

A cross-sectional study of the scientific production of doctoral graduates in Peru

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Abstract

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Objective

To determine the scientific production of doctoral graduates in Peru.

Methods

We made a descriptive cross-sectional study with a quantitative analysis approach of the scientific production of doctoral graduates in all areas of science registered in the National Council of Science, Technology and Technological Innovation of Peru until December of 2019.

Results

We analyzed the scientific production of 942 doctoral graduates with a median time since the graduation of 84 months (interquartile range: 36 to 132). In total, 532 (56.48%) had published an article in their lifetime. The median of published articles was four (interquartile range: 2 to 12), and the median H-index of the doctoral graduates who had published was two (interquartile range: 1 to 5). We found that the number of publications and H-index was statistically different according to the doctorate area of science ($p < 0.05$ for both). Natural Sciences (69.13%), Engineering (67.47%), and Health Sciences (67.08%) had the highest proportion of doctoral graduates with at least one publication. Regarding gender and university of

origin (foreign or Peruvian), it was found a difference concerning the number of articles published and the H-index ($p < 0.05$ for both) being that male and doctoral graduates with a foreign doctoral degree had higher scientific production.

Conclusions

Only six out of 10 Peruvian doctoral graduates have published at some point in their life. The areas of science with the highest production by doctoral graduates were Natural Sciences, Engineering, and Health Sciences. There is higher scientific production in males and graduates from a foreign university.

Main messages

- There is limited information about the scientific production of Peruvian doctors.
- The study's limitations include only evaluating articles published among journals indexed in Scopus in the Peruvian doctor lifespan.
- Only six out of 10 Peruvian doctors have published a scientific article at some point in their lives. Higher scientific production is found in males and graduates from a foreign university.

Introduction

Human resources in Science, Technology, and Technological Innovation are pillars for countries' scientific and technological development and the improvement of their competitiveness^{1,2}.

It is expected that professionals with a doctoral degree contribute to the development of science because of the training received in postgraduate programs. This training process is completed through activities that aim to generate knowledge and innovation that contribute to the economic growth of their countries².

The 2019 World Economic Forum recognizes through the "Availability of Scientists in Engineers" 12th pillar – Innovation Capacity – the importance of investing in qualified human resources as part of the nations' development¹. In 2019, the World Economic Forum Global Competitiveness Index reported Peru in the 65th rank among 141 nations (2018: 63rd rank)¹. In that year, Peru lost two positions compared to the previous year, and "Innovation Capacity" was one of its weaknesses³.

The National Council of Science, Technology and Technological Innovation of Peru is an institution of the National System of Science and Technology and Technological Innovation that includes the Academy, the State Research Institutes, business organizations, communities, and civil society⁴. Its purpose is to regulate, direct, guide, promote, coordinate, supervise and evaluate the actions of the State in the field of Science, Technology, and Technological Innovation and promotion⁴. According to the "2016 national research and development census of research centers" (organized by the National Council of Science, Technology and Technological Innovation of Peru), 5408 people were dedicated to Research and Development, which represented an increase of 13.1% compared to 2014⁵. Moreover, 62.4% declared themselves researchers, and 31.8% stated they had a doctoral degree, compared to 32.7% in 2014⁵. Through the "Bicentennial Plan: Peru towards 2021", the Peruvian government established strategies to promote the branches of science and engineering, as well as specialization at postgraduate levels⁶. These strategies include the "President of the Republic Scholarship" for doctoral studies⁷, in addition to funds for the consolidation of doctoral programs through the National Fund for Scientific, Technological Development and Technological Innovation⁸. Likewise, strategies have been developed to recognize professionals with a doctoral degree, including the regulation for qualification and registration for researchers, which have the highest denomination when possessing a doctoral degree⁹, and the Promotion Law of the Development of the Scientific Researcher in Peru for professionals with a doctoral degree¹⁰.

The National Superintendence of Higher University Education of Peru states that there are currently 403 doctoral programs nationwide and 4186 applicants to these programs¹¹. The described number of doctoral programs in Peru is greater than the number of doctoral programs in other Latin-American countries like Argentina (326 in 2015) or Chile (93 programs with more than four years of accreditation in 2014)^{12,13}. However, a lower scientific production is viewed in published articles in journals indexed to Scopus in Peru compared to the latter countries. Therefore, the investment made to train researchers in Peru could be wasted².

Previously, it has been reported that only one out of four Peruvian doctors from health sciences has ever published a scientific article in journals indexed to Scopus¹⁴. However, there is no information about the scientific production in other areas of science by Peruvian doctors. Therefore, this study aims to determine the scientific production of Peruvian doctors in journals indexed to Scopus.

