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Retinopathy of prematurity publications: A bibliometric analysis

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Abstract

Objective: In this study, we aimed to evaluate the cytometric features of the retinopathy of prematurity (ROP) in literature in the period of 1979-2019.

Materials and methods: This study utilized data from Thomson Reuters' Web of Science (WoS) database from 1979 to 2019, focusing on 'Retinopathy of Prematurity.' The research incorporated the VOS viewer tool for arranging bibliometric networks and figures. The data were divided and analyzed based on variables like time, country, authors, research institutes, and document types. Info maps and bibliometric infographics were created with Microsoft Excel and VOS-Viewer tools. Moreover, population data, GDP per capita, health expenditure, and ICU bed data were sourced from the World Bank and OECD Health Statistics.

Results: A total of 4080 publications in the period of 1979-2019 were scanned. Of all the evaluated publications, 2217 (54.33%) were original articles, 989 (24.24%) were meeting abstracts and 375 (9.19%) were letters, while the others were of the proceeding paper, editorial material, review, correction, book chapter types, respectively. The most widely used language was English with 3977 (97.47%) publications, while German was ranked second, followed by French, Spanish, Portuguese, Italian, and Turkish. A total of 83 countries made 4080 publications on ROP. The United States was the country with the most publications - 1820 (44.6%), followed by the UK - 262 (6.42%), India -242 (5.93%), Turkey - 178 (4.36%), Canada -167 (4.09%), Germany -154 (3.77%), China-153 (3.75%), respectively.

Conclusions: ROP is a significant global health issue with socio-economic implications. Despite higher citation rates in developed countries, efforts should be aimed at reducing healthcare and publication disparities. Screening programs and health policies are crucial, particularly in developing countries.

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Introduction

Retinopathy of Prematurity (ROP) is a vascular retinal disease observed in premature infant cases and is one of the most important avoidable causes of childhood vision loss in both developed and developing countries (1). Increasing premature birth rate and viability of very low weight babies have increased the prevalence and seriousness of ROP disease. Over time, a better understanding of ROP pathogenesis, compliance with screening guidelines, and the development of imaging methods and treatment options have also increased the number of publications on ROP.

Bibliometrics is a recent field and is performed to quantitatively assess the academic quality of journals or authors by using statistical procedures such as citation rates, contents, authorship relations, and productivity. Bibliometrics is connected to the broader term "infometrics" (2,3), and the narrower term "scientometrics" (4).

Bibliometric analysis is a type of advanced review methodology used to analyze publications on a particular topic. This methodology provides an analytical and holistic perspective on the subject, which is scientific knowledge. In the detailed nature of scientific topics, it provides an overview of the data and allows joining up the dots.

Pritchard was the first author that suggested using the term "statistical bibliography" in 1969 (5). Scientometrics and bibliometrics often involve the assessment of scientific contribution of journals or specific works, citation analysis, a content analysis of words in titles, and abstracts or full texts of journals. They also focus on authorship, social network analysis, co-word, and keywords assigned to published articles. These days, producing reports via software made much easier. Databases such as Scopus, *Web of Science (WoS,)* or *Google Scholar* have added and incorporated reference handling features (6). Bibliometrics could be considered as the knowledge of science because scientific literature itself becomes the subject of analysis.

In this study, we aimed to evaluate the cytometric features of the ROP in literature in the period of 1979-2019. To the best of our knowledge, our study is the first to evaluate the ROP literature from a bibliometric and scientometric perspective.

Materials and methods

Due to the design of the study, the board of directors' approval of Medipol University Faculty of Medicine Clinical Research Ethics was not required. All the procedures in this study were conducted following the highest ethical standards as contained in the Declaration of Helsinki (2008).

For this study, the data were obtained from the database of Thomson Reuters Web of Science (Clarivate Analytics, London, UK) in the period of 1979 - 2019. Web of Science (WoS) bibliographic is the strictest database in terms of acceptance and includes four databases titled SciELO Citation Index, Core Collection, Russian Science Citation Index, and Korean Journal Database. The database is accessible from back to 1940. The documents were searched using keywords (Retinopathy of Prematurity) in the 'Title' field, and the VOS viewer software tool to arrange and set biblimetric Networks and figures (VOS viewer 2018) was used. Data were transferred from WoS in the "Full Record and Cited References" content pattern.

