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Self-Management of Kidney Transplant Recipients Research: A Comprehensive Bibliometric Analysis

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Objective: This study analyzes research trends in self-management among kidney transplant recipients to inform future directions.

Methods: Bibliometric analysis was performed on 444 English articles related to self-management of kidney transplant recipients in the Core Collection of Web of Science and Scopus databases using COOC 12.8, R software, Microsoft Excel 2019, VOSviewer, and CiteSpace, with a focus on citation ranking, publication year, journal, country, organization, author, impact factor, and keywords.

Results: Four hundred and forty-four English articles revealed the United States as the leading publisher on kidney transplant recipient self-management. Norway's University of Oslo was the most productive institution, with Mirjam Tielen as the most prolific author and SCHÄFER-KELLER as the most influential. Belgium's research was most cited. Emerging hotspots included medication adherence, quality of life, psychological aspects, telemedicine, and health literacy in self-management research.

Conclusion: This study has identified the most influential articles concerning the self-management of kidney transplant recipients, documented the pivotal journals in the field, and noted the most prolific countries, organizations, and authors contributing to the literature, as well as highlighted upcoming research trends. Going forward, the research in kidney transplant recipient self-management should explore the full potential of interdisciplinary integration, particularly by incorporating telemedicine into self-management education. Future efforts should also be directed towards refining the existing post-transplant follow-up management systems and enhancing lifelong care for kidney transplant recipients. Concurrently, there is a need to improve health literacy and self-management capabilities among these patients, with the ultimate goal of improving their prognosis.

Keywords: self-management, kidney transplant, recipients, bibliometric analysis, visual analysis

Introduction

End-stage renal disease is recognized as a major public health problem, and kidney transplantation is a life-saving treatment for patients with renal failure.[1] Because of the primary kidney disease of renal transplant recipients and immunosuppressive therapy after renal transplantation, renal transplant recipients have a lot of related symptoms and high symptom burden, affecting their quality of life.[2,3] Early diagnosis and preventive measures are necessary to reduce the occurrence of life-threatening complications and graft loss.[4] Self-management is a critical and challenging aspect of health management in kidney transplantation. Kidney transplant recipients are required to adhere to long-term postoperative treatment and comply with medical instructions to regulate their health behaviors for optimal outcomes.[5] Recipients with inadequate self-management exhibit higher rates of

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rejection, post-transplant rehospitalization, and increased susceptibility to graft failure.[6] Individualized and professional self-management programs are of great significance to improve the quality of life of kidney transplant. In recent years, significant advancements and numerous research accomplishments have been made in the field of self-management for renal transplantation. However, there is a lack of comprehensive bibliometric analysis to examine the current research status, identify key areas of focus, and explore emerging research directions in this domain. Therefore, it is necessary to analyze the development status and predict the development trend of self-management for kidney transplant recipients to help health care workers develop and improve self-management programs for renal transplant recipients. Bibliometric analysis is a research method based on mathematical statistics that clarifies academic productivity, summarizes research trends and hot spots, and predicts the development direction of the research field through qualitative and quantitative evaluation.[7,8] In this study, we aimed to analyze the current status, hot spots, frontier directions of self-management of renal transplantation and puts forward targeted suggestions, in order to provide reference for the development of self-management of kidney transplant recipients in the future.

Data and Methods

Data Source and Search Strategy

The articles were identified from a literature search using Core Collection of Web of Science (WOSCC), SCOPUS. We performed a Boolean search on two lists with the operator "and". Refer to the subject words and free words compiled by the National Library of Medicine to formulate search words. The first list included the following search structure: TS = (Kidney Transplantation OR Renal Transplantation OR Renal Transplantations OR Transplantations, Renal OR Transplantation, Renal OR Grafting, Kidney OR Transplantation, Kidney OR Kidney Transplantations OR Transplantations, Kidney). The second list included the following search structure: TS = (self-management OR Self Care OR Self Efficacy OR Self-Control OR Self-Regulation OR Self Control). We searched articles (Document Type) in English (Languages) published between the literature from the establishment of the database to April 30, 2024.

Data Extraction and Collection

The data for this investigation were gathered from Core Collection of Web of Science (WOSCC), SCOPUS.[9] All the information, including the number of publications and citations, titles, publication year, countries of publications, institutions, journals, authors, keywords, and references, was collected. For more accurate bibliometric data analysis, information such as countries, institutions, and keywords, was cleaned from the above-mentioned document data to reduce the bias caused by some inherent weaknesses in these databases. Furthermore, the impact factor (IF) (2023) and Journal citation reports (JCR) (2023) were obtained from the Web of Science.

Inclusion/Exclusion Criteria

The inclusion criteria were as follows: (a) articles as the type of literature; and (b) literature published in English; and (c) literature form the establishment of the database to April 30, 2024. Duplicate publication and other types of publications (such as meeting abstracts, editorial materials, letters and early access, etc) were excluded. The included literature was manually checked by two authors independently. The deduplicated data is converted into a data format that can be recognized by the software through the built-in data converter of CiteSpace. The format is converted by the software's own format conversion tool.

Bibliometric Analysis

The analysis conducted in this study utilized the Bibliometrix package in R software (4.3.11), Microsoft Excel 2019, VOSviewer (1.6.18), and CiteSpace (6.2.R4.). We used Microsoft Excel 2019 to analyze the publication trends in the literature and applied a polynomial-fitting curve to predict future publication numbers. In addition, we also used the Bibliometrix software package and VOSviewer to construct national cooperation networks, author cooperation networks, institutional cooperation networks and document co-citation relationships. Finally, we created keyword bursts and keyword cluster visualization maps using CiteSpace.

Results

Bibliometric Analysis of Publication Years

A total of 444 articles were published before April 30, 2024. The annual volume of articles on self-management of kidney transplant recipients showed a gradual upward trend. Overall, there was an overall upward trend in the number of publications (Figure 1). The curve fitting results show that the annual publications conform to a binomial formula, expressed by the formula $y = 0.0393\times^2 + 0.0695x$. The polynomial-fitting curve suggests that research in this area will continue to grow, as indicated by an R^2 value of 0.6527 (Figure 1).

Analysis of Most Productive Countries/Regions

In this study, 229 countries contributed to the publication on self-management of renal transplant recipients. Table 1 lists the 10 most productive countries. The United States (USA) published the highest number of papers. China was the next leading country followed by NETHERLANDS. Publications from the USA were cited the most (Cited 2004 times). Publications from SWITZERLAND had the highest average citation per paper (61.5), followed by AUSTRALIA (30.8). There were large number of papers on multi-country publications (MCP) from the USA. The country co-authorship analysis showed the level of interaction between influential countries in this field. With a threshold of at least 3 publications per country, 59 countries are selected, forming a graph of national collaborations with 322 links and a total link strength (TLS) of 473 (Figure 2). Researchers from the USA displayed the highest collaboration level with a TLS of 35, followed by the Netherlands (TLS = 20) and Germany (TLS = 17). Furthermore, USA maintained close relations with Canada, Netherlands maintained close relations with Iran, Germany, whereas Belgium had strong cooperative bonds with Brazil and Switzerland (Figure 2).

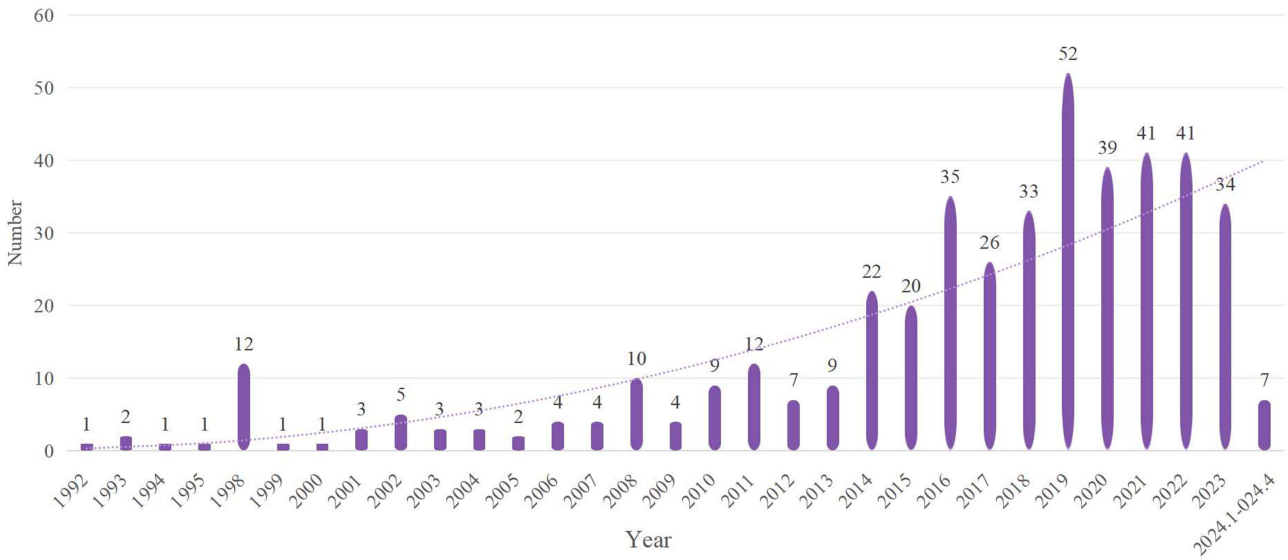

Figure 1 Annual trend chart of publications.

