Spring 3-31-2018

Measuring Co- authorship Pattern in Research Output of Chromosome Anomalies

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Abstract

This article studies about the collaborative measures of published documents in the field of chromosome anomalies. It discusses about inadequacies of collaborative measures in analyzing the collaborating behavior and strength of collaboration in a discipline. It also suggests centrality measures, as degree centrality, closeness, and betweenness in analyzing the collaboration among the researchers and scientists in the field of chromosome anomalies. The bibliographical database PubMed is used as sources for bibliometrics and 35912 citations examined for co – authorship pattern, collaborative behavior of the scientists. Centrality measures were used to construct a network for co – authorship in chromosome anomalies research during the year 2007 – 2016 and to find out the most influential predominant author in the field.

Keywords : Chromosome anomalies, Collaborative Measures, Centrality Measures, collaborative behavior, Network analysis, Birth defects, Genetic disorder.

1. Introduction

A healthy and prosperous nation is mainly depends on its people. World Health Organization reports that an estimated 303 000 newborns die within 4 weeks of birth every year, worldwide from congenital anomalies. One of the most common and frequent congenital anomalies are chromosome anomalies. Scientists estimate that approximately one in every 200

babies is born with chromosome anomalies of one kind or another. Chromosome anomalies are also thought to be responsible for at least 50% of miscarriages in the first trimester. It is important to prevent birth of a child with a malformation or a genetic disease, to build healthy and prosperous nation and to reduce the socio - economic burden of a country.According to March of Dimes (MOD) global report on birth defects 7.9 million births (6% of total births) occur annually worldwide with serious birth defects and 94% of these births occur in the middle and low income countries. According to joint WHO and MOD meeting report, birth defects account for 7% of all neonatal mortality and 3.3 million under five deaths.

It is evident from the report of World Health Organization, birth defects due to chromosome anomalies are increased tremendously. Chromosome anomalies are a significant public health issue but there was no scientometrics analysis carried out to quantifying research publication in this field.

A study about collaborative behavior among the scientists in the field of chromosome anomalies using collaborative measures along with centrality measures will helps to analysis the growth of number of authors involved in the development of the studies, in the dissemination of research results, and research efforts taken by the research institutions to address the problems.

2. Review of Literature

Chromosome anomalies are sub field of genetics in medicine. Corpus of literatures is available for scientometrics analysis on genetic, heredity related diseases. Some of the noteworthy studies are by Garg (2010) et.al who conducted a scientometrics analysis on genetic and heredity research in India during 1991-2008. The study analyzed 2899 papers published by Indian scientists indicate that the growth of publication output was slow in the initial stages and increased after 2000. Gupta, Kaur & Kshitig (2015) analyses the dementia research output from India during 2002-2011 on different parameters includes the growth, global publications share, citation impact authorship pattern, contribution of various subject fields and by type of dementia, most cited journal and impact factors. Vellaichamy & Jeyshankar (2014) made an attempt to make the quantitative study of research output on anemia disease. The study showed that 5085 papers were published during the period under study. The highest number of papers (739) was published in the year 2013 but it received 178 citations only. The minimum number (47) of

papers was published in the year of 1996, but they have received 3245 citations. The study reveals that lowest number (0.56%) of citations received in the year 2013.

received in the year 2013. Chitra, Jeyshankar & Abu (2014) examines the research output of lung cancer in the G7 and the BRIC countries. They compared the growth rate (CAGR), Collaboration Coefficient (CC) and Publication Activity (TAI) of the countries of both the groups. Two relative indicators– Absolute Citation Impact (ACI) and Relative Citation Impact (RCI) have been adopted to compare the quality and impact of the lung cancer research. Jeyshankar, & Vellaichamy (2016) analysed 13079 global literature on Autism, indexed in Scopus database during 2007- 2011. They found that totally 70 countries contributed to the literature, majority of the papers coming from USA (49.24%), followed byUnited Kingdom (15.61%), Germany (4.93%) etc.

