Contribution of Turkey in Heart Transplant Research: A Web of Science Database Search

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Abstract

Objectives: **In 2001, Turkey performed its the first successful heart transplant. Since 2011, 765 heart transplants have been conducted among 15 heart transplant centers. The scientific impact of Turkish articles on heart transplantation remains uncertain. The purpose of this study was to evaluate Turkey's contributions in international heart transplant research.**
Materials and Methods: **The bibliometric study approach was used to assess publications on heart transplantation, which included analysis of year of publication, organizations/authors, sponsorship, keywords, citations, and other characteristics. Titles, abstracts, and key words were searched in the Web of Science database for terms that included "heart" or "cardiac" and "transplantation." Methods for both quantitative and qualitative data analysis were used.**
Results: **During the analysis period of 1970 through 2021, 6370 article publications were retrieved with an average of 20.88 citations/article and 133 018 total citations. H index was 129. Most of the retrieved articles were from research areas of surgery (n = 2876; 45.14%), followed by transplantation (n = 2818; 44.23%) and cardiovascular system cardiology (n = 2522; 39.59%). Annual citation growth showed slow growth until 1986. The highest number of citations was seen in 2021 (n = 702). The United States led countries on articles (n = 2924; 45.9%), followed by Germany (n = 458; 7.19%), England (n = 411; 6.45%), Canada (n = 384; 6.02%), France (n = 330; 5.18%), and Spain (n = 329; 5.16%). The other 84 countries totaled 753 (11.82%) articles. Turkey ranked eighteenth with 87 publications, with Başkent University (n = 37) and Ege University (n = 13) being the leading centers on heart transplant research in Turkey.**
Conclusions: **Publications from the United States continue to increase. The workload of both transplant surgery and research and publishing is challenging and Turkish researchers are encouraged to make strides at innovations.**

Key words: *Articles, Bibliometrics, Literature search, Publications*

Introduction

Heart transplantation is now a recognized treatment for end-stage heart failure despite ongoing difficulties.[1] Since Doctor Christiaan Barnard conducted the first human heart transplant in history more than 50 years ago, heart transplantation has significantly advanced, lowering the morbidity and mortality experienced by patients with heart failure.[2] Survival and quality of life of heart transplant recipients have improved with numerous recent developments.[1]

The total number of heart transplants performed each year in the United States has increased over the past 5 years. In 2016, more than 3000 hearts were transplanted.[3] The number of new heart transplants increased by 42.5% between 2008 and 2019, from 2867 to 4086.[4] After 2008, there have been some notable demographic changes in heart transplant recipients, including stable ratios of men and women, a decline in the proportion of White recipients (from 70.4% in 2008 to 60.4% in 2019), an increase in the number of Black recipients (from 19.1% to 26.0%) and Hispanic recipients (from 7.4% to 9.7%), a marginal rise in recipients with congenital heart disease, and a marked decline in recipients with coronary artery disease. However, the percentage of candidates with cardiomyopathy diagnosis has grown, with it being the most prevalent diagnosis

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among candidates in 2019 (59.7%).[3] In October 2018, the new adult heart allocation rule went into effect after being authorized in 2016. The Annual Data Report offered early perspectives on this legislation. With 4086 new candidates, new postings in 2019 grew again, with 3597 heart transplants conducted in 2019, up 157 (4.6%) from 2018. Of these, 509 were performed on children and 3088 on adults. Posttransplant death rates both in the short-term and long-term have decreased. Overall, the mortality rates for adult transplant recipients were 6.4% at 6 months, 7.9% at 1 year, 14.4% at 3 years, and 20.1% at 5 years in 2018, 2016, and 2014.[3]

To maximize the utilization of donor hearts, there was discussion on considering transplanting hearts from donors positive for hepatitis C virus or donors who died from opioid overdose because of ongoing donor shortages and the high waitlist mortality rate.[5] The key rate-limiting step in heart transplant continues to be donor supply. In addition, heart transplant candidates are older, more frequently use mechanical circulatory support devices, and have higher levels of antigen sensitization.[6]

