Research article

A 32-year global analyses on dynamic trends and geospatial visualization of genital tuberculosis and female infertility: A scientometric study

Juan Alvitez [a], Luis Huarachi [a], Abigail Temoche [a], Miriam Rojas [b], Daniel Alvitez-Temoche [c], Fran Espinoza-Carhuancho [d], Frank Mayta-Tovalino [e,*]

[a] *Department of Social Medicine and Conduct, Faculty of Medicine, Universidad Nacional Federico Villarreal, Lima, Peru*
[b] *Department of Physiological Sciences, Faculty of Medicine, Universidad Nacional Federico Villarreal, Lima, Peru*
[c] *Academic Department, Faculty of Dentistry, Universidad Nacional Federico Villarreal, Lima, Peru*
[d] *Grupo de Bibliometria, Evaluacion de evidencia y Revisiones Sistematicas (BEERS), Human Medicine Career, Universidad Cientifica del Sur, Lima, Peru*
[e] *Vicerrectorado de Investigación, Universidad San Ignacio de Loyola, Lima, Peru*

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ABSTRACT

Introduction: Genital tuberculosis (GT) is an infection that can affect the female reproductive system, including the uterus, cervix, and ovaries.
Objective: To perform a scientometric exploration to analyze the spatiotemporal trend, evolution, and emerging patterns of scholarly output on GT and female infertility.
Methods: An observational, descriptive, retrospective study employing a scientometric methodology was carried out. Metadata from scholarly articles spanning the years 1990–2022 were extracted from the Web of Science. The metadata from the chosen articles, totaling 172 manuscripts, were exported on May 17, 2023, in plain text format, which will allow the analysis and integration of the data in the software used.
Results: We found at 111 sources and found 172 documents on tuberculosis and female infertility. We observed an average annual growth rate of 7.46 %, and the average age of the documents was 10.4 years. The dual overlay map showed the distribution of scientific publications on tuberculosis and female infertility. Journals on the left side of the map are cited mainly in the journals on the right. We found that Clinical Infectious Diseases and Lancet journals condensed patterns and trends in 1995, while the Indian Journal of Tuberculosis did so in 1996. Dheda K., Joubert JJ., and Wang Y. were the authors who had India, Iran, and China as their main affiliation, respectively, and they mainly published their studies in the "American Journal of Respiratory and Critical Care Medicine" and "Tropical Doctor," among others.
Conclusions: This bibliometric study examined different sources and found an average annual growth rate of 7.46 %. Each article received an average of 16.48 citations. Different collaborative networks between countries were observed. In addition, there was a steady growth in published research in the field of tuberculosis and female infertility.

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* Corresponding author. Postgraduate Department, Universidad San Ignacio de Loyola, Av. la Fontana 550, La Molina, 15024, La Molina, Peru.
E-mail address: fmayta@usil.edu.pe (F. Mayta-Tovalino).

1. Introduction

Tuberculosis is one of the most common infectious diseases in the world, caused by the bacillus *Mycobacterium tuberculosis*, which is spread through the air when exhaled by people with the disease [1]. Research suggests that a significant portion of the global population may have been exposed to the infection, yet the majority do not manifest the disease. This condition is both treatable and preventable, with a considerable number of cases in 2021, showing an increase in the incidence rate over 2020, after having declined for most of the past 20 years. It affects adult men, adult women, and children [2].

Tuberculosis of the genital tract is typically a secondary condition resulting from pulmonary or extrapulmonary tuberculosis, with prevalence rates estimated between 9 % and 20 %. Female genital tuberculosis (GT) is often identified in women aged 20–40 during infertility assessments. A common outcome of these cases is irreversible harm, including fallopian tube distortion or blockage, intrauterine adhesions, or inflammation-induced ovarian tissue destruction [3,4].

The incidence of infertility among women is on the rise. Current data suggests that it impacts one out of every seven women of childbearing age in developed nations and one in four in developing nations. The lowest reported rates (5.7 %) are in high-income countries, while the highest (24 %) are in low-income countries. A worldwide affectation of between 8 and 12 % of couples of reproductive age is observed, with anovulation being a common cause in high-income countries, while infectious etiology is frequent in low- and middle-income countries, due to the fact that tuboperitoneal damage affects fertility [3–6]. The overall infertility rate among women with genital tuberculosis is reported to be 88 %, with primary and secondary infertility rates at 66 % and 34 %, respectively. In the United States, genital tuberculosis affects 1 % of infertile women between the ages of 20 and 40, while in India, this figure rises to 18 %. Tuberculosis impacts various female genital organs, including the fallopian tubes (95–100 %), myometrium (2.5 %), endometrium (50–60 %), vagina (1 %), ovaries (20–30 %), and cervix (5–15 %). Furthermore, addressing female infertility associated with genital tuberculosis through in vitro fertilization presents substantial risks to both mother and fetus. These risks underscore the importance of monitoring, early diagnosis, and prompt treatment [7,8].