Gupta (2012) analyzed the heredity blood disorder research output carried out during 2002-2011 on different scientometrics indicators. It reveals that, India has published 921 papers in heredity blood disorder accounted for 3.09% share in global publications output. The 10 most productive Indian authors involved in heredity blood disorder research together contributed 49.84% share in India's total output with an average of 45.9 papers per author during 2002-2011.Sangam (2014) et.al conducted a study to assess the research output of genetics research based on the distribution of publications in different sub-specialties of genetics. The study compared the research priorities of 16 sub-specialties of genetics in 10 Asian countries for two time-spans. Molecular genetics as sub-specialties accounts for the largest output of 38 % in 1992-2001and 30 % in 2002-2011. Sweileh et al., (2010) analyzed the research output on Autism spectrum disorders during the period 2005 -2014. Bibliometric indicators were investigated by analyzing annual research output, languages, countries, institutions, journals, title terms, highly cited articles, and co-authorship relations.

Since the proclamation of collaborative measures by Lawani and Subramanyam were tested and redefined by Ajiferuke (1988) as collaborative index, was further modified by Savanur and Srikanth (2010). Jeyshankar, Ramesh Babu & Rajendran (2011) used collaborative measures to analysis the research productivity of scientists in CECRI revealed that high degree of collaboration of 0.98 in the year 2005. Cronin et.al investigated the co-authorship and sub authorship collaboration in the scholarly journal of Psychology and Philosophy and they found that single authored publications (74%) were dominant among a total of 2,707 articles of 2001.

Newman used network analysis to construct the collaboration networks for scientists in the field of physics, biomedical research and computer science. González-Alcaideetal (2015) studied about the evolution of scientific collaboration in field of Psoriasis research and constructed a giant co – authorship network consist of 161 components of researchers containing 6 highly cohesive sub-components.

Jeyshankar and Vellaichamy (2014) discussed the worldwide productivity of Cervical Cancer research output. The study analyzed 18060 records during the study period. The study found that USA was the most productive country on cervical cancer research with 26.04% of publications. Indian researchers have contributed 730 (4.04%) papers on cervical cancer research with seventh place. There are enormous literatures available on collaborative and centrality measures used as scientometrics indicators in quantifying the research productivity of various subject fields. But a gap in the literature of studying both collaborative and centrality measures in research output of chromosome anomalies felt and addressed by the present study.

3. Objectives

The main intention of this study is

- To examine the growth of publication output of chromosome anomalies research
- To rank top 20 prolific author in the field of chromosome anomalies
- To determine degree of collaboration
- To find out the most prominent and collaborative author in the field of chromosome anomalies research
- To construct and analyze the co – authorship network for research output of chromosome anomalies
- To find out the centrality measures for the constructed co – authorship network
- To study about the collaborative behavior among the researcher in the field of chromosome anomalies

4. Methods and Methodology

The bibliographical database PubMed is used as sources for bibliometrics and employed to study about the indicators. PubMed is a free resource developed and maintained by the National Centre for Biotechnology (NCBI) at the National Library of Medicine (NLM). It has over 26.7 Million citation covering Life Science, Biomedicine, Health Science, Molecular

Biology and complementary Medicine. Totally 36367 articles were retrieved from PubMed by using the keyword "chromosome anomalies" and search filters Human, all publication type, from 1/1/2007 to 31/12/2016 are applied to retrieve data. Various scientometrics relative indicators, degree of collaboration, collaborative index, collaborative coefficient, modified collaborative coefficient, mean paper per author, mean author per paper are employed to explore cohesive intellectual collaboration between scientists and researchers in the field of Chromosome anomalies. In addition, network centrality measures, closeness, betweenness and degree centrality are computed and implication of scale free network tested in the data set.

Data set were standardized for name of the author, source type. Generally types of sources in the PubMed database are categorized as Clinical Trial phase I, phase II, and Phase III was integrated as Clinical Trial. During standardization and data cleaning process 455 records are removed from the dataset. Bibexcel, MS Excel used to process the bibliographical information and Pajekto visualize the intellectual structure of the co-authorship network and to compute network centrality measures,

Collaborative Indicators: Collaborative measures are used to study about the trend of co-authorship in any field or discipline. The mean number of authors per paper profound by Lawani (1980) as collaborative Index (CI) and the proportion of multi authored papers are known as degree of collaboration (DC) by Subramanyam (1983). Ajiferuke (1988) addressed the inadequacies of Collaborative index and degree of collaboration and formulated collaborative coefficient (CC) which rectify the shortfalls of both collaborative measures with the following formula

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

Where Fj = the number of j authored research papers

N = total number of research papers published and

k = the greatest number of authors per paper.