Although the first heart transplant applications in Turkey in 1968 did not achieve clinical success, Bayezid and colleagues later performed a successful heart transplant.[7] Turkey's first successful pediatric heart transplant was at Gazi University in April 2001.[8] Today, heart transplants are performed in 15 centers in Turkey, mostly in 3 large cities (Istanbul, Ankara, and Izmir).[9] According to data from the Turkish Ministry of Health, 765 heart transplants have been performed in Turkey since 2011.[9] Although these facts are generally recognized and well-documented, the scientific impact of Turkish articles on heart transplantation remains uncertain. The purpose of this study was to evaluate international heart transplant research and Turkey's status.

Materials and Methods

The ethics committee waived study approval because this study was a literature survey. Typically, no ethical approval is needed for bibliometric-type investigations because there are no human or animal participants.

Key words related to heart transplant (Dataset: TI = *heart or cardiac and transplant** or transplantation) were used in a search query in the Web of Science (WOS) search engine. SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, and ESCI indexes were searched.

Results were limited to United Kingdom English and United States English words. The time span was set from January 1970 through December 2021. From the WOS database, general information about the retrieved documents was ascertained, such as growth of publications, the most active countries and institutions, and the most cited journals, with analysis of mapping of publications and keywords.

With 79 different types of results, the search query was limited to only journal articles (Table 1). We analyzed retrieved data to present various bibliometric indicators, and data presented as maps were visualized using the VOSviewer (version 1.6.10, Leiden University). From the WOS database, we retrieved complete text versions of the included publications. We used the VOSviewer program during bibliometric analysis to display the collaboration networks, emphasis, and potential future trends. Data were loaded into the VOSviewer program. We extracted and examined authorship, affiliation, citation, keywords, and theme words. Finally, we created bubble maps to display the findings of the bibliometric investigation. We used colors in the bubble maps to represent item clusters and the space and width between 2 bubbles to represent the frequency of associations. We used diameters of the bubbles to represent the numbers of documents, citations, and occurrences. We used the Hirsch (H) index and journal impact factor as indicators of impact of publications.

To access the data, we used the online library of the Çanakkale Onsekiz Mart University. We used Microsoft Excel spreadsheets and both quantitative and qualitative methodologies to assess the data.

Results

All publications

A total of 14 832 publications were retrieved. The first publication was in 1970. The annual growth of the publications and the distribution of publications by document type are shown in Figure 1 and Table 1.

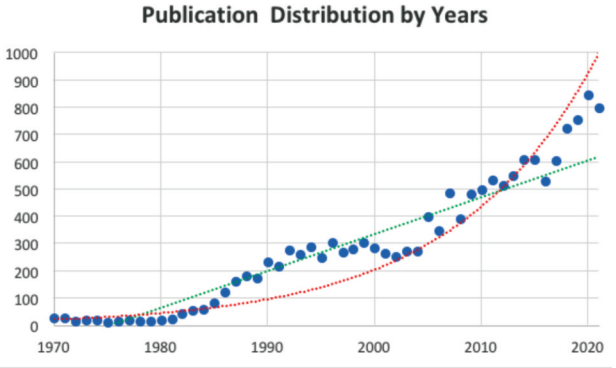
Articles

A total of 6370 article publications were retrieved, with an average of 20.88 and total of 133 018 citations. The H index was 129. The first cited article from 1970 had 1 citation; in total, 16 articles were published in 1970.

Table 1. Publication Types

Document Type	Number	%
Meeting abstracts	6624	44.660
Research articles	6369	42.941
Proceedings papers	870	5.866
Letters	574	3.870
Editorial materials	525	3.540
Review articles	296	1.996
Notes	164	1.106
Corrections	59	0.398
Early access	47	0.317
News items	47	0.317
Book chapters	24	0.162
Book reviews	23	0.155
Corrections, additions	6	0.040
Biographical items	5	0.034
Discussions	3	0.020
Expressions of concern	3	0.020
Retractions	2	0.013
Poetry	1	0.007
Reprints	1	0.007
Retracted publications	1	0.007

Figure 1. Total Publication From 1970 Through 2021



Red dotted line is the exponential median. Green dotted line is the trendline.

