

Trends in *Anisakis simplex* Global Research: A Bibliometric Analysis Study

Anisakis simplex Araştırmalarında Küresel Trend: Bibliyometrik Bir Analiz

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ABSTRACT

Objective: *Anisakis simplex* is a fish-borne zoonotic parasite. Although this parasite has been known since the 19th century, publications on anisakiasis have increased in recent years. Despite this, this subject has yet to be well studied by bibliometric analysis. This study was conducted to show the research points and trends of *A. simplex*.

Methods: The Web of Science Core Collection (WoSCC) was mined for articles on *A. simplex*. The VOSviewer software visually evaluated countries, institutions, authors, references, and keywords in this field.

Results: A total of 1362 publications were included in this bibliometric analysis. The included publications were published between 1970 and 2022 from 79 countries, mainly from Spain (n=456, 33.48%). The most prolific year was 2020 (n=74). The research area that attracted the most publications was parasitology (n=452), while the most productive author in this area was Cuellar C (n=53). “*Anisakis simplex*”, “*Anisakis*” and “anisakiasis” were the most used three keywords.

Conclusion: The number of publications on anisakiasis has been increasing over time, suggesting that *A. simplex* is becoming an increasingly important disease worldwide. Research cooperation should be established between researchers from developed and developing countries to determine effective control strategies for anisakiasis.

Keywords: *Anisakis simplex*, bibliometric analysis, VOSviewer, fish

ÖZ

Amaç: *Anisakis simplex*, balık kaynaklı zoonotik bir parazittir. Bu parazit 19. yüzyıldan beri bilinmesine rağmen son yıllarda anisakiasis ile ilgili yayınlar artmıştır. Ancak, bu konuyla ilgili herhangi bir bibliyometrik analiz yapılmamıştır. Bu çalışma, *A. simplex*'in araştırma noktalarını ve eğilimlerini göstermek amacıyla yapılmıştır.

Yöntemler: Web of Science Core Collection (WoSCC) veri tabanında *A. simplex* ile ilgili makaleler taranmıştır. VOSviewer yazılımı kullanılarak, *A. simplex* ile ilgili çalışma yapan ülkeler, kurumlar, yazarlar, referanslar ve anahtar kelimeler görsel olarak değerlendirilmiştir.

Bulgular: Bu bibliyometrik analize toplam 1362 yayın dahil edilmiştir. Dahil edilen yayınlar 1970 ile 2022 yılları arasında, başta İspanya (n=456, %33,48) olmak üzere 79 ülkeden yayınlanmıştır. En fazla yayın yapılan yıl 2020 (n=74) yılı olmuştur. En çok yayın yapılan araştırma alanı parazitoloji (n=452) olurken, bu alandaki en üretken yazar Cuellar C (n=53) olmuştur. “*Anisakis simplex*”, “*Anisakis*” ve “anisakiasis” yayınlarda en çok kullanılan üç anahtar kelime olmuştur.

Sonuç: Anisakiasis ile ilgili yayınların sayısının zaman içinde artması, *A. simplex*'in dünya genelinde giderek önem kazandığını göstermektedir. Anisakiasis için etkili kontrol stratejilerinin belirlenmesi amacıyla gelişmiş ülkelerdeki araştırmacılar ile gelişmekte olan ülkeler arasında araştırma iş birliği kurulmalıdır.

Anahtar Kelimeler: *Anisakis simplex*, bibliyometrik analiz, VOSviewer, balık



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INTRODUCTION

Anisakiasis is a parasitic zoonotic disease brought on by members of the Anisakidae family. *Anisakis*, *Hysterothylacium*, *Pseudoterranova*, and *Contracaecum* are genera that belong to the family *Anisakidae* (1). But, according to reports, infections in humans are caused by three species of the genus *Anisakis*: *A. simplex sensu stricto*, *A. pegreffii*, and *A. physeteris* (2). *A. simplex* is a parasitic worm that infects marine animals that consume fish and cephalopods, its intermediate hosts (3).

