

# A BIBLIOMETRIC ANALYSIS OF TELEMEDICINE: REMOTE HEALTHCARE DELIVERY OVER THE YEARS

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**Abstract:** *The concept of telemedicine plays a huge role in the digital evolution of healthcare. With the onset of social distancing and lockdowns, remote healthcare that allows efficient diagnosis and treatment using telecommunication devices, plays a major part in our daily lifestyle (Gochhait & Omale ,2019). Over 70% of the healthcare industry uses telemedicine in the form of gadgets or apps to connect with their patients. The purpose of this paper is to analyze how much telemedicine has grown and its diverse applications and benefits in the field of healthcare and technology throughout the years by performing a bibliometric analysis of databases from the Web of Science Core Collection. Numerous records were analysed which talks about the various trends of telemedicine that have been used all around the world to improve healthcare and make it more available to us at anyplace and anytime. According to the analysis, the USA had the maximum number of publications on telemedicine, with Australia and England following. The years 2016-2019 showed the maximum publication as these were the years when telemedicine and e-health devices and applications started to grow and become more popular. Telemedicine is now considered as the answer to transform the healthcare business and improve patient care irrespective of where they are without compromising on their satisfaction. This analysis gives us an overview of the progress of e-health implemented around the world over the years (Gochhait & Omale ,2018).*

**Keywords:** *Telemedicine, E-Health, Remote healthcare, Bibliometric analysis, Web of Science.*

## Introduction

Telemedicine was an idea used since the invention of telegraphs and telephones (Bashshur&Shannon, 2009). Communication of medical information using such technologies was a fast and easy way of dealing with many health crises, especially in the military. The first idea of telemedicine was introduced in the April 1924 issue of Radio News magazine (FIPS, 1924). The front page, titled 'Radio Doctor – Maybe', depicted a television and a radio that was used to treat a patient, measure his body temperature and give necessary reports based on the diagnosis. Since then, telemedicine has only bloomed the healthcare industry.

The rise of the internet has allowed the world to be more connected, and thus, telemedicine has always brought a plethora of benefits to all persons especially those living in the rural or remote areas who do not have easy access to a medical centre. Telemedicine has also aided in inevitable cost savings and several studies and proved that telemedicine has been a success in the healthcare industry. Many such benefits or applications of telemedicine in different fields of healthcare has been published in numerous records over the years. The analysis of these records can help us understand how much telemedicine has progressed, and how the world is applying the concept of telemedicine to improve the remote delivery of healthcare (Fatehi and Wootton, 2012).

A bibliometric analysis is used to examine the knowledge structure and the research development based on the analysis of related publications, which includes analysis based on quantitative indicators such as the number of citations, most ranked authors, prime publication, and so on. This is a very useful strategy to track the growth and productivity of any field within any period or place. Similarly, the purpose of this paper is to examine how much the concept of telemedicine has grown in terms of remote diagnosis, monitoring, or treatment of patients all around the world (Venkatesha et al., 2012).

### ***Objective***

As we are moving on to what is termed ‘Telemedicine 2.0’, it is important to understand how telemedicine has been improving ‘remote delivery of healthcare’ throughout the years (Yang et al., 2015). This paper aims to analyse the growth of telemedicine and explore its various trends adopted globally. 2495 records were collected from the Web of Science Core Collection database within the period 1980 – 2019. ‘Telemedicine’ was used as the major keyword for this study. The database was analysed to make a qualitative and quantitative assessment on research output such as core research areas, growth of publications, productive countries, the languages used and highly cited publications.

### ***Analysis and Result***

#### ***Core Research Areas:***

The keyword used for this study was ‘Telemedicine’. Any record within the years 1980-2019, that has the keyword ‘Telemedicine’ in their title has been considered for the analysis. The key research areas for this study has been depicted in the table below:

<b>Research Area</b>	<b>Percentage (%)</b>
<i>Health Care Science Services</i>	68.49
<i>General Internal Medicine</i>	24.28
<i>Medical Informatics</i>	13.58
<i>Computer Science</i>	9.53
<i>Telecommunication</i>	3.40

***Table 1: Key research area for the analysis***

Other areas included are business economics, research experimental medicine, public environmental occupational health and engineering.

*Journals used:*

The most productive journals for this study and the record count has been listed below.