CC has lower limit 0 and upper limit 1. The lower limit 0 indicates dominance of single authors and upper limit 1 indicates dominance of collaborative authors. CC differentiates single and multiple authors. But it fails to yield 1 for maximal collaboration except when number of authors

is infinite. It was rectified by Savanur and Srikanth, (2010) by the factor (1 – 1/A) with CC and enunciated Modified Collaborative Coefficient (MCC) as,

$$MCC = \frac{A}{A-1}\left\{1 - \frac{\sum_{j=1}^{A}(1/j)f_j}{N}\right\}$$

Co – Authorship Index (CAI): Schubert and Braun (1986) elaborated CAI for the first time. Garg and Padhi suggested formula to computer CAI. It is obtained by calculating proportionally the publications by single, two, three for more authored papers for different blocks of the years /nations / sub – disciplines.

$$CAI = \left(\frac{N_{ij}}{N_{oj}}\right) \div \left(\frac{N_{io}}{N_{oo}}\right) X100$$

Where N_{ij} = No. of publication for the particular authorship pattern for a particular country / sub – discipline / year

N_{io} = total output for the particular authorship pattern

N_{oj} = total output of the particular year

N_{oo} = total output of the year

CAI = 100 The number of publications corresponds to the average within a co-authorship pattern.

CAI >100 The number of publications are higher than the average

CAI <100 The number of publications are lower than the average

Centrality Measures: Centrality measures are techniques used in social network analysis which provide new perception for the study about the characteristic of scientific collaboration and collaboration behavior among the scientific community. It also helps in measuring the collaborative strength of the researcher in any field of study, determining the most collaborative practices and in identifying the most potential predominant collaborators within the whole scientific community under study.Centrality Measures are most basicand widely used measures in network analysis. The most frequently used centrality measures are degree, closeness, betweenness, and eigenvector. The first three were proposed by Freeman (1979)and eigenvector

was proposed by Bonacich (1972). Measures of centrality help to study about the intellectual collaboration between scientific communities and discover the collaboration among the invisible communities of scientists. This measure is also known as degree centrality. Co- authorship network is a non-directed network and in-degree or out- degree measures cannot be calculated. In the co-authorship network nodes are authors and edges or links represents co-authorship.

Degree Centrality: An author with high degree centrality maintains numerous collaborators or co-workers in the network and occupies a structural position that serves as source or conduit for larger volumes of information exchange and other resource transactions with other authors. Degree centrality equals to the number of links that a node has with other nodes. It is expressed as -

$$\mathbf{C_D(n_i) = d_i(n_i)}$$

Closeness Centrality: A more sophisticated centrality measure is closenesswhich is defined as the centrality of a given node is the sum of geodesics distance from all other nodes, which is defined as the length of the shortest path from one node to another. (Freeman, 1979) Closeness centrality describes the extent of influence of a node on the network. It is computable by

$$C_c^1(i) = [\sum_{j-i}^{N} d\ (i-j)]^{-1}$$

Normalized closeness centrality:

$$C_c^1(i) = \ (C_c\ (i)|(N-1))$$

Centralized network have the closeness centrality value of one and the decentralized network have the closeness centrality value of zero.

Betweenness Centrality: It is based on the number of shortest paths passing through a node. Being betweenness means that a node has the ability to control the flow of knowledge between most others. Thus the highly influential Authors can be derived by the betweenness centrality. The authors with high betweenness are the pivots in the Co-authorship networks.

Betweenness centrality measures for node i:$C_B(i) = \sum_{j,k} g_{jk}(i)/g_{jk}$

g_{jk}(i) stands for path between node j and k that pass through node i

g_{jk} stands for all paths between node j and k.

Normalized betweenness centrality for direct network:

$$C_B^1(i) = \ C_B(i)/[(N-1)(N-2)]$$

5. Data Analysis and Interpretations

Table 1: Annual Publication Output of Chromosome Anomalies Research

Sl. no	Year	No of Output	% of Output	Cum. Output	Cumulative % of output
1.	2007	3615	10.07	3615	10.07
2.	2008	3553	9.89	7168	19.96
3.	2009	3561	9.92	10729	29.88
4.	2010	3770	10.50	14499	40.37
5.	2011	3998	11.13	18497	51.51
6.	2012	4100	11.42	22597	62.92
7.	2013	2443	6.80	25040	69.73
8.	2014	4001	11.14	29041	80.87
9.	2015	3886	10.82	32927	91.69
10.	2016	2985	8.31	35912	100.00
Total		**35912**	**100.00**		

The research publication output on chromosome anomalies cumulated to 35912 during the year 2007-2016 presented in the Table & Figure - 1. It shows that fluctuations in the research output of chromosome anomalies research. An average of 10.74 increases in research output is observed from the year 2009 to 2012. In 2013 the growth of output decreased to 6.80 and again it increased to 11.14 with an immediate fall of output to 8.31 during the year 2016.