Most of the retrieved articles were from research areas of surgery (n = 2876; 45.14%), followed by transplantation (n = 2818; 44.23%), cardiovascular system cardiology (n = 2522; 39.59%), immunology (n = 1268; 19.90%), respiratory system (n = 1236; 19.40%), and varied areas (Table 2).

Active countries, institutions, and journals

The United States led other countries on number of articles (n = 2924; 45.9%), followed by Germany (n = 458; 7.19%), England (n = 411; 6.45%), Canada (n = 384; 6.02%), France (n = 330; 5.18%), and Spain (n = 329; 5.16%). The other 84 countries had 753 articles (11.82%). Turkey ranked eighteenth (Table 3).

Articles coauthored by authors from more than 1 country were classified as "international collaborations." These international studies were conducted among 82 countries. Figure 2 shows a visualized map of international collaboration networks. International collaboration analysis for active countries with at least 1 document showed that there were clusters of international collaborations (Figure 2).

Table 2. Main Research Areas of Publications

Main Research Area	No.	% (N = 6370)
Surgery	2876	45.149
Transplantation	2818	44.239
Cardiovascular system cardiology	2522	39.592
Immunology	1268	19.906
Respiratory system	1236	19.403
General internal medicine	314	4.929
Pediatrics	287	4.505
Infectious diseases	166	2.606
Pharmacology pharmacy	160	2.512
Radiology nuclear medicine medical imaging	131	2.057
Research experimental medicine	127	1.994
Pathology	113	1.774
Urology nephrology	87	1.366
Engineering	73	1.146
Anesthesiology	71	1.115
Nursing	68	1.068
Medical laboratory technology	62	0.973
Microbiology	62	0.973
Physiology	62	0.973
Psychology	60	0.942
Hematology	57	0.895

Table 3. Top 19 Active Countries in Publishing Articles on Heart Transplant

Ranking	Countries/Regions	No.	% (N = 6370)
1	USA	2924	45.903
2	Germany	458	7.190
3	England	411	6.452
4	Canada	384	6.028
5	France	330	5.181
6	Spain	329	5.165
7	Italy	326	5.118
8	Japan	174	2.732
9	Australia	130	2.041
10	Netherlands	126	1.978
11	Peoples Republic of China	126	1.978
12	Poland	125	1.962
13	Switzerland	120	1.884
14	Austria	106	1.664
15	Belgium	103	1.617
16	Brazil	99	1.554
17	Sweden	88	1.381
18	Turkey	87	1.366
19	Norway	83	1.303

Citing analysis

Retrieved articles had 133 018 total citations, with an average of 20.88 citations per article. The H index of the retrieved articles was 129.