Description: This figure depicts the annual publication trend in the field of Self-management of kidney transplant recipients Research from the establishment of the database to April 30, 2024.It illustrates the number of scholarly articles published each year, providing a visual representation of the research activity and growth in this domain over time.

Data Source: 444 English articles related to self-management of kidney transplant recipients in the Core Collection of Web of Science and Scopus databases, which are renowned for their comprehensive indexing of scholarly publications. The data extraction period extends from January 1992 to April 2024, ensuring a thorough capture of the research landscape in the field.

Time Frame: The chart covers a period of 1992 to April 30, 2024.

Methodology: The data was compiled and plotted using Microsoft Excel 2019. The trend line was generated using the best-fit linear regression model to highlight the overall pattern of publication growth.

Y-Axis: Represents the number of publications per year, with the scale adjusted to accommodate the maximum number of publications recorded.

X-Axis: Represents the years from 1992 to April 30, 2024, with each Vertical bar corresponding to a year.

Trend Line: The solid line represents the linear trend of annual publications, indicating the rate of increase or decrease in publication output.

Markers: Individual data points are marked with Vertical bar, representing the actual number of publications for each year.

Table 1 Top 10 Most Productive Countries on Self-Management of Renal Transplant Recipients

Rank	Country	Record Counts	Total Citations	Average Article Citations	MCP[a]	SCP[b]	Frequency
1	USA	80	2004	25	6	74	0.184
2	CHINA[c]	38	401	10.6	4	34	0.087
3	NETHERLANDS	19	470	24.7	3	16	0.044
4	KOREA	18	111	6.2	0	18	0.041
5	CANADA	15	332	22.1	3	12	0.034
6	AUSTRALIA	12	370	30.8	3	9	0.028
7	SWITZERLAND	12	736	61.5	1	11	0.028
8	IRAN	10	60	6	3	7	0.300
9	UNITED KINGDOM	10	283	28.3	1	9	0.023
10	GERMANY	8	193	24.1	1	7	0.125

Notes: MCP[a]: articles in which all authors have the same country affiliation are called SCP and are considered to represent intra-country (within) collaboration. SCP[b]: Articles with authors having different country affiliations are called MCP and are considered to represent the international collaboration of that country. [c] CHINA: Including the mainland of China, Hong Kong.
Abbreviations: SCP, single-country publications; MCP, multiple-country publications.

Concerning the top 10 most frequent institutions, ERASMUS MC in the Netherlands is the leading institution, followed by ERASMUS UNIVERSITY ROTTERDAM in the Netherlands (Table 2). Four were located in the USA, and three were located in the Netherlands. The network of institutional collaborations is shown in Figure 3. Using a threshold of at least three publications per institution, a total of 137 countries were selected, resulting in a chart with a total link strength (TLS) of 164 (Figure 3). The institutions with the most collaborations included Northwestern University (TLS=35), UNIVERSITY OF SYDNEY (TLS=23), and University of Pennsylvania (TLS=21).

Analysis of Influential Authors

In terms of the most influential authors, Tielen, Mirjam (TLS 85) first and Weimar Willem (TLS 76) with 18 publications, followed by Van Gelder (TLS 61) with 7 publications, Boonstra, Charlotte with 5 publications. The top three local authors with the most citations are SCHÄFER-KELLER 115 times, DE GEEST 108 times, and DENHAERYNC 102 times. The network visualization maps for author co-authorship on kidney transplant recipient self-management are shown in Figure 4. Remarkably, several authors tended to cooperate with a small group of collaborators, generating five major clusters of authors, each usually having two or three core authors.

Analysis of Most Active Journals

The results of this study provide an overview of the 10 most productive journals on kidney transplant recipient self-management. The overview includes information such as journal name, number of publications, JCR ranking, IF for the year 2023, and journal country. According to the JCR (2023) standards, more than half of these journals are classified as Q1 or Q2 (see Table 3). Out of the 10 journals, five are published in the USA and three are published in the UK. The journal with the highest number of publications was *TRANSPLANTATION PROCEEDINGS*, followed by *CLINICAL TRANSPLANTATION*. Table 3 presents the top 10 research areas ranked by publication counts.

Analysis of Highly Cited References

Table 4 provides a summary of the key attributes of the top 10 highly cited research papers focusing on self-management among kidney transplant recipients. These studies were classifiied based on JCR 2023 standards, with 3 being cross sectional studies, 1 prospective cohort study, 1 review, 2 systematic reviews, 1 Quasi-randomized controlled study and 2