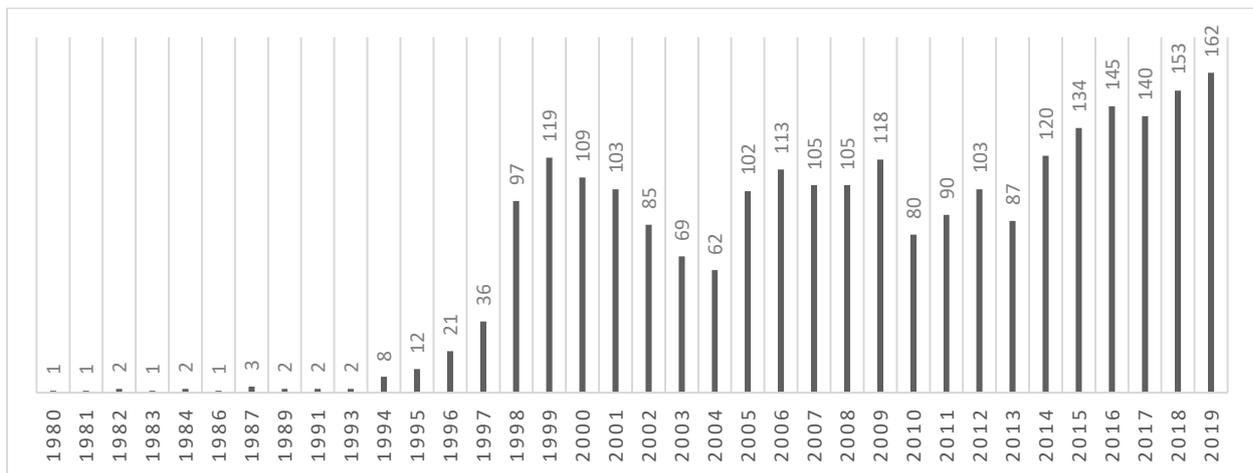
<b>Journals</b>	<b>Record Count</b>
<i>Journal of Telemedicine and Telecare</i>	610
<i>Telemedicine and E-health</i>	277
<i>Telemedicine Journal and E-health</i>	277
<i>Critical Care Medicine</i>	61
<i>Journal of the American Medical Informatics Association</i>	57

**Table 2:** Journals with the record count

**Annual Publication Growth Output:**

Out of the 2495 records collected from the Web of Science database, it was found that 70.9% of the data were original articles. The collection also includes editorial materials, proceeding papers, meeting abstract, reviews, early access and book chapters.

The graph below represents the number of records published in each year from 1980-2019. The year 2019 is ranked highest with 162 records published (6.49% of the total 2495 records collected), with 2018 and 2016 following with 153 (6.13%) and 145 (5.81%) records respectively. This indicates that in recent years, more research was conducted to understand how telemedicine can beinvolved in applications and technologies for our day to day healthcare needs.



**Figure 1:** Number of records published during 1980-2019 on Telemedicine

**Country-wise analysis of Publications:**

The 2495 records collected for this study have been published by 25 countries. According to the analysis, the USA has the highest number of records published, which is 1046 records

which accounts for 41.92% of the total collected records. The USA is followed by Australia with 171 records (6.85%) and England with 163 records (6.53%).

*H-Index:* The index of ‘h’ indicates that a value of h records (under analysis) has been cited h number of times within the selected period (1980-2019). It is an important tool to evaluate a researcher’s output in terms of its quality and consistency.