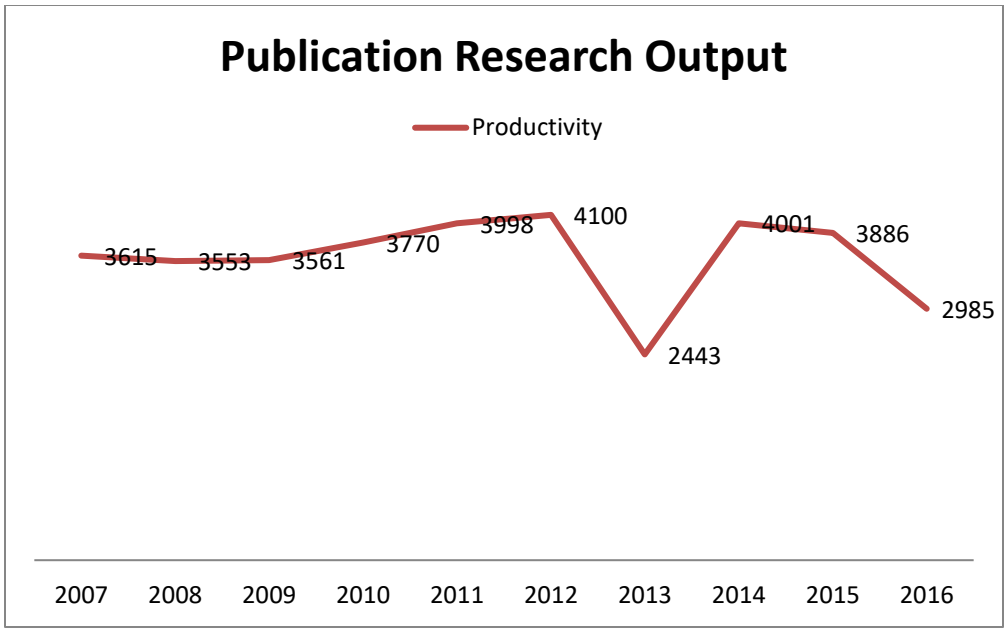

Figure1: Publication Output of Chromosome Anomalies research during the year 2007-2016

Table 2 - Indicate the source wise distribution of research out in Chromosome Anomalies A corpus of research publications on chromosome anomalies appeared as journal articles (21084) followed by case reports (7674) and by clinical trials (2669), reviews (1288), abstracts (1393). Remaining 1804 research output are published as editorial (224), letter (1078), comments (346)and 156 are found as lectures, news, interviews, biographies. One of important mode of knowledge is through clinical trial and case report. It is evident from the above table, 28% productivity is found in case reports (21.36%) and clinical trial (7.43%). On the contrary, case reports and clinical trial form of publication were not found in genetic, genetic hereditary, dementia, cervical cancer research.

Table 2: Source wise distribution of research out in Chromosome Anomalies

Sl. no	Year	Editorial	Abstract	Journal Article	Letter	Review	Case Reports	Clinical Trail	Comment	Congresses	Lectures	News	Biography / Auto biography	Interview	Total
1.	2007	20	186	2063	65	245	871	105	44	6	3	7	0	0	3615
2.	2008	28	155	2100	109	68	828	225	25	7	0	5	3	0	3553
3.	2009	11	160	2122	95	42	766	321	32	1	1	6	4	0	3561
4.	2010	38	159	2175	95	82	858	334	19	1	0	7	2	0	3770
5.	2011	27	154	2395	79	52	895	336	35	7	1	15	0	2	3998
6.	2012	19	121	2464	81	59	864	442	37	4	0	7	2	0	4100
7.	2013	21	130	1157	200	172	668	51	31	2	0	8	2	1	2443
8.	2014	13	139	2396	52	207	829	251	81	4	4	14	11	0	4001
9.	2015	30	141	2429	218	149	613	260	32	6	0	7	0	1	3886
10.	2016	17	48	1783	84	212	482	344	10	0	0	4	1	0	2985
Total		**224**	**1393**	**21084**	**1078**	**1288**	**7674**	**2669**	**346**	**38**	**9**	**80**	**25**	**4**	**35912**

