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Co-authorship pattern and Collaboration in Colorectal Cancer Research

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ABSTRACT

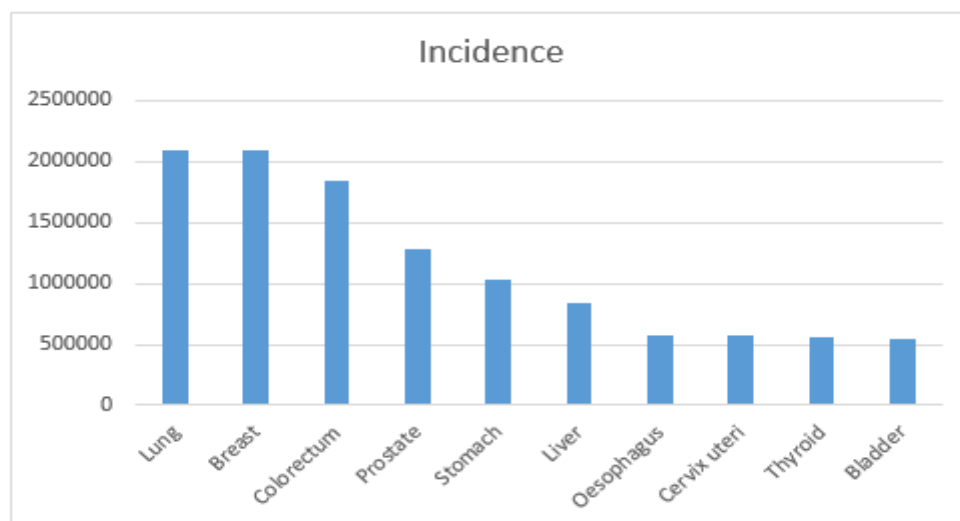
The study focused on authorship pattern and collaboration in colorectal cancer research output as reflected in the web of science database for the period 2010-2017. Using various scientometrics approaches, the study presents co-authorship and collaborative patterns for different countries, institutions, and authors. We find multi and mega author contributions which are increasing and dominate the CRC research. In case of collaborative patterns, we found domestic collaboration which dominates the CRC research compared to international collaborations. Institution wise we find mostly domestic inter-institutional collaboration. Country pair wise collaboration pattern shows that US is the most preferred country for collaborations and the author wise collaborative pattern in CRC research shows that the collaboration of domestic or local inter-institutional collaboration between the authors and highest possible combinations.

Keywords: Colorectal Cancer, Scientometric, Collaboration, Collaborative Index, Collaboration Coefficient

INTRODUCTION

According to World Health Organization, colorectal cancer is one of the most common cancer sites that have caused 8,62,000 deaths across the globe. As per the GLOBOCAN -2018 report, it is the third most commonly diagnosed cancer. International agencies like WHO (International Agency for Research on cancer) have been taking various steps to prevent and reduce the incidence rate; steps like cancer control program was undertaken by WHO for early diagnosis, screening treatment, and prevention, etc. Besides International organizations like WHO, various other local agencies in their respective countries have been taking various steps to educate, create awareness regarding the prevention and treatment of various cancers across the States to provide cancer care services to the people¹. Such deadly disease not only lead to the establishment of the National Institute of Cancer Prevention and Research but also collaborations among the various cancer support communities like Doctors and Researchers at various institutions across the countries to collaborate and find better ways and means for preventing it.

Figure 1: Estimated number of the incident (Both Sexes and All ages, worldwide)



Source: GLOBOCAN 2018, WHO (International Agency for Research on Cancer)

The word collaboration is “the action of working with someone to produce something” Thus research collaboration defined by (Katz & Martin, 1997) is the process of “working together by the researchers to pursue common objectives in undertaking and producing new scientific knowledge”. Though its origin could be traced way back to 19th century in France in the form of joint research (Beaver & Rosen, 1978). In recent past, collaborative research has become increasingly important due to increase in complexity of the scientific inquiry and to reap the benefits associated with it. The benefits from such collaborative research work have been highlighted by the work (Campbell, 1969) wherein he opines that research is most effective when people with diverse knowledge backgrounds collaborate within the same subject area or across institutions or disciplines to answer the

¹ <https://www.cancersupportcommunity.org/resources>

specific questions or to find solution to the research problems. The increasing need for collaboration has also been recognized and highlighted by international organizations like UNESCO in recent science report wherein collaboration especially internationally is a must (UNESCO, 2015) and countries like Germany have already gained success in international collaboration. Scientific collaboration has been greatly acknowledged towards its contribution for development in the field of science technology in the present era of globalization wherein research integration between different countries, and various inter discipline is a must to the global level for sustainable growth and development. Shaikh, 2015 opines that collaboration should be encouraged as perception of individuals which differs from others and thus collaboration will lead to innovative solutions, frequently ensuing high-impact research and development in a selective field. The importance of scientific collaboration has even led to building several theories to improve the public policy framework for successful research (Bozeman & Boardman, 2014; Campbell, 1969); (Bennett & Gadlin, 2012) Research collaboration just like any other field also gains its importance in medical research to discover new effective medicines for the patients with dreaded diseases like cancer and HIVs. The government of various countries has been taking initiatives to promote collaboration for solutions to provide quality health care services to its citizens. A recent solid example is an initiative by the French government wherein the honorable president signed a new cancer research collaboration with Deakin University². An example shows how important research collaboration is in present-day context to find suitable solutions to the problems combining innovative ideas of different researchers, across various countries and institutions.