This parasite causes humans disease when raw or undercooked fish meat containing live larvae is consumed. Humans may have one of two unique clinical symptoms after consuming infected fish, cuttlefish, or squid: Living larvae entering the digestive mucosa cause anisakiasis (3). In a person who has already been exposed to allergens, allergies are brought on by IgE-mediated hypersensitivity to live or dead larvae. Anisakiasis may present as severe epigastric pain, an acute abdomen, or eosinophilic gastroenteritis. Histology or endoscopy are two methods that can be used to see the larvae. The primary allergens in *Anisakis* are resistant to digestion and are not denatured by heat or cold. The accurate history and identification of particular IgE are essential for allergy diagnosis (3,4).

According to estimates from the World Health Organization, parasite infections brought on by eating fish products affect roughly 56 million people worldwide (5). The parasites in question include the family of anisakids, which have a reputation for causing severe pathologies in people and are widely dispersed geographically across all continents (4). A significant cause of the infection is the culinary practice of consuming marinated or raw fish in European nations like Italy, and the regular consumption of contaminated raw fish dishes like sushi and sashimi in Japan's national cuisine (6,7). Due to increased public knowledge of anisakiasis infection and better public health diagnosis (better diagnostic tool development), anisakiasis reports have increased across most countries (7).

Leuckhart documented the first case of anisakiasis disease in 1876. Still, it wasn't until the 1960s that the disease became well known as a result of outbreaks of anisakiasis in the Netherlands brought on by the ingestion of lightly salted herring (8). *A. simplex* has a substantial role in human diseases and reports of anisakiasis have increased in most countries. *A. simplex* has become the etiologic agent included in standard allergen sets for research into food allergies, drug allergies, and even anaphylaxis (9). However, there is no systematic bibliometric analysis study on this topic. In order to better understand how fundamental and clinical research might grow in the future, we used a bibliometric analysis to illustrate the research hotspots and trends of *A. simplex*.

METHODS

Data Collection

Data were extracted from (<https://www.webofscience.com/wos/woscc/basic-search>) Web of Science Core Collection (Science Citation Index Expanded and Emerging Sources Citation Index) and was downloaded within one day on November 8, 2022. The search formula was set to topic = *Anisakis simplex* and, search date was from June 1, 1970, to November 8, 2022.

A total of 1362 publications were retrieved, including articles, editorial materials, reviews, letters, meeting abstracts, corrections, retractions and proceedings papers. All entries and references from the retrieved data were exported as plain text files and saved in the download text format.

Statistical Analysis

The Web of Science Core Collection (WoSCC) was used to gather the data, which was then imported into Microsoft Excel 2019 and VOSviewer for visual analysis.

VOSviewer was used to create and display bibliometric maps. Based on collaborative data, it can be used to create author or journal maps, and keyword maps created from co-occurrence data. It is a viewer that the project offers enabling in-depth in-depth analysis of bibliometric maps. VOSviewer, in contrast to the generally used bibliometrics tool, places significant emphasis on the graphic representation of bibliometrics. It is particularly helpful for displaying big bibliometrics in an understandable manner. It is beneficial for understandably displaying big bibliometrics. The primary goal of creating VOSviewer was to evaluate the bibliometric network, create a visual network map, and acquire a thorough comprehension of the dynamic structure of scientific research (10).

We utilized VOSviewer software to examine the country/region and institutional collaborations, author contributions, and keyword analysis. We also used Microsoft Office Excel 2019 to assess the trends.

RESULTS

We retrieved 1362 publications according to search criteria. The publications were primarily published in the Science Citation Index Expanded (96.696%) index. 82.379% of the documents were research articles, and 32.526% were open access. English was the most preferred language (95.448%).

Anisakis simplex has been the subject of an increase in articles each year (Figure 1). The publication outputs from 1970 to 1990 are incredibly low, and the research was still at a standstill. The literature output increased steadily between 1990 and 2000, indicating that *A. simplex* started to draw attention. The volume of articles published between 2010 and 2022 has skyrocketed. 55.07% of the articles were published since 2010.

Most of the publications were from parasitology (33.19%), immunology (18.36%) and allergy (14.91%) research areas (Table 1).