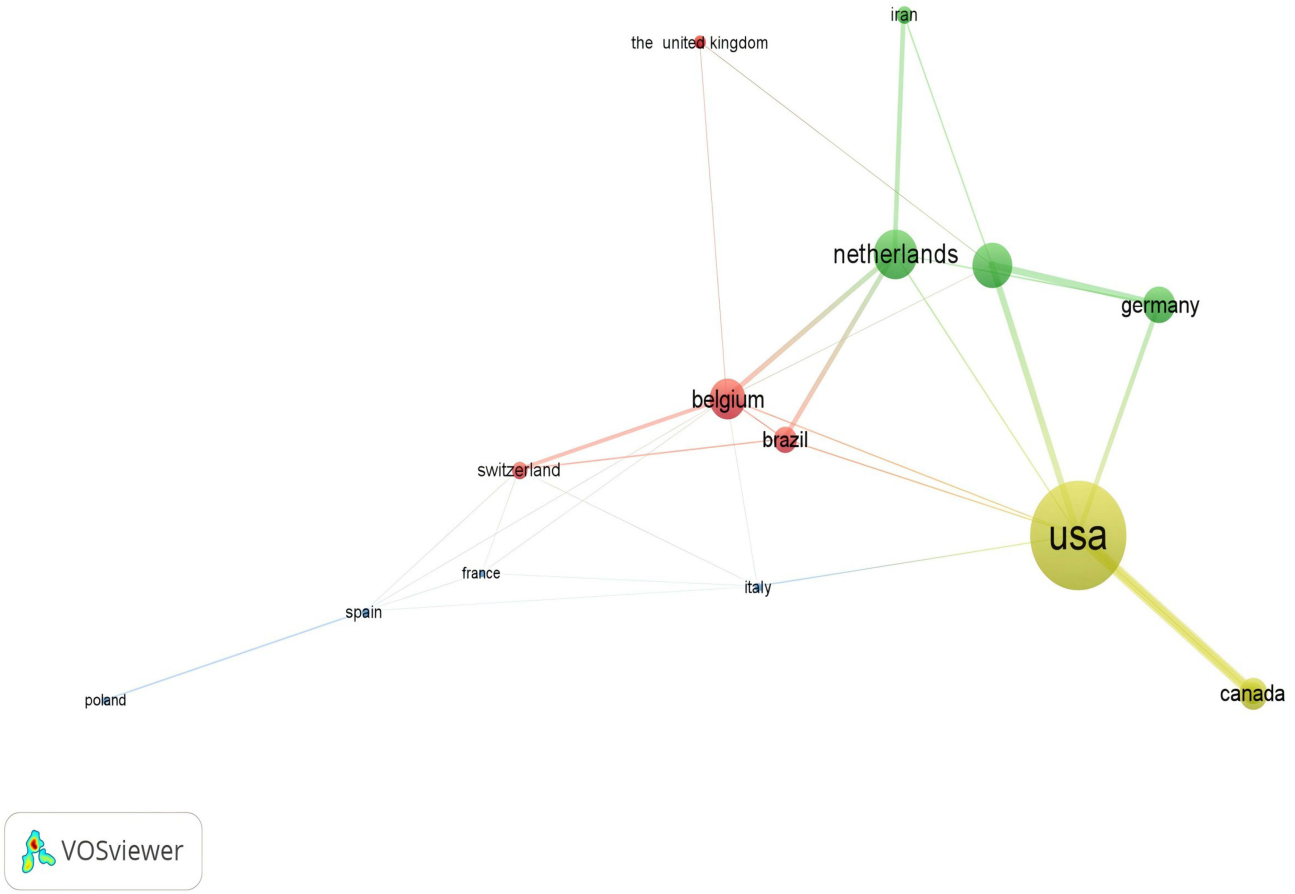

Figure 2 Network visualization map for Country collaboration.
Description: This network visualization map delineates the collaborative landscape among countries engaged in research on the self-management of kidney transplant recipients. The map is constructed based on the collaborative countries data extracted from scholarly publications indexed in Web of Science and Scopus databases, spanning from 1992 to April 2024.
Data Source: 444 English articles related to self-management of kidney transplant recipients in the Core Collection of Web of Science and Scopus databases, which are renowned for their comprehensive indexing of scholarly publications. The data extraction period extends from January 1992 to April 2024, ensuring a thorough capture of the research landscape in the field.
Time Frame: The analysis encompasses a 32-year period, offering a longitudinal view of international research collaboration trends in the specified domain.
Methodology: VOSviewer (1.6.18) software was utilized to create the network visualization, employing bibliometric techniques to map and analyze the collaborative ties between countries. The software's clustering algorithm was applied to identify dense areas of collaboration, revealing the structure of the global research network.
Nodes: Each node represents a country that has contributed to the research on self-management of kidney transplant recipients. The size of the node is proportional to the total number of publications or collaborations attributed to that country, reflecting its research output and collaborative activity.
Edges: The edges connecting the nodes indicate Collaboration Network between countries. The thickness of the edges corresponds to the strength of collaboration, with thicker lines signifying more robust research partnerships.
Clusters: Countries are grouped into clusters based on their collaborative ties. Each cluster represents a distinct community of countries that frequently collaborate with each other in the field of study.
Colors: The color coding of nodes and clusters facilitates the visualization of different research Country within the global network.
Labels: Country names are labeled for nodes with significant research output or centrality in the network, aiding in the identification of key players in the field.
Scale: The map is scaled to reflect the density of collaborations, with the most active regions of the network appearing larger due to the concentration of collaborations.

randomized controlled studies. The studies encompass various topics, such as patient compliance and education. Seven of the 10 most cited articles provided evidence of noncompliance with medical advice in renal transplant recipients. PA Frazier analyzed Correlates of noncompliance among renal transplant recipients, including follow-up compliance and medication compliance, noncompliant with the follow-up regimen noncompliant with medications, stress was the strongest predictor of both medication and follow-up compliance.[10] DEnhaerynck and Geest, who reported at different times the Incidence, determinants, and consequences of noncompliance with immunosuppressive therapy in renal transplant recipients.[11,12] Sabina De Geest conducted a pilot randomized controlled trial (RCT) to test the efficacy of educational behavioral intervention in improving compliance in non-compliant RTx patients.[13] Jac Kee Low proposed

Table 2 Top 10 Most Frequent Institutions on Self-Management of Renal Transplant Recipients

Affiliation Country Articles	Affiliation Country Articles	Count
ERASMUS MC	The Netherlands	40
ERASMUS UNIVERSITY ROTTERDAM	The Netherlands	28
FEINBERG SCHOOL OF MEDICINE	USA	24
MCGILL UNIVERSITY	Canada	24
UNIVERSITY SYSTEM OF OHIO	USA	24
NORTHWESTERN UNIVERSITY	USA	23
UNIVERSITY OF OSLO	Norway	18
UNIVERSITY OF PENNSYLVANIA	USA	18
UNIVERSITY OF SYDNEY	AUSTRALIA	17
ERASMUS UNIVERSITY ROTTERDAM	The Netherlands	17

that interventions to improve medication compliance in adult renal transplant recipients require multi-level interventions of behavior, education, and emotional changes, encouraging patients to participate in the development of management plans and conduct self-monitoring.[14]

Painter reported a randomized clinical trial of exercise after renal transplantation (RTX). Exercise training after RTX results in higher levels of measured and self-reported physical functioning; however, exercise alone does not affect body composition.[15] McGillicuddy investigated the attitudes of kidney transplant recipients toward mobile phone health monitoring. Kidney transplant recipients had a positive overall attitude toward mobile phone-based health technology (mHealth) and believed that mHealth provided an opportunity to increase self-efficacy and improve provider-driven medical management.[16] Jamieson conducted Motivations, Challenges, and Attitudes to Self-management in Kidney Transplant Recipients: A Systematic Review of Qualitative Studies and found that a multicomponent intervention of personalized care plans, education, psychosocial support, decision aids, and self-monitoring tools can enhance self-management skills and improve transplant outcomes.[17]

Bibliometric Analysis of Co-occurring Keywords Cluster and Reference Burst

The frequency of a keyword indicates its significance in inferring research hot spots in the field. Keyword clustering is reasonable when the S value is greater than 0.5 and convincing when the clustering module value exceeds 0.7. The clustering structure is significant when the clustering module value is greater than 0.3.[18] For kidney transplantation self-management, the S value of the keyword clustering is 0.8799 and Q value is 0.5662, indicating high clustering credibility. Figure 3 shows that the keyword clustering involves seven categories: # 0 “middle aged”; # 1 “quality of life”; # 2 “medication adherence”; # 3 “young adult”; # 4 “intentions”; # 5 “medical care”; # 6 “patient education”; # 7 “pharmacist”. Table 2 reveals that among the top 20 high-centrality keywords, including Kidney transplantation (count, 210), quality of life (count, 113), medication adherence (count, 60), self-care (count, 60), renal transplantation (count, 57), recipients (count, 55), self-management (count, 55). Based on Table 5 and Figure 5, the identified research hotspots are compliance, quality of life, psychology, self-management across all ages, and education.

The clustering algorithm in CiteSpace software employs nominal terms to identify hot spots in subject research, allowing researchers to discover significant keywords in knowledge maps, analyze research trends, and determine research directions. As depicted in Figure 6, the occurrence of explosive words is mainly concentrated in four stages. They are Stage 1: Focus on Kidney Transplant Disease, Treatment Adherence (1998–2013) Stage 2: Improve Quality of Life through Risk Factor Management (2013–2016) Stage 3: Focus on Psychology, Starting from Self-efficacy (2016–2020) Stage 4: Improve health literacy through patient education, thereby enhancing self-management ability (2020–2024).

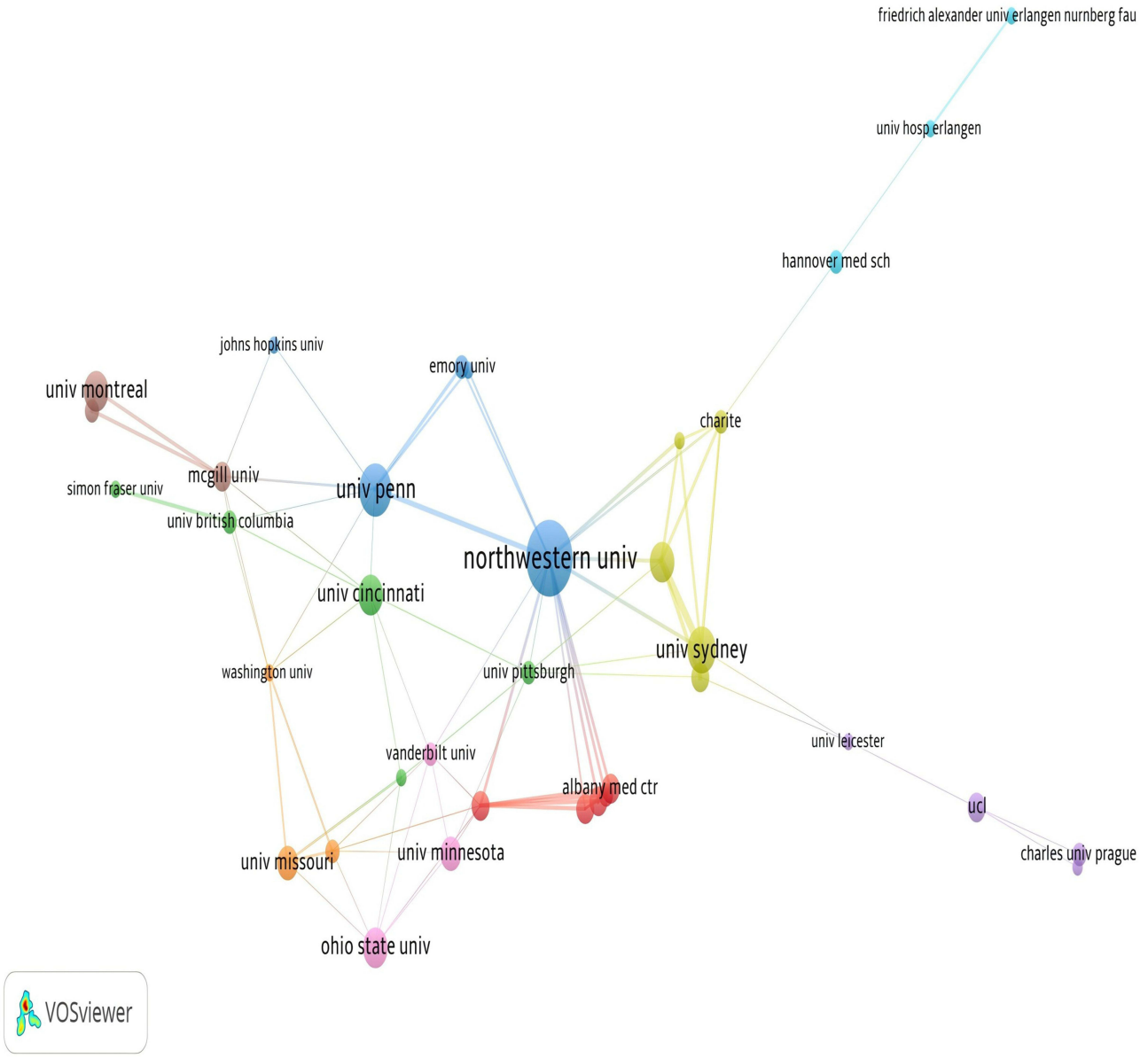

Figure 3 Network visualization map for institution collaboration.