Review of Literature

Review of the previous study on articles relating to collaboration pattern shows that there is the ample number of literature in various disciplines undertaken by scholars like (Dwivedi & Garg, 2018) wherein they examined the pattern of a domestic and international collaboration of scholarly communication on male breast cancer; in the field of energy science, (Lu & Ma, 2017) studied collaboration network of International Methane Hydrate Research and analysis focuses on cooperation rate, cooperation degree in methane hydrate research at various levels i.e. between the authors and between the countries, departments. (Chinchilla-Rodríguez et al, 2012) used social network analysis to determine the pattern of intra and extra - regional scientific collaboration on medical research in Latin America and the Caribbean. The interdisciplinary field between computer science and mathematics have also been explored by researcher like (Gaskó et al, 2016) inter countries collaborative pattern between China and Germany in the field of physics by (Zhou & Lv, 2015) in linguistic research by (Ezema, 2016) in information science literature (Rattan, 2015) in field of solar cell (Dutt & Nikam, 2015) in the field of science and technology (Persson et al, 2004) on identifying the national characteristic in scientific co-authorship relations (Glänzel, 2001). Authors like (Amaratunga, et al, 2018) also studied the level of engagement in international collaborative research work within the institutions in higher education to improve their research in the field of disaster risk reduction. Studies like (Sabah et al., 2018) focused on the impact of international collaboration on institutional research performance. (Kamradt et al.,

² <http://www.deakin.edu.au/about-deakin/media-releases/articles/french-president-signs-off-on-new-cancer-research-collaboration-with-deakin>

2015) point out that it has become common for health care professionals of different settings for effective communication and collaboration to ensure best possible care to the patient with colorectal cancer. The findings from their study led to explore few important research questions like types of collaboration in colorectal cancer research among the countries, among the institutions and researchers in the field of colorectal cancer research. Therefore, considering this, the present study tries to focus on research collaboration in “colorectal cancer research”, adopting scientometric approach. Use of Scientometrics is gaining momentum in the recent past to evaluate the various aspects of scholarly communications which is evident from its usage like for example (Murugan, 2017) using the scientometrics approach explores research productivity in nephrology. Previous studies related to CRC research have also used scientometric methods to assess its productivity see (Narzary & Murugan, 2018); (M. Chinnaraj & Narzary, 2018) on Indian and Asian countries. Though their studies concentrated on CRC research but had failed to focus extensively on the collaboration of colorectal cancer research. Hence the present study tries to fill this gap using a scientometrics approach to study the Authorship pattern and collaboration in colorectal cancer research internationally.

Objectives of the study

The objectives of this paper is to understand the Authorship pattern and collaboration in colorectal cancer research. The study aims to achieve these objectives by (i) examining the various Co-authorship pattern and (ii) the type of collaboration in colorectal cancer research; concentrating on the country-wise, institution, and author wise.

Methodology

Publications between 2010-2017; related to Colorectal Cancer research were downloaded from Web of Science database which consists of Science Citation Index Expanded (SCI-EXPANDED), Social Science Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI). The basic search query used for data collection was by using Keyword= "colorectal cancer" OR "neoplasm colorectal" OR "colorectal tumor" OR "carcinoma colorectal", in the topic field. The search strategy was restricted to the occurrence of search terms as a Title, Abstract, and Keywords of the publications. Boolean operator "OR" was applied for the present study to obtain a comprehensive data set. A total record of 35889 publications published in colorectal cancer research output was retrieved. The downloaded data were analyzed using Bibexcel, HistCite, and were tabulated using MS Excel spreadsheets to gain important insights from the data collected.

Collaborative Index (CI)

The collaborative index was calculated using the formula given by (Lawani, 1980) as follows.

$$CI = \frac{\sum_{j=1}^A jf_j}{N}$$

Collaboration Coefficient (CC)

We also incorporated the measure suggested by (Ajiferuke et al., 1988) based on fractional productivity defined by (Price & Beaver, 1966).

$$CC = 1 - \frac{\sum_{j=1}^k \left(\frac{1}{j}\right) f_j}{N}$$

Where,

f_j denotes the number of j authored research papers,

N denotes a total number of research papers published,

K is the greatest number of authors per paper.

According to Ajiferuke, CC tends to zero as single author paper dominated and to $1 - 1/j$ as j authored papers dominated. This implies that the higher the value of CC, the higher the probability of multi or mega authored papers.

Degree of Collaboration

The degree of collaboration of authorship was calculated using the formula given by (Subramanyam, 1983).

$$C = \frac{NM}{NM+NS}$$

C = Degree of Collaboration.

NM = No. of Multi-authored papers.

NS = No. of Single author papers.