Table3 indicates diminishing rate of collaborative pattern in chromosome anomalies research. During the year 2007 to 2012 the contribution by single authored papers was increased constantly from 7.05 % to 12.13% with the variant rate of multi authored papers. A great fluctuation is observed in the collaborative behavior of the scientists in chromosome anomalies research (11.00 to 10.01 to 10.55 to 11.20 to 6.59). It shows that solo research

tendency among the researchers in the field of chromosome anomalies. Overall 76.35 % of the output is collaborative and remaining 23.65% are solo researcher.

Table 3: Authorship Pattern of Research Output in Chromosome Anomalies during 2007-2016

Sl. No	Year	No of single authored papers	%	Total No of Authors	No of Multi Authored Paper	%	Total No of Multi Authors	Total No of Papers
1.	2007	599	7.05	21863	3016	11.00	21264	3615
2.	2008	685	8.07	21314	2868	10.46	20629	3553
3.	2009	817	9.62	20853	2744	10.01	20036	3561
4.	2010	878	10.34	22530	2892	10.55	21652	3770
5.	2011	942	11.09	23973	3056	11.15	23031	3998
6.	2012	1030	12.13	25918	3070	11.20	24888	4100
7.	2013	635	7.48	14827	1808	6.59	14192	2443
8.	2014	1077	12.68	25458	2924	10.66	24381	4001
9.	2015	1038	12.22	25214	2848	10.39	24176	3886
10.	2016	792	9.33	19580	2193	8.00	18788	2985
Total		**8493**		**221530**	**27419**			**35912**

Table 4 depicts productivity of research groups. Small research group consist of 2 to 5 authors contributed 10420 and medium group consist of 6 to 9 authors contributed 10038 articles. It shows that small and medium group of researchers are the most productive research group compared to other research groups. It reveals that when the number of authors in the group increases the productivity will decreases.

During 2007 to 2016, decreasing trend of productivity of small and medium research groups identified. On the contrary the large research group and single researcher shows increasing trend of productivity in the field of chromosome anomalies.

Table 4. Productivity of Research Groups

Sl.no	Year	No docs with 1 Author (Single)	No docs with 2–5 Authors(Small group)	No docs with 6–9 Authors (Medium group)	No docs with >_10 Authors(large group)	Total
1.	2007	599	1246	1148	622	3615
2.	2008	685	1147	1096	625	3553
3.	2009	817	1080	1029	635	3561
4.	2010	878	1108	1097	687	3770
5.	2011	942	1165	1166	725	3998
6.	2012	1030	1138	1098	834	4100
7.	2013	635	692	631	485	2443
8.	2014	1077	1035	1019	870	4001
9.	2015	1038	1018	990	840	3886
10.	2016	792	791	764	638	2985

Collaborative Measures: Table 5. Illustrate fluctuations in the publication output reflected in the mean number of authors per paper. CI for the research output on chromosome anomalies during the year 2007-2016 is observed as 6.16. Collaboration during the year 2011 (5.99) is higher than the year 2012 (6.32). But, for the same year DC is decreased from 0.764 to 0.749. It explicit the proportionate increase in the single authored papers during the year 2011 to 2012 (1.04) is stronger than the effect of higher level of multi authorship for the same year (0.05). It is observed that increase of 0.02 percentages in CC value for the year 2011 to 2012 is higher than the increase in DC value (0.01), because DC does not reflect the higher level of collaboration in 2012. MCC was calculated to overcome the short fall of CC and ranges between 0.65 and 0.58. CC and MCC were identical over the period of entire study.