The data were divided into the topics of time, countries, authors, research institutes, language, document types, publications, and citations with the WoS analysis tool. Info maps were created with Microsoft Exel software and Bibliometric infographics were created with VOS-Viewer software tool (7).

For the purpose of the research, the population numbers of the countries used in the productivity score accounts were obtained from The Word Bank Data bank (8): The data on GDP per capita was obtained from 2018 World Bank Datahealth expenditure per capita - from OECD Health Statistics 2019 data, and intensive care unit (ICU) beds per 100.000 person data –from the study by Rhodes (9).

Statistical analysis

The data of this study were based on the database of WoS (Clarivate Analytics, London, UK). "Retinopathy of Prematurity " was used as the keyword to search the WoS database. Statistical analysis was completed using IBM SPSS 23.0 (SPSS for Windows, SPSS Inc., Chicago, IL, USA). Correlation analysis was assessed and finalized by the Spearman test since the data were not normally distributed. $P < 0.05$ was accepted as statistically significant.

Results

The aim of the study was to evaluate four decades; therefore, a total of 4080 publications in the period of 1979-2019 were scanned. Of all the evaluated publications, 2217 (54.33%) were original articles, 989 (24.24%) were meeting abstracts and 375 (9.19%) were letters, while the others were of the proceeding paper, editorial material, review, correction, book chapter types, respectively. The most widely used language was English with 3977 (97.47%) publications, while German was ranked second, followed by French, Spanish, Portuguese, Italian, and Turkish (**Table 1**).

Table 1: Document types and published languages in the top 10 in the ROP literature

Type of documents	Number of publications	% of 4080
Article	2217	54,33
Meeting abstract	989	24,24
Letter	375	9,19
Proceedings paper	233	5,71
Editorial material	209	5,12
Review	143	3,5
Correction	35	0,85
Book chapter	17	0,41
Note	12	0,29
Early access	8	0,19
Languages	**Total number of documents**	**% of 4080**
English	3.977	97,47
German	49	1,2
French	16	0,39
Spanish	16	0,39
Portuguese	6	0,14
Italian	5	0,12
Turkish	4	0,09
Korean	3	0,07
Japanese	2	0,04
Polish	1	0,02

Global productivity of countries

A total of 83 countries made 4080 publications on ROP. The United States was the country with the most publications - 1820 (44.6%), followed by the UK - 262 (6.42%), India -242 (5.93%), Turkey - 178 (4.36%), Canada -167 (4.09%), Germany -154 (3.77%), China-153 (3.75%), respectively (**Figure 1**).

The number of publications, the total number of citations, the rate of citations per publication, H-index and the Productivity score of the 10 most productive countries in the ROP field was calculated using the formula (Publication Number/PopulationX 1000, 000). The country with the highest productivity score was Sweden (101.22), followed by the USA, Australia, the UK and Canada, respectively. The country with the most citations is the USA (32463), followed by the UK, Australia, Sweden and Canada, respectively. The country with the most citations per publication was Sweden (25,72 citation per item), followed by Australia, the UK, the USA, and Canada. When the H-Index of countries was evaluted, the USA (77) was in the first place, followed by the UK, Australia, Canada, and Sweden, respectively (**Table 2**).

Top authors

A total of 10117 authors have contributed to ROP literature. Quinn Graham E from Children's Hospital of Philadelphia is the most contributing author to ROP literature, with 139 (3.4%) publications. Chiang Michael F (126; 3%), Chan RV Paul (102; 2, 5%), Trese Michael (86; 2.1%) are the other most contributing authors to the ROP literature (Table 3). The most cited author in the top 10 most published author rankings is Palmer, EA with 6296, while the highest author in the H-index with 35 publications is Quinn, Graham E. (**Table 3**).