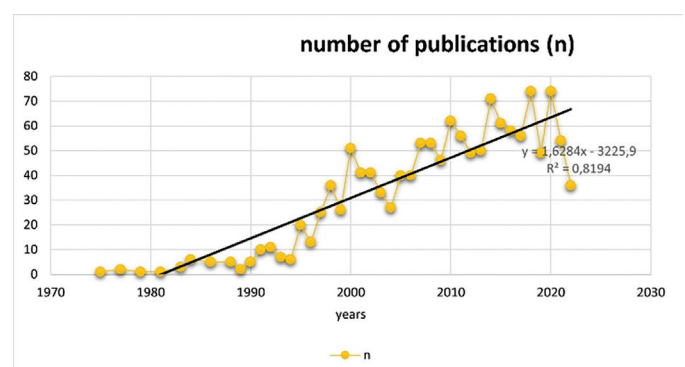


Figure 1. Publications on *A. simplex* over time

The authors from 79 countries contributed to the *A. simplex* research (Figure 2). Spain (33.48%), Italy (15.57%) and the United States (6.90%) were the countries that contributed the most (Table 2). Network visualization using VOSViewer showed a strong collaboration between countries for *A. simplex* research (Figure 3).

Network visualization using VOSViewer revealed 54 authors with at least ten publications and 100 citations. According to the strengths of the authors' relationships, 54 authors were divided into 3 clusters (Figure 4). European agencies mostly funded the studies (Table 3).

Figure 5 shows the maps of the keyword co-occurrence networks. According to the strengths of the co-occurrence relationships, 151 keywords were divided into 10 clusters. The first five most used keywords are *Anisakis simplex*, anisakis, anisakiasis, fish and allergy, respectively (Figure 5).

DISCUSSION

The bibliometric analysis provides important epidemiological data about the course of diseases from past to present in

medicine all over the world. This analysis explored global research trends and findings in anisakiasis, a zoonotic fish-borne parasitic disease. Our bibliometric analysis determined a steady increase in anisakiasis-related publications from 1970 to 2022. Especially from 1980 to 2020, a significant and long-term increase was observed in publications, and this increase was regular. It was seen with this bibliometric analysis that most articles about anisakiasis were published in 2020. This is because, during this period, more funds may be allocated by economically developed countries. In our analysis, Spain was the country with the most articles, followed by Italy. Our findings show the existence of reported cases of *A. simplex* around the world, with a trend of increasing research output from countries worldwide. Spain and Italy are landlocked countries with highly developed economies where seafood is consumed, and their scientific research capacity and impact on global health research may have increased accordingly. Unsurprisingly, the USA ranks third in the publications list, as this zoonotic fish-borne parasite can find an opportunity for infection on a continent surrounded by water. Another reason the USA is the third most researched country may be that it has similar trends as many other bibliometric studies in different areas, confirming that it is one of the global research leaders, both quantitatively and qualitatively (11-14).

Table 1. Research areas of the publications on *A. simplex*

Research areas	Record count	% of 1362
Parasitology	452	33.19
Immunology	250	18.36
Allergy	203	14.91
Food science technology	146	10.72
Veterinary sciences	130	9.55
Fisheries	121	8.88
Zoology	114	8.37
Marine freshwater biology	101	7.42
Microbiology	66	4.85
Infectious diseases	61	4.48
Tropical medicine	49	3.60
Biochemistry molecular biology	42	3.08
Biotechnology applied microbiology	36	2.64
Ecology	36	2.64
Gastroenterology hepatology	29	2.13
Medicine general internal	28	2.06
Oceanography	25	1.84
Public environmental occupational health	22	1.62
Pharmacology pharmacy	21	1.54
Dermatology	20	1.47
Chemistry applied	19	1.40
Multidisciplinary sciences	18	1.32
Genetics heredity	15	1.10
Biodiversity conservation	14	1.03
Biochemical research methods	12	0.88
Agriculture multidisciplinary	11	0.81
Medicine research experimental	10	0.73
Surgery	10	0.73

Table 2. Top 25 countries related to *A. simplex*

Countries/regions	Record count	% of 1362
Spain	456	33.48
Italy	212	15.57
USA	94	6.90
Japan	83	6.09
Poland	82	6.02
Norway	69	5.07
Germany	67	4.92
Australia	50	3.67
South Korea	50	3.67
Portugal	49	3.60
Canada	42	3.08
Scotland	42	3.08
People's Republic of China	37	2.72
France	36	2.64
Denmark	34	2.50
Brazil	32	2.35
Croatia	28	2.06
England	28	2.06
Argentina	22	1.61
Taiwan	20	1.47
Chile	16	1.18
Belgium	14	1.03
New Zealand	14	1.03
South Africa	14	1.03
Czech Republic	13	0.95