Scientometrics are quantitative research methods on the development of science as a process of information transmission [9], applied to the analysis of the bibliographic characteristics of the scientific literature of a certain area, such as medicine, which allows the analysis of many publications according to the variables of interest [10]. Characteristics such as the number of citations and publications that different authors, research groups or institutions have had in each period are important [11]. The resulting information can be used in the planning and administration of economic and institutional resources directed to research, by considering the impact of scientific activity on society, in addition to its performance in the scientific field [12].

The objective of this research was to conduct a 32-year global analysis of dynamic trends and geospatial visualization of GT and female infertility through a scientometric study.

2. Methods

2.1. Study design

An observational, descriptive study utilizing a scientometric methodology was carried out. All Metadata from scholarly articles were extracted from the Web of Science WOS. Search terms from PubMed, MeSH, and Emtree were employed. The analysis encompassed articles published between the years 1990 and 2022.

2.2. Search strategy

In this study, a rigorous selection and extraction of data for analysis with Bibliometrix was carried out. The metadata of scientific articles were obtained in plain text format from the Web of Science (WOS) database and then exported to Bibliometrix, where documents published from 1990 to 2022 were analyzed. Articles related to the topic were analyzed in the present study. There were no language restrictions in WOS, which is one of the most prestigious databases in the world. The metadata (n = 172 investigations) were exported on May 17, 2023, in plain text format, which will allow the analysis and integration of the data in the software used. The following search strategy was used: TS = ("Tuberculosis*" OR "latent tuberculosis" OR "extensively drug-resistant tuberculosis" OR "endometrial tuberculosis" OR "phthisic" OR "phthisical" OR "pulmonary phthisis" OR "tuberculous" OR "tuberculous salpingitis" OR "genital tuberculosis" OR "latent genital tuberculosis" OR "female genital tuberculosis" OR "tubercular*" OR "scrofula" OR "TB" OR "Mycobacterium tuberculosis" OR "*M. tuberculosis*") AND TS = ("Infertility" OR "female infertil*" OR "secondary female infertil" OR "barrenness" OR "sterile" OR "infertile" OR "infertile woman" OR "sterile women" OR "sterile woman" OR "infertile woman" OR "infertile patients" OR "reproductive disorders" OR "reproductive health" OR "reproductive medicine" OR "reproductive system abnormalities") AND SU = ("Medicine" OR "Medical Science" OR "Clinical Medicine" OR "Healthcare" OR "Medical Research").

2.3. Bibliometric indicators

Various scientometric indicators were used to examine impact, and collaboration networks. These included the H-index, yearly growth, Bradford's law, the Sankey diagram, Lotka's law, citation maps and visualization tools were utilized to discern collaboration networks.

2.4. Data analysis

Data processing was performed using Bibliometrix R version 4.2.3. Additionally, CiteSpace 6.2 R2 was utilized. This enabled the detection of thematic evolution, collaboration patterns, and co-citation associations.

3. Results

A comprehensive review of 111 sources yielded 172 documents. The documents exhibited an annual growth rate of 7.46 % and had an average age of 10.4 years. Each document garnered an average of 16.48 citations, and a total of 4644 references were noted. The documents contained 443 additional keywords and 438 author-specific keywords. The research involved 871 authors, with only 11 papers authored by a single individual. Collaborative efforts resulted in an average of 5.26 co-authors per article. (Table 1).

Between 1990 and 2017, the number of published articles remained stable, having a significant increase from 2018 to 2022, with 2021 being the year that recorded the highest number of published articles with more than 20 papers, while in 1997 and 2003 no articles were published (Fig. 1A). In addition, a progressive decrease in the average number of citations per article was observed. In 2001, the average number of citations per article was above 15, with slight increases observed in 2011 and 2017 (Fig. 1B).