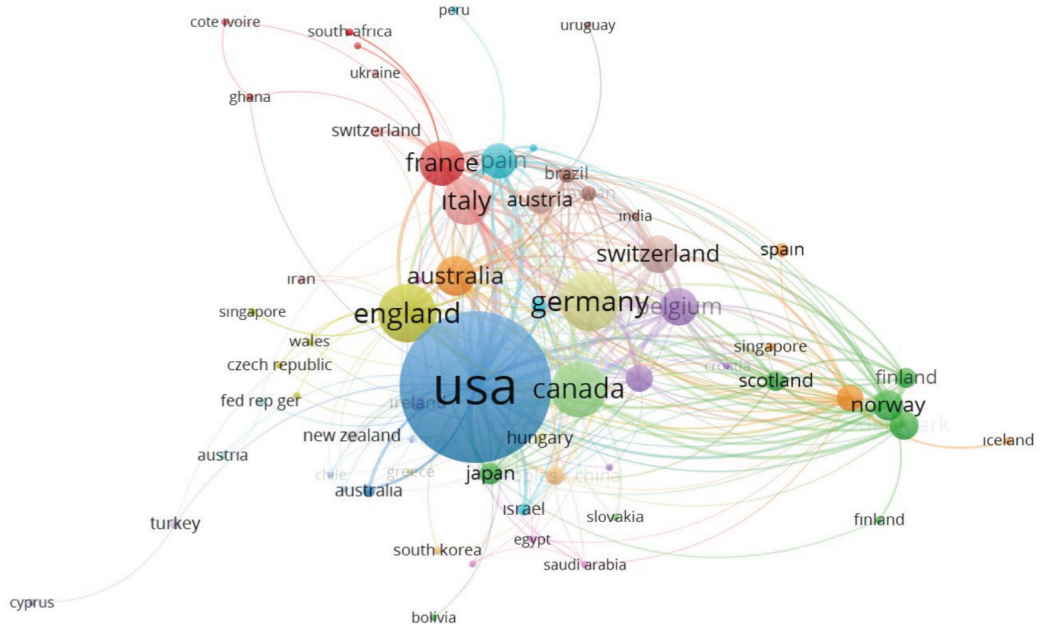
Status of citation numbers

Annual citation growth showed slow growth until 1986. The highest number of citations was seen in 2021 (>700) (Figure 3).

Country citations

Collaboration among different nations are shown in Figure 4 (with stronger partnerships represented by

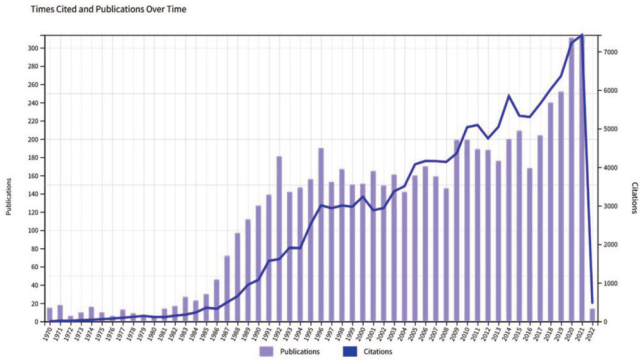
Figure 2. Network Visualization Map of Coauthorship Among Countries With ≥1 Publication on Heart Transplant



Lines connecting countries are indicative of collaboration. Thicker lines indicate stronger collaborations. Countries represented with larger circle size or font size had relatively more international collaborations.

thicker lines and greater international cooperation shown as countries with larger circles or letter sizes).

Figure 3. Citations From 1970 Through 2022



Line shows the cite number.

Author citation

Lines connecting countries are indicative of citations. As shown in Figure 5, larger circle size or font size showed authors with relatively more citations.

Journals

The top 3 cited articles on heart transplant were published in *The Journal of Heart and Lung Transplantation* (n = 827), *Transplantation Proceedings* (n = 719 citations), other transplant journals (306 citations) (Table 4).

Stanford University published the highest number of heart transplant articles (n = 271, 4.254%). Table 5 summarizes publishing organizations and affiliations on heart transplant.

Table 4. Top 25 Journals on Heart Transplant

	Journal	No. of Articles	% (N = 6370)		Journal	No. of	% (N = 6370)
1	*Journal of Heart and Lung Transplantation*	827	12.983	14	*Journal of the American College of Cardiology*	69	1.083
2	*Transplantation Proceedings*	719	11.287	15	*Journal of Heart Transplantation*	43	0.675
3	*Transplantation*	306	4.804	15	*European Journal of Cardio Thoracic Surgery*	41	0.644
4	*Clinical Transplantation*	202	3.171	17	*CHEST*	40	0.628
5	*Pediatric Transplantation*	180	2.826	18	*Vestnik Transplantologii I Iskusstvennyh Organov*	36	0.565
6	*American Journal of Transplantation*	138	2.166	19	*European Heart Journal*	32	0.502
7	*Circulation*	134	2.104	20	*Progress in Transplantation*	32	0.502
9	*Journal of Thoracic and Cardiovascular Surgery*	102	1.601	21	*American Heart Journal*	31	0.487
9	*Annals of Thoracic Surgery*	101	1.586	22	*Interactive Cardiovascular and Thoracic Surgery*	31	0.487
10	*American Journal of Cardiology*	93	1.460	23	*International Journal of Cardiology*	30	0.471
11	*Experimental and Clinical Transplantation*	89	1.397	24	*Revista Espanola de Cardiologia*	29	0.455
12	*Transplant Infectious Disease*	75	1.177	25	*Transplant Immunology*	28	0.440
13	*Transplant International*	70	1.099				