Description: This network visualization map illustrates the collaborative relationships among institutions engaged in research on the self-management of kidney transplant recipients. The map is constructed based on the collaborative institution data extracted from scholarly publications indexed in Web of Science and Scopus databases, spanning from 1992 to April 2024.

Data Source: 444 English articles related to self-management of kidney transplant recipients in the Core Collection of Web of Science and Scopus databases, which are renowned for their comprehensive indexing of scholarly publications. The data extraction period extends from January 1992 to April 2024, ensuring a thorough capture of the research landscape in the field.

Time Frame: The analysis encompasses a 32-year period, offering a longitudinal view of international research collaboration trends in the specified domain.

Methodology: VOSviewer (1.6.18) software was utilized to create the network visualization, employing bibliometric techniques to map and analyze the collaborative ties between institutions. The software's clustering algorithm was applied to identify dense areas of collaboration, revealing the structure of the global research network.

Nodes: Each node represents an institution that has contributed to the research on the self-management of kidney transplant recipients. The size of the node is proportional to the total number of publications or collaborations attributed to that institution, reflecting its research output and collaborative activity.

Edges: The edges connecting the nodes represent the collaboration between the institutions. The thickness of the edges corresponds to the strength of collaboration, with thicker lines signifying more robust research partnerships.

Clusters: Institutions are grouped into clusters based on their collaborative ties. Each cluster represents a distinct community of institutions that frequently collaborate with each other in the field of study.

Colors: The color coding of nodes and clusters facilitates the visualization of different research institution within the global network.

Labels: Institution names are labeled for nodes with significant research output or centrality in the network, aiding in the identification of key players in the field.

Scale: The map is scaled to reflect the density of collaborations, with the most active regions of the network appearing larger due to the concentration of collaborations.

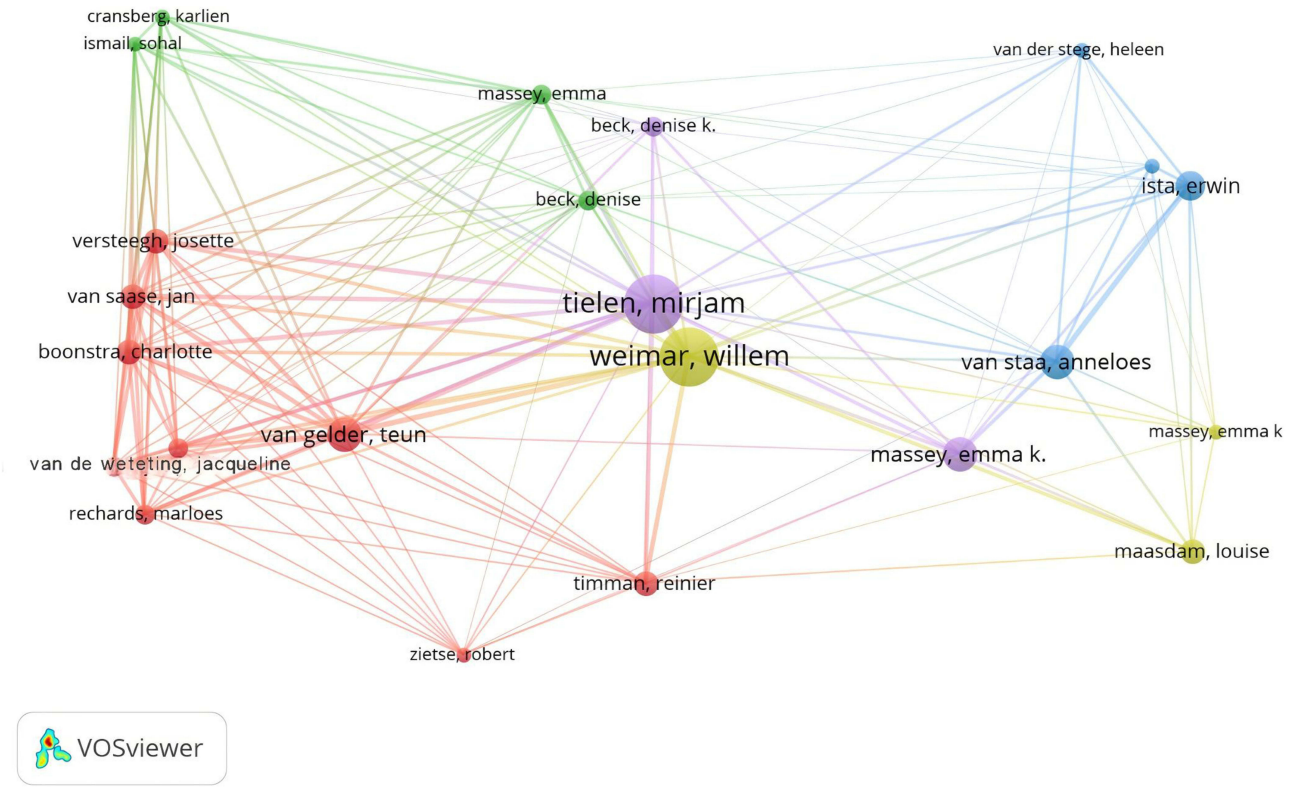

Figure 4 Network visualization map for authors collaboration.
Description: This network visualization map depicts the collaborative ties among authors contributing to the field of self-management of kidney transplant recipients. The map is constructed based on co-authorship data extracted from scholarly publications indexed in Core Collection of Web of Science (WOSCC) and Scopus databases from 1992 to April 2024.
Data Source: 444 English articles related to self-management of kidney transplant recipients in the Core Collection of Web of Science and Scopus databases, which are renowned for their comprehensive indexing of scholarly publications. The data extraction period extends from January 1992 to April 2024, ensuring a thorough capture of the research landscape in the field.
Time Frame: The analysis spans a 32-year period, providing an in-depth view of international research collaboration trends within the specified research domain.
Methodology: VOSviewer (1.6.18) software was employed to generate the network visualization, utilizing bibliometric techniques to map and analyze the collaborative relationships between authors. The software's clustering algorithm was applied to identify and visualize dense areas of collaboration, revealing the structure of the global research network.
Nodes: Each node in the network represents an author who has contributed to the research on self-management of kidney transplant recipients. The size of the node is proportional to the author's total number of publications or collaborations, indicating their research output and level of engagement in the field.
Edges: The edges connecting the nodes signify collaboration between authors. The thickness of the edges corresponds to the strength of collaboration, with thicker lines indicating more frequent or impactful collaborative efforts.
Clusters: Authors are grouped into clusters based on their collaborative ties. Each cluster represents a distinct community of authors who frequently collaborate with each other within the research domain.
Colors: Color coding of nodes and clusters helps visualize the different research authors in the global network.
Labels: Author names or initials are labeled for nodes with significant research output or centrality in the network, aiding in the identification of key contributors in the field.
Scale: The map is scaled to reflect the density of collaborations, with the most active regions of the network appearing larger due to the concentration of collaborations.

Discussion

This study utilizes bibliometric methods to analyze the developmental trends and research priorities concerning the self-management of kidney transplant recipients. Moreover, it aims to identify the primary contributors to this field of research and significant cited documents. The research outcomes provide valuable insights for studying the self-management of renal transplant recipients, ignite ideas for future research, and offer benefits to researchers by leveraging the advantages of disciplinary integration and resource complementarity. These findings contribute to the advancement and improvement of self-management practices for individuals who have undergone renal transplantation.