In the analysis of cross-country collaboration in tuberculosis and female infertility research, several interactions were highlighted. Collaboration was recorded between Canada and Belgium, as well as between China and Australia. Ethiopia and the Netherlands also collaborated on one occasion. France showed collaborations with the Netherlands and Zimbabwe, while Germany collaborated with France, the Netherlands, Switzerland, and Zimbabwe. In addition, one collaboration was documented between India and Indonesia. In total, ten international collaborations were observed, underlining the relevance of global cooperation in this field of study. These findings may provide a basis for future research and collaborations in this field (Fig. 2).

The dual overlay map showed the thematic evolution of scientific output on tuberculosis and female infertility. The colored paths indicate the relevance of the reference between the two fields of knowledge. Two main citation paths were found. In cluster 2 (Medicine, medical clinic) on the left side in main color, it is indicated that studies are often published in journals in cluster 8 (Molecular, Biology, Genetics) and cluster 5 (Health, Nursing, Medicine) (Fig. 3).

The Time Zone visualization, based on the source and author, demonstrated the temporal distribution of scientific publications over time. Clinical Infectious Diseases and Lancet journals condensed patterns and trends in the year 1995, while the Indian Journal of Tuberculosis did so in 1996. While in 2011 Plos One condensed most publications in the area and thereafter publications in the area were more scattered, with no journal condensing the majority. Finally, between the years 2017–2020 little activity was observed (Fig. 4).

Fig. 5 shows the relationship between authors (left side), countries (center) and journal (right). Authors Dheda K., Joubert JJ., and Wang Y. were found to have the country of India, Iran, and China as their main affiliation respectively and mainly published their studies in the sources "American Journal of respiratory and Critical Care Medicine", and "Tropical Doctor" among others.

The references in the timeline view showed the cluster where the Female GT cluster was located. The cluster represented a cluster with several circular nodes representing the most cited references in the time analyzed. In addition, several links were observed

Table 1
Scholarly output.