Table 5. Top 25 Organizations / Affiliations on Heart Transplant

Organization/Affiliation	No. of Articles	% (N = 6370)
Stanford University	271	4.254
Pennsylvania Commonwealth System of Higher Education PCSHE	211	3.312
Harvard University	205	3.218
University of California System	195	3.061
Columbia University	179	2.810
University of Pittsburgh	175	2.747
University of Toronto	158	2.480
Assistance Publique Hopitaux Paris APHP	142	2.229
Cleveland Clinic Foundation	128	2.009
University of California Los Angeles	126	1.978
University of Utah	124	1.947
Utah System of Higher Education	124	1.947
Mayo Clinic	122	1.915
University of Alabama System	110	1.727
University of Alabama Birmingham	108	1.695
University of Pennsylvania	106	1.664
Johns Hopkins University	103	1.617
University of Munich	100	1.570
University of Texas System	100	1.570
University Health Network Toronto	92	1.444
Papworth Hospital	87	1.366
University of Michigan	87	1.366
University of Michigan System	87	1.366
State University System of Florida	85	1.334
Brigham Women's Hospital	84	1.319

Key words

Table 6 shows the preferred keywords on heart transplant among publications.

Articles from Turkey

There were 87 articles from Turkey, with 77 affiliations contributing to medical literature on heart transplant research. Başkent University (n = 37) and Ege University (n = 13) were the leading affiliations from Turkey on heart transplant research (Table 7).

Experimental and Clinical Transplantation was the largest publishing journal on heart transplant research from Turkey, showing 34 articles according to our findings (Table 8).

Figure 6 presents a bibliographic coupling visualization map of articles with a minimum of 1 occurrence on heart transplantation from Turkey (with connecting lines representing occurrence relations in articles and key words with larger circle size or font size showing relatively strong correlation in the articles).

Figure 4. Visualization Map of Citations for Countries With ≥1 Publication on Heart Transplant

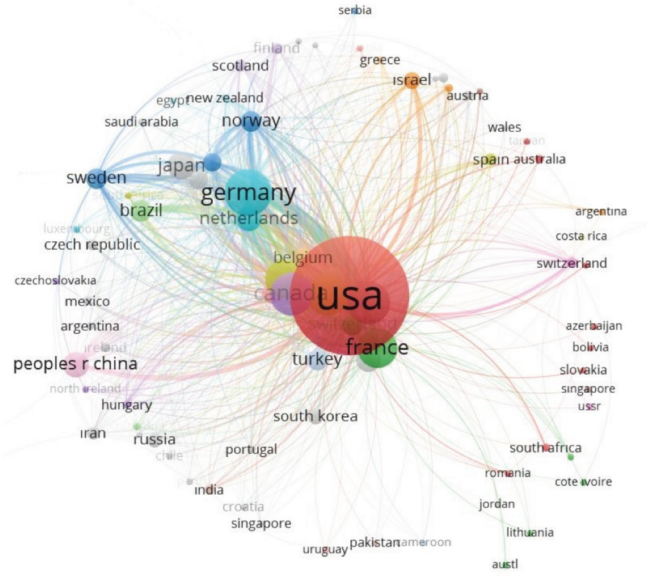


Figure 5. Authors With ≥20 Publications and 200 Citations on Heart Transplantation