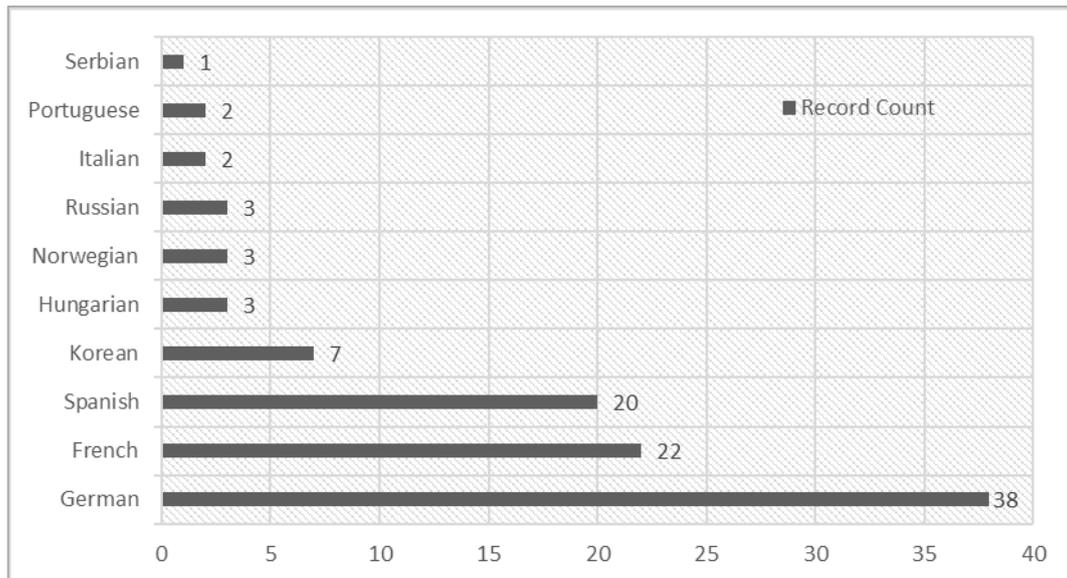
The table shows the top 15 countries with the highest publications. It also includes statistical analysis of the citations of records for each of these countries, that is, the h-index value, the total number of citations (with and without self-citations), and total cited articles (with and without self-citations). Self-citation refers to the external citations in the record. The publication of countries not mentioned in the table below represents less than 1.5% of the total publications under analysis.

Country	No. of Publications	Percentage (%)	H Index	Total Citations	Total Citations (Without Self citations)	Total no. of Citing Articles	Total no. of Citing Articles (Without Self citations)
USA	1046	41.924	56	17663	15603	10117	9521
Australia	171	6.854	30	2989	2859	2354	2279
England	163	6.533	29	3978	3848	3083	3014
Canada	112	4.489	23	2362	2304	2002	1969
Germany	95	3.808	15	807	775	707	686
Spain	85	3.407	17	1178	1148	1070	1048
Italy	83	3.327	17	1194	1165	1082	1060
Norway	79	3.166	19	1800	1730	1494	1463
Peoples R China	64	2.565	13	1023	1004	995	979
France	52	2.084	10	409	400	398	391
Scotland	48	1.924	16	1085	1071	974	962
Japan	47	1.884	14	501	486	464	458
India	43	1.723	10	486	476	451	442
South Korea	43	1.723	11	365	349	330	319
Netherlands	38	1.523	12	574	562	547	536

*Table 3: Top 15 countries with the highest publications and citation details*

**Languages:**

English is the language used for **2394** records, which is 95.95% of the total published records collected. The rest of the records are published in 10 languages, which is depicted in the figure below.



**Figure 2:** Record count of each language

**Most Cited Records:**

The table represents the top 12 highest cited records published within the 2495 data collected. It also includes the information on the authors of the publications, the country, and the year they were published in.

Further results of the study are as follows:

- According to the analysis of 2495 records, the total number of citations (sum of citations of all records under analysis) is **34352**.
- The total number of citations without self-citations (external citations in the paper) is **28742**.
- The total number of citing articles, that have cited any of the records under the analysis is **17237**.
- The H-index of all 2495 collected record is **71**.
- The average citation per article is **13.77**. This value is given by the total number of times cited divided by the total number of records collected.