Description	Results
Timespan	1990–2022
Sources	111
Manuscripts	172
Annual Growth %	7.46
Manuscript Average Age	10.4
Citations per document	16.48
References	4644
DOCUMENT CONTENTS	
Keywords Plus (ID)	443
Author's Keywords (DE)	438
AUTHORS	
Authors	871
Authors of single-authored docs	11
AUTHORS COLLABORATION	
Single-authored docs	11
Co-Authors per Doc	5.26
International co-authorships %	12.21
DOCUMENT TYPES	
article	133
article; early access	1
editorial material	6
letter	3
meeting abstract	3
note	2
review	24
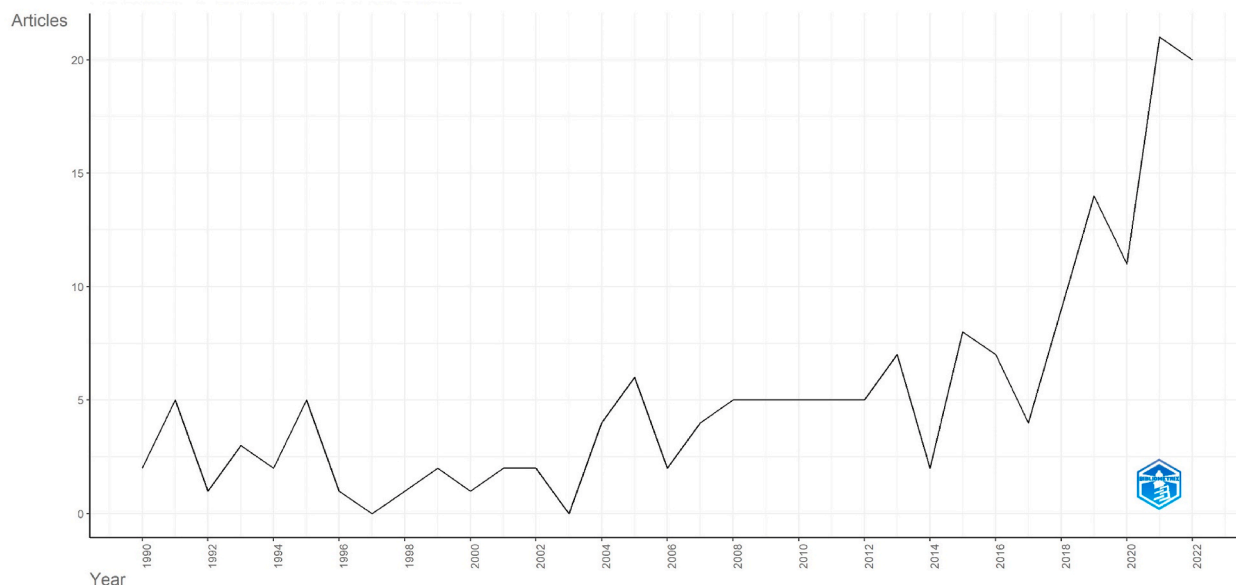
A
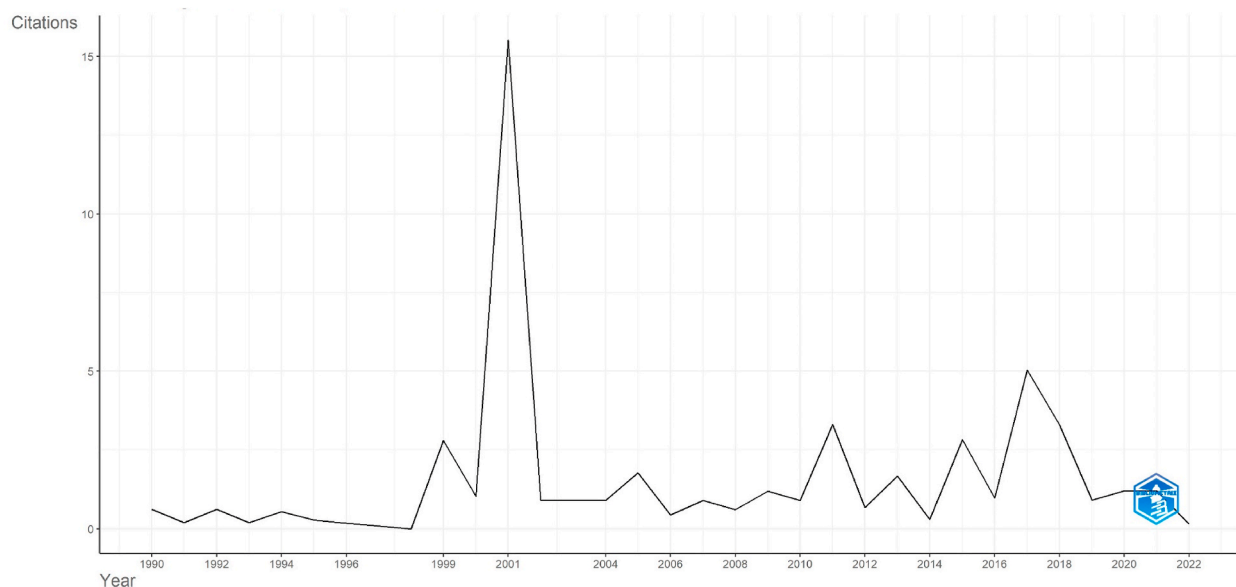
B

Fig. 1. AB: Scientometric production and citation characteristics.

between the nodes, representing co-citation between the various references identified in the graph. The most representative author was Sharma JB. (2015), followed by Ahmadi F. (2014), Neonakis IK. (2011) and Flibotte JJ. (2013) (Fig. 6).

4. Discussion

Female GT is a significant contributor to morbidity and infertility, particularly in regions with a high incidence of tuberculosis [4]. Most patients suffer from this disease asymptomatically or with clinically insignificant symptoms, which are diagnosed after evaluation for infertility, which affects between 60 and 80 % of women suffering from the disease [3,4]. In view of this problem, scientometrics allows the analysis of scientific production and its development as an information process, using quantitative methods, with the purpose of knowing the impact and characteristics of research for making strategic decisions for research funding and facilitating collaboration among researchers [10–12]. The database used to conduct the research was WOS for their high quality [13,14].