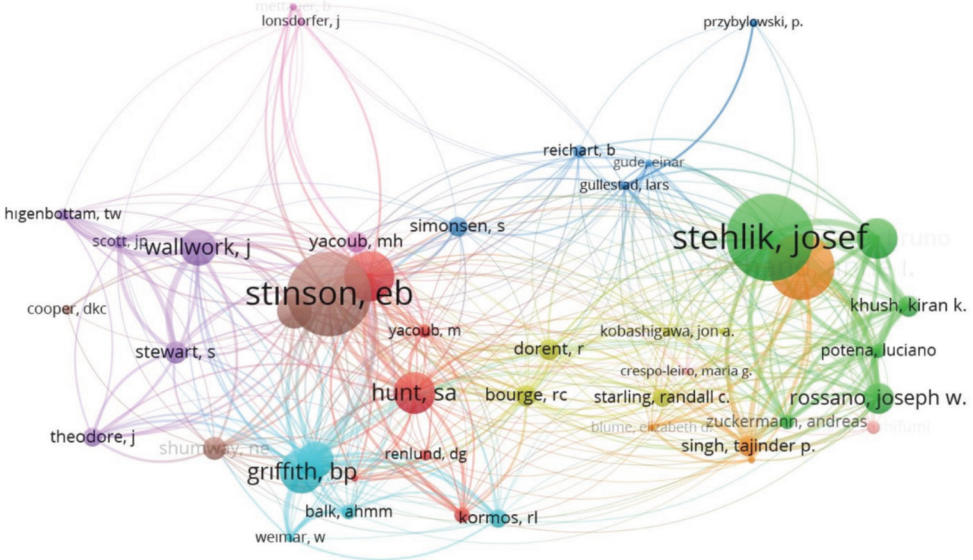


Figure 6. Bibliographic Coupling Visualization Map of Turkish Heart Transplant Publications With ≥1 Occurrence

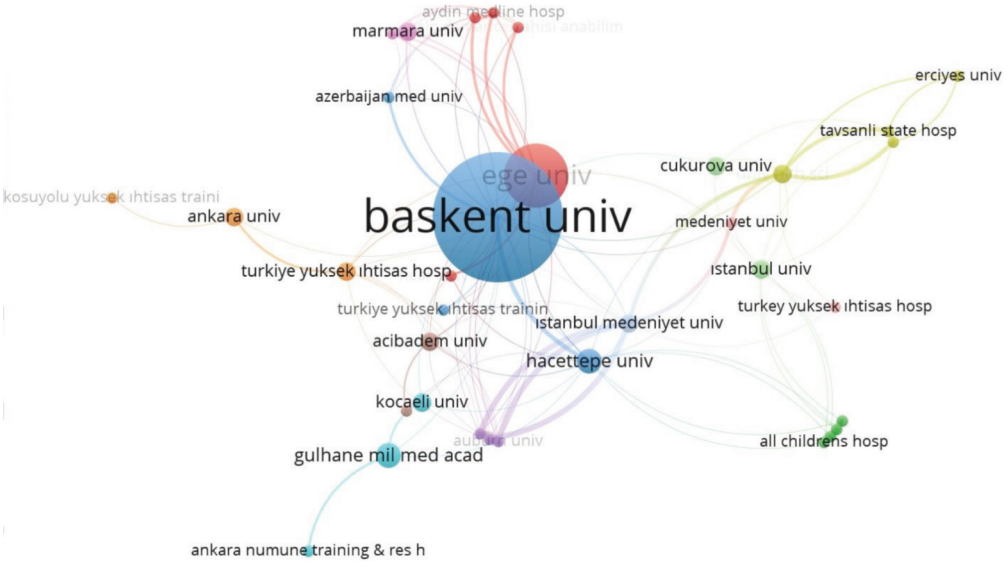


Table 6. Number of Keyword Occurrences Within Published Articles (Minimum of 15 Occurrences)