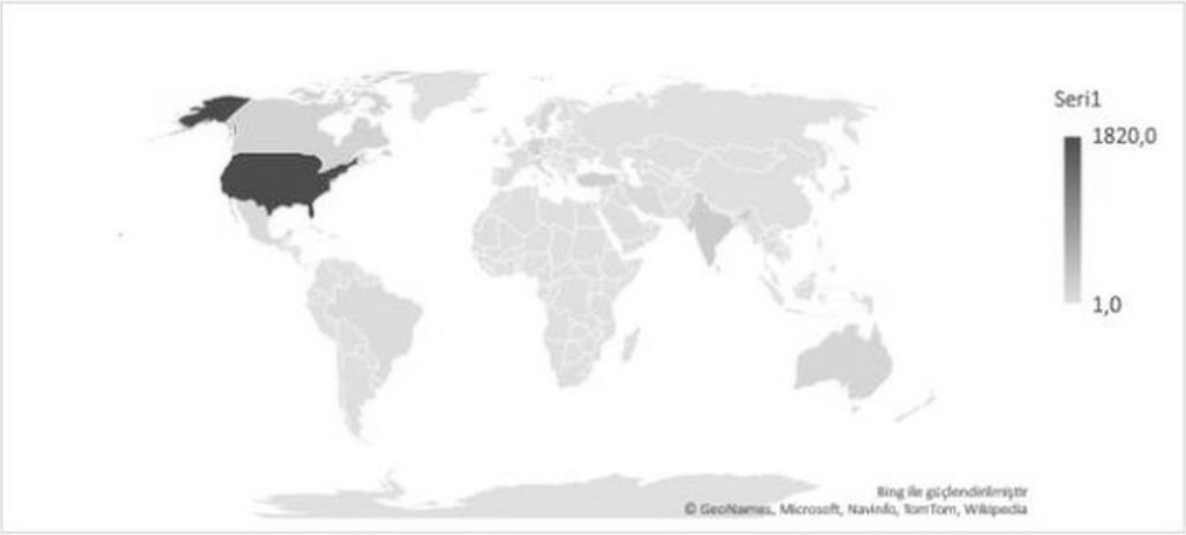

Figure 1: Distribution of ROP publications by country

Table 2: Top 10 countries producing the most publications for ROP literature

Country	Total number of publications	Total citation	Average citation per item	H-index	Productivity score
USA	1820	32463	17,84	77	55,71
UK	262	6263	23,9	40	46,8
Australia	135	3354	24,84	26	54,03
Canada	167	2243	13,43	26	45,06
Sweden	103	2649	25,72	25	101,22
Germany	154	2041	13,25	24	18,57
India	242	1347	5,57	20	1,78
Japan	118	1565	13,26	19	9,32
Turkey	178	1049	5,89	17	21,62
China	153	905	5,92	15	1,09

Bibliometric co-authorship analysis

In bibliometric studies, co-authorship assessments determine the status of authors who publish with local or international cooperations. In the study, the authors co-authorship analysis was mapped (**Figure 2**).

This bibliometric map includes the top 10 authors in Table 3. However, to get a meaningful image of this map, authors who contributed to at least 8 publications were selected, consequently, 275 authors were included on the map making the visualization simple and inclusive.

Evolution of publications and most cited articles

The H- index of Retinopathy of Prematurity literature is 90; so far there are 56753 citations and an average of 13.91 citations per publication. Meanwhile, 1558 publications have received no citation. ROP literature has been steadily increasing in publication over the years (**Figure 3**).

Published in Archives of Ophthalmology Journal (JAMA Opthalmology) in 2005, the article "The International classification of retinopathy of premature revisited has received the most citations in the ROP field. That publication, which received a total of 1288 citations, receives an average of 80.5 citations per year.

Top 10 journals

ROP literature has been published in 468 journals for the last 40 years. The study shows that ome journals make a considerate amount of contributions to ROP literature. A total of 2008 publications are available in the 10-most-published journals, and they cover as much as 49.21% of the entire literature (**Table 5**).