Results and Discussion

Co-Authorship Pattern

Year Wise Co-Authorship Pattern

To examine the authorship, a pattern we first depict the Co-Authorship pattern during the period of our study in Table 1 below. The results obtained from the data indicate that number of authors contributing to the field of colorectal cancer shows an increasing trend. When we segregate the authors to various possible combinations i.e. into single authors, or collaboration of two, three, four, or greater than five authors. we find that in the case of single authors the result shows a bit of decreasing trend while in case of joint contributions of two, three, four, or greater than five authors show a remarkable increasing trend. Out of the total publications related to colorectal cancer research, most of the publications came in the form of a joint contribution of more than five authors. Other indicators like collaborative index, collaborative coefficient, and degree of collaboration support the fact that joint collaborative

practices, collaboration among the authors, and collaborative research have been increasing rapidly in colorectal cancer research.

Table 1- Year-wise co-authorship pattern during the year 2010-2017

Year of Publication	Single author	Two authors	Three authors	Four authors	≥ Five authors	Total Publication	Total authors	CI	CC	DC
2010	206	236	279	307	2243	3271	22395	4.283	0.712	0.937
2011	125	213	292	357	2442	3429	24269	4.101	0.735	0.963
2012	188	217	329	442	2960	4136	29651	4.394	0.732	0.954
2013	196	233	312	386	3178	4305	32249	4.420	0.733	0.954
2014	187	245	318	444	3438	4632	35782	4.446	0.737	0.959
2015	218	257	376	483	3814	5148	41080	4.440	0.736	0.957
2016	165	255	400	461	4034	5315	43210	4.494	0.746	0.968
2017	197	259	365	516	4316	5653	46343	4.502	0.745	0.965
Total	1482	1915	2671	3396	26425	35889	274979	4.431	0.736	0.958

Authorship Pattern

Authorship pattern in Colorectal Cancer research output during the study period, shows that single authored contributed 4.129 % of total publications. Two author publications account for 5.336% of the total output and three author articles amount for 7.442% publications. The highest number of publications was six authored with 10.822% and five authored with 10.750 % of publications. As the collaborating number of authors increased, articles published also increased, the production quantum of multi-author publications increases, so much that the above 21 authors collectively published 35889. It is revealed that collaborative research has dominated the field of Colorectal Cancer research.

Table 2- Authorship pattern- of publications trends in colorectal cancer

S. N	No. of Author	Total No. of Publications	Percentage of 35889
1	1 author	1482	4.129
2	2 authors	1915	5.336
3	3 authors	2671	7.442
4	4 authors	3396	9.463

5	5 authors	3858	10.750
6	6 authors	3884	10.822
7	7 authors	3302	9.201
8	8 authors	3170	8.833
9	9 authors	2458	6.849
10	10 authors	2594	7.228
11	11 authors	1500	4.180
12	12 authors	1219	3.397
13	13 authors	858	2.391
14	14 authors	678	1.889
15	15 authors	520	1.449
16	16 authors	391	1.089
17	17 authors	357	0.995
18	18 authors	296	0.825
19	19 authors	243	0.677
20	20 authors	467	1.301
> 21	21 authors	630	1.755
Total		35889	100.000

Country-wise Authorship pattern

To better understand the country-wise trend in colorectal cancer research output next we illustrate the co-authorship pattern of different countries in table 3. Based on our convenience we sorted the output based on the total number of publications than we separated the colorectal cancer research output by a single author, two authored, multi-authored, and mega authored publications for each country. The results of the country-wise comparison show that the USA, Peoples R China (PRC), Japan, UK, Italy, Germany, Spain, France, Australia, South Korea, Netherlands, Canada, Belgium, Taiwan, Sweden tops the list. Approximately 90 percent of the papers are contributed by these countries via collaborations of two and more than two authors. The collaborative coefficients of these countries are more than the average coefficient obtained combining all the countries that have contributed to colorectal cancer research; which means that these countries have higher co-authorship records either in the form of multi-authored or mega-authored papers.

Table 3- Country wise Authorship pattern

Country	Single author papers	Two authored papers	Multi-authored papers	Mega authored papers	Total	CC
USA	341	624	2242	5313	8520	0.731
Peoples R China	31	157	1391	3806	5385	0.775
UK	98	205	1137	1744	3184	0.726
Japan	42	42	336	2545	2965	0.797
Italy	37	68	333	2055	2493	0.789

Germany	58	108	415	1581	2162	0.762
Spain	39	51	234	1284	1608	0.778
France	38	42	226	1247	1553	0.779
Australia	34	48	340	983	1405	0.761
South Korea	21	60	311	975	1367	0.767
Netherlands	24	37	258	969	1288	0.774
Canada	21	58	349	827	1255	0.757
Belgium	10	15	64	625	714	0.799
Taiwan	21	32	194	463	710	0.748
Sweden	7	12	162	405	586	0.770
Other 106 Countries	558	400	2541	6510	10009	0.731
Total	1380	1959	10533	31332	45204	0.754

Authorship pattern by type of document

There are various types of documents by which authors communicate in the form of Article, Meeting Abstract, Review, Editorial Material, Letter, Unknown, Correction, Article; Proceedings Paper, News Item, Article; Retracted Publication, Article; Book Chapter, Review; Book Chapter, Article; Data Paper, Reprint, and Editorial Material; Retracted Publication, Editorial Material; Book Chapter, etc. as shown in Table 3. Most of the contributions in the field of CRC research were in the form of Article, meetings abstract and review, and most of which were mega authored papers which is evident for the collaboration coefficients.