Key Word	No.	Key Word	No.	Key Word	No.	Key Word	No.
heart transplantation	946	ventricular assist device	41	pharmacokinetics	26	organ transplantation	19
heart transplant	478	acute rejection	39	transplantation	26	orthotopic heart transplant	19
transplantation	250	risk factors	39	immunosuppression	26	chronic kidney disease	18
heart failure	179	sirolimus	39	clinical research	25	coronary angiography	18
rejection	138	everolimus	38	graft rejection	25	depression	18
cardiac transplantation	126	mechanical circulatory support	38	practice	25	dysfunction	18
immunosuppression	114	cardiology	37	renal function	25	therapeutic drug monitoring	18
cardiac allograft vasculopathy	99	cardiomyopathy	37	vasculopathy	25	complications	17
transplant	92	congenital heart disease	36	acute cellular rejection	24	heart (allograft) function	17
survival	91	cytomegalovirus	35	cardiac	24	hemodynamics	17
heart	90	liver transplantation	35	magnetic resonance imaging	24	patient survival	17
heart transplantation	80	quality of life	35	extracorporeal membrane oxygenation	23	allograft	16
pediatric	78	coronary artery disease	34	graft survival	23	cardiovascular disease	16
pediatrics	74	mycophenolate mofetil	33	covid-19	22	nitric oxide	16
pediatric heart transplant	71	pediatric heart transplantation	33	orthotopic heart transplantation	22	primary graft dysfunction	16
echocardiography	68	exercise	32	cyclosporine	21	renal failure	16
cardiac transplant	65	left ventricular assist device	32	lung transplant	21	allograft vasculopathy	15
mortality	55	prognosis	31	outcome	21	biomarker	15
outcomes	55	renal transplantation	30	endomyocardial biopsy	20	blood pressure	15
children	51	lung transplantation	29	heart rate variability	20	case report	15
tacrolimus	50	antibody-mediated rejection	28	infection	20	coronary allograft vasculopathy	15
cyclosporine	47	heart rate	28	cardiac function	19	donation after cardiac death	15
pulmonary hypertension	44	cardiac transplantation	27	heart transplant recipients	19	epidemiology	15
kidney transplantation	43	myocardial infarction	27	hypertension	19	rejection	15

Table 7. Affiliations With More Than 3 Articles on Heart Transplant Research From Turkey

Affiliations	No.	% (N = 87)
Baskent University	34	39.080
Ege University	13	14.943
Turkey Specialized Higher Education Research Hospital	7	8.046
Istanbul Kartal Kosuyolu Yuksek Ihtisas Training Research Hospital	6	6.897
Gulhane Military Medical Academy	4	4.598
Akdeniz University	3	3.448
Ankara Training Research Hospital	3	3.448
Hacettepe University	3	3.448
Istanbul University	3	3.448

Table 8. Journals With the Most Published Articles (≥2) on Heart Transplant Research From Turkey

Journal	No.	% (N = 87)
Experimental and Clinical Transplantation	34	39.080
Transplantation Proceedings	12	13.793
Turk Gogus Kalp Damar Cerrahisi Dergisi [Turkish Journal of Thoracic and Cardiovascular Surgery]	4	4.598
Turk Kardiyoloji Dernegi Arsivi [Archives of the Turkish Society of Cardiology]	4	4.598
Anadolu Kardiyoloji Dergisi [The Anatolian Journal of Cardiology]	2	2.299
Clinical Research in Cardiology	2	2.299
Clinical Transplantation	2	2.299
Journal of Heart and Lung Transplantation	2	2.299
Thoracic and Cardiovascular Surgeon	2	2.299

Discussion

Research plays a large role in the growth and advancement of a nation. The scientific community can learn new things thanks to an investigator's project being published, and researchers can share their findings by publishing their original research. Publications are usually consulted to determine whether research efforts were successful. There has been a recent increase in interest in creating scientific metrics that could help with the analysis of study results.[10,11] Preoperative planning and postoperative treatment, which are both time-consuming but essential elements of surgery, are also included in transplantation in addition to the actual surgical procedure. Balancing the workload of conducting research, publishing, and transplant surgery is challenging.[12]

This study provided a bibliometric review of the heart transplant literature from 1970 to 2021, examining the characteristics of global publications and the publications from Turkey. The goal of this study was to produce a systematic and comprehensive overview of articles on heart transplantation. To our knowledge, no similar bibliometric study on heart transplantation exists in the literature.