Table 3: In ROP literature, top 10 authors ' publication numbers, H-index and citation values

Authors	Number of published articles	Total citation		Institution
Quinn, Graham E.	139	5568	35	Childrens Hospital of Philadelphia
Chiang, Michael F.	126	1997	24	Oregon Health&Science University
Chan, R. V. Paul	102	817	19	New York-Presbyterian Hospital
Trese, Michael T.	86	1881	25	Oakland University
Capone, Antonio	77	3785	22	Cagliari State Univ
Palmer, EA	72	6296	29	Oregon Health&Science University
Hellstrom, Ann	70	2063	19	University of Gothenburg
Phelps, Dale L.	66	4243	27	State University of New York
Hartnett, M. Elizabeth	65	1575	21	University of Utah
Wallace, David K.	60	2375	20	Indiana University System

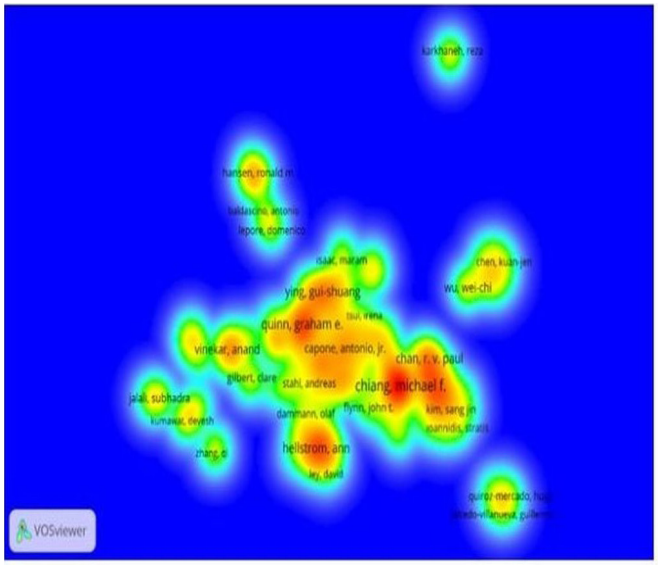

Figure 2: Co-authorship density visiualitation map of ROP

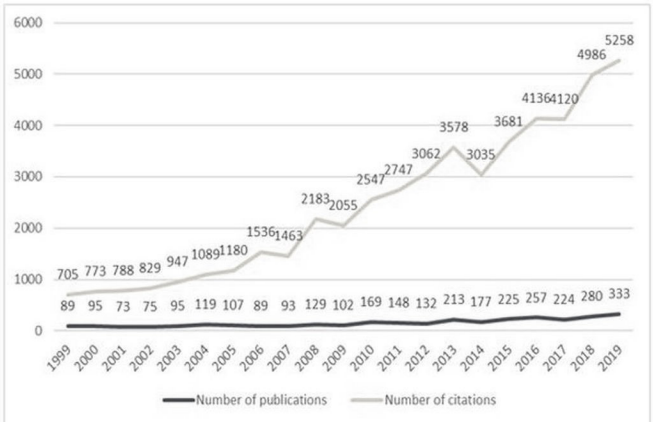

Figure 3: Number of ROP publication and citation on last 20 year

The most published *Investigative Ophthalmology Visual Science* which covers 18.23% of all ROP literature with 744 publications. Other journals with the most contributions to ROP literature are *Archives of Ophthalmology (JAMA Opthalmology)* (n=185; 4.53%) and *Opthalmology* (N=174; 4.26%), respectively.

The most cited journal is *Archives of Ophtalmology (JAMA Opthalmology)*, with an average of 48.63 citations per publication and a total of 8963 citations. Among the top-10 journals, we determined that *the Journal Pediatrics* was the journal that received the most citations (average 50,02) per publication on ROP.

Top 10 institutions

Harvard University is seen as the most contributing Institute to ROP literature with 246 (5.9%) publications and 39 H- index. It was followed by the University of Pennsylvania (N= 180; 4.4%) and The Children's Hospital of Philadelphia (n=157; 3.8%). We determined that 9 of the top 10 institutions are the universities of the USA (**Table 5**).

Bibliometric network analysis

Most frequent keywords

In the keyword term frequency network study, authors were determined to use a total of 2049 keywords. 146 clustered terms were determined when the terms used for a minimum of 5 times in network maps were evaluated. Most frequent terms Figure 4 show density visualization map of the most commonly used terms in our studies.