Table 4- Authorship pattern of Colorectal Cancer research (CRC) output by type of document

Document Type	Single author papers	Two authored papers	Multi-authored papers	Mega authored papers	Total	CC
Article	184	583	4574	13363	18704	0.773
Meeting Abstract	346	455	3547	7812	12160	0.748
Review	102	312	893	614	1921	0.705
Editorial Material	457	319	185	56	1017	0.324
Letter	163	185	390	126	864	0.529
Unknown	16	23	113	335	487	0.751
Correction	65	13	77	147	302	0.597
Article; Proceedings Paper	12	3	50	144	209	0.740
News Item	141	6	3	2	152	0.043
Article; Retracted Publication	0	2	11	12	25	0.733
Retraction	1	3	9	1	14	0.595
Article; Book Chapter	2	1	6	4	13	0.603
Review; Book Chapter	2	6	5	0	13	0.487

Article; Data Paper	0	0	1	3	4	0.792
Reprint	1	0	1	0	2	0.335
Editorial Material; Retracted Publication	0	1	0	0	1	0.500
Editorial Material; Book Chapter	1	0	0	0	1	0.000
Total	1493	1912	9865	22619	35889	0.735

Authorship pattern based on Institutions

Institutions wise authorship pattern as depicted in Table 5 shows the 15 most prolific institutions and pattern of authors in CRC research. Institutions wise University of Texas MD Anderson Cancer Centre, Harvard University, Mayo Clinic, Shanghai Jiao Tong University, National Cancer Centre, Sun Yat Sen University, German Cancer Research Centre, Fudan University, Dana Farber Cancer Institute, Mem Sloan Kettering Cancer Centre, Zhejiang University, NCI, University of North Carolina, Fred Hutchinson Cancer Research Centre, University Toronto are the leading contributors in CRC research. Most of these institutions are from the US and China. These pioneering institution in CRC research have less single-author papers, most of the scholarly communications from this institute are the outcome of the joint contribution of more than two authors, and prolific institutions had a maximum contribution in the form of mega-authored papers resulting in a high value of CC.

Table 5- Institution Wise Authorship pattern

Institution	Single author papers	Two authored papers	Multi-authored papers	Mega authored papers	Total	CC
Univ. Texas MD Anderson Cancer Center	19	25	58	393	495	0.764
Harvard University	13	33	80	353	479	0.759
Mayo Clinic	7	28	83	320	438	0.767
Shanghai Jiao Tong University	2	11	77	348	438	0.791
Natl Cancer Center	0	6	49	379	434	0.809
Sun Yat Sen University	1	8	35	383	427	0.811
German Cancer Research Center	2	15	78	309	404	0.784
Fudan University	0	8	73	279	360	0.792
Dana Farber Cancer Institute	3	14	49	282	348	0.789
Mem Sloan Kettering Cancer Center	17	24	41	253	335	0.776
Zhejiang University	1	8	68	245	322	0.787
NCI	0	12	47	262	321	0.796
University N Carolina	12	16	70	221	319	0.748
Fred Hutchinson Cancer Research Center	4	11	37	266	318	0.791

University Toronto	1	12	53	236	302	0.788
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Collaboration: In this section, we present the results of different types of collaboration in Colorectal cancer research first which shows the number of domestic and international collaboration papers of most prolific countries. The level of inter-country collaboration than inter-institution wise collaboration and author level collaboration in CRC research was also preferred.

Domestic and international collaboration papers

Country-wise segregation of collaborating papers reveals that most of the papers related to colorectal cancers are in the form of domestic collaboration such as collaboration between the authors from the same country, country-wise domestic collaboration papers range from 58 percent to 89 percent of total publications. Papers without collaboration are negligible i.e. it constitutes one to four percent of total publications. International collaborating papers that is a collaboration between international authors of different countries varies from country to country. The percentage of paper collaborated internationally out of total collaboration differs from 7 percent to 47 percent. Sweden has the highest number of international collaborative papers followed by Taiwan and Belgium. While though total publications are high in the case of US the number of international collaboration papers is low.

Table 6- No of Domestic and International collaboration papers

Country	PWD	DCP	ICP	Total
USA	341(4.00)	7622(89)	557(7)	8520
Peoples R China	31(0.58)	4813(89)	541(10)	5385
UK	98(3.08)	2582(81)	504(16)	3184
Japan	42(1.42)	2434(82)	489(16)	2965
Italy	37(1.48)	2042(82)	414(17)	2493
Germany	58(2.68)	1706(79)	389(18)	2162
Spain	39(2.43)	1172(73)	397(25)	1608
France	38(2.45)	1123(72)	392(25)	1553
Australia	34(2.42)	1044(74)	327(23)	1405
South Korea	21(1.54)	1030(75)	316(23)	1367
Netherlands	24(1.86)	949(74)	315(24)	1288
Canada	21(1.67)	932(74)	302(24)	1255
Belgium	10(1.40)	413(58)	291(41)	714
Taiwan	21(2.96)	102(14)	287(40)	710
Sweden	7(1.19)	305(52)	274(47)	586

PWD: Paper without collaboration; DCP: Domestic collaborating papers; ICP: International collaborating papers. Figures in the parenthesis indicate the percentage

Inter-Country collaboration

In the chart given below, we show the result of inter-country wise collaboration i.e. what are the countries to collaborate. The results reveal that most of the countries 10 out of the 15 most prolific countries collaborate with the US. Joint inter-country collaboration between the People Republic of China and the US has the highest number of collaboration that is they contribute 3.47 percent of total inter-country collaboration on colorectal cancer research. Next is, Germany's collaboration with the US followed by UK collaboration with the US. Inter-regional collaboration also could be observed between the countries of European regions like an inter-country collaboration between Italy, Spain, France, Germany, and the UK.