Article	Author	Country	Year	Citations
Telemedicine Technology and Clinical Applications	Perednia, DA; Allen, A	USA	1995	414
Systematic review of studies of patients satisfaction with telmedicine	Mair, F; Whitten, P	England, USA	2000	413
Effectiveness of Telemedicine: A systematic review of reviews	Ekeland, Anne G; Bowes, Alison; Flottorp, Signe	Norway, Scotland	2010	363
A novel biometrics method to secure wireless body area sensor networks for telemedicine and M-health	Poon, CCY; Zhang, YT; Bao, SD	Peoples R China	2006	286
Systematic review of cost effectiveness studies of telemedicine interventions	Whitten, PS; Mair, FS; Haycox, A; May, CR; Williams, TL; Hellmich, S	USA, England	2002	286
Assessing telemedicine: A systematic review of the literature	Roine, R; Ohinmaa, A; Hailey, D	Canada, Finland	2001	249
Twenty years of telemedicine in chronic disease management - an evidence synthesis	Wootton, R	Norway	2012	236
Effect of a multiple sized intensive care unit telemedicine program on clinical and economic outcomes: An alternative paradigm for intensivist staffing	Breslow, MJ; Rosenfeld, BA; Doerfler, M; Burke, G; Yates, G; Stone, DJ; Tomaszewicz, P; Hochman, R; Plocher, DW	USA	2004	215
Intensive care unit telemedicine: Alternative paradigm for providing continuous intensivist care	Rosenfeld, BA; Dorman, T; Breslow, MJ; Pronovost, P; Jenckes, M; Zhang, N; Anderson, G; Rubin, H	USA	2000	210
Systematic review of evidence for the benefits of telemedicine	Hailey, D; Roine, R; Ohinmaa, A	Canada, Finland	2002	203
Wireless telemedicine systems: An overview	Pattichis, CS; Kyriacou, E; Voskarides, S; Pattichis, MS; Istepanian, R; Schizas, CN	Cyprus, England, USA	2002	203
Determinanats of successful telemedicine implementations: A literature study	Broens, THF; in't Veld, RMHAH; Vollenbroek-Hutten, MMR; Hermens, HJ.; van Halteren, AT; Nieuwenhuis, LIM	Netherlands	2007	195

**Table 4:** Top 12 highly cited publications with details on author, country and year

### Author

The top authors and their publication details have been tabulated and shown below. Doarn, Charles R. and Merrell, Ronalds C. have the highest number of record publications with 84 counts each, which accounts for 3.36% of the total collected set. Their highest cited paper is titled ‘*What is telemedicine? A collection of 104 peer-reviewed perspectives and theoretical underpinnings*’ has been cited 173 times.

Wootton R has the second-highest record with 58 publications (2.32%), and his paper titled ‘*Twenty years of telemedicine in chronic disease management - an evidence synthesis*’ has 236 citations.

31 records published within the collected set remain anonymous and makes up 1.28% of the total 2495 records.

Author	Record Count	Percentage (%)
Doarn C. R., Merrell R. C.	84	3.367
Wootton R.	58	2.325
Krupinski E. A., Marcin J. P.	32	1.283
Smith A. C.	25	1.002

Weinstein R. S.	23	0.922
Whitten P.	22	0.882
Bashshur R. L.	17	0.681
Kahn J. M., Weinstock R. S.	16	0.641
Latifi R., Shea S.	15	0.601
Ferguson J., Hailey D., Nesbitt T. S.	14	0.561
Blanchet K. D., Grigsby J., Tachakra S.	13	0.521

*Table 5: Authors and record count*

## Conclusion

This paper has analyzed the progress and various trends of telemedicine in the past years. According to the analysis, most of the records collected were from the Health Care Science Service (68.49%) area. The year 2016 onwards, more than 140 records have been published every year. This shows that the concept of telemedicine has become more popular during this time and has been adapted in many remote healthcare service applications. Several records analyzed were a study of telemedicine and its applications, while others describe the benefits of telehealth services combined with wireless technologies or how telemedicine can be used for preventive care and disease treatment.

A country-wise analysis was done which depicted that the USA had the highest number of records published with a high-count of 1046 publications. The rest of the country's count was less than 200 publications. The USA healthcare system spends a high amount of its gross domestic product and has been coming up with many innovative and productive ways to improve remote delivery of healthcare over the years.

The collected set of records for this analysis was published in 15 languages. English was the most used language (2394 records), and it was followed by German (38 records) and French (22 records). The authors Doarn, Charles R. and Merrell, Ronalds C. have published the most records in this analysis (84 publications, 3.367% of the total). The most cited article titled 'Telemedicine Technology and Clinical Applications' received 414 total citations, and was published in the USA in 1995, gives an overview of how telemedicine can be helpful to provide easier speciality care services (Perednia & Allen, 2008).

The potential of telemedicine has not yet been completely understood. The recent pandemic times have brought the necessity for remote healthcare and shined a light on the millions who do not receive the required healthcare. Multiple studies have proven that telemedicine can be the solution to many of these issues (Pal et al., 2004). Further studies on the use and application of telemedicine must be encouraged to aid the under-developed as well as the developed country healthcare systems (Senel & Demir, 2014).

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