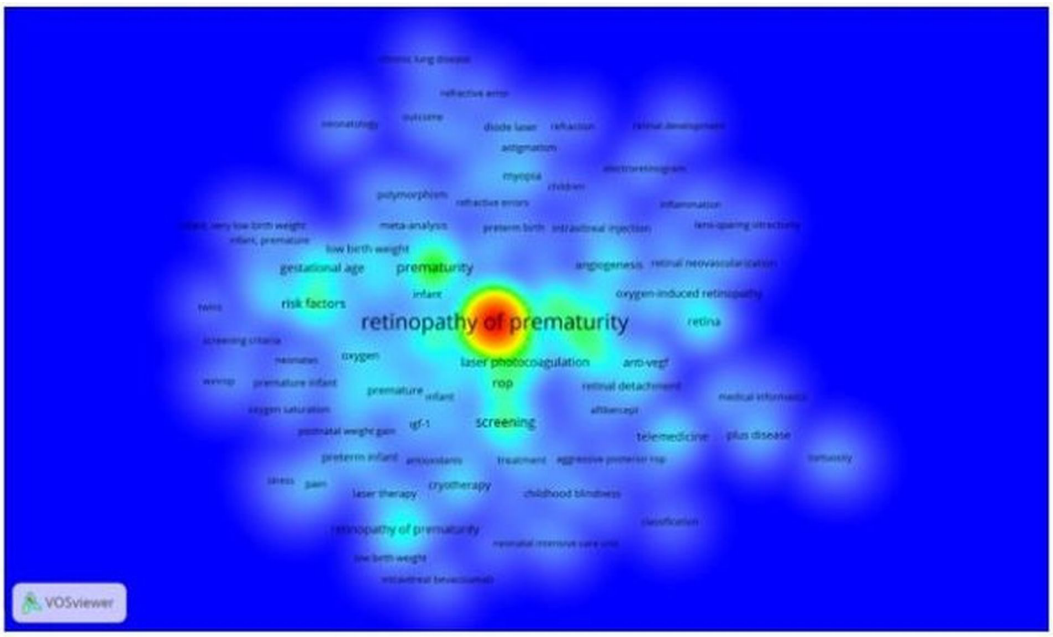

Figure 4: Most frequency key words densitiy visiualization map of coccurence for ROP

Table 4: The most cited articles in the ROP literature

Publication name	Journal	Author	Year	Total number of citations	Number of citations per year
The international classification of retinopathy of prematurity revisited	Archives of Ophthalmology (JAMA)	Gole GA et al.	2005	1288	80,5
Vascular Endothelial Growth-Factor Acts As A Survival Factor For Newly Formed Retinal-Vessels And Has Implications For Retinopathy of Prematurity	Nature Medicine	Alon, T et al.	2005	1205	46,35
Revised indications for the treatment of retinopathy of prematurity-Results of the early treatment for retinopathy of prematurity randomized trial	Archives of Ophthalmology (JAMA)	Good WV et al.	2003	981	54,5
An International Classification of Retinopathy of Prematurity	Archives of Ophthalmology (JAMA)	Garner A	1984	769	20,78
Efficacy of Intravitreal Bevacizumab for Stage 3+Retinopathy of Prematurity	New England Journal of Medicine	Mintz-Hittner, Helen A et al.	2011	591	59,1
Multicenter Trial of Cryotherapy For Retinopathy of Prematurity -Preliminary-Results	Archives of Ophthalmology (JAMA)	Palmer EA	1988	451	13,67
Incidence And Early Course of Retinopathy of Prematurity	Ophthalmology	Palmer EA et al.	1990	445	14,83
Supplemental Therapeutic Oxygen For Prethreshold Retinopathy of Prematurity	Pediatrics	Phelps et al.	2000	413	19,67
Characteristics of Infants With Severe Retinopathy of Prematurity in Countries With Low, Moderate, and High Levels of Development: Implications For Screening Programs	Pediatrics	Gilbert C et al.	2005	398	24,88
Low IGF-I Suppresses VEGF-Survival Signaling in Retinal Endothelial Cells: Direct Correlation With Clinical Retinopathy of Prematurity	Proceedings of The National Academy of Sciences of The USA	Hellstrom A et al.	2001	361	18,5