Showing 25 out of 79 entries; 9 record(s) (0.66%) do not contain data in the field being analyzed

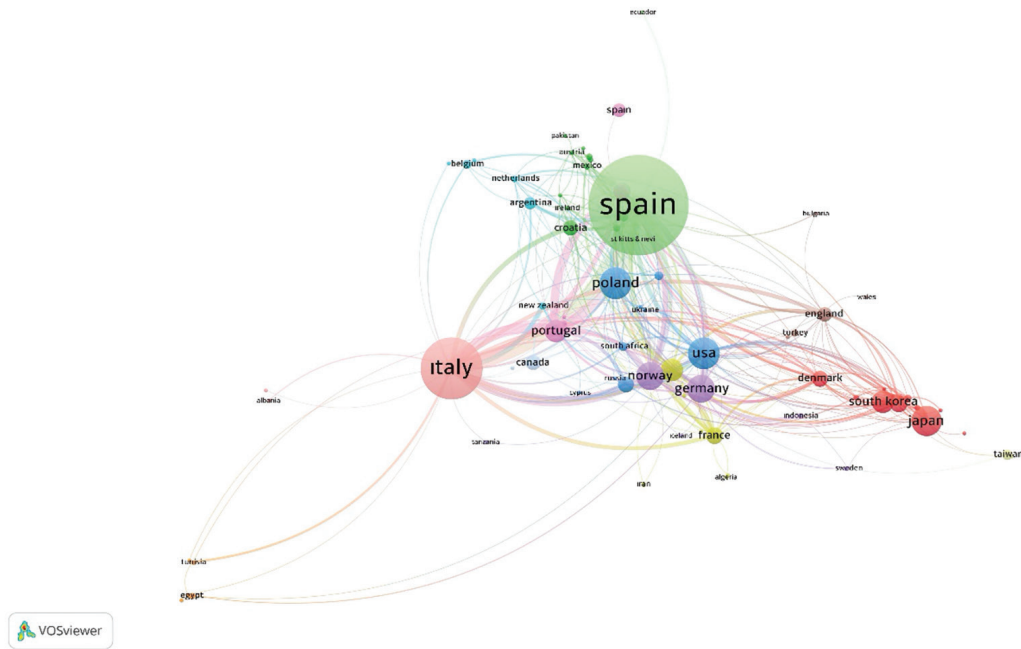


Figure 2. International collaboration network map

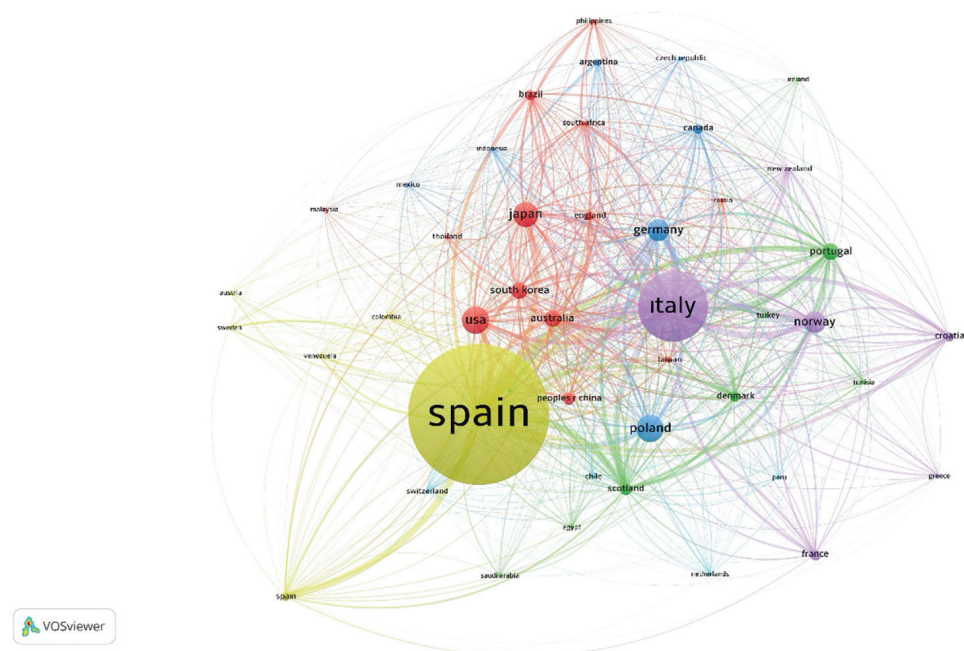


Figure 3. Countries with at least five publications and five citations are shown on the map. Collaboration is shown with lines linking nations. Thicker lines indicate stronger cooperation. Countries with a more giant circle or text size had higher international collaboration