Table 3 Top 10 Most Active Journals on Self-Management of Renal Transplant Recipients

Sources	Record Counts	IF (2023)	JCR (2023)	JC
TRANSPLANTATION PROCEEDINGS	23	0.8	Q4	USA
CLINICAL TRANSPLANTATION	19	1.9	Q3	ENGLAND
PROGRESS IN TRANSPLANTATION	17	0.6	Q4	USA
TRANSPLANTATION	16	5.3	Q1	USA
JOURNAL OF CLINICAL NURSING	13	3.2	Q1	ENGLAND
PLOS ONE	12	2.9	Q1	USA
AMERICAN JOURNAL OF KIDNEY DISEASES	11	9.4	Q1	USA
PATIENT EDUCATION AND COUNSELING	10	2.9	Q2	IRELAND
PEDIATRIC TRANSPLANTATION	10	1.2	Q3	DENMARK
BMC NEPHROLOGY	9	2.2	Q2	ENGLAND

Temporal Trends on Kidney Transplantation Self-Management

The change in the number of academic publications serves as a vital indicator of evolving trends within a field. The global trend regarding the annual number of publications and the corresponding cumulative number demonstrated a steady increase starting from the establishment of the database to April 30, 2024, with approximately fifty percent of these articles being published in the past six years. Furthermore, the curve-fitting results further confirmed this trend. The outcomes of the study highlighted that kidney transplantation self-management has emerged as an increasingly significant research topic, drawing substantial attention and scholarly effort. In recent years, advancements in surgical techniques and the utilization of more effective immunosuppressive agents have led to improved patient survival rates. In view of this, it is predictable that as countries worldwide engage in comprehensive research on self-management across the entire kidney transplantation recipient life cycle, the number of publications in this domain will continue to increase.

General Knowledge Structure on Kidney Transplantation Self-Management

From the perspective of countries, the total number of publications serves as a crucial indicator reflecting a country's productivity and output.[19] The USA held an overwhelmingly dominant position in terms of both publication count and citation impact. The country co-authorship map revealed that the USA possessed the largest nodes and densest links, demonstrated significant national and international collaboration in kidney transplantation self-management research suggesting its early involvement in research within this domain. The aforementioned outcomes underscored the substantial contribution of the USA to research in kidney transplantation self-management.

Regarding the economy, among the top ten most socially representative countries, all except China and IRAN were developed nations. This observation indicates a close correlation between the level of scientific research and economic development. China emerged as the second-largest publishing country, a development that could be attributed to the policy guidance from the organ transplantation community. The international organ transplantation community and its Chinese counterpart exhibit mutual understanding, support, communication, and cooperation, leading to a growing closeness in their relationship. Moreover, China is increasingly engaged in the establishment of an international transplant governance system.

From the perspective of author, Lotka's Law is utilized to analyze the distribution of authors in Social Network Service research. According to the formula $f(x)=f(1)/x^2$ (where f(x) represents the number of authors who have written x papers, and f(1) represents the number of authors who have written 1 paper), it becomes evident that authors who have written only one paper constitute approximately 60% of the total proportion of all authors.[20] However, in this study, the

Table 4 Characteristics of Top 10 highly Cited Literature on Self-Management of Renal Transplant Recipients

Title	Author	Public Year	Journal	DOI/PMID	TC per Year	Normalized TC	IF (2023)	JCR (2023)	Article Type	Global Citations
Prevalence, consequences, and determinants of nonadherence in adult renal transplant patients: a literature review	DENHAERYNCK K	2005	*TRANSPLANT INTERNATIONAL*	10.1111/j.1432-2277.2005.00176.x	15.68	4.64	3.10	Q1	review	298
Incidence, determinants, and consequences of subclinical noncompliance with immunosuppressive therapy in renal transplant recipients	DEGEESTS	1995	*TRANSPLANTATION*	10.1097/00007890-199502150-00006	9.20	1.00	5.30	Q1	cross-sectional study	276
A study of treatment compliance following kidney transplantation	KILEY DJ	1993	*TRANSPLANTATION*	10.1097/00007890-199301000-00010	7.06	2.06	5.30	Q1	cross-sectional study	219
Prevalence and risk factors of non-adherence with immunosuppressive medication in kidney transplant patients	DENHAERYNCK K	2007	*AMERICAN JOURNAL OF TRANSPLANTATION*	10.1111/j.1600-6143.2006.01611.x	8.33	3.06	8.90	Q1	prospective cohort study	150
A randomized trial of exercise training after renal transplantation	PAINTER PL	2002	*TRANSPLANTATION*	10.1097/00007890-200207150-00008	6.43	2.66	5.30	Q1	randomized controlled trial	148
Correlates of noncompliance among renal transplant recipients	FRAZIER PA	1994	*CLINICAL TRANSPLANTATION*	7865918	4.45	1.00	1.9	Q3	cross-sectional study	138
Patient attitudes toward mobile phone-based health monitoring: questionnaire study among kidney transplant recipients	MCGILLICUDDY JW	2013	*JOURNAL OF MEDICAL INTERNET RESEARCH*	10.2196/jmir.2284	9.50	2.36	5.8	Q1	Quasi-experimental study	114
Motivations, Challenges, and Attitudes to Self-management in Kidney Transplant Recipients: A Systematic Review of Qualitative Studies	JAMIESON NJ	2016	*AMERICAN JOURNAL OF KIDNEY DISEASES*	10.1053/j.ajkd.2015.07.030	12.56	4.68	9.4	Q1	systematic review	113
Interventions to improve medication adherence in adult kidney transplant recipients: a systematic review	LOW JK	2015	NEPHROL DIAL TRANSPL	10.1093/ndt/gfu204	10.90	4.60	4.80	Q1	systematic review	109
Supporting medication adherence in renal transplantation (SMART): a pilot RCT to improve adherence to immunosuppressive regimens	DE GEEST S	2006	CLINICAL TRANSPLANTATION	10.1111/j.1399-0012.2006.00493.x	5.16	1.84	1.9	Q3	randomized controlled trial	98

Table 5 Keywords in the Top 20 of Self-Management of Kidney Transplantation

Rank	Keyword	Initial Occurrence Time	Count
1	Kidney transplantation	1994	210
2	Quality of life	2002	113
3	Medication adherence	2014	60
4	Self-care	2014	60
5	Renal transplantation	2010	57
6	Recipients	1999	55
7	Self-management	2010	49
8	Adherence	1999	39
9	Nonadherence	2010	37
10	Kidney transplant	2004	36
11	Outcome	2010	32
12	Kidney graft	2015	31
13	Psychology	2014	31
14	Patient education	2012	30
15	Aged	2014	29
16	Questionnaire	2016	28
17	Depression	2008	27
18	Care	2006	25
19	Follow up	2003	24
20	Education	2019	19

proportion of authors who have published only one paper in English is 84.13%, which is significantly higher than the expected 60%. Therefore, no core contributors were formed. Analyzing the most influential authors aids scholars in comprehending both the current and potential cooperative relationships within their field, both domestically and internationally.[21] The co-citation analysis reveals that SCHÄFER-KELLE, DE GEEST, DENHAERYNC were hold prominent positions, having received the highest number of citations. In conjunction with the surge of highly cited literature and references, these papers were published earlier and have garnered more frequent citations. Thus, researchers can gain insight into authoritative trends in this field by paying attention to its research direction.

From an institutional perspective, the University of Oslo in Norway was considered the leading institution in kidney transplantation self-management. While the United States has the highest number of publications among countries, the ERASMUS MC in Netherland holds the highest number of publications among institutions. This can be attributed to the extensive presence of domestic research institutions in the United States. Consequently, fostering collaboration and knowledge sharing among institutions across different regions and among authors within these institutions is imperative. This is particularly crucial for promoting cooperation between colleges and clinical hospitals in various fields, such as pharmacy, public health, clinical medicine, nursing, psychology, among others. These collaborative efforts will facilitate cross-professional and cross-regional academic cooperation, ultimately enhancing the integration of scientific research theory and its practical application. An encouraging trend is the growing attention from authors towards the study of