Table 5: Collaborative Measures for Research Output in Chromosome Anomalies during 2007 - 2016

Sl. no	Year	Degree of Collaboration	Collaborative Index	Collaborative Coefficient	Modified collaborative Coefficient
1.	2007	0.83	6.05	0.65	0.65
2.	2008	0.81	6.00	0.63	0.63
3.	2009	0.77	5.86	0.60	0.60
4.	2010	0.77	5.98	0.60	0.60
5.	2011	0.76	6.00	0.60	0.60
6.	2012	0.75	6.32	0.58	0.58
7.	2013	0.74	6.07	0.57	0.57
8.	2014	0.73	6.36	0.57	0.57
9.	2015	0.73	6.49	0.57	0.57
Total	**2016**	**0.73**	**6.56**	**0.57**	**0.58**

It is evident from the table6 that collaborative authorship index for the output of chromosome anomalies for the entire study period is diversed with higher and lesser than the average. CAI of single author and more than 10 authorsshows incresing trend (70.064 – 112.191and 88.767 – 110.267). CAI for the year 2007 to 2011 are lesser than average for single and more than 10 authors. On the contrary CAI for 2-5 authors and 6-9 authors are higher than average and shows declining trend.

Table 6: Collaborative Authorship Index during the year 2007 to 2016

Sl. no	Year	CAI for Single Author	CAI for 2-5 Authors	CAI for 6-9 Authors	CAI for >=10 Authors
1.	2007	70.064	118.790	113.612	88.767
2.	2008	81.522	109.352	110.359	90.751
3.	2009	97.013	104.526	103.380	91.996
	2010	98.476	101.291	104.102	94.012
	2011	99.629	100.428	104.339	93.554
	2012	106.226	95.660	95.810	104.942
	2013	109.908	97.624	92.406	102.420
	2014	113.822	89.155	91.117	112.181
	2015	112.947	90.285	91.143	111.518
	2016	112.191	91.328	91.568	110.267

Centrality Measures for Co – Authorship Network Analysis: Co- authorship network is constructed for the research output of chromosome anomalies during the year 2007 -2016. The properties of co – authorship network are given below. The network is undirected and excludes productivity of single authors.

Total No of Nodes - 995

Total No of links - 23602

Density - 0.04760

Average Degree - 47.4412

Betweeness centrality- 0.03862516

Closeness centrality - cannot be computed since the network is stronglyconnected

Strong Components of N1 [>=2] - 4

Average distance among reachable pairs - 2.67087

- The connectedness of a network can be studied by its density value. The density value of the co – authorship network 0.04760 indicates that the network is not poorly connected so that closeness centrality cannot be computed for the network.
- Average degree centrality (47.4412) indicates average number of collaborators for per nodes in the network. Wang Y has high degree centrality collaborated with 370 collaborators which means that he is the central collaborator of the whole network

- Wang X has the highest betweenness(0.0402) which indicates heis the most influential author in the network connecting different group of collaborators and controls the flow of information among the others.
- Wang X (0.05253) again has the highest closeness indicates he is close to many others can quickly interact and communicate with them without going through many intermediaries. Thus the two authors need not necessarily co-singed for an article, but their co-workers may jointly sing an article. The higher closeness centrality will be helpful in analyzing invisible community structure.
- The network has four strong components. The largest component has 987 nodes. Brassesco MS (0.2010) and Vundinti BR (0.2010) formulated a separate small components consists of two nodes which implies that neither these two author nor their co – authors are not collaborated. They might be independent group of researchers specialized in specific field of chromosome anomalies research.
- Average distance is a measure associated with the time required to disseminate information and innovation in the network. Average distance among reachable pairs is 2.67087. The most distant vertices areFragouli E and Durante M with a distance of 7. Thus the chromosome anomalies network is matured which facilitates effective dissemination of information, innovation among the research community.
- Wang W (268) ranked one among the top 20 prolific author in the field of chromosome anomalies during the year 2007 – 2016 (Table7), but his centrality measures (degree centrality – 241, closeness – 0.48 , betweeness– 0.0300) shows his tendency towards solo research.
- Wang Y (243) ranked two has secured highest in degree centrality (370), second highest in closeness (0.51) and betweenness (0.0326). This indicates that he tend to conduct most of the research accompany by his peer researchers.
- Wang X (163) ranked eighth in the top 20 prolific author in the field of chromosome anomalies but he has positioned first in centrality measures. (Closeness – 52, betweenness – 0.0402, degree centrality – 355 (2^{nd} position)). He obviously collaborated to a much larger research community.

- Liu Y and Chen Y (109) shared 15th rank with different centrality measures (Closeness – 46, 48; betweenness – 0.0022, 0.0159; degree centrality – 193, 222) implies their collaborative behaviours.