The function of the budget allocated by countries for diseases that burden their economies in the health system is essential in promoting science and research (15). This bibliometric analysis supports this. The findings show that most funding agencies are from European countries (European Commission). The results of our study are consistent with other studies (16). Our results

suggest the need for further large-scale research on anisakiasis disease, focusing on preventive aspects and increasing importance in several countries.

Journals are indispensable tools for announcing and disseminating research; therefore, the prestige of a journal plays a vital role in communicating the achievement to the relevant part

Table 3. Funding agencies of the publications on *A. simplex*

	Record count	% of 1362
European Commission	66	4.85
Spanish Government	24	1.76
Portuguese Foundation for Science and Technology	20	1.47
Instituto De Salud Carlos Iii	15	1.10
Ministry of Education Culture Sports Science and Technology Japan Mext	15	1.10
United States Department of Health Human Services	14	1.03
National Natural Science Foundation of China	13	0.95
Ministry of Science and Innovation Spain	12	0.88
National Institutes of Health USA	12	0.88
Australian Research Council	11	0.81

Showing 10 out of 597 entries; 849 record(s) (62.335%) do not contain data in the field being analyzed

published literature sometimes changes the journal preference of the author.

On the other hand, among the authors included in the bibliometric analysis from 79 countries, we found that the authors with the most articles were from Spain. Among the authors with at least ten articles and 100 citations on *A. simplex*, the highest scorer was Mattiucci Simonetta. Of course, the count of publications does not always lead to more citations, but it should not be forgotten that the work will be cited for its content, originality and new contributions to science. One of the leading authors in the field of anisakidosis, one of the published works of Mattiucci Simonetta received the highest number of citations.

Keywords play an important role in finding the document we are scanning. The most used keywords in our analysis were “*Anisakis simplex*” and “*Anisakis*”. The keywords we chose pointed to the aetiology of the zoonosis. In anisakiasis, most published studies focused on knowledge of prevalence, causes of the disease, and epidemiology. Suppose we want to increase the number of citations and reach of articles while increasing the number of articles on a subject. In that case, we should avoid publishing similar information repeatedly in the introduction. It will suffice to give enough information to understand the disease initially for diagnosis and later for treatment. Overworking on just one aspect of a disease loses interest in the scientific community, which can hamper control of its spread.

Study Limitations

This study utilized only one database search (WoSCC), which may impact on the publication frequency and the citation count in anisakiasis. However, WoSCC is one of the most common databases used for bibliometric analysis. Our results must be evaluated in line with this limitation.

CONCLUSION

The research results are of particular value to veterinarians, parasitologists, and other researchers in this field, and provide insights into research boundaries and trends in anisakiasis. This study will provide a fundamental reference for designing future policies and research funding to manage the disease effectively in regions where it is endemic. The most commonly used keyword in anisakiasis was “*Anisakis simplex*”, the most studied research area was parasitology, and the most studied country was Spain.

Spain made 33.48% of the publications on anisakiasis and 15.57% by Italy. To develop effective control strategies in the fight against anisakiasis, it would be beneficial for researchers in countries with a small number of studies where the disease is seen and researchers in developed countries to establish research cooperation.

* Ethics

Ethics Committee Approval: Since the study was a bibliometric analysis, ethics committee approval was not received.

Informed Consent: Not applicable.

* Authorship Contributions

Concept: M.E.A., S.K.A., Design: S.A., S.AL., Data Collection or Processing: S.A., S.K.A., M.E.A, Analysis or Interpretation: S.A., S.AL., Literature Search: M.E.A., S.K.A., Writing: M.E.A., S.K.A., S.A.

Conflict of Interest: No conflict of interest was declared by the authors.

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