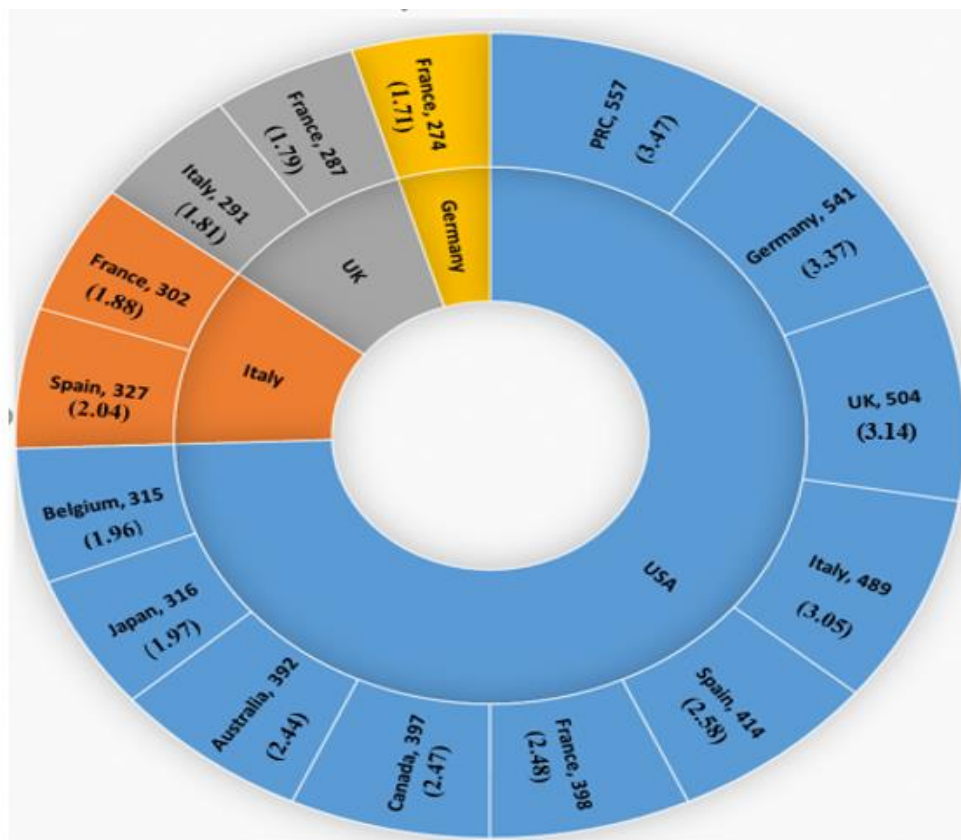


Figure in the parenthesis indicates percentage of Inter-country collaboration to Total Inter-country collaboration

Figure 1: Inter-country collaboration

The inter country collaboration network is depicted in figure 2 below. The collaboration network shows that most of the countries collaborating partner is with countries like USA, China and UK.