Among the authors with the highest production, Dheda K. and Wang come from India and China, countries that presented a large
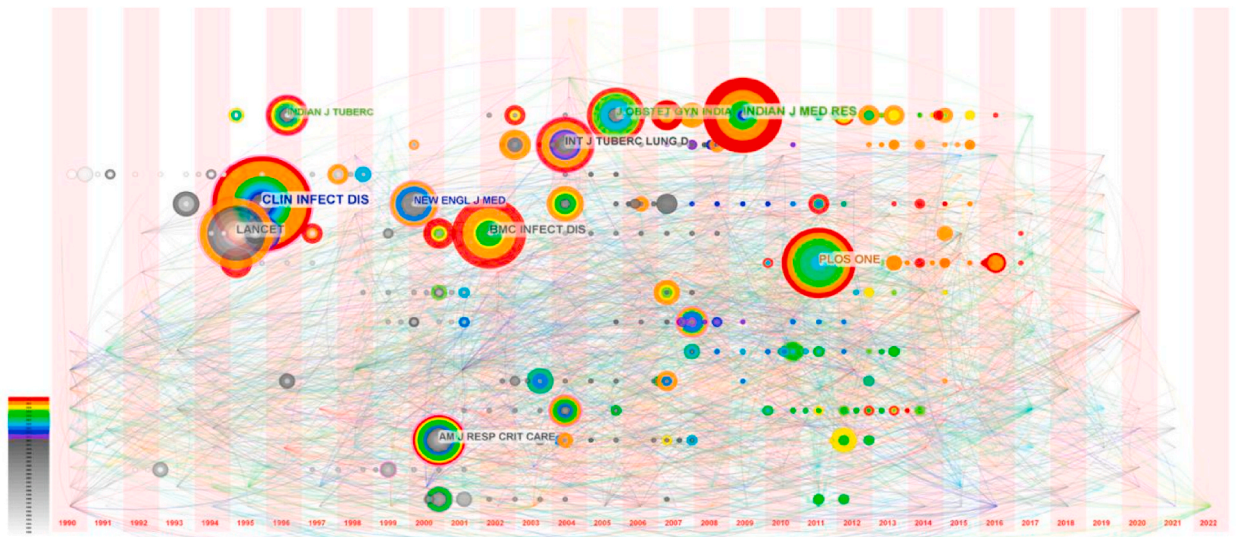
Fig. 2. Scientific production and collaboration by country.

Fig. 3. Overlay map.

percentage of the tuberculosis cases presented worldwide with 28 % and 7.4 %. The need to solve the health problems in these countries leads to a greater production of research and publications on tuberculosis and infertility, as well as other complications related to this disease [15].

Clinical Infectious Diseases, Lancet and the Indian Journal of Tuberculosis were the journals that published the most papers between 1995 and 1996, while Plos One did so in 2011, results like those found in other bibliometric studies on tuberculosis, which reveals the importance of journals in this area [16].

Numerous studies have been conducted to determine the prevalence of female GT and its effects on both primary and secondary infertility. A meta-analysis comprising 42 studies revealed that, of the 30,918 women surveyed, roughly 20 % experienced infertility. This was predominantly observed in countries with limited resources [17].

GT in the female reproductive tract results in potential infertility in women. Generally, the bacteria can infect the reproductive organs by hematogenous dissemination because the fallopian tube is the most affected area, resulting in infertility. Current treatment consists of a combination of antituberculous therapy and tubal surgery [18].

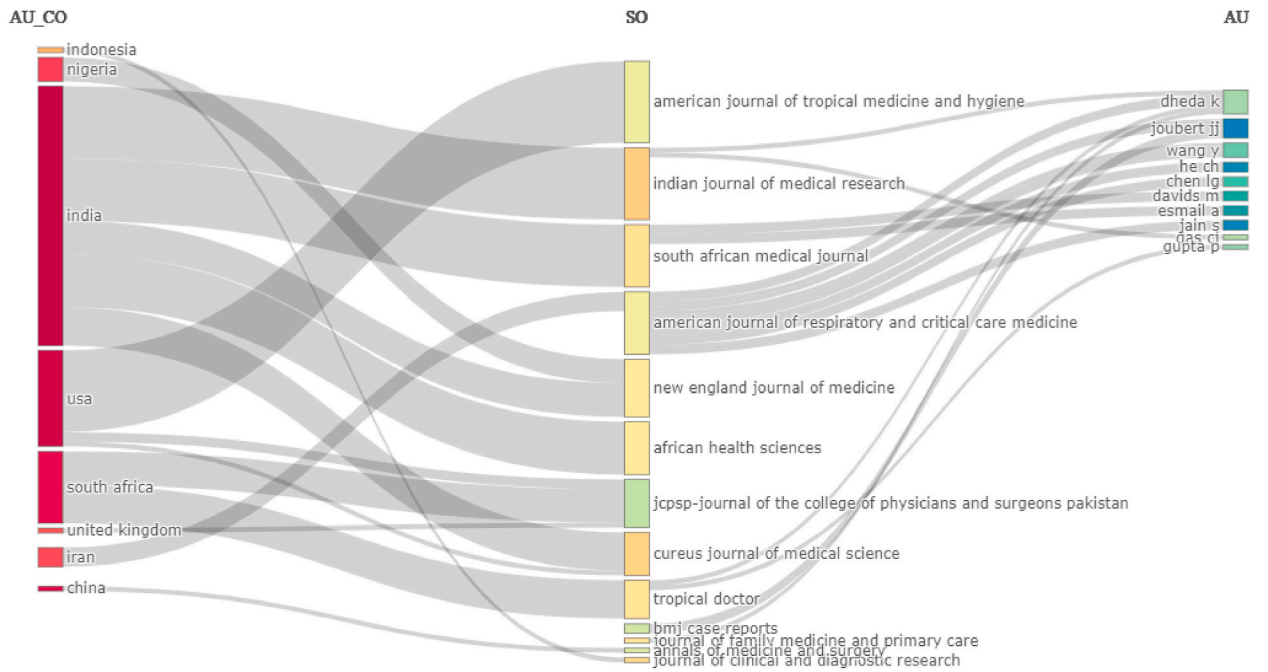**Fig. 4.** Time zone visualization according to source.