Methods

Study design

We did a descriptive, cross-sectional study with a quantitative analysis approach of the scientific production of doctors in all areas of science registered in the National Council for Science, Technology and Technological Innovation of Peru. These areas include Agricultural Sciences, Medical and Health Sciences, Natural Sciences, Social Sciences, Humanities, and Engineering and Technology. The latter areas of science are proposed by the Organization for Economic Co-operation and Development.

Data sources

The list of doctoral graduates was officially requested from the National Council for Science, Technology and Technological Innovation of Peru. This institution provided an Excel spreadsheet (Microsoft Corporation, USA) that included the following data for each Peruvian doctor: full name, degree title, the university, and date in which the doctoral degree was obtained. The data was verified using the Virtual Science and Technology Curriculum Vitae of each researcher. Each researcher's Virtual Science and Technology Curriculum Vitae is a virtual public personal file of researchers registered in the National Council for Science, Technology and Technological Innovation of Peru containing their research activities, including the publication of books, scientific articles in indexed journals, patents, among others. More information about the Virtual Science and Technology Curriculum Vitae is available at <https://ctivitae.concytec.gob.pe/appDirectorioCTII/>. The data recorded is an affidavit

that researchers must keep updated. Also, this file includes the academic degrees and the university where the degree was obtained.

A search was done in the ORCID platform (<https://orcid.org/>) to obtain information for each researcher. In this platform, information about the articles published and the academic degree of a researcher is recorded in an individual register called ORCID ID. The Scopus ID is registered in the Virtual Science and Technology Curriculum Vitae and the ORCID ID. Through these platforms, the scientific production information could be verified.

When doctors did not have the Virtual Science and Technology Curriculum Vitae or ORCID ID, a manual search was conducted for publications within journals indexed to Scopus, using a combination of names and surnames to identify scientific articles. Homonymy cases were treated individually. Finally, if the science where the doctorate was obtained could not be found, the corresponding individual was excluded from the analysis.

All searches were conducted in December of 2019.

Data analysis

A descriptive statistical evaluation was made studying, for each doctor, the publication of an article in his lifetime, an article in the last five years, an article in the last year, the total number of articles published, and the H-index, considering the information appeared in Scopus until December of 2019. There were no limitations regarding the type of articles registered.

The doctorates were divided according to the area of science as follows: Exact and natural sciences (Mathematics, physics, chemistry, biology, agronomy, animal health, geology), Social sciences (anthropology, sociology, and psychology), Humanities (philosophy, linguistics, history), Education, Engineering, Health Sciences (Medicine, Stomatology), Legal sciences (Law), Administrative Sciences (Administration), and Economic Sciences.

Quantitative variables are presented as the median and interquartile range, and qualitative variables as frequencies and percentages. The differences between groups of quantitative variables were established using the Kruskal-Wallis test for more than two groups or Mann-Whitney U test for two groups. In all cases, a $P < 0.05$ was considered statistically significant. All the analyses were performed using the software SPSS version 25.0.

Ethics

To conduct this study, we used information obtained through a request to public access websites. Hence, approval by an ethics committee was not required to conduct this study since it is a secondary analysis of data obtained from public sources.

Results

The scientific production of 942 doctors was analyzed. We found that 652 (69.21%) were men and that 775 obtained their doctoral degree in a Peruvian university (82.27%). The median time from their doctoral degree obtention was 84 months (interquartile range: 36 to 132). Regarding the area of science, the most frequent doctoral degrees were Exact and Natural Sciences (31.63%), Education (21.55%), and Health Sciences (17.09%) (Table 1).

Table 1. Doctorate characteristics according to science area and lifetime published articles of doctors in Peru.

| | Frequency | Percentage |
|---|-----------|------------|
| Science area (n = 942) | | |
| Exact and natural sciences | 298 | 31.63 |
| Education | 203 | 21.55 |
| Health Sciences | 161 | 17.09 |
| Engineering | 83 | 8.81 |
| Humanities | 53 | 5.63 |
| Social Sciences | 50 | 5.31 |
| Administrative Sciences | 43 | 4.56 |
| Legal Sciences | 27 | 2.87 |
| Economic Sciences | 19 | 2.55 |
| Number of published articles (n = 532) | | |
| Lower than 5 | 281 | 52.82 |
| 5 to 9 | 91 | 17.11 |
| 10 to 19 | 82 | 15.41 |
| 20 to 50 | 48 | 9.02 |
| More than 50 | 30 | 5.64 |

Source: Prepared by the authors of this study.