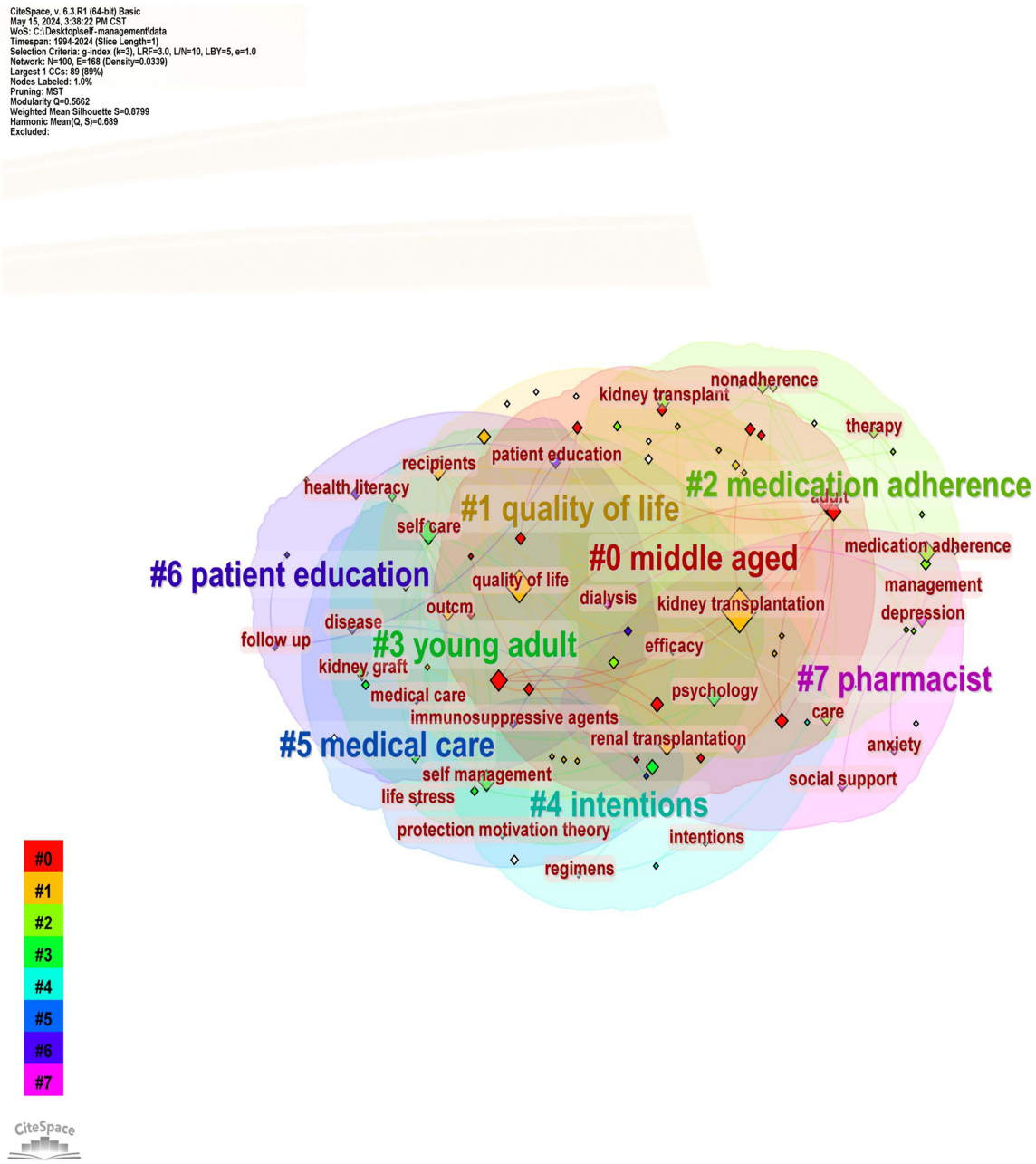

Figure 5 Keywords involved in the research for self-management of kidney transplantation Network of the main keywords in publications.

Description: This figure presents a co-occurrence network of the predominant keywords identified in the literature on self-management of kidney transplant recipients, spanning from 1992 to April 2024. The network map visualizes the intellectual structure and thematic interconnections within the research domain.

Data Source: 444 English articles related to self-management of kidney transplant recipients in the Core Collection of Web of Science and Scopus databases, which are renowned for their comprehensive indexing of scholarly publications. The data extraction period extends from January 1992 to April 2024, ensuring a thorough capture of the research landscape in the field.

Time Frame: The analysis encompasses a 32-year period, offering a longitudinal perspective on the thematic evolution and research priorities in self-management of kidney transplant recipients.

Methodology: CiteSpace (6.2.R4) software was employed to perform bibliometric analysis and construct the keyword co-occurrence network. This software utilizes algorithms to identify and map the frequency and proximity of keyword occurrences within the corpus of publications.

Nodes: Each node in the network represents a keyword that has been extracted and processed for significance. The size of each node is indicative of the keyword's prominence, with larger nodes reflecting higher frequency of occurrence in the literature.

Edges: The edges connecting nodes represent the co-occurrence relationships between keywords within the publications. The weight of the edges is proportional to the strength of the association, with darker and thicker lines signifying more frequent co-occurrences.

Clusters: The network is partitioned into clusters, each representing a distinct thematic group of keywords. These clusters reveal the underlying thematic structures and research areas within the field.

Colors: Different clusters are assigned unique colors to distinguish between various thematic groups, aiding in the visual differentiation of research topics.

Labels: Keywords with significant centrality within the network or high frequency of occurrence are labeled for clarity and ease of reference.

Scale: The network's scale is designed to reflect the density of connections, with densely connected areas indicating a concentration of thematic relevance and research activity.

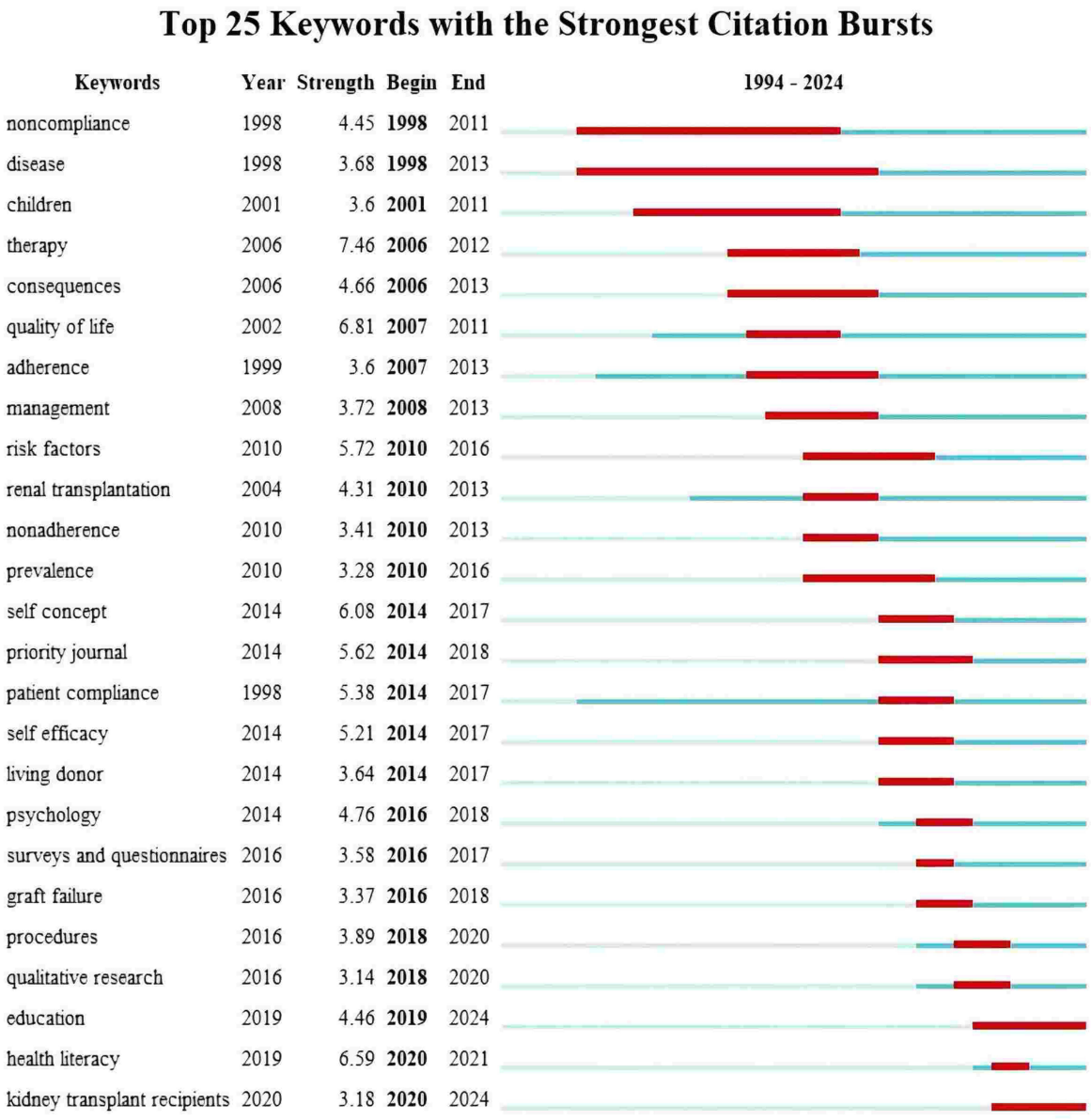

Figure 6 Citespace visualization of Burstness map of keywords on self-management of kidney transplant recipients.
Description: This figure presents a Citespace-generated burstness map of keywords, highlighting the dynamic trends and focal points within the self-management of kidney transplant recipients research field. The map visually represents the emergence of new research topics and the intensification of existing ones over the specified period.
Data Source: 444 English articles related to self-management of kidney transplant recipients in the Core Collection of Web of Science and Scopus databases, which are renowned for their comprehensive indexing of scholarly publications. The data extraction period extends from January 1992 to April 2024, ensuring a thorough capture of the research landscape in the field.
Time Frame: The data encompasses a 32-year period from 1992 to April 2024, providing a comprehensive analysis of the evolution of research themes in the field.
Methodology: Utilizing CiteSpace (6.2.R4), this visualization employs bibliometric techniques to detect significant changes in keyword frequency, indicating periods of intense research activity. The software's burst detection algorithm identifies keywords with a surge in usage, suggesting their importance in the research discourse.
Keywords: Each node on the map represents a keyword, with the size of the node correlating to the term's burst strength, and the color indicating the year of the burst. Larger nodes signify keywords with a more pronounced impact on the research field.
Colors: The color coding of keywords corresponds to the year of their burst, with each color representing a specific time frame within the study period. This visual cue allows for the tracking of the emergence and development of research trends.
Keywords: Keywords that have a significant spike in frequency over a period of time.
Burst Strength: The intensity of the burst is represented by the numerical value of the keyword node, with larger numerical value indicating a stronger burst, reflecting a more significant and rapid increase in the keyword's usage within the research literature.
Year: The year of the burst is indicated by the color and the presence of a red circle around the keyword node, signifying the time when the keyword's usage surged.
Begin and End: The beginning and end of the red segments or circles around the nodes represent the start and end years of the keyword's burst period, providing insight into the duration of each trend's prominence.

kidney transplantation self-management, which has resulted in strengthened relationships among authors in different clusters over time.