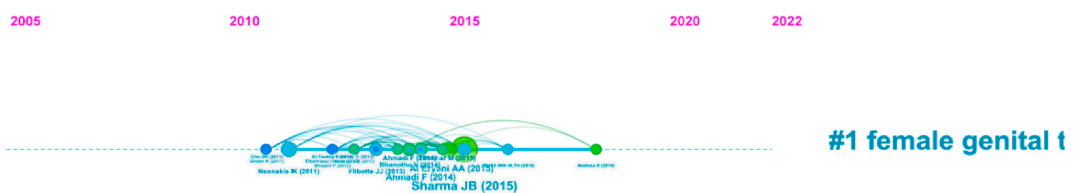**Fig. 5.** Sankey diagram.

Fig. 6. The timeline view clusters.

Extrapulmonary tuberculosis is an illness secondary to primary tuberculosis infection in the lungs, which can have serious health consequences. The bacilli often affect other organs after reactivation of the primary site, making diagnosis and treatment difficult. Therefore, the need to seek new therapies and methods for diagnosis should be emphasized. For example, nuclear receptors have been shown to play an important role, suggesting their potential therapeutic and biomarker use in this disease [19].

An alternate study tracked infertile women from 2000 to 2019 in a Portuguese hospital. The identification of GT was grounded in histological standards. Out of 2653 endometrial samples, 19 cases (0.72 %) tested positive for tuberculosis upon pathological examination. This suggests that despite Portugal's high tuberculosis prevalence, GT does not appear to significantly influence the causes of female infertility in the country [20].

It's important to note that this study has some limitations. Firstly, the database used only included metadata from scientific articles in the WOS database, which is highly regarded but not all-inclusive. This means that some relevant articles may have been excluded from the analysis. Secondly, the study focused on articles published between 1990 and 2022, which may limit the applicability of the results since it doesn't include articles published outside of this time frame. Thirdly, the search strategy may not have been exhaustive enough to retrieve all relevant articles since search strategies are frequently evolving and improving. Finally, the bibliometric measures employed in the study are contingent upon the quality and comprehensiveness of the available metadata, factors that could potentially influence the precision of the findings.

5. Conclusions

This bibliometric analysis scrutinized various sources, revealing an average annual growth rate of 7.4 %. Each article garnered an average of 16.4 citations. The research involved a total of 871 authors, with an average of 5.2 co-authors per article. Diverse collaboration networks among countries were identified. The dual overlay map displayed the thematic dispersion of scientific publications on GT and female infertility. The Time Zone visualization highlighted the temporal distribution of these scientific publications. Consequently, this study offers an in-depth survey of scientific output in the realm of tuberculosis and female infertility.

Data availability statement

The study data are available upon request to the corresponding author.

Financial support and sponsorship

None to declare.

CRediT authorship contribution statement

Juan Alvitez: Investigation, Data curation. **Luis Huarachi:** Methodology, Investigation, Formal analysis. **Abigail Temoche:** Writing – original draft, Investigation, Conceptualization. **Miriam Rojas:** Investigation, Formal analysis, Conceptualization. **Daniel Alvitez-Temoche:** Writing – review & editing, Writing – original draft, Software, Conceptualization. **Fran Espinoza-Carhuancho:** Writing – review & editing, Writing – original draft, Investigation. **Frank Mayta-Tovalino:** Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

None to declare.

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