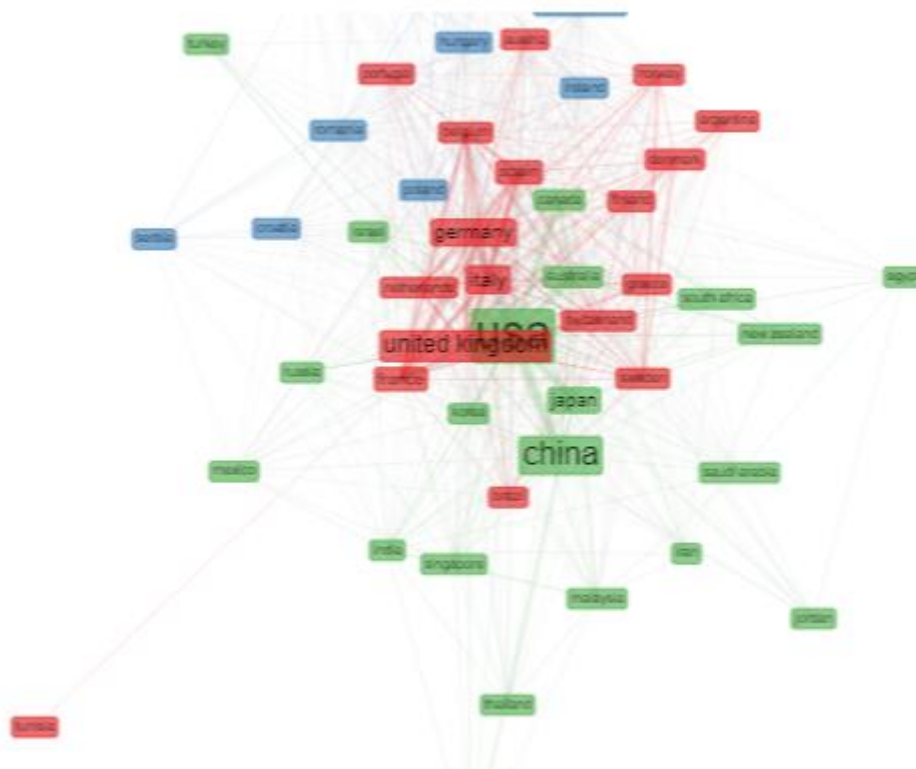


Figure: 2: Inter-Country collaboration Network

Institution wise collaboration

The result from inter-institutions wise collaborations shows that collaboration of inter-institutions within the countries itself contributes the most i.e. say for example inter-institution collaboration between Brigham & Women's Hospital and Harvard University both of which are from the US, Inter institution collaboration between Fudan University and Shanghai Jiao Tong University both from China, etc. Apart from inter-institutions within the country itself we also found international inter institution collaboration that is said for example collaboration between Fred Hutchinson Cancer Research Center and the University of Melbourne i.e. inter-institution situated in the US and Australia. Another example of international inter- institution collaboration is between the German Cancer Research Center and Harvard University.

Table 7- Top 15 Most Collaborative Institutions in Colorectal Cancer Research

S. No	Collaborative Institution		No. of papers Collaborated
1	Brigham & Women's Hospital	Harvard University	202(5.30)
2	Brigham & Women's Hospital	Dana Farber Cancer Institute	187(4.91)
3	Dana Farber Cancer institute	Harvard University	181(4.75)
4	Harvard University	Massachusetts Gen Hospital	144(3.78)
5	Brigham & Women's Hospital	Massachusetts Gen Hospital	125(3.28)

6	Dana Farber Cancer Institute	Massachusetts Gen Hospital	120(3.15)
7	Fred Hutchinson Cancer Research Center	University Melbourne	92(2.41)
8	Fred Hutchinson Cancer Research Center	University of South California	87(2.28)
9	Fred Hutchinson Cancer Research Center	Mayo Clinic	83(2.18)
10	Mayo Clinic	University of So California	76(1.99)
11	Mayo Clinic	University Melbourne	67(1.75)
12	University Melbourne	University of South California	65(1.70)
13	Fred Hutchinson Cancer Research Center	German Cancer Research Center	64(1.68)
14	Fudan University	Shanghai Jiao Tong University	58(1.52)
15	German Cancer Research Center	Harvard University	57(1.49)

Note: Figure in the parenthesis indicates the percentage

In order to clearly understand the institutions wise collaborating partners in figure 3 we depict the institution wise collaborating network. From the figure it is evident that most of the institutions are having their collaboration with institutions like Dana Farber Cancer Institute, Brigham & Women's Hospital, Fred Hutchinson Cancer Research Center, Massachusetts Gen Hospital, German Cancer Research Center, University Melbourne.