Regarding the scientific production of the doctors, 532 (56.48%) had published an article in their lifetime. Most doctors who have published at least once in their entire life have published fewer than five articles (52.82%). Of those who had published at least one article, 474 (89.10%) had published in the last five years, and 259 (48.68%) had published it in the last year. The median number of articles published by doctors that at least published one article was 4 (interquartile range: 2 to 12). The median H-index of the doctoral graduates who had published at least one article was 2 (interquartile range: 1 to 5).

We found a difference in the number of publications and H-index ($p < 0.05$ for both) between areas of science (Table 2). A higher percentage of doctors with at least one publication was found in Natural Sciences (69.13%), Engineering (67.47%), and Health Sciences (67.08%). Regarding gender and university of origin, a discrete predominance among males and doctors with a foreign degree was found concerning the number of articles published and the H-index compared to females and graduates of Peruvian universities, respectively ($P < 0.05$ for both) (Table 2).

Table 2. Scientific production according to the area of the doctorate, sex, and the University origin in Peruvian doctors

| Variable | Doctors with at least one publication (%) | Doctors with publications in the last five years (%) | Doctors with publications in the last year (%) | Median number of publications (interquartile range) | P value | H-index | P value |
|-------------------|---|--|--|---|----------------------|------------|----------------------|
| Doctorate | | | | | | | |
| Natural Sciences | 206 (69.13) | 185 (89.81) | 105 (50.97) | 2 (0 to 8) | < 0.001 ^a | 1 (0 to 3) | < 0.001 ^a |
| Health Sciences | 108 (67.08) | 95 (87.96) | 52 (48.15) | 2 (0 to 8) | | 1 (0 to 3) | |
| Engineering | 56 (67.47) | 49 (87.50) | 28 (50.00) | 3 (0 to 12) | | 1 (0 to 3) | |
| Education | 73 (35.96) | 67 (91.78) | 34 (46.58) | 0 (0 to 2) | | 0 (0 to 1) | |
| Administrative | 19 (44.19) | 16 (84.21) | 9 (47.37) | 0 (0 to 3) | | 0 (0 to 1) | |
| Legal Sciences | 6 (22.22) | 5 (83.33) | 3 (50.00) | 0 (0 to 0) | | 0 (0 to 0) | |
| Economic Sciences | 9 (37.50) | 7 (77.78) | 4 (44.44) | 0 (0 to 1) | | 0 (0 to 1) | |
| Humanities | 32 (60.38) | 28 (87.50) | 16 (50.00) | 1 (0 to 9) | | 1 (0 to 2) | |
| Social Sciences | 23 (46.00) | 22 (95.65) | 8 (34.78) | 0 (0 to 6) | | 0 (0 to 3) | |
| Gender | | | | | | | |
| Male | 387 (59.36) | 340 (87.86) | 188 (48.58) | 1 (0 to 6) | 0.010 ^b | 1 (0 to 2) | 0.011 ^b |
| Female | 145 (50.00) | 134 (92.41) | 71 (48.97) | 0.5 (0 to 4) | | 0 (0 to 2) | |
| University | | | | | | | |
| Foreign | 118 (70.66) | 108 (91.53) | 62 (52.54) | 4 (0 to 14) | < 0.001 ^b | 2 (0 to 4) | < 0.001 ^b |
| Peruvian | 414 (53.42) | 366 (88.41) | 197 (47.58) | 1 (0 to 4) | | 0 (0 to 2) | |

^a Calculated with the Kruskal-Wallis test

^b Calculated with the Mann-Whitney U test

Source: Prepared by the authors of this study.

Discussion

This study sought to determine the scientific production of doctoral graduates in Peru. It was found that only half of the doctoral graduates have published a scientific article in a journal indexed in Scopus during their lifetime and that most of this scientific production has been published in the last five years. Half of the doctoral graduates who have ever published in their lives had done so in the last year, and only half of the authors with publications had more than five of them. Also, we found that the impact of the scientific production of doctoral graduates was low on average (median H-index = 2).

