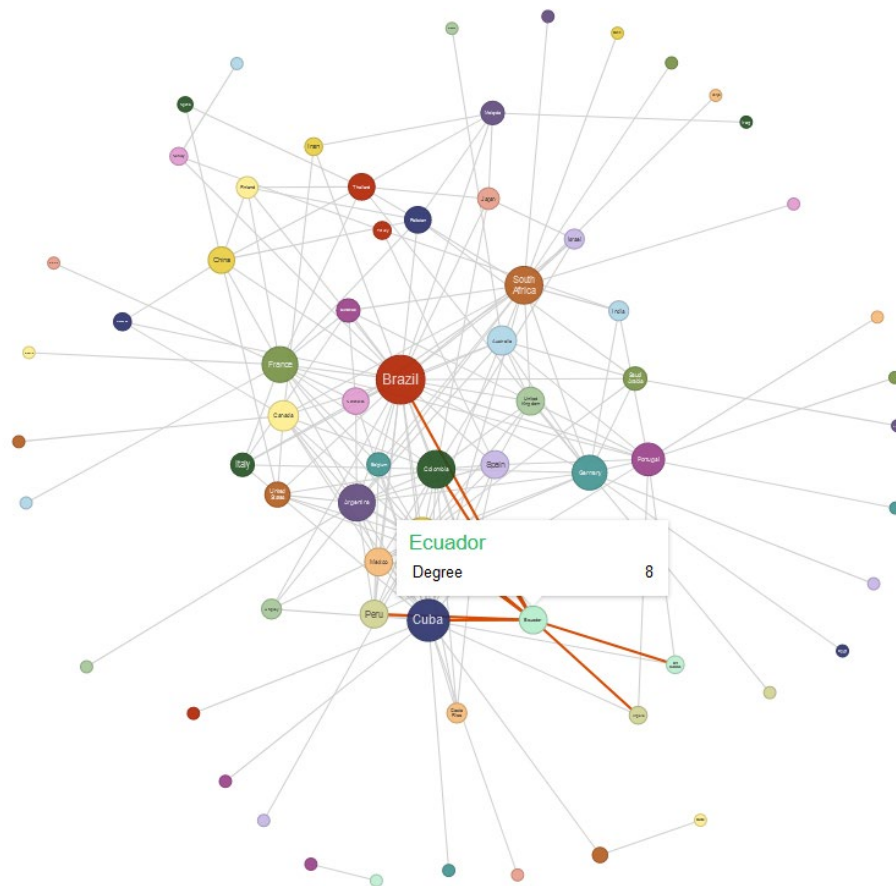
(figure.12) Relación de coautoría por países de filiación..

Publishing License

Figure 13 illustrates the number of scientific documents categorized by the type of Creative Commons license used in SciELO. The BY-NC-SA/4.0 license, which allows non-commercial use with the same shared license, is the most used with 1,488 documents. It is followed by BY-NC/4.0 with 992 documents, which also prohibits commercial use. The BY-NC-ND/4.0 license, which restricts both commercial use and the creation of derivative works, has 922 documents. The BY/4.0 and BY/3.0 licenses, which allow greater freedom of use, have 483 and 346 documents respectively, while the non-derived versions, BY-ND/3.0 and BY-ND/4.0, have 246 and 224 documents. The BY-NC/3.0 license is the least used, with only 11 documents. These figures reflect a preference in the scientific community to protect the commercial use of their works and promote open access under specific terms.
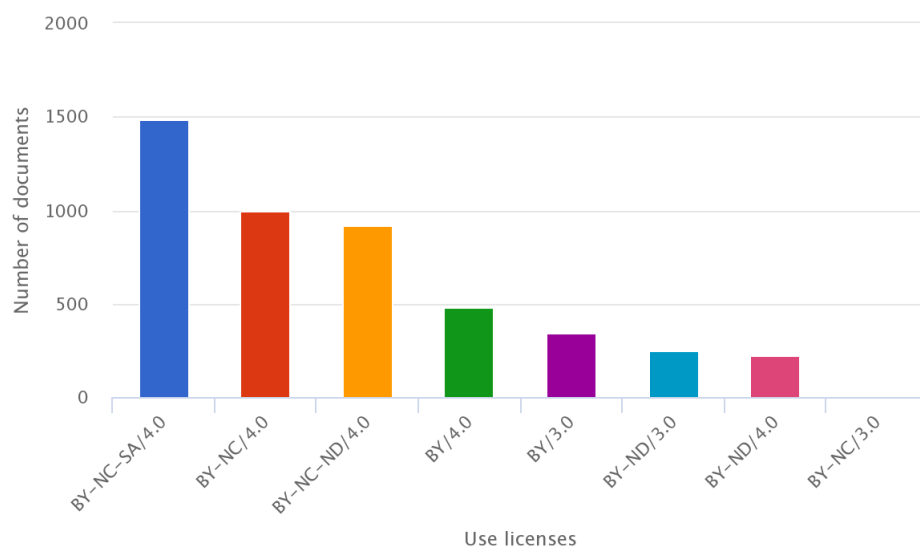
(figure.13) Documents by type of used license

4. **Discussion**

4.1. Expansion and Improvement of Scientific Research in Ecuador: An Approach Based on SciELO

Although Ecuador has experienced a notable increase in its scientific production in recent years, this progress has not been proportionally reflected in the number of journals and documents present in SciELO. This phenomenon could be attributed to a national strategic approach that prioritizes visibility in high-impact databases such as Scopus and Web of Science (Aldás-Onofre & Cordero, 2023), in response to university policies that encourage academics to publish in magazines indexed by these platforms. This approach could be diverting resources and attention from bases like SciELO which, although prestigious, do not have the same perception of prestige or impact.

Therefore, a challenge for Ecuador is to balance its publication goals between different databases to ensure a broader distribution of its research (Sisa et al., 2021). Recognizing and promoting the quality of open-access platforms such as SciELO can be vital to increasing the accessibility and dissemination of knowledge generated in Ecuador. This, in turn, could enrich the national and regional academic landscape, fostering a diversity of scientific contributions and expanding the scope of Ecuadorian research.

Ecuador's participation in the SciELO network offers a window to the country's scientific development in the Latin American sphere. Compared to the figures of Colombia, with its 249 journals, and Argentina, with 154 journals that give rise to thousands of documents, Ecuador has the opportunity to expand its presence in this important academic database. This expansion must not only be measured in quantitative but also in qualitative terms, where the depth and impact of the research become central focuses. In turn, countries such as Peru and Bolivia, despite their differences in terms of resources and population, have managed to establish a solid footprint on SciELO, indicating that Ecuador can also aspire to greater visibility (Limaymanta Alvarez *et al*., 2020).

To realize this potential, it is imperative to consider the relationship between research infrastructure and scientific production. The practices of Colombia and Argentina, where investment in research facilities and the promotion of academic networks have been fundamental for the strengthening of science and technology (Herrera-Franco et al., 2021). Likewise, the Peruvian and Bolivian model demonstrates the importance of resilience and adaptability in the management of limited resources.

Internationalization is another crucial pillar. Ecuador can benefit greatly by encouraging collaboration with international researchers and universities, which would not only increase the number of co-authorships but also raise the quality of research. A focus on knowledge sharing and cross-border collaboration could help more effectively integrate Ecuadorian science into the global community, following the example of Cuba's interconnected network of collaborations in SciELO.

4.2. Specific Strategies to Advance Ecuador's Scientific Production in SciELO:

- Strengthening Research Infrastructure: Improve the facilities and resources available to Ecuadorian researchers, ensuring that they are equipped with the technology and support necessary to conduct cutting-edge research.
- Investment in R&D and Support Policies: Increase the allocation of funds for research and development, complemented by government policies that encourage research in strategic areas for the country.
- Internationalization and Collaboration Programs: Establish programs that promote academic mobility and international collaboration, in order that Ecuadorian researchers can be part of global research networks.
- Promotion of Academic Specialization: Identify and develop research niches where Ecuador can contribute in a unique and significant way, taking advantage of its geographical and cultural characteristics.
- Adoption of Open Access Policies: Promote open-access publication to improve the visibility and impact of Ecuadorian scientific production.

By addressing these points, Ecuador could not only increase the number of publications in SciELO but also improve the quality and relevance of its overall scientific production. With a well-defined strategy and a focus on quality, Ecuador could establish itself as a regional leader in research and innovation, expanding its influence on the international scientific scene.

5. **Conclusions**

The results of this study provide an in-depth view of Ecuador's scientific production in its SciELO collection, from 2014 to 2022. Through the analysis of various indicators, significant conclusions can be drawn about the trends, strengths, and challenges that the country faces in its scientific development.

Temporal Evolution and Publication Trends

Scientific production, in general, in Ecuador has experienced a notable change since the 1990s, showing an acceleration in the quantity and quality of publications (Herrera-Franco et al., 2021). This dynamism reflects the country's response to global knowledge needs and its adaptation to international research trends (UNESCO, 2021).

In this sense, the upward trajectory of scientific production in the SciELO-Ecuador collection from 2014 to 2022 reflects a clear expansion of the Ecuadorian academic field. This growth, which shows an increase from less than 250 documents in 2016 to more than 750 in 2022, suggests a strengthening of the research infrastructure and an increase in scientific activity. It should be examined whether this quantitative increase also translates into qualitative progress, aligned with the regional and global trends observed in similar studies based on other databases such as Scopus (Chavez & Gaybor, 2021; Hernán González-Parias et al., 2022).

Areas of expertise

The distribution of scientific production in areas such as Applied Social Sciences and Engineering may reflect national policies that emphasize these sectors as essential for the country's socioeconomic development (Beigel et al., 2022). However, it is essential to promote greater thematic diversification and support emerging areas that may be strategic for national and global interests, thus guaranteeing a more balanced approach and scientific production that responds to a broader range of current challenges (Mansutti Rodríguez et al., 2023).

Likewise, other studies (Herrera-Franco et al., 2021) have reflected that the areas of Computer Sciences, Biological Sciences, and Medicine have emerged as fields of special interest in the scientific production of Ecuador, aligning with the objectives of sustainable development and the fight against climate change. These disciplines reflect a commitment to pressing global problems and show the country's potential for scientific impact.

Document Diversity and Access Policies

The predominance of research articles in the SciELO-Ecuador collection indicates a focus on original contributions, although it is essential to encourage the publication of systematic reviews and meta-analyses that synthesize and evaluate existing knowledge. The adoption of open-access licenses, a movement that Ecuador appears to have largely adopted, is essential for the dissemination of science and technology within a framework of equitable access (Chavez & Gaybor, 2021).

International Collaboration

This is a critical facet of contemporary science, and Ecuador is no exception. The analysis of co-authorships in SciELO-Ecuador reveals collaboration networks that deserve to be strengthened and expanded. Establishing mechanisms and programs that promote strategic alliances with global research centers could be a decisive step to increase the quality and impact of Ecuadorian research (Rodríguez et al., 2022).

In this sense, it is important to highlight that international collaboration has been a key driver for the scientific development of Ecuador. The interaction with leading research countries such as Spain and the United States has led to growth in fields such as Computer Science and Medicine. These collaborations have not only strengthened local capacities but have also raised the international visibility of Ecuadorian contributions (Herrera-Franco et al., 2021).

Language and International Scope

The preference for Spanish in publications is consistent with the local linguistic reality, but a push towards publication in English is recommended to guarantee greater international reach and the inclusion of Ecuadorian scientific production in broader global discussions (Herrera-Franco et al., 2021).

An analysis of the intellectual structure of the scientific production of the SciELO-Ecuador collection, based on the co-occurrence of keywords, could reveal thematic networks and cognitive trends, providing a deeper understanding of the research focuses and their evolution over time, which are possible areas of future research.

These discussion points reveal that, although Ecuador has advanced in its scientific development, there are still areas where it can be improved and expanded (Avello Martínez et al., 2023). The SciELO-Ecuador collection serves as a mirror reflecting these advances and challenges, providing a solid foundation for future research strategies and policies that promote balanced and sustained growth in the scientific field.

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