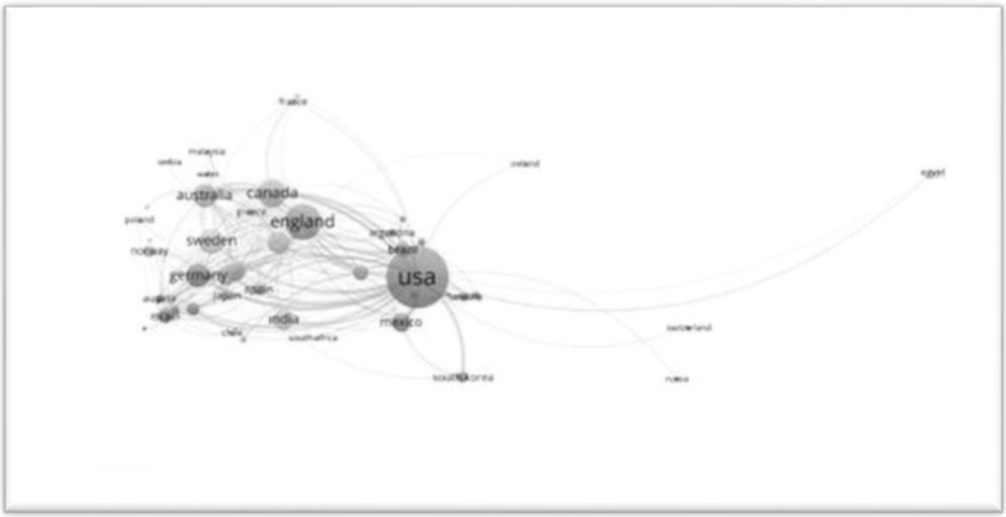

Figure 5: Bibliometric network visualition map of ROP of countries

Table 5: The 10 most published journals and the top 10 Institutions in the ROP literature

Journal	Number of articles	% literature	Total number of citations/ citation per articles		Institution	Number of publica-tion	% Of 4080			
Investigative ophthalmology& visual science- arvo	744	18,23	2759/3,71		Harvard University	243	5,95	5428	22,34	39
Archives of ophthalmology (jama)	185	4,53	8993/48,61	42	University of Pennsylvania	180	4,41	5904	32,8	36
Ophthalmology	174	4,26	5530/31,78	43	Childrens Hospital of Philadelphia	157	3,84	5611	35,74	34
Journal of aapos	166	4,06	2452/14,72	29	Oregon Health Science University	156	3,82	3781	24,24	29
Pediatric research	157	3,84	622/3,96	10	Boston Childrens Hospital	145	3,55	4474	30,86	36
British journal of ophthalmology	142	3,48	3029/21,33	34	University of Texas System	113	2,77	4233	37,46	32
Journal of pediatric ophthalmology strabismus	120	2,94	925/7,71	18	University of Illinois System	99	2,46	1279	12,92	18
Pediatrics	111	2,72	5552/50,02	38	Duke University	98	2,4	1791	18,28	24
American journal of ophthalmology	110	2,69	2042/18,56	25	University of Illinois Chicago	96	2,35	1266	13,19	18
Retina the journal of retinal and vitreous diseases	99	2,42	1994/20,14	25	University of London	94	2,3	3425	36,44	23

Bibliometric analysis of countries

When the relationships between the publications were investigated, the most prominent country with total link strength of 399 is the USA, followed by the UK (161), Canada (106), Sweden (90), and Germany (81). Figure 5 shows the ROP bibliometric network visual map of the countries.

Correlations between socio-economic and health indices with ROP publications:

According to Spearman's correlation analysis, the number of ROP publications of the top 10 countries did not correlate with any of the economic and health system indices (**Table 6**).

However, the productivity scores correlated with the gross domestic product (GDP) per capita and health expenditure per capita (r=0.745 p=0.013 and r=0.697 p=0.025, respectively).

In addition, each of the total citation, average citation and H index values are modarately correlated with income per capita (r=0.758 p=0.011, r=0.673 P=0.033, r=0.693 p=0.026 respectively) and health expenditure per capita (r=0.697 p=0.025, r=0.636 p=0.048, r=0.620, p=0.056 respectively).

As a result, economic development and health system development are related to productivity scores rather than the total number of publications at the ROP disease.