Table7: Centrality Measures for Top 20 Prolific Authors in Chromosome Anomalies Research during 2007 – 2016

Sl. no	Author	Output	Rank	Degree	Closeness	Betweenness
1.	Wang W	268	1	241	0.48	0.0300
2.	Wang Y	243	2	**370**	**0.51**	**0.0326**
3.	Chen CP	208	3	34	0.36	0.0024
4.	Zhang Y	201	4	314	0.50	0.0244
5.	Li Y	174	5	353	0.52	0.0301
6.	Wang J	167	6	301	0.49	0.0183
7.	Zhang J	166	7	265	0.48	0.0144
8.	Wang X	163	8	355	**0.52**	0.0402
9.	Chern SR	153	9	31	0.33	0.0011
10.	Li J	151	10	288	0.48	0.0159
11.	Liehr T	151	10	82	0.44	0.0164
12.	Zhang L	139	11	244	0.50	0.0277
13.	Wang H	117	12	214	0.47	0.0047
14.	Cheung SW	114	13	115	0.44	0.0088
15.	Zhang X	111	14	250	0.48	0.0124
16.	Liu Y	109	15	193	0.46	0.0022
17.	Chen Y	109	15	222	0.48	0.0159
18.	Li X	108	16	225	0.48	0.0148
19.	Siebert R	98	17	100	0.45	0.0148
20.	Medeiros LJ	96	18	91	0.43	0.0014
21.	Wang L	96	18	201	0.46	0.0076
22.	Shaffer LG	95	19	98	0.44	0.0113
23.	Haferlach C	92	20	94	0.42	0.0086

In order to study the structure of co – authorship network a threshold of 50 papers per author resulted in 107 nodes of prolific authors formed undirected network of co –authorship.