Regarding the journals, most of the top 10 journals with the most outputs belonged to Q1 or Q2, most of them are high-level journals in the field of transplantation. However, the top journal was Q4. This may be related to the publication frequency of periodicals. The quality of research in the field of self-management of kidney transplantation is good, but there are still uneven conditions. The countries of the journals were all developed countries in Europe and America. Current research on kidney transplant self-management is mainly published in transplantation professional journals, whereas there are also comprehensive journals such as *PLOS ONE*; nursing journals such as *JOURNAL OF CLINICAL NURSING*; and medical education journals such as *PATIENT EDUCATION AND COUNSELING*. Furthermore, special attention should be given to the literature published in these journals to gain insights into the latest advancements in this field and to identify future research directions.

Main Research Domains on Kidney Transplantation Self-Management

The study of self-management of renal transplant recipients can be divided into three aspects: patient compliance, Quality of Life, outcome assessment of kidney transplant recipient psychology.

There are different definitions of noncompliance in kidney transplantation, including holistic non-adherence (HNA), suboptimal-immunosuppressor levels (SIL), appointment non-adherence (ANA), procedure non-adherence (PNA) and INA. Immunosuppressive non-compliance (INA) is the most studied definition in renal medicine research.[22] Medication adherence is a critical topic in the field of self-management of kidney transplantation. After kidney transplantation, patients need to take immunosuppressants such as tacrolimus for a long time.[23] Adherence to immunosuppressive drugs following renal transplantation is crucial for patient outcomes. Poor adherence is associated with a 1.5-fold increased risk of acute rejection and a 65% greater likelihood of graft loss.[24] Kidney transplant recipients are often motivated to take medications as prescribed, yet medication fatigue, depression, and amnesia can affect adherence.[25] Furthermore, poor communication with medical staff post-discharge or interruptions in post-discharge care transitions can also impact medication compliance. Therefore, addressing the needs, motivations, and obstacles of kidney transplant recipients who have undergone long transplant times, received living donor kidneys, experienced complications, and undergone short dialysis periods is a challenging research issue. Improving the preoperative medication behavior and beliefs of renal transplant patients and scientifically intervening in patients' medication behavior are necessary to improve compliance with immunosuppressive drugs and enhance clinical efficacy.[26,27] Improving medication non-adherence requires a scientific, systematic, and multi-level approach. It is not just about solving the patient's problem. It must integrate patients, health care providers, families, and society, and consider socioeconomic and medical insurance factors. In-depth exploration of more cost-effective immunosuppressant medication compliance management strategies for renal transplant patients will improve patient outcomes.

Quality of life (QOL) is the focus of kidney transplantation self-management researchers. Currently, the expectations of patients who undergo kidney transplantation have shifted beyond pain reduction and increasing activity levels towards achieving a long-term active lifestyle and improved quality of life.[28] Health-related quality of life is a critical factor when evaluating kidney transplant patients and serves as an essential indicator of kidney graft survival.[29] An inter-group comparison of health-related quality of life after renal transplantation showed that patients reported higher HRQOL after successful KT than before transplantation compared with patients undergoing dialysis. Compared with non-dialysis-dependent patients with CKD stage 3–5, the HRQOL of KTRS patients also improved slightly. Shortly after the success of KT, HRQOL seemed to return to the pre-CKD level, but these higher HRQOL levels did not last long. Future studies need to investigate the intervention of modifiable risk factors for HRQOL damage.[30] A study constructed a structural equation-based symptom experience model to identify the symptom experience of kidney transplant recipients and explore the relationship between antecedents, symptom experience and quality of life. The results showed that time since transplantation, complications, immunosuppressants, and sense of coherence predicted symptoms experienced in the quality of life model, with coherence having the strongest correlation with symptom experience. Habitual residence, economic burden, time after transplantation, renal function, optimism and symptomatic experience accounted for more than 70% of the impact on quality of life. Therefore, comprehensive health education should be carried out as soon as possible to encourage people to change their lifestyles, such

as quitting smoking and exercising regularly. In addition, timely adjustment of drugs according to the different stages of individual rehabilitation can reduce the side effects caused by multi-drug combination and drug interaction.[31] Considering the comprehensiveness of the problems experienced by renal transplant recipients, self-management intervention is a natural way to improve their quality of life. The optimization of quality of life requires the cooperation of the team, including patients and medical team members. At present, members of the medical team focus on how to improve the biological response and physical function after transplantation, and lack of relevant tools to guide patients to participate in optimizing the quality of life.[32] In the future, longitudinal design can be used to investigate the quality of life over time during treatment, and to expand the range of empowered people in the field of renal transplantation by encouraging renal transplant recipients and family members to participate in the whole disease recovery process. To enable patients, family members and medical staff cooperate with each other to promote the recovery of kidney transplant recipients. At the same time, strengthen the combination of artificial intelligence and empowerment, through the combination of artificial intelligence and empowerment therapy, so that renal transplant recipients are empowered, actively participate in disease self-management, and improve the quality of life.

A comprehensive and systematic evaluation of the health status of kidney transplant recipients is of great significance for understanding the outcomes after transplantation. Currently, patient assessment tools include the Disease-Specific Questionnaire for Kidney Transplant Patients,[33] Kidney transplantation understand tool,[34,35] kidney transplantation knowledge assessment,[36,37] self-management scale,[38,39] kidney transplantation quality of life scale,[40] kidney transplant recipient dietary self-management evaluation tool,[41] immunosuppression-related side effect symptom experience scale,[42] kidney transplant recipient extended care effectiveness evaluation index system.[43] Future research in this domain should aim to encompass a broader spectrum of influencing factors and account for temporal dynamics to construct a forward-looking, scientifically rigorous, and comprehensive evaluation tool. This will facilitate a more accurate assessment of health outcomes among kidney transplant recipients. Additionally, conducting multi-center and prospective external validation studies will be crucial to establishing the tool's broad applicability across different populations and settings. Such an approach will not only validate the tool's effectiveness but also highlight its versatility in various clinical contexts, thereby showcasing its extensive utility in the field of kidney transplantation research.

In addition to the above patient evaluation results, psychological evaluation should also be paid attention to after kidney transplantation. The psychological evaluation of kidney transplantation is a crucial area of research within the field of kidney transplantation self-management. Previous studies have demonstrated that while patients' physical and social functioning generally improves after organ transplantation, their psychological outcomes do not exhibit sustained positive changes.[44] Kidney transplant recipients experience varying degrees of adverse psychosocial experiences after surgery, including stresses such as depression, anxiety, and reduced quality of life related to graft function, social isolation, and financial problems.[45] Long-term emotional problems escalate the risk of mortality, graft rejection, and readmission.[46] To optimize graft function, clinicians, nurses, and psychologists should prioritize the psychosocial adaptation of young and middle-aged kidney transplant recipients. They should guide these recipients to develop a positive perception of their condition during the early postoperative period and identify potential negative consequences. Identifying the sources of emotions, strengthening multidisciplinary collaborative interventions, and providing support to early kidney transplant recipients are essential for their successful adaptation to post-transplant changes and improvement of their social and psychological adaptability.[47] Future research on mental health in kidney transplantation should prioritize investigating transplant preparation pathways, self-efficacy, disease awareness, social and family support, and the influence of health education on post-transplantation factors. This research should involve multidisciplinary experts such as surgeons, nephrologists, psychiatrists, and psychologists, with a specific focus on interdisciplinary interventions, collaborative discussions on transplant patient plans, conducting thorough psychosocial assessments for kidney transplants, and adequately preparing patients for discharge.[48]

Future Trends on Kidney Transplantation Self-Management

As lifestyles and disease spectrum change, health concepts have also shifted from "disease-centered" to "health-centered". Research on self-management of kidney transplantation has also gradually evolved from early focus on disease and treatment compliance, risk factor management, to disease risk factor management and lifestyle treatment. In addition to paying attention to physical conditions, more attention is paid to kidney transplant recipients full life cycle

care and self-efficacy, and health literacy is improved through patient education to meet the self-management needs of kidney transplant recipients.