Although investing in the training of doctoral graduates generates multiple benefits that translate into countries' economic growth, doctors must dedicate themselves thoroughly to generating knowledge through research^{14,15}. Only four out of 10 doctors have not had a scientific publication in their life, which is disappointing but understandable in the Peruvian context, characterized by low research investment. Even though the Research Centers' expenditure in research and development in Peru increased from 438 to 518 million soles between 2014 and 2015, it still represented 0.08 percent of the gross domestic product. This expenditure is the lowest at the international level compared to the other members of the Pacific Alliance, whose average is 0.75; or with the United States, whose percentage of research and development spending exceeds two percent of the gross domestic product². The National Superintendency of University Education of Peru and the National System for the Evaluation, Accreditation, and Certification of Educational Quality of Peru have assumed strategies to improve research development in Peruvian universities. These strategies include the requirement of qualified personnel and a budget for financing research projects^{16,17}, which represented 46.8% of research and development spending at the national level in 2015⁵. Similarly, The National Fund for Scientific and Technological Development of Peru (2020) joined forces

with World Bank to finance research projects in various strategic areas such as engineering and natural sciences, closing the financing gaps in some universities¹⁸. This set of efforts could explain the highest number to date of Peruvian universities that entered the Scimago Institution Ranking, going from 5 to 9 between 2019 and 2020¹⁹.

The World Economic Forum Global Competitiveness Index suggested that the area with the highest scientific production was engineering among Peruvian doctors. However, according to SciVal, Peru produced 13719 scientific articles from 2013 to 2018, but more than 50% corresponded to the Life Sciences and Medicine category¹⁴. The latter finding suggests that a large percentage of Peruvian scientific production is made by professionals who do not have a doctoral degree and, depending on their merits, could also be included as scientific researchers¹⁰.

The efforts of the National Superintendency of University Education of Peru – the institution in charge of providing licensing to universities through the evaluation of minimum conditions of functioning – have denied operating licenses to 46 universities and two graduate schools in Peru²⁰. The evaluation of the development of university programs is still incomplete. However, the quality may not be the best to judge by the small number of universities in the Scimago Institution Ranking, unlike other countries in the region such as Argentina (25 universities in 2020), Chile (35 universities in 2020), or Colombia (36 universities in 2020)²¹. This difference could explain that doctorates from foreign universities have better scientific production than their counterparts with doctoral degrees from a Peruvian university. In this regard, efforts to repatriate Peruvian researchers to strengthen national research teams could be a positive long-term strategy²².

Higher scientific production was found in male doctors, which is in line with other studies. A study that addressed various branches of

science found that, although the gender gap is narrowing in countries with reduced scientific production (cases in which women predominantly make publications), only a third of the world's publications were made by women, varying by context²³. These findings are related to personal characteristics or structural problems in research institutions, which include fewer possibilities for women to occupy positions of senior researchers; and, therefore, a lower probability of obtaining funds, leading research projects, or being the first author on scientific articles²³. A study that included only physicians in Peru found that only four out of 10 were women, a finding that could be explained by gender discrimination²⁴.

This study has some limitations. First, this research evaluates doctors registered by the National Council for Science, Technology and Technological Innovation of Peru – i.e., doctors who have an individual inclination to research. In this sense, it is expected that the scientific production of all Peruvian doctors could be lower. Second, this study only evaluated articles published in journals indexed in Scopus. Some doctors may have likely published articles that (at the time of data collection for the study) are not indexed. Therefore, this scenario would reduce the number of publications found and analyzed. Third, although the average time since obtaining the degree was seven years and the evaluation time was up to 5 years, this research cannot ensure that all scientific production analyzed was produced after the evaluated doctors obtained their degree. Despite these limitations, we consider that adopting an official registry of doctors and a bibliographic database to evaluate the scientific production of researchers is useful for studying the scientific production of doctoral graduates in Peru.

In conclusion, six out of 10 Peruvian doctors have published a scientific article at some point in their life. The areas of science with the highest production were Natural Sciences, Engineering, and Health Sciences. There is a higher scientific production if the doctor is male and graduated from a foreign university. To the best of our knowledge, this is the first study to evaluate the scientific production of doctoral graduates by area of science through a nationwide sample. Our results suggest that, despite their academic degree, many doctors do not do research. There are probably aspects in Peruvian universities that should be improved, including better opportunities for female researchers. We suggest that this type of research should be replicated in other countries, including those where governmental strategies are applied to increase the number of professionals with doctorates, in order to evaluate the effectiveness of strategies designed to promote scientific production.

Notes

Contributor roles

PHA: conceptualization, data curation, supervision. GVR, RHV, CTH and GBQ: Formal analysis, methodology. PHA, GVR, RHV, CTH, and GBQ: Writing – original draft, writing – review & editing.

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Competing interests

The authors declare that they have no conflict of interest.

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Ethics

An approval by an ethics committee was not required to conduct this study since it is a secondary analysis of data obtained from public sources.

Language of submission

English.

Data sharing statement

Restrictions apply to the availability of the study data. The data that support the findings of this study are available on request from the National Council for Science, Technology and Technological Innovation of Peru and a third party (Scopus).

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