The well-known WOS database, which we used for our study, has been used in earlier published bibliometric analyses.[11,13-17] Our results showed that, during the past 10 years, the number of publications on heart transplantation has been increasing steadily. The fact that the H index is high despite the small number of publications shows how important this topic is to a wide range of doctors and academics. Top countries of research publications were the United States, Germany, and England. Turkey ranked eighteenth with 87 articles, whereas the United States published 2924 research articles and had the greatest percentage of publications among the listed countries. Scientific activity can be measured quantitatively by the number of publications, and it can also be measured qualitatively by the number of innovations.[13-17] Our results also took into account this numerical condition in relation to cardiac transplants. We also found that the United States and other European countries produced the most research articles on cardiac transplantation (45.903%). These findings suggest that Turkey has to publish substantially more to prevent its scientific significance from being diminished.

The growing numbers of heart transplant articles needs to be investigating with regard to the disparity between coauthorship and citation counts. This topic is a worldwide issue that necessitates more investigations conducted in partnership with other countries. A law governing the collection, storage, grafting, and transplantation of organs and tissues was passed in 1979 as a result of the work of Prof. Haberal and his teams.[18] Religion can have an impact on transplant in Turkey and other nations. For Muslims around the world, Haberal and his teams' efforts in 1980 resulted in the Religious Affair Supreme Council's declaration that the Quran had no prohibitions against organ transplantation. In addition, the Turkish Ministry of Health created Nationwide Coordination Centers for the distribution of dead donor organs in 2001 after launching a national organ exchange program in 1989.[19]

Presently, Turkey has more than 15 heart transplant centers.[9] Finding a suitable heart donor can be quite difficult in Turkey. Because of the scarce number of available organs, only 24 heart transplants were performed in 2021 and 21 in 2020. The highest number of heart transplants (n = 95 and n = 91) were performed in 2018 and 2011.

There have also been substantial developments in heart transplantation in Turkey. The first heart transplant in our country was performed in 1968 at Ankara Yüksek İhtisas Hospital by Dr. Kemal Beyazıt. Three days later, at Istanbul Haydarpasa Thoracic Surgery Center, Dr. Siyami Ersek performed the second heart transplantation in Turkey. However, these 2 patients died. Cevat Yakut and Ömer Bayezid make the first successful heart transplant in 1989 at Istanbul Koşuyolu Heart and Research Hospital. Later, in 1990 at Hacettepe University and Ankara University İbni Sina Hospital, became heart transplant operations centers. With heart transplant operations performed in different clinics since 1998, operation speed has increased. However, the annual number of heart transplants, which is around 20 to 30, is insufficient. The most important problem with regard to low number of transplants in Turkey is donor supply.[20,21] The Başkent University treatment program was started in 2002, and it is still one of the busiest transplant centers in our country. Heart support devices and heart transplant operations are used as a surgical treatment of end-stage heart failure in pediatric and adult patients.[22] This situation may

explain the highest number of publications on heart transplantation from Turkey.

Limitations

The research consisted of a single database search. However, the retrieved data may have only represented the information that was accessible on the day of study because new articles are published every day and publications from other databases were excluded.

Conclusions

Heart transplantation is expanding, placing more of an emphasis on equity and giving patients who are most in need this important limited resource. The donor pool should be increased, a new allocation method should distribute donors more fairly, desensitization techniques should evolve, and a better ability to identify rejection and allograft vasculopathy is required.

To predict risk and optimize therapy, we foresee a more tailored approach to posttransplant care that includes customized immunosuppressive regimens, biomarkers, and advanced scanning. The next major area of development in transplant cardiology will probably be our understanding of tailored and precise care.

Publications on heart transplantation have been increasing over the past 2 decades. Although the United States has had a continuous growth of publications, the rest of the world contributed considerable shares, with growing numbers of articles worldwide. Although citation numbers are high, international collaborations are needed.

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