Telemedicine Has a Broad Application Prospect in the Self-Management of Kidney Transplant Recipient Education

The increasing popularity of smartphones and internet applications has made telemedicine a crucial means for transplant recipients to acquire medical information and patient education. In the wake of pandemics, telemedicine possesses the potential to make kidney transplant assessments and follow-up care more accessible, efficient, and convenient for both recipients and donors, thereby having a lasting impact on the field of kidney transplantation.[49] It is an important form to design different solution development programs to enhance self-management behavior and make transplant patients follow a series of self-management tasks. These programs are mainly divided into the following functional modules, including daily symptom monitoring, drug management, appointment and access module, reporting and saving data, applying intelligent tools, suggesting a healthy lifestyle module, physical activity management and rehabilitation, psychological indicators and training and education functions. Among them, symptom monitoring and patient education are the most common functions and abilities. Interventions based on information technology, such as mobile health, wearable devices and computer systems, can improve the self-management of renal transplant recipients.[50] The MAC CS platform, developed by Duettmann, facilitates vital sign, health status, and medication intake uploads by transplant recipients via a smartphone app. The app then directly transmits this information to databases and electronic health records, which are subsequently used for routine patient care through medical messages or video consultations. Additionally, doctors can securely transmit updated medication plans and lab data through the platform.[51] The KTx360 study by Schiffer et al is a multi-center, multi-department, multi-modality telemedicine-based follow-up care model that enhances patient and graft survival, minimizes avoidable hospitalizations and comorbidities, lowers healthcare costs, and improves the quality of life of renal transplant recipients. This is achieved through the introduction of e-health elements and comprehensive treatment options for recipient management.[52] The rise of wearable technology, sensing technology, mobile information, and other technologies is changing the existing methods of medication for patients and providing technical support to enhance medication compliance. Face recognition technology, smart pills, smart medicine bottles, smart pill boxes, and personal assistant reminders are utilized in the patient's medication. Meanwhile, investigator van Lint from the Netherlands examined the adherence level of renal transplant patients to the creatinine monitoring program and assessed the reliability of creatinine values recorded in the web-based self-management support system (SMSS).[53] The advancement in immunosuppressant testing equipment technology has made it possible to remotely detect drug concentration. Emerging sampling methods, such as Dried Blood Spot (DBS) and quantitative absorptive microsamplers (VAMS), have been developed.[54,55] In the future, it is necessary to further explore the hospital needs of transplant recipients using telemedicine, learn from the transplant recipient self-management model based on telemedicine, evaluate its economic costs and benefits, and improve the quality of medical services launch a comprehensive and scientific self-management program for renal transplant recipients. Forthcoming years, the implementation of telemedicine will necessitate collaborative efforts from government regulators, infrastructure developers, and insurance providers to enhance the well-being of a greater number of transplant patients.

Strengthen the Whole Life Cycle Follow-Up Management and Make the Best Transition Plan

After renal transplant patients are discharged from hospital, Follow-up after kidney transplantation is essential for the long-term survival of the recipient and the graft. In this study, it is found that in keyword clustering and burst words, the population of self-management of renal transplantation covers children, young adult, middle aged, aged. Follow-up after renal transplantation is very important for the long-term survival of recipients and transplanted organs. To improve the self-management ability of renal transplant recipients, medical staff should actively carry out long-term and effective communication and follow-up.[56] Children and adolescents are at high risk of poor medication compliance and discontinuation of follow-up, which can lead to a poorer prognosis. Adolescence and young adulthood are particularly high-risk periods as increased immune activity, combined with poor compliance with immunosuppressive drugs, increases the risk of premature graft loss.[57]

Although there are currently no programs specifically designed for kidney transplant recipients, further research is needed to determine the most effective way to provide transitional care.[58] Developing a child-adolescent-young adult care transition plan and strengthening the life cycle follow-up management of renal transplant recipients is necessary. Research on care transition for kidney transplantation in younger patients should focus on designing intervention measures with increased patient participation and educational theory to formulate personalized and professional transitional care plans suitable for children and adolescents.[59,60] Few studies involve evidence-based educational methods or theories. At the same time, for young and middle-aged renal transplant patients, early psychosocial adaptability should also be paid attention to. Some studies have shown that the early psychosocial adaptation level of young and middle-aged renal transplant patients is negative. The medical team should pay attention to the social and psychological adaptation of young and middle-aged kidney transplant patients in the early stage after kidney transplantation, especially in the early stage (< 1 year after surgery), and help patients establish positive disease cognition shortly after kidney transplantation. At the same time, psychological care and support are also provided to help early renal transplant recipients successfully adapt to the changes after transplantation, rebuild their social roles, return to work or school as soon as possible, and improve their psychosocial adaptation. By contrast, Senile renal transplantation has been paid more and more attention by both doctors and patients. Because of its older age, long medical history and various complications, the reserve function of each organ tends to decline obviously. The implementation of professional, standardized, persistent, personalized and procedural follow-up management for renal transplant recipients is of great significance for graft survival time and prevention of complications. Therefore, when designing research plans in the future, it is necessary to increase patient participation and combine educational theory to formulate personalized and professional transitional care plans suitable for kidney transplant recipients throughout the life cycle.

Kidney Transplantation Health Literacy and Self-Management

Health literacy means acquiring a certain degree of knowledge, personal skill sand confidence in taking action to improve personal and community health by changing individual life styles and living conditions.[61] The lack of treatment compliance caused by lack of understanding of medical information related to modified drug therapy after organ transplantation or inability to search for appropriate information about lifestyle correction or support system will increase the possibility of re-hospitalization and transplant organ failure.[61] Health literacy has recently received attention as a key factor in treatment compliance and health-related quality of life, which can improve patients' understanding of their own health and their ability to follow treatments provided by health professionals after organ transplantation.[62] Studies have shown that patients' health literacy should be evaluated before transplantation to determine the treatment non-compliance of potentially high-risk patients.[63] A prospective cohort study of renal transplant health literacy and self-management once again demonstrated the importance of self-management of renal transplantation, and the knowledge and understanding of renal transplant-related complications and the management of these complications are changeable factors, especially in the first six months after renal transplantation. In view of this, we believe that it is necessary to study health literacy and self-management during pre-transplant inspection. Future research should investigate not only post-transplant patients, but also dialysis and pre-dialysis patients. Researchers should start with kidney disease to better understand the importance and relationship between health literacy and self-management, as well as to obtain transplant and clinical outcomes at all stages of kidney disease. Health care professionals need to know those who need more support in learning post-transplant lifestyles and drug treatments. Therefore, this requires close cooperation within multidisciplinary teams, who need self-management support interventions to achieve improvement. We focus on the post-transplantation period, but it may be more effective to start self-management support before migration. After transplantation, intervention measures for patients should be formulated and self-management should be provided to reflect the level of health literacy of patients and ultimately improve the prognosis of patients.[6] To improve the literacy of health management and compliance with treatment, it is necessary to increase patients' sense of responsibility for their health maintenance and management and include them in the decision-making of treatment process and health management.[63] In the future, medical staff can set up a feedback reward system to gradually guide patients to understand the benefits brought by changes in their self-behavior, and to establish or restore their sense of self-efficacy, so as to promote the production and maintenance of healthy lines by patients. Guiding patients to formulate a commitment agreement on rehabilitation plans can assist patients to strengthen self-restraint and help patients to fully understand their own diseases

and specific measures of health behavior. Through functions such as self-discipline, peer influence, and emotional feedback, it encourages patients with chronic diseases to find their own ways of self-management, thereby improving their health behaviors.

Conclusion

At present, the research hotspots of self-management of kidney transplant recipients tend to focus on medication compliance, psychological evaluation of kidney transplant patients, quality of life, health literacy and other aspects. To advance the research and development of self-management for renal transplant recipients, it is crucial to leverage the benefits of interdisciplinary collaboration and resource complementarity. In the future, it is necessary to improve the cognitive level of renal transplant recipients, pay attention to patient empowerment, and apply the technologies of telemedicine, Internet of things, big data, wearable equipment and immunosuppressant testing equipment to the self-management of renal transplant recipients. Broaden the channels of health information for renal transplant recipients, improve drug compliance and self-management, reduce related complications, and further improve quality of life. At the same time, improve the existing follow-up management system and strengthen the life cycle follow-up management of renal transplant recipients.

Data Sharing Statement

All data generated or analyzed during this study are included in this published article.

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