Discussion

Bibliometric indicators (metrics) are numerical measurements that provide quantitative information about research performance. Also, this statistic analysis can be used to evaluate the performance and impact of different entities such as authors, departments, institutions, countries, journals, documents, subject areas, and categories. Bibliometric identifies research trends and the growth of knowledge. It can identify strength the strengths and weaknesses of areas of research and it can be forecast future publishing trends. It also predicts the productivity of publishers, individual authors, organization, and countries, and it can identify potential research collaboration opportunities.

ROP isa disease characterized by retinal blood vessel development disorder in preterm infants. It was first described by Terry in the 1940s (10). Since then, exponentially increasing scientific knowledge has significantly affected the diagnosis and follow-up. Whereas, the causes of childhood vision impairment

Table 6: Correlations of the number and features of publications with economic data and health system data in the top 10 countries publishing about ROP disease.

	GDP (PPP) per capita	Health expenditure (HE) per capita	ICU beds per 100.000 person
Publication numbers	**r=-0.030**	**r=-0.115**	**r=0.212**
	p=0.934	**p=0.751**	**p=0.556**
Productivity Score	**r=0.745***	**r=0.697***	**r=0.273**
	p=0.013	**p=0.025**	**p=0.446**
Total Citation	**r=0.758***	**r=0.697***	**r=0.176**
	p=0.011	**p=0.025**	**p=0.627**
Average Citation	**r=0.673***	**r=0.636***	**r=-0.006**
	p=0.033	**p=0.48**	**p=0.987**
H index	**r=0.693***	**r=0.620**	**r=0.182**
	p=0.26	**p=0.056**	**p=0.614**

*Correlation is significant at the 0.05 level. Statistically significant (0.00<*r*<0.25: little if any correlation; 0.26<*r*<0.49: low correlation; 0.50<*r*<0.69: moderate correlation; 0.70<*r*<0.89: high correlation; 0.90<*r*<1.00: very high correlation). GDP: Gross domestic product; ICU: Intensive care unit

vary considerably across low-income countries, congenital cataract is a leading cause in middle-income countries, which is more likely to result in ROP. In the World Health Organization Vision 2020 study, the frequency and adverse consequences of ROP disease were emphasized and the prevention of childhood blindness was highlighted as a priority (11). Evaluating scientific studies in the field of ROP disease with a bibliometric analysis is important from a global perspective.

There have been three distinct periods that could be termed as ROP "epidemics"; 1940s and early 1950s. The third epidemic, first recorded in the 1990s, developed when ROP blindness was increasingly observed in countries developing neonatal intensive care. The ROP incidence increased due to the increase in assisted reproduction methods, the rate of premature birth, and the increase in the chances of survival of extremely premature babies. The third outbreak is characterized by severe ROP in bigger premature infants in developing countries (12,13).

The ROP literature has been steadily increasing in publication over the years as an indicator of increasing scientific knowledge. We see that the amount of publications, which were in limited numbers prior to 1980, has increased and diversified rapidly. Our study focused on the second and third outbreaks due to the scarcity of publications in the first years. However, when each year was compared to the previous year, it was observed that the citation rates have been increasing continuously, especially for the last 20 years. Between 1979 and 2019, a total of 4080 publications were published. The most citations and most publications were made in 2019, with 5258 citations and 333 publications respectively.

When the bibliometric analysis is evaluated based on the countries, it is possible to see the distribution in the world more clearly. Although 83 countries publish in the field of ROP, the USA took first place and the UK came second **(Table 3)**. More than half of these publications (54,33%) were original articles. It is considered to be a result of ongoing scientific studies. The language of the studies is overwhelmingly English. As English is the generally accepted scientific language, therefore, most of the publications must be from the UK and the USA. Harvard University played an important role in contributing to the ROP literature. The top 10 institutions in the ROP literature were in these two countries. The most cited and H-indexed publications are from these two countries as well.

The bibliometric analysis provides the opportunity to evaluate the contribution of journals to the literature on a particular scientific subject. The contribution of *The Investigative Ophthalmology Visual Science*, *Archives of Ophthalmology (JAMA Opthalmology)*, and *Journal of Pediatrics* to the literature is remarkable. It is noteworthy that the publications in 10 journals cover half of the entire literature.

Authors like Quinn GE, Chiang MF, Chan RVP, Trese

M, Capone A, Palmer EA, and Hellstrom A have published considerable number of studies on ROP. The density visualization map makes the bibliometric analysis more visual. This mapping shows prominent authors who have the most publications and strong links with the references they received.

Bibliometric analyzes of the number of publications and citations have shown that multicentric randomized studies receive the most citations in the ROP field, as in many other fields. Two studies became the touchstone of ROP literature: International Classification of Retinopathy of Prematurity (IC-ROP) Cryotherapy for Retinopathy of Prematurity (CRYO-ROP), and Early Treatment for Retinopathy of Prematurity (ET-ROP) respectively.

The prognosis of the disease has started to change with the development of treatment methods. Firstly, cryotherapy, then indirect laser photocoagulation and anti-vascular endothelial growth factors drugs have been used for treatment, resulting in rapid increase of treatment-related publications. In literature, it is evident that the terms "vascular endothelial growth factor" (n=74) and "bevacizumab" (n=71) are frequently used as key words.

Another important development that affected the prognosis of the disease was the definition and implementation of screening programs in many countries. When we look at the bibliometric analysis, we see that in literature, after the key words "retinopathy of prematurity"(n=1013) and "prematurity"(n=106), the most used keyword was "screening" (n=74). Screening programs, which require an advanced healthcare system, physicians, hospital-related infrastructure, and technical devices, could not be implemented with the same success in every country.

It has been reported that approximately 15 million babies are born premature each year. 1.2 million babies are born in high-income countries with full access to neonatal intensive care. 8.2 million babies are born in middle-income or low-income countries. Due to limited facilities, staff, and equipment in hospitals, in many low-income countries, there are 5.6 million infants born with home care, therefore, with limited chances of survival (14). Also today, necessary ROP treatment is seen in babies with much wider birth weights and gestational ages in middle and low-income countries than in well-developed countries. The reason for this situation is that babies are exposed to risk factors well-controlled in industrialized countries.

GDP per capita is a measure of the economic well-being of a country. HE per capita and ICU beds per 100000 people are indices of advanced levels of the health system. During the study, it was analyzed whether there were possible correlations between the total numbers of ROP publications and the productivity score between the economical productivity index (GDP per capita) and advanced levels of the health system (HE per capita and ICU beds per 100000 people) in the countries. It was an interesting finding that ICU beds per 100.000 people do not correlate with ROP publications in the top 10 countries. The number of intensive care beds was not correlated with the findings in the literature. Economic development index and health expenditure increased the number of publications and citation rate. There were only three countries whose GDP per capita is under 30.000 USA dollars: Turkey, China, and India. The scientific studies of these three countries can be considered to be remarkable.

Our study had some limitations. Firstly, for the purpose of the study, data prior to 1980 and after 2020 were not scanned and in addition to this, only the WoS database was used to search publications. The Wos database was preferred due to its reliable service for publications and citations. All the journals indexed in the WoS database had impact factors. Moreover, a lower number of publications were found because the databases including more journals than WoS, such as Medline, Scopus, or Index Copernicus, were not searched. Finally, only one term (ROP) as a keyword was incluted to prevent the results from being incomprehensible.

Conclusions

ROP and its complications are important public health problems and they pose major socio-economic challenges. This disease affects babies worldwide both in developing and developed countries. ROP publishing has increased in parallel with the increasing rate of disease worldwide, but more high citation ROP studies have been published in developed countries.

Although ROP is a disease directly related to the socio-economic status and health system, it should be aimed to reduce shortcomings in both health practices and publications. Screening programmes and public health policies designed for the developing world are essential. It can be expected that the number of ROP studies will gradually increase in developing countries.

Researching scientific publications on major health issues from a general perspective can produce valuable information onthe scientific background of writers, institutions, countries, and it can shed light on the future of the world.

Conflict of interest

The authors report no conflict of interest.

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Contributions

Research concept and design: **YHO, TAÖ**
Data analysis and interpretation: **YHO, TAÖ**
Collection and/or assembly of data: **YHO, TAÖ**
Writing the article: **YHO, TAÖ**
Critical revision of the article: **YHO, TAÖ**
Final approval of the article: **YHO, TAÖ**

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