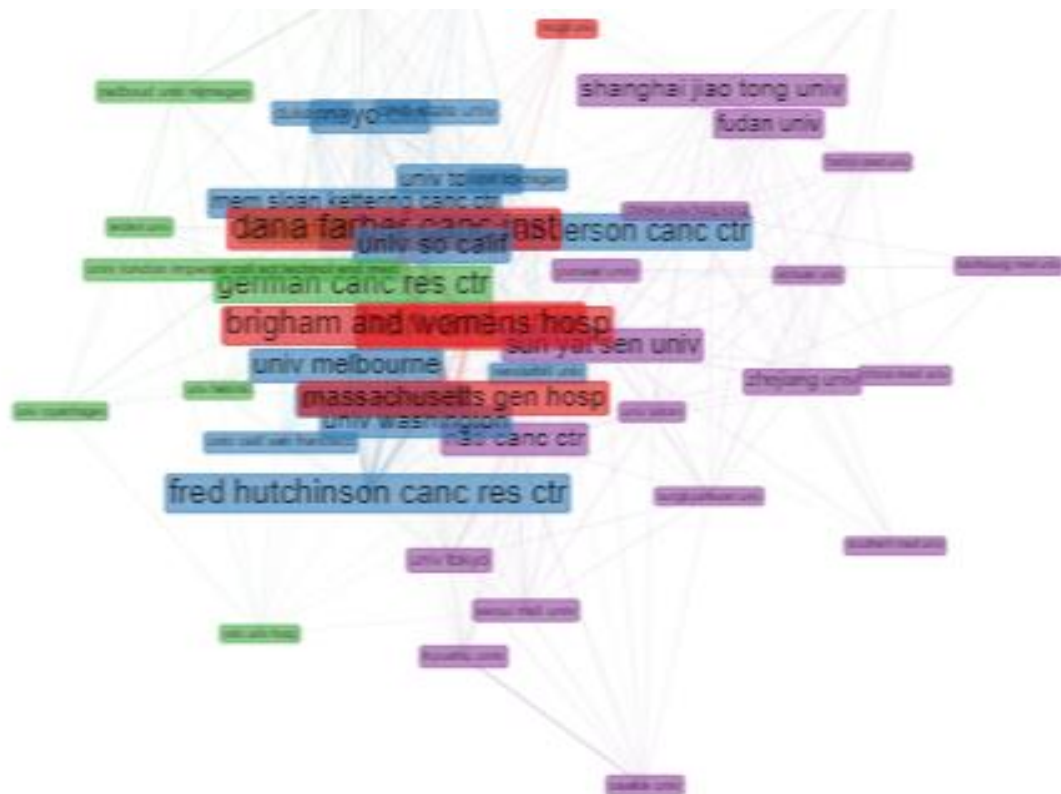


Figure 3: Institution wise collaborating network

Author wise collaboration

The result of the author wise collaboration in colorectal cancer research shows the collaboration of various possible cooperation of authors. The first type of collaboration is between Falcone A and Loupakis F which is highest, both the author's affiliation country is Italy but differs in institutions affiliations. This type of author's collaboration refers to the domestic or local inter-institutional collaboration between the authors like for example between Fuchs CS and Ogino S, between Chan AT and Ogino S, between Chan AT and Fuchs CS. The second type of collaboration between the authors is inter-country and inter-institutional which is a collaboration between authors of different counties and institutions across borders like for example between Falcone A who is affiliated with University of Pisa Italy and Lenz HJ affiliated to the University of Southern California. Another important type of collaboration could also be observed from the result that is Regional authors collaboration that is a collaboration between different countries but the same region example between Falcone A whose affiliation is University of Pisa, Italy and Vancutsem E affiliated to Department of Digestive Oncology, University Hospitals Leuven, Belgium.

Table 8- Top 15 Most collaborative authors in Colorectal Cancer Research

S. No	Collaborative Author		No. of papers Collaboration
1	Falcone A	Loupakis F	146(10.17)
2	Fuchs CS	Ogino S	113(7.87)
3	Chan AT	Ogino S	102(7.10)
4	Chan AT	Fuchs CS	101(7.03)
5	Tabernero J	Vancutsem E	71(4.94)
6	Falcone A	Lenz HJ	58(4.04)
7	Lenz HJ	Vancutsem E	52(3.62)
8	Lenz HJ	Loupakis F	51(3.55)
9	Falcone A	Vancutsem E	51(3.55)
10	Vancutsem E	Yoshino T	50(3.48)
11	Lenz HJ	Yoshino T	48(3.34)
12	Brenner H	Chan AT	46(3.20)
13	Falcone A	Yoshino T	43(2.99)
14	Tabernero J	Yoshino T	41(2.85)
15	Lenz HJ	Tabernero J	36(2.50)

Note: Figure in the parenthesis indicates the percentage

In figure 4 we try to plot the author wise collaborating network to better understand the collaborating pattern of various authors. It is seen from the figure that authors like Falcone A, Vancutsem E, Tabernero J, Loupakis F have higher number of collaboration network in the field of CRC research.