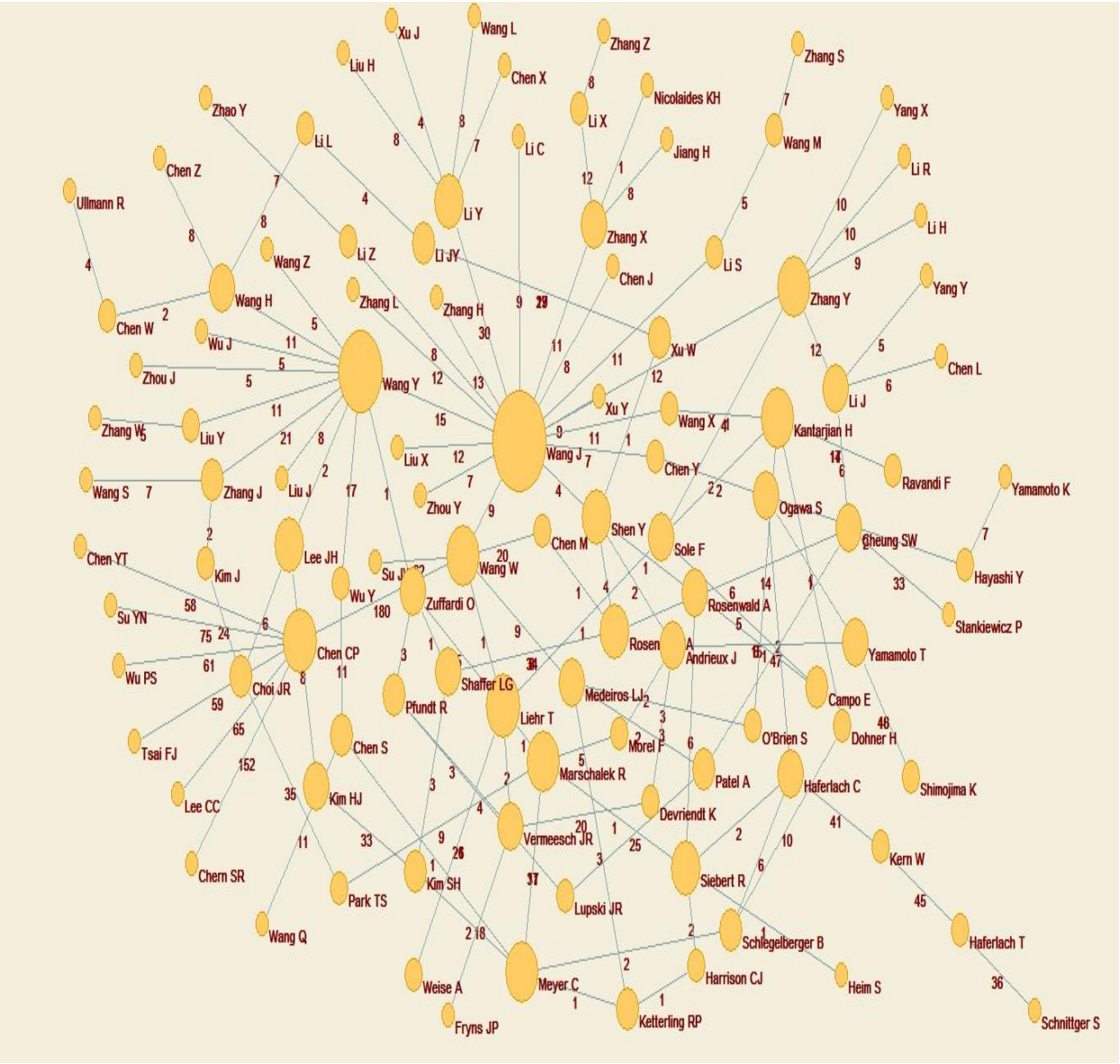

Figure 2: Mapping of Co –Authorship Network of highly prolific authors (node – 107)

In the above figure - 2 Degree centrality is represented by the size of vertices. Wang J, Wang Y, Chen CP has highest degree centrality and collaborators located on center of the network and formulated cluster. This might be influential characteristics of the researcher and tendency to dominate in the field. The line between two nodes represents collaboration between two authors and their strength of collaboration is indicated by line value. Chen CP and Wang W has the highest line value of 180 and the second highest is Chen CP and Chern SR 152. But the degree centrality for Chen SR is one. It denotes Chen SR has collaboration with Chen CP in the field of chromosome anomalies and contributed 152 research works together.The highest ranked

researchers in closeness and betweenness measures are Wang J (0.3955, 0.5889), Wang W (0.3365, 0.2207), Wang Y (0.3397, 0.3143) those who plays a key role as intermediaries and connected intellectually to a larger research community in a shortest path of the network. They are the most prominent authors in the field of chromosome anomalies research during the year 2007 – 2016. Zhang Y (0.12, 0.31) plays an incredible role as bridge between, connecting different clusters of Li J and Wang J and facilitates dissemination of information, research methodologies, and innovation between these two clusters,

6. Major Findings

- Collaborative measures indicate that scientists and researchers in the field of chromosome anomalies are tend towards solo research activity.
- 307 authors collaborated to produce an article in the selected research field. The collaborators may consist of authors who provide concrete technical and instrumental support or specialists in analyzing the specific field of chromosome anomalies.
- Productivity of small and medium research groups is comparatively high. Chronological analysis of authorship pattern reveals diminishing rate of small and medium research group and increasing rate of large research group. 19.38 % of research is carried out by the large research group which is comparatively high value observed on other discipline in terms of productivity. For example in Psoriasis research the productivity of 9 and more than 9 author is only 2.85% only.
- Chronological analysis of source wise distribution of research output in chromosome anomalies during the period of study reveals increasing trend of clinical trial. Thus more clinical research, multi - centered studies and clinical studies in chromosome anomalies may resulted in increasing rate of large research group along with rate of clinical trails
- In this study 7.43 % are clinical trial paper but in the field of psoriasis research 10.46 and in leishmaniasis research 2%.
- Inadequacies of collaborative measures have felt in measuring the collaborative strength and in analyzing the collaborative behavior of scientists in the selected research field.
- This study suggests centrality measures are more appropriate to analyse the collaborative behavior of scientists rather than collaborative measures.

- Wang W is the most productive author in chromosome anomalies research based on his overall productivity in the field.
- Wang W, Wang X, Wang Y and Li Y are the most influential scientists in the field of chromosome anomalies received high degree of centrality measures in the co – authorship network. These few scientists are intellectually collaborated with other research community and occupied center position of the network
- This study identifies Wang X (0.52, 0.0301) as most predominant and potential collaborator in the field of chromosome anomalies.
- Chen CP and Wang W have strongest collaborative strength in the co – authorship network.
- This study also identifies the peripheral authors located spatially at the margins of a network with few or no collaboration between other authors. For example Durante. M, Vidal F, Sismani C etc., because of their types or nature of research in the field of chromosome anomalies.

7. Discussion and Conclusion

This study made an attempt to overcome superimposing theoretical shