

# Research trends and hotspots of Health-Related Quality of Life: A Bibliometric Analysis from 2000 to 2019

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## Research

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# Abstract

## Purpose

To analyze the global scientific output of health-related quality of life (HRQoL) research and figure out general trends and hotspots in HRQoL.

## Methods

HRQoL research articles were collected from the Web of Science (WOS) database between 2000 and 2019. A bibliometric analysis was performed based on the number of articles, citations, published journals, authors' address and keywords. Descriptive analysis, visualization of geographic distribution and keyword clustering analysis were applied to the collected data.

## Results

The annual number of articles showed a growth over the past twenty years, but the annual TA (Total Citations) and annual CPA (Citations Per Article) were both in decreasing trends. Articles about HRQoL were more likely to be published in journals of multi-subject categories, The HRQoL research was mainly distributed across North America and Europe throughout the twenty years and ushered in a vigorous development worldwide after 2015. Research institutions with high productivity in HRQoL research were more inclined to collaborate, but the cooperation strength between domestic institutions was much greater than that between international institutions. There were a large number of author keywords were only used once or twice during 2000 to 2019. SF-36, EQ-5D, depression, obesity, disability, oncology, fatigue were identified as hot research areas. Also, dementia, HIV, chronic disease, OHRQoL, PRO, stress, well-being, the elderly, women and children may become new hotspots in future research.

## Conclusion

This study provided an overall perspective on global research trends and hotspots in HRQoL research, as well as a potential guide for future research. Researchers need to strengthen international cooperation, as well as pay more attention to the standardization and unity of keywords in future study.

## Introduction

The Health-Related Quality of Life (HRQoL) was derived from the concept of Quality of Life (QoL). Initially, the QoL was a sociological concept proposed by American economist J. K. Calbraith in the 1950s[1]. When the QoL is related to the individual's disease conditions and therapeutic interventions, it is termed as HRQoL[2]. The HRQoL is multidimensional, consisting at the minimum of the physical, psychological and social health dimensions[3]. Although the term "QoL" is sometimes used

interchangeably with “HRQoL”, QoL is actually a broader concept and HRQoL has emerged as an essential health outcome measure in clinical trials and health care services research [4].

In line with the increasing focus on HRQoL, a large body of related literature has been accumulated. The scope of HRQoL research is vast, dynamic and has been influenced by the shift of diseases from communicable to non-communicable chronic diseases [5]. Over time, HRQoL research mainly focused on chronic conditions such as rheumatoid arthritis, Parkinson’s disease, multiple sclerosis, stroke, and traumatic brain injury, as well as the evaluation of specific groups, especially the chronic patients such as cancer, diabetes, the elderly, rural women and other vulnerable populations [6–8]. However, the general trend and impact of the research production on this topic is not yet documented.

Measuring the output of research and its impact is multidimensional and complex[9]. One important tool employed for this purpose is bibliometric analysis. Bibliometric analysis is an approach used to measure the influence and production of research literature on a specific subject [10]. It utilizes many indicators including impact factor (IF), the total number of articles, the total number of citations, authorship and researchers’ or institutions’ collaboration network among others [11]. Bibliometric study on HRQoL will help to produce some evidence on publication growth trends, citation trends, collaboration networks and other related bibliometric indicators that might guide the activities and decisions of researchers, policymakers and other stakeholders [12].

Therefore, in this study, the bibliometric analysis of published HRQoL articles for the period from 2000 to 2019 was performed to (a) summarize global research patterns and trends from multiple perspectives; (b) figure out the hotspots and advances in HRQoL research; (c) provide potential directions for future research.

## **Material And Methods**

### **Data Collection**

Data used in this study were retrieved from the Web of Science Core Collection, the online version of the Science Citation Index-Expanded (SCIE) and the Social Sciences Citation Index (SSCI). The search strategy was developed by querying the term (“Health-Related Quality of Life”) or (“HRQoL”) as topics in the Web of Science database. All publications which had been published between 2000 (1st January) and 2019 (31st December) were included. The search process was carried out between March 24 and 30, 2020 (Fig. 1). From 2000 to 2019, a total of 48,035 publications related to HRQoL were published. Our analyses were limited to only articles, and we eliminated 69 articles which the publishing years were marked as 2020 (early accessed in 2019). Then we reviewed the titles and keywords of rest articles and filtered out 10655 articles which were found to be less related to our topic. Finally, 25,119 articles were included in the analyses in the scope of bibliometrics.

### **Analyses**

Four types of analysis were conducted. First, Microsoft Excel 2013 was used to calculate and rank the number of published articles and citations, from which the general trend of HRQoL research is derived. Secondly, the authors' addresses were contained in the C1 field of the collected database. We did geography and collaboration analysis according to the authors' addresses provided by WOS, we used Python as a geocoding tool to find the longitude and latitude of each address, then used ArcGIS to finish the visualization of the worldwide geographic distribution of authors. In addition, articles from England, Scotland, Northern Ireland, and Wales were unified as articles from the UK, articles from Taiwan were treated as articles from China.

Thirdly, the cumulative impact of an institution's output was measured by the index  $h$ , defined as the number of papers with citation number  $\geq h$  (Hirsch, 2005), the one with the higher  $h$  is likely to be the more accomplished institution.

Finally, the keyword analysis took author keywords as analysis objects. Before analysis, we merged some synonymous keywords. For instance, "Health-related Quality of life", "health related quality of life", "HRQOL", "health-related quality of life (HRQOL)" and other synonymous keywords were merged into "Health-related Quality of life/HRQoL". Then we treated every five years as a period (2000–2004, 2005–2009, 2010–2014, 2015–2019), numbering in chronological order ( $i = 1, 2, 3, 4$ ). We calculated the Sequential Growth Rate (SGR) for each period, to compare the heat of the top 100 most frequently used keywords in the recent period with the period preceding it, and to select quickly rising terms of HRQoL research. The SGR was calculated based on the following formula:

$$\text{SGR} = \frac{(N_i - N_{i-1})}{N_{i-1}}$$

in which  $N_i$  is the number of articles published in the period  $i$ . When SGR is greater than 0, the heat of the keyword increases during this period, and the greater the SGR, the faster the heat of the keyword increases during this period. Using surged topical terms rather than the most frequently occurring title words is particularly suitable for detecting emerging trends and abrupt changes.

Keyword clusters can be used to analyze the hotspot in the research field[13], and to examine trends in research topics[14]. The keyword cluster analysis was acted as follow: Finding keyword clusters was conducted in two steps, firstly we used citespace5.6.R3 to find the keyword clusters in HRQoL research, it can group the most closely related keywords into a cluster based on the connections between the keywords of the articles, and those clusters were ranked by the most frequently used keyword in articles[15]. After that, we secondly used our specialized knowledge to optimize the clustering of keywords and come to the conclusion.

## Results

### General trend

The number of articles about HRQoL and citations over 2000–2019 were counted and displayed in Fig. 2, Fig. 2a is the trend of the number of articles and the annual growth rate, Fig. 2b is the trend of annual Total Citations (TA) and annual Citations Per Article (CPA). The Fig. 2a shows that the number of HRQoL studies has increased continuously over the years, the annual number of HRQoL articles increased from 337 in 2000 to 2294 in 2019. The growth rate fluctuated greatly in the twenty years, but overall, the growth rate in the last six-year period was smaller and more stable than before. From Fig. 2b, the trend of TA had a turning point in the year 2007, it rose in undulation before 2007 and then showed a downward trend to 2019. As for the CPA, generally, it had been a downward trend over the twenty years, the higher citations per article were found in the period between 2000 and 2003. The most cited ten articles are listed in Table 1. As can be seen, most of them were about the measurements or general law related to HRQoL (Rank1, 2, 3, 6, 7, 8, 9), and other articles were about HRQoL of certain groups (Rank4, 5, 10). We also calculated the average number of authors per article (AAP), the average number of references cited per article (ARP) and the average number of pages per article (APP) by published years to see how the study changed over the time. These three indicators increased slightly during this period, AAP increased from 4.64 in 2000 to 8.5 in 2019, ARP increased from 32.6 in 2000 to 38.89 in 2019, and APP increased from 8.42 in 2000 to 9.29 in 2019.

Table 1  
Top 10 most-cited articles (with citations  $\geq$  900)

Article title	TC(R)	PY	Publication name
PedsQL (TM) 4.0: Reliability and validity of the pediatric quality of life Inventory (TM) Version 4.0 generic core scales in healthy and patient populations	2313(1)	2001	Medical Care
Interpretation of changes in health-related quality of life - The remarkable universality of half a standard deviation	2212(2)	2003	Medical Care
Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L)	1628(3)	2011	Quality of Life Research
Quality of life and satisfaction with outcome among prostate-cancer survivors	1450(4)	2008	New England Journal of Medicine
The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcome	1190(5)	2010	Journal of Clinical Epidemiology
Development and first validation of the COPD Assessment Test	1123(6)	2009	European Respiratory Journal
The PedsQL (TM) 4.0 as a pediatric population health measure: Feasibility, reliability, and validity	1117(7)	2003	Ambulatory Pediatrics
The Patient-Reported Outcome Measurement Information System (PROMIS) progress of an NIH roadmap cooperative group during its first two years	1069(8)	2007	Medical Care
The PHQ-8 as a measure of current depression in the general population	1057(9)	2009	Journal of Affective Disorders
Health-related quality of life of severely obese children and adolescents	945(10)	2003	JAMA- Journal of the American Medical Association
<b>TC(R):</b> total citations count (rank); <b>PY:</b> published year			

## Journal analysis

From 2000 to 2019, 25119 articles were published in 2565 journals, the top twenty most productive journals on HRQoL are listed in Table 2. Most of the journals fall into two or more categories at once, articles about HRQoL were more likely to be published in journals of multi-subject categories, this illustrates that HRQoL had developed into a multidisciplinary field. Public, Environmental & Occupational Health and Health Care Sciences & Services are the top two categories, indicating they exerted a wide influence in the HRQoL field. In addition, Cancer has the highest five-year impact factor (6.412) with 131

articles, followed by Value In Health (6.131) with 203 articles. When examining citations, Medical Care has the highest CPA (127.79), this is consistent with the results in Table 1: Medical Care had three articles in the most cited ten articles (Table 1).

Table 2  
Top 20 journals with the most published literature on HRQoL

Journal Title	TA(R)	CPA	JCR Categories	IF(5 year)
Quality Of Life Research	1477(1)	27.48	P, E&OH; HCS&S; HP&S	2.979
Health And Quality Of Life Outcomes	844(2)	19.57	HCS&S; HP&S	3
PloS One	296(3)	10.51	Multidisciplinary Sciences	3.337
Value In Health	203(4)	30.87	Economics; HCS&S	6.131
Supportive Care In Cancer	185(5)	16.77	Oncology; Rehabilitation; HCS&S	3.002
Psycho-Oncology	153(6)	25.12	PM; Oncology; SS, B; Psychology	4.115
Spine	153(6)	30.12	CN; Orthopedics	3.616
BMC Public Health	143(8)	19.2	P,E&OH	3.275
Cancer	131(9)	50.92	Oncology	6.412
Epilepsy & Behavior	127(10)	19.27	CN; BS; Psychiatry	2.677
Journal Of Urology	126(11)	40.56	U&N	4.961
BMJ Open	116(12)	5.5	M,G&I	2.863
Community Dentistry And Oral Epidemiology	113(13)	49.09	P,E&OH; D,OS&M	2.778
Journal Of Clinical Epidemiology	113(13)	59.35	P,E&OH; HCS&S	5.645
Disability And Rehabilitation	112(15)	16.72	Rehabilitation	2.311
International Journal Of Environmental Research And Public Health	106(16)	5.32	P,E&OH; Environmental Sciences	2.948
Respiratory Medicine	106(16)	31.33	C&CS; Respiratory System	3.702
Journal Of Rheumatology	100(18)	41.14	Rheumatology	3.774

**TA(R)**: total articles of each journal (rank in all articles); **CPA**: citations per article; **JCR Categories**: Categories in Journal Citation Reports; **IF(5 year)**: 5-year impact factor; **P, E&OH**: Public, Environmental & Occupational Health; **HCS&S**: Health Care Sciences & Services; **HP&S**: Health Policy & Services; **PM**: Psychology, Multidisciplinary; **SS, B**: Social Sciences, Biomedical; **CN**: Clinical Neurology; **BS**: Behavioral Sciences; **U&N**: Urology & Nephrology; **M, G&I**: Medicine, General & Internal; **D, OS&M**: Dentistry, Oral Surgery & Medicine; **C&CS**: Cardiac & Cardiovascular Systems

Journal Title	TA(R)	CPA	JCR Categories	IF(5 year)
Medical Care	100(18)	127.79	P,E&OH; HCS&S; HP&S	3.991
Archives Of Physical Medicine And Rehabilitation	99(20)	36.19	Sport Sciences; Rehabilitation	3.618
Journal Of Psychosomatic Research	99(20)	34.53	Psychiatry	3.311
<b>TA(R):</b> total articles of each journal (rank in all articles); <b>CPA:</b> citations per article; <b>JCR Categories:</b> Categories in Journal Citation Reports; <b>IF(5 year):</b> 5-year impact factor; <b>P, E&amp;OH:</b> Public, Environmental & Occupational Health; <b>HCS&amp;S:</b> Health Care Sciences & Services; <b>HP&amp;S:</b> Health Policy & Services; <b>PM:</b> Psychology, Multidisciplinary; <b>SS, B:</b> Social Sciences, Biomedical; <b>CN:</b> Clinical Neurology; <b>BS:</b> Behavioral Sciences; <b>U&amp;N:</b> Urology & Nephrology; <b>M, G&amp;I:</b> Medicine, General & Internal; <b>D, OS&amp;M:</b> Dentistry, Oral Surgery & Medicine; <b>C&amp;CS:</b> Cardiac & Cardiovascular Systems				

## Geography and collaboration Analysis

In the collected data, 38 articles lacked the information of authors' addresses, hence 25,081 articles were used to the geographic analysis. We divided every five years as a period, the background corresponded to each country's Gross Domestic Product (GDP) per capita in the last year of each period. Furthermore, the authors' addresses are often the institutions to which they belong, so every dot represented a research institution to which the author belongs, as shown in Fig. 3a-3d. In the first period (2000–2004), the main HRQoL research areas were distributed across North America and Europe. In the second period (2005–2009), besides North America and Europe, HRQoL research boomed in eastern Asia, southern Brazil and Turkey. In the next period (2010–2014), China and India became newly-active areas in HRQoL research, and there's a small cluster of dots in eastern Australia, Western Asia and Africa. In the last period (2015–2019), South America and Africa became more active than previous periods, HRQoL had ushered in a vigorous development worldwide in this period, but the Central Asia and Russia still showed a low interest in HRQoL research, and clusters in Africa are more scattered, these phenomena illustrate that HRQoLs research interest varies among regions around the world. What's more, the research interest in HRQoL may be related to regional GDP per capita: regions with high GDP per capita are the leading areas for research, like South America and Europe; but regions where GDP per capita was under 500 USD had few institutes interested in HRQoL, such as some areas in Africa.

At the country/territory level, there were 145 countries/territories participating in HRQoL research. The top 20 countries/territories with articles are listed in Table 3. USA was the leading country in HRQoL research, published 30.37% of all articles, followed by UK(12.4%), Germany(9.22%) and Canada(8.04%). In addition, international co-operations between different countries varied significantly. The USA, Germany, China, Netherlands, Sweden, Spain, Japan, Brazil, Norway, South Korea, Finland and Turkey preferred to give priority to independent research, the number of internationally-collaborative articles (CA) were all less than their number of single country articles (SA); UK, Canada, Australia, Italy, France, Switzerland, Denmark and Belgium seemed more inclined to cooperation.

Table 3  
Top 20 most productive countries in HRQoL research

Country	TA (%)	SA (%)	CA (%)	SA/CA
USA	7628(30.37)	4945(64.83)	2683(35.17)	1.84
UK	3114(12.4)	1257(40.37)	1857(59.63)	0.68
Germany	2315(9.22)	1258(54.34)	1057(45.66)	1.19
Canada	2019(8.04)	893(44.23)	1126(55.77)	0.79
Netherlands	1911(7.61)	1133(59.29)	778(40.71)	1.46
Sweden	1541(6.13)	864(56.07)	677(43.93)	1.28
Spain	1537(6.12)	911(59.27)	626(40.73)	1.46
Australia	1380(5.49)	636(46.09)	744(53.91)	0.85
China	1242(4.94)	812(65.38)	430(34.62)	1.89
Italy	1148(4.57)	568(49.48)	580(50.52)	0.98
France	1006(4)	390(38.77)	616(61.23)	0.63
Japan	858(3.42)	643(74.94)	215(25.06)	2.99
Brazil	845(3.36)	556(65.8)	289(34.2)	1.92
Norway	701(2.79)	398(56.78)	303(43.94)	1.31
Switzerland	590(2.35)	131(22.2)	459(77.8)	0.29
South Korea	582(2.32)	447(76.8)	135(23.2)	3.31
Denmark	572(2.28)	230(40.21)	342(59.79)	0.67
Finland	559(2.23)	408(72.99)	151(27.01)	2.70
Belgium	479(1.91)	79(16.49)	400(83.51)	0.20
Turkey	470(1.87)	391(83.19)	79(16.81)	4.95
<b>TA (%)</b> : the number of articles published by each country (percentage of all articles); <b>SA (%)</b> : the number of single-country articles (percentage of TA); <b>CA (%)</b> : the number of internationally-collaborative articles (percentage of TA)				

At research institution level, we calculated the *h*-index in HRQoL research of each institution, the top 20 influential institutions are listed in Table 4, according to the rank of *h*-index. Among the top 20 institutions, 12 were in the USA, 5 were in Canada, 3 in Netherlands, and 1 in each of Sweden, Finland and Norway. University of California, Los Angeles (UCLA) has the highest *h*-index (63) in HRQoL research,

followed by University of Toronto, Canada (59); Harvard University, USA (57) and McMaster University, Canada (56). The CA of these 20 institutions were all exceeded their SA. The CA of University of Oslo, Norway and Harvard University, USA reached more than 28 times of their SA, and the CA of the institution with the smallest gap also reached 4.9 times of the SA (University of North Carolina, USA). These results indicated that cooperative study between institutions was the main pattern in influential HRQoL research.

Furthermore, we analyzed the inter-institutional collaboration for the top 20 highest *h*-index institutions in HRQoL research (Fig 4). The sectors differ in color and area: a specific color corresponds to an institution, whereas its area is proportional to the number of articles from that country. Moreover, the thickness of lines between sectors represents the number of collaborative articles between institutions, it also revealed the strength of cooperation among these 20 influential institutions. As can be seen, these institutions preferred to cooperate with their domestic institutions to conduct HRQoL research. For example, University of Amsterdam, Netherlands cooperated most with University of Groningen, Netherlands and Leiden University, Netherlands. The same was true for institutions in the United States and Canada, cooperation strength between domestic institutions was much greater than that of international institutions.

Table 4  
Top 20 highest *h*-index institutions in HRQoL research

Institution	<i>h</i> -Index(R)	TA (%)	SA (%)	CA (%)
University of California, Los Angeles (UCLA),USA	63(1)	436(1.74)	39(8.94)	397(91.06)
University of Toronto(UT), Canada	59(2)	543(2.16)	33(6.08)	510(93.92)
Harvard University (HU), USA	57(3)	298(1.19)	10(3.36)	288(96.64)
McMaster University (MMU), Canada	56(4)	312(1.24)	18(5.77)	294(94.23)
University of Washington(UW), USA	51(5)	308(1.23)	23(7.47)	285(92.53)
University of Amsterdam(UA), Netherlands	50(6)	294(1.17)	43(14.63)	251(85.37)
Karolinska Institute(KI), Sweden	49(7)	425(1.69)	29(6.82)	396(93.18)
University of Helsinki(UH), Finland	48(8)	325(1.29)	29(8.92)	296(91.08)
University of Michigan(UM), USA	47(9)	339(1.35)	36(10.62)	303(89.38)
Johns Hopkins University (JHU), USA	47(9)	266(1.06)	12(4.51)	254(95.49)
University of California, San Francisco (UCSF),USA	46(11)	330(1.31)	26(7.88)	304(92.12)
Northwestern University (NU), USA	45(12)	401(1.6)	24(5.99)	377(94.01)
University of North Carolina(UNC), USA	45(12)	268(1.07)	45(16.79)	223(83.21)
University of Groningen(UG), Netherlands	44(14)	312(1.24)	35(11.22)	277(88.78)
University of California, San Diego (UCSD),USA	44(14)	199(0.79)	18(9.05)	181(90.95)
University of Pittsburgh(UP), USA	43(16)	266(1.06)	28(10.53)	238(89.47)
University of British Columbia(UBC), Canada	43(16)	258(1.03)	15(5.81)	243(94.19)
McGill University (MGU), Canada	42(18)	240(0.96)	12(5)	228(95)
University of Oslo(UO), Norway	41(19)	278(1.11)	9(3.24)	269(96.76)
Duke University (DU), USA	40(20)	268(1.07)	16(5.97)	252(94.03)
Leiden University (LU), Netherlands	40(20)	256(1.02)	33(12.89)	223(87.11)
University of Alberta(UoA), Canada	40(20)	247(0.98)	28(11.34)	219(88.66)
University of Pennsylvania(UP), USA	40(20)	233(0.93)	24(10.3)	209(89.7)

**H Index(R)**: *h* index (rank); **TA (%)**: the number of articles published by the institution (percentage of all articles); **SA (%)**: the number of single-institution articles (percentage of TA); **CA (%)**:inter-institutional collaborative articles (percentage of TA)

## Keyword analysis

According to the statistics of keywords, a total of 25,191 keywords were used between 2000 and 2019, among which 19,155 keywords were appeared only once or twice. And after the keywords clustering work, we found that the HRQoL research has 6 concentrated categories:

1. **Health-Related Quality of Life (HRQoL)**, it was closely linked with terms like: “questionnaire”, “SF-36”, “EQ-5D”, “patient-reported outcome”, “children”, “health status”, “validity”, “psychometrics”, “clinical trial”, “reliability”, “patient satisfaction”, “pedsql”, “Parkinson's disease”, “rheumatoid arthritis”, “breast cancer”, etc.
2. **Depression**, this category includes terms such as “anxiety”, “rehabilitation”, “exercise”, “elderly”, “mental health”, “social support”, “cognition”, “Parkinson's disease”, “stroke”, “physical activity”, “hemodialysis”, “HIV”, “Epilepsy”, etc.
3. **Obesity**, with terms like “adolescent”, “bariatric surgery”, “weight loss”, “children”, “morbid obesity”, “stress”, “BMI”, “physical activity”, “gastric banding”, “exercise”, etc.
4. **Disability**, including terms such as “multiple sclerosis”, “functional disability”, “Oswestry Disability Index”, “comorbidity”, “pain”, “migraine”, “rheumatoid arthritis”, “survival”, “complication”, etc.
5. **Oncology**, with “cancer”, “breast cancer”, “radiotherapy”, “chemotherapy”, “survivorship”, “psychological distress” etc.
6. **Fatigue**, has “chronic fatigue syndrome”, “cognition”, “burden of illness”, “anxiety”, “sleep”, etc. In addition, fatigue was a quickly rising term during 2000 to 2019.

Table 5 lists the top twenty quickly rising keywords sorted by their SGR 4, we chose SGR 4 because the terms chosen according to the sudden increase in popularity are particularly appropriate to characterize a current research front[16]. Among the top 100 most frequently used keywords, the research interest in these 20 keywords had grown the fastest in period 4 (2015–2019). All keywords besides “women” maintained a growing interest in HRQoL research from 2000 to 2019, “women” experienced a decline in the period 3. What's more, these keywords have different growth rates in different periods. The growth in research interest for “dementia” has continued to accelerate over the past 20 years; growth rate in research interest of “well-being”, “surgery”, “health”, “HIV”, “chronic disease”, “aging”, “women” and “stress” has slowed down in the period 3 (2010–2014), but has grown rapidly in period 4 (2015–2019). Therefore, we believe that the heat of these nine keywords will continue to increase in future research. For the keywords which have high rank of ASGR but the growth rate in research interest slowed down in period 4 (2015–2019), such as “patient-reported outcome”, “survivorship”, “oral health-related quality of life/OHRQoL” and “physical activity”, researchers may need to focus on finding new research directions in future research.

Table 5  
Top 20 quickly rising keywords in period 4

Keyword	ASGR (R)	SGR 2	SGR 3	SGR 4
older adults	2.92(6)	6.33	0.41	2.03
dementia	0.99(41)	0.57	0.91	1.48
cognition	1.54(14)	1.20	2.00	1.42
patient-reported outcomes	3.26(4)	4.00	4.40	1.37
survivorship	2.16(6)	2.50	2.86	1.11
well-being	1.44(13)	2.80	0.47	1.04
surgery	1.29(16)	2.25	0.69	0.93
health	0.83(47)	1.44	0.15	0.91
mental health	1.38(14)	1.50	1.77	0.88
HIV	1.06(30)	2.15	0.22	0.82
pediatric	1.26(18)	1.60	1.38	0.81
oral health-related quality of life/OHRQoL	2.37(4)	5.46	0.89	0.76
chronic disease	1.1(26)	2.43	0.13	0.74
aging	0.71(51)	0.50	0.89	0.74
women	0.79(42)	1.75	-0.09	0.70
stress	0.99(29)	1.67	0.63	0.69
pain	1.14(22)	1.38	1.37	0.68
fatigue	1.07(25)	1.71	0.82	0.66
physical activity	1.55(9)	1.36	2.64	0.65
sleep	1.13(21)	2.00	0.76	0.62
<b>ASGR *(R):</b> Average of SGR 2, SGR 3 and SGR 4 (rank); <b>SGR 2, SGR 3 and SGR 4:</b> the Sequential Growth Rate of period 2, period 3 and period 4				

## Discussion

### Citation phenomenon

The growing trend of the number of articles in HRQoL indicated that the research interest in HRQoL had been on the rise during this period. But it is worth noting that the TA and CPA were both in decreasing trend. Citations are attractive raw data for evaluating scientific performance[17]. In some fields, older

important literature is more likely to be cited [18], it means recent articles about HRQoL may need more time to increase the citation counts, which may have contributed to the decreasing trend of TA in recent years. Besides the impact of decreasing TC, the decreasing trend of CPA was also influenced by the annual increase in the number of articles, since the chance of being cited is related to the number of articles[19]. Another phenomenon we take into consideration is that the most cited articles were more about HRQoL instruments, it suggested that articles about instruments have a greater impact on HRQoL. And most of them were published before 2011, to some extent, this indicated that the HRQoL instruments were approaching to maturity in 2011: researchers published more and more articles about HRQoL over the years, but they were more likely to adopt or refer to the survey instruments which were developed before 2011.

## **Research collaboration**

The results of our analysis showed that institutions with high productivity in HRQoL research are more inclined to collaboration, earlier studies have also shown a high degree of correlation between collaboration and research productivity[20]. Collaboration might have a consistently positive effect on research productivity[21], cause collaboration may enable scientists to work on more projects simultaneously, and allows authors to combine expertise from different fields to increase the range of subjects they study[22, 23]. However, we found that in HRQoL research, cooperation strength between domestic institutions was much greater than that of international institutions. This mode of cooperation has also led those leading countries in HRQoL research to show a low interest for international cooperation, most of the 20 countries have higher SA than CA. What's more, this cooperation mode may also have an impact on some less-developed countries, as what we found in our geographical analysis. On the one hand, because of the poverty and backward education, less-developed countries tend to be weak in research productivity, so collaboration has seemed to hold the greatest promise to enhance research productivity [24]. When those leading countries adopt more collaboration among domestic institutions, it will inevitably reduce the opportunities for less-developed countries to enhance the research productivity in HRQoL through collaboration. On the other hand, seeking collaborators with complementary skills or strong scientific reputations will have the greatest productivity gains from collaboration [21]. It means that in an already small amount of international collaboration, less-developed countries have less advantages in international collaboration than those leading countries, which may further lead to the weakness of less-developed countries in the field of HRQoL research. May be in the future, in order to reduce the imbalance of scientific resources between regions, it is vital to carrying out inter-country research collaboration and paying more attention to the HRQoL in less-developed countries, which may have significant impacts on the dissemination of knowledge and research results and fostering the overall advancement of HRQoL knowledge.

## **Hotspots and future trend**

Author keywords provide a reasonable description of an article's theme, and could offer the information of research trend that is concerned by researchers [13]. Therefore, keyword analysis can identify the research focus, explore research hotspots, and discover scientific research trends.

From the keyword clusters we can explore research hotspots mainly in three parts as follows: First was about the measuring instruments in HRQoL. The equivalency among scales; the scale validation, translation and cultural adaptation have been studied extensively. The SF-36 and EQ-5D were the most widely used HRQoL instruments in the world. These two instruments are comprehensive, psychometrically sound and brief, they are more practical than the lengthy health surveys used in research projects, and more comprehensive than the relatively coarse single-item health measures used in numerous clinical investigations [25].

Second one was the disease-specific HRQoL. For example, HRQoL in Parkinson's disease, rheumatoid arthritis and oncology have received a lot of attention, owing that the maintenance or improvement of HRQoL are the important objectives within the treatment of these diseases [26].

The third part was some clinical signs and symptoms, which could be comorbidities associated with other diseases. These symptoms generally have negative impact on several domains of HRQoL, for instance, depressed patients have substantially more days of impairment across multiple domains of HRQoL [27, 28]. Persons with obesity have significantly lower HRQoL than those who are normal weight [29, 30], and weight loss has a general positive outcome on HRQoL [31, 32]. Disability and fatigue are often the outcomes of diseases which can affect the patient's HRQoL [33], which are interacting with patient characteristics [34]. Therefore, conditions which patients may demonstrate these symptoms become the focus of HRQoL research.

Besides the hotspots revealed by keyword clusters, the quick rising terms also indicate some possible research hotspots in the future. Diseases like dementia, HIV and oral diseases may attract more attention in the future. With the increased prevalence of dementia, more attention will be attracted to this area. There are difficulties in obtaining HRQoL data from patients with dementia, because they suffer from a progressive decline in memory and cognitive functioning [35]. So new measurement techniques for data from patients can be used as a research direction in future, since the use of Patient-Reported Outcomes (PROs) to measure the effectiveness of treatment (like surgery) is increasing as clinical scientists attempt to evaluate the impact of therapy on the recipient [36]. HIV had become a chronic disease with the prospect of long-term survival, thus how to improve HRQoL of HIV-infected individuals has become a central issue in the treatment [37, 38], which can be deeply explored in future study. In addition, oral disease produces a wide range of clinical signs and symptoms through inflammation and destruction of the periodontium, some of which may have a considerable impact on daily life [39, 40].

Stress is associated with physical and psychological symptoms, taking appropriate intervention may have long-term beneficial effects on HRQoL [41], and achieving and maintaining optimal well-being is an important objective of disease treatment and of rehabilitation and aftercare [42], which needs more attention in the future. As for the HRQoL in special populations, special attention has been paid more and more to the elderly, women and children (from the clustering result), which is consistent with previous researches [6, 7]. Some special HRQoL instruments were separately built for these populations [43]. In

future study, these populations will be further studied in more aspects, and the HRQoL in some minority populations or the specific industries can become new research directions.

Besides, a large number of author keywords were only used once or twice during 2000 to 2019, it indicates a lack of continuity in HRQoL research and a wide disparity in research focuses[44], and the research on HRQoL has a lot of room for further development. In addition to the hotspots and future trend mentioned above, more importantly, researchers should focus on a certain area of HRQoL for in-depth research. Categorizing the key research issues of HRQoL and using standard research keywords in future research, may effectively improve research continuity.

## Conclusion

This study provided an overall perspective of global research trends and hotspots in HRQoL, and a potential guide for future research. HRQoL researches showed a growing trend over the past twenty years, presented the characteristics of multi-discipline, and the HRQoL instruments were approaching to maturity. But the mode that the cooperation strength between domestic institutions was much greater than that of international institutions was not conducive to the development of HRQoL research in less-developed countries. In another way, this illustrates that HRQoL research has a big gap in less-developed areas, which can be filled by strengthening international cooperation in future. Over the 2000–2019, the research of HRQoL was mainly focusing on (1) HRQoL survey instruments, (2) HRQoL in specific diseases and symptoms, (3) HRQoL in specific populations. We found that a large number of author keywords were only used once or twice during 2000 to 2019, but it is still certain that SF-36, EQ-5D, depression, obesity, disability, oncology and fatigue are important hotspots. Also, dementia, HIV, chronic disease, OHRQoL, PRO, stress, well-being, the elderly, women and children may become new hotspots in future research. More importantly, in order to improve the continuity and depth of research, researchers need to pay more attention to the standardization and unity of key words in future study, it will facilitate an in-depth study of the same HRQoL issues.

## Limitations

The analysis presents some limitations associated with this study. First, in the data screening stage, we did not filter the search terms in the abstract, which may result in the omission of a small number of articles that are closely related to the research topic. Secondly, many institutions in the author's address use abbreviations, so that we lost a small part of the information when using Python to obtain the author's geographic information. Although we supplemented it by manual query, there are still some omissions. Thirdly, before the keyword analysis, synonymous keywords were merged. Although the process was carried out in parallel by two authors and the results of each step were carefully compared, some merge errors and missed merges may still occur. The same problem may occur in the keyword clustering work. Finally, in the analysis of citations, there is no exclusion of self-citation, it might have some effect on the results.

## Abbreviations

HRQoL: Health-Related Quality of Life; WOS: Web of Science; TA : Total Citations; CPA : Citations Per Article; QoL: Quality of Life; IF: impact factor; SCIE: Science Citation Index-Expanded; SSCI: Social Sciences Citation Index; SGR: Sequential Growth Rate; AAP: The average number of authors per article; ARP: The average number of references cited per article; APP: The average number of pages per article; GDP: Gross Domestic Product; CA: Internationally-collaborative articles; SA: Single country articles; OHRQoL: The Oral Health Related Quality of Life; PROs: Patient-Reported Outcomes.

## Declarations

### Ethics approval and consent to participate

Not applicable

### Consent for publication

Not applicable

### Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors declare that they have no competing interests

### Funding

Not applicable

### Authors' contributions

Peigang Wang contributed to study design and critical revision. All authors participated in study conception, data analysis, data interpretation, article drafting and approved the final article. Si Zheng and Anqi He contributed equally to this article.

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Not applicable

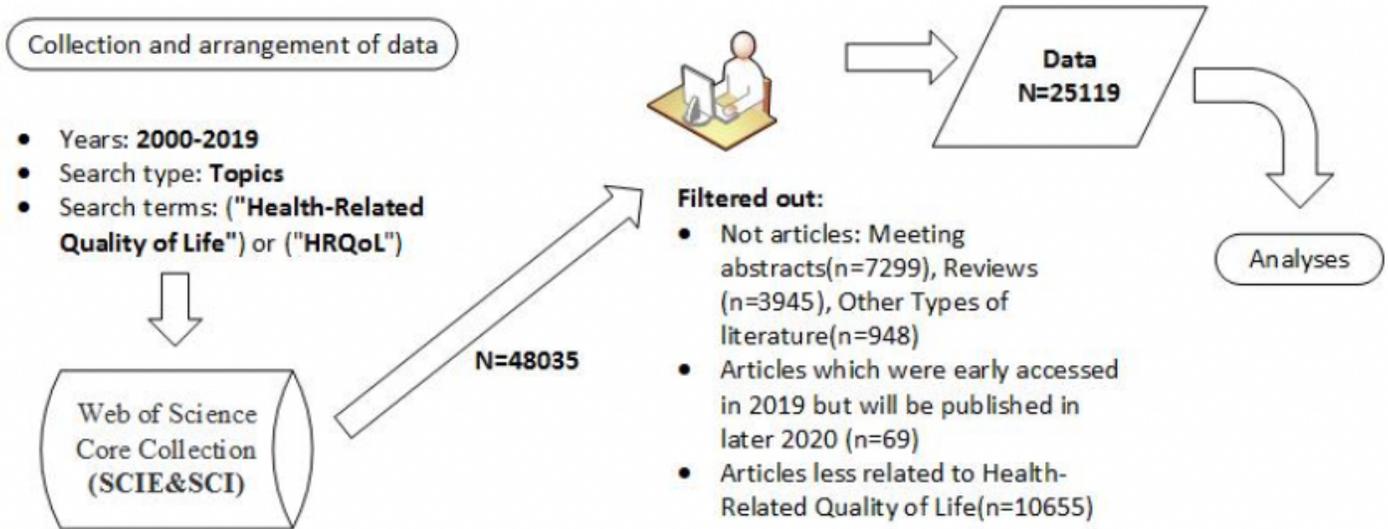
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## Figures



**Figure 1**

The process of data collection

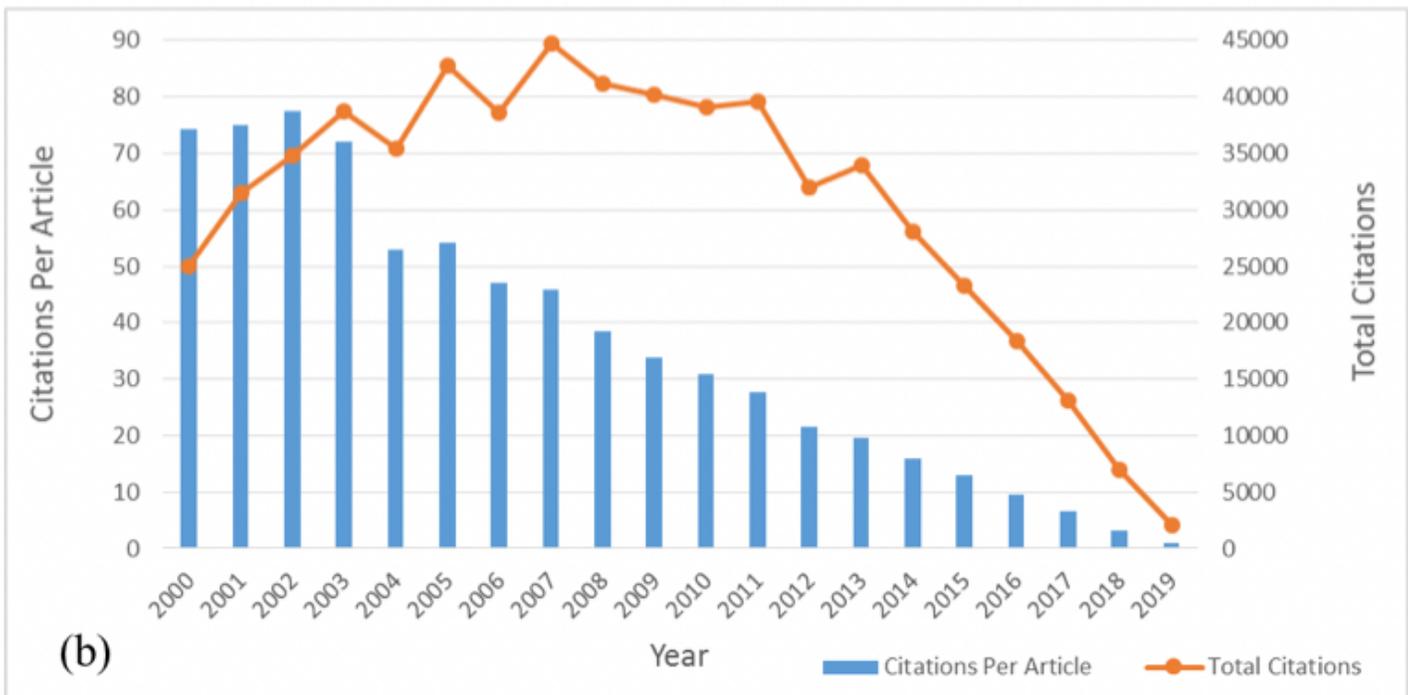
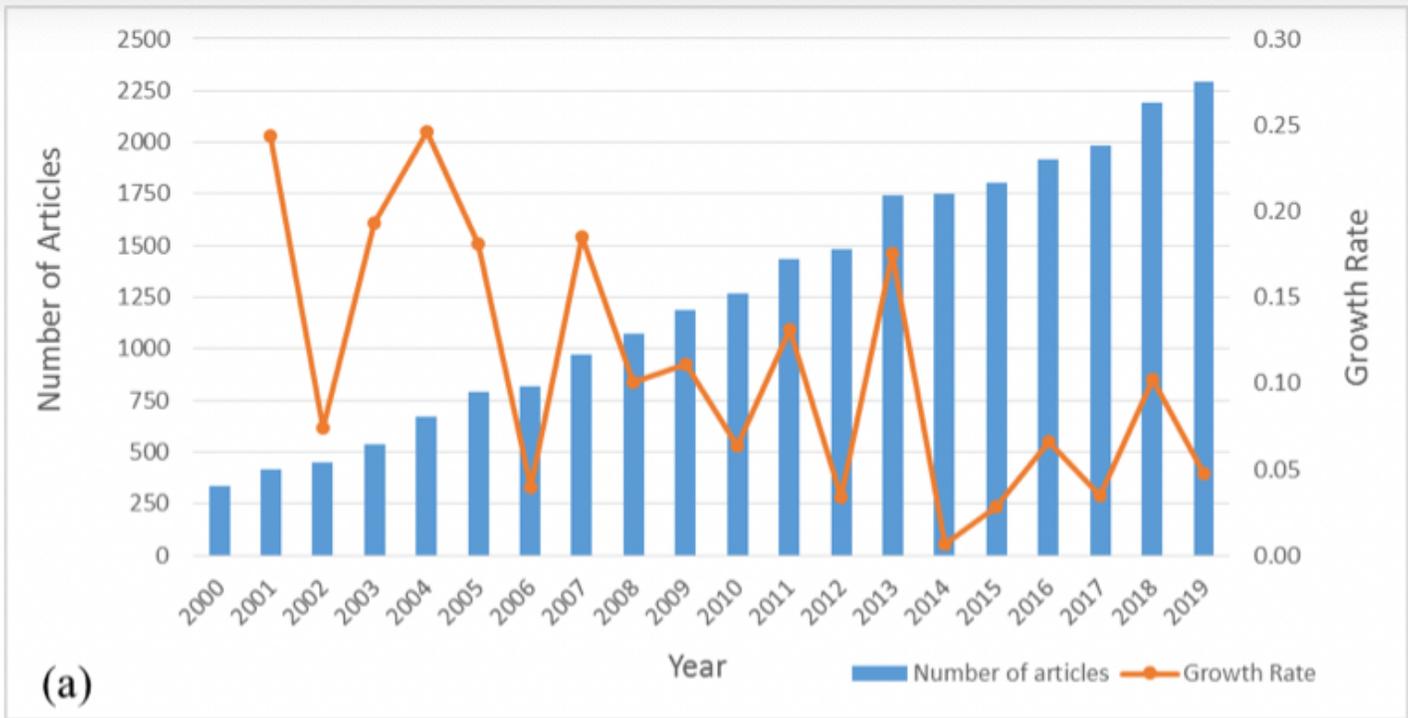
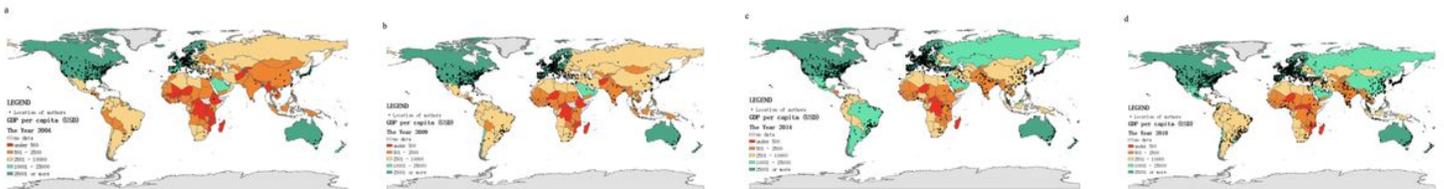


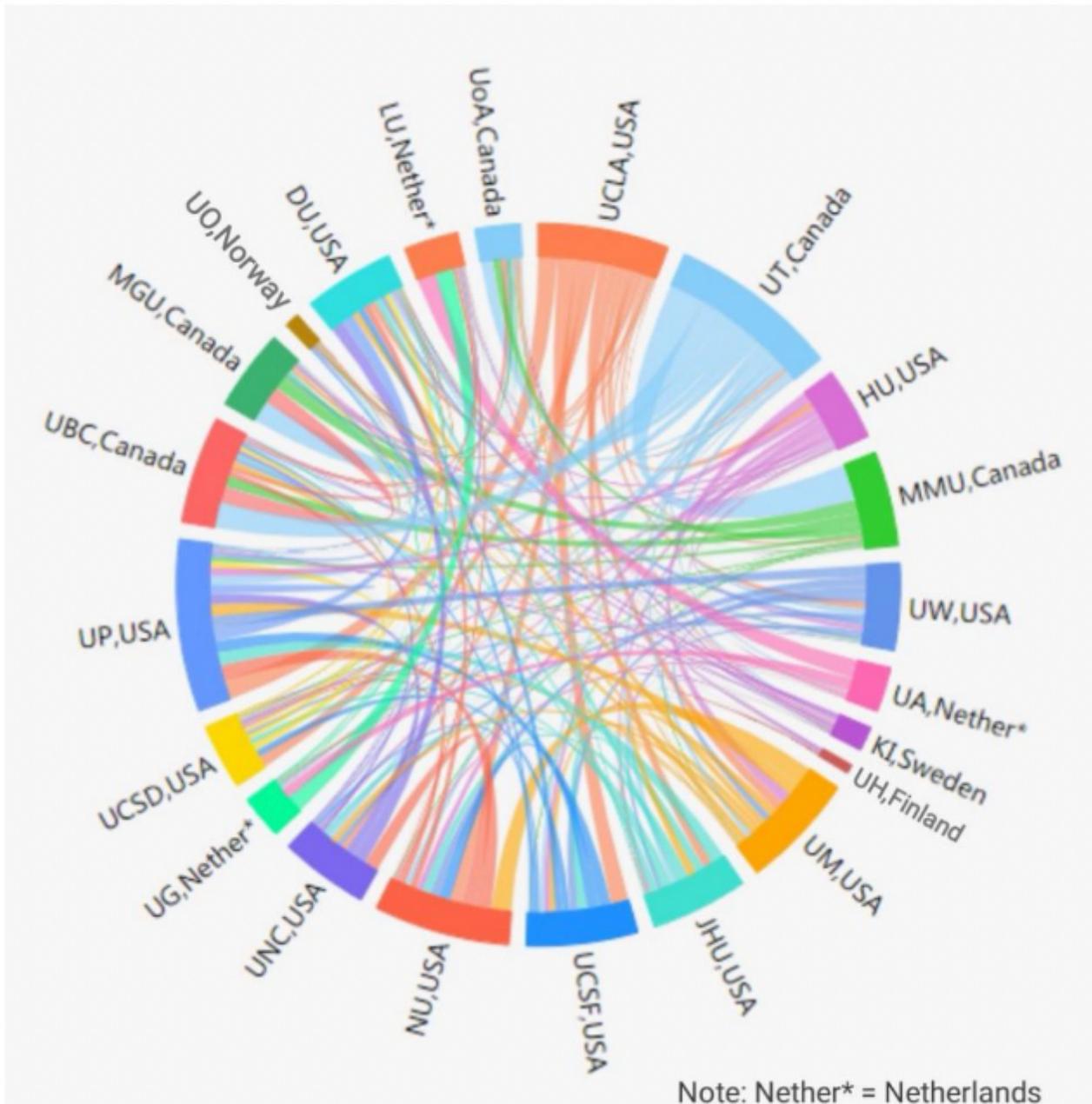
Figure 2

Trends of HRQoL articles and Citations from 2000 to 2019



**Figure 3**

a Geographical distribution of authors (2000-2004). b Geographical distribution of authors (2005-2009). c Geographical distribution of authors (2010-2014). d Geographical distribution of authors (2015-2019).  
Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.



**Figure 4**

Collaboration network of the top 20 highest h-index institutions