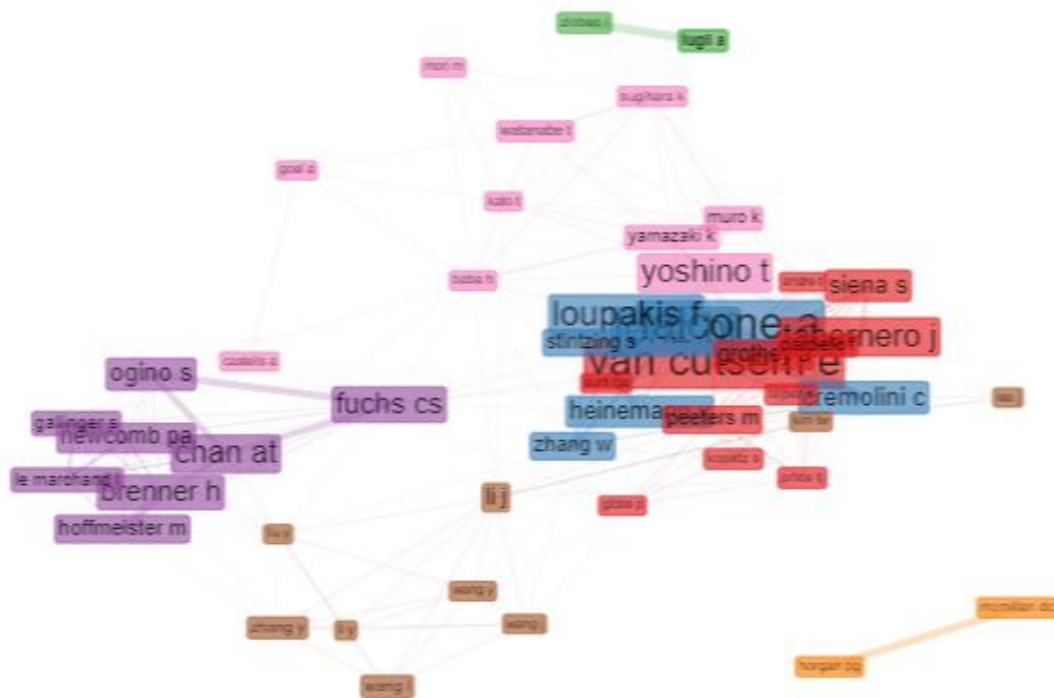


Figure 4: Author wise collaborating network

Findings and Conclusions

This paper tries to examine and understand the authorship patterns and collaboration in colorectal cancer research. By examining the various pattern of authorship and different types of collaborations, the findings revealed that number of authors contribution in the field of colorectal cancer shows an overall increasing trend in all possible groupings i.e. collaboration of two, three, four and greater than five authors. A slight decreasing trend could be observed in the case of single authors' contribution when compared to joint contributions of two, three, four, and greater than five authors. Country-wise groupings of authorship pattern in colorectal cancer research output by a single author, two authored, multi-authored and mega authored publications for each country shows that approximately 90 percent of the papers contributed by these 15 countries given in table 3 are in the form of collaborations of two and more than two authors. The Multi and mega authored papers in the field of CRC research were in the form of articles, meetings abstract and review, and conference proceedings. Institutions wise authorship pattern as depicted in Table 5 shows that most prolific institutions were mostly from the US except few from other countries like China, Germany, and Korea. Most of the contributions from these pioneering institutions in CRC research had less single-author papers, most of the scholarly communications from this institute were in the form of collaboration of more than two authors. As a whole authorship pattern reveals that collaboration of more than two authors dominates in CRC research be it country-wise, institution wise or the type of document. The most prolific institutions and

countries to encourage and promotes collaborative effort, which is evident for the collaboration coefficients, supported by other measures like collaborative index, and degree of collaboration, that joint collaborative practices, collaboration among the authors and collaborative research among the institutions have been increasing rapidly in colorectal cancer research. One of the possible reasons for such an increasing trend could be due to the increasing role of stakeholders and policymakers and promotions of such collaborative efforts by various incentives by various agencies national or international to find a suitable solution to overcome this menace globally.

The findings from the collaborative pattern show that percentage of domestic collaboration papers is higher compared to international collaboration. The country-wise domestic collaboration of papers ranges from 58 percent to 89 percent of total publications compared to International collaborating papers from 7 percent to 47 percent. The collaborative papers vary from country to country. US only 7% of the paper is internationally collaborated, the domestic collaboration rate is high i.e. 89 percent one of the possible reasons could be due to the availability of experts and eminent research communities and institutions of excellence in the US wherein most of the research collaboration takes place within and between authors of different institutions domestically. Sweden, Taiwan, and Belgium have the highest number of international collaborative papers. One of the possible reasons for such highly international collaborative papers could be due to bilateral agreement of the promotion of joint research groups between various governments or institutions by the policymakers through various funding, research grants, etc. The results of inter-country collaboration reveal that most of the countries that are 10 out of 15 most prolific countries collaborate with the US. Joint inter-country collaboration between the People Republic of China and the US has the highest number of collaboration i.e. they contribute 3.47 percent of total inter-country collaboration on colorectal cancer research. Next is, Germany's collaboration with the US followed by UK collaboration with the US. Inter-regional collaboration also could be observed between the countries of the European region like an inter-country collaboration between Italy, Spain, France, Germany, and the UK. The US is found to be the most preferred collaborating country for research collaboration. The possible reasons could be to top rankings institutions and cancer research centers that are available in the US like for example MD Anderson Cancer Center, The Brigham, etc. The result from inter-institutions wise collaborations shows that collaboration of inter-institutions within the countries itself contributes the most i.e. say for example inter-institution collaboration between Brigham & Women's Hospital and Harvard University both of which are from the US, Inter institution collaboration between Fudan University and Shanghai Jiao Tong University both from China, etc. next is international inter institution collaboration that is said for example collaboration between Fred Hutchinson Cancer Research Center and the University of Melbourne i.e. inter-institution situated in US and Australia. Another example of international inter- institution collaboration is between the German Cancer Research Center and Harvard University. The result of authors wise collaboration in colorectal cancer research shows the collaboration of domestic or local inter-institutional collaboration between the authors, like for example between Fuchs CS and Ogino S, between Chan AT and Ogino S, between Chan AT and Fuchs CS, tops the list followed by the collaboration between

authors if inter-country and inter-institutional that is a collaboration between authors of different countries and institutions across the borders like for example between Falcone A who is affiliated with University of Pisa Italy and Lenz HJ affiliated to the University of Southern California and Regional authors collaboration between different countries but same region example between Falcone A whose affiliation is University of Pisa, Italy and Vancutsem E affiliated to Department of Digestive Oncology, University Hospitals Leuven, Belgium. Overall the results indicate that the US holds the top positions in CRC research be it in terms of institution wise, country wise or in terms of authors. The reasons for such representation could be due to the increasing importance given by the US government and institutions in CRC research as it third leading cause of death in the US. The research grants provided for CRC related research could mean how important it is that is in the financial year 2017 around \$208,406,608 were spent for funding colorectal cancer research.

(Chinchilla-Rodríguez et al., 2012) points out that a rise in scientific collaboration which is one of the most discernible features of the revolution taking place in science. But despite such growing importance of research collaboration authors like (Lawler et al., 2018) points lack coordination of CRC research and its funding as one of the major research gaps and calls for multi-disciplinary teams with diverse experts to find an optimal solution to the problem related to CRC. The changing global scenario and its possible effect on various countries and its populations call for more collaborative and joint research work to explore and disseminate new knowledge to society. (Goodgame et al., 2019) highlights an increasing number of cases in young adults in the US which has led to changes in screening guidelines from the age of 50 to 45 and calls for more research work to bring appropriate health response. For which there is a need for extensive and joint collaborative work of various minds to bring efficient discovery of new means to counter such problems and pave a way for sustainable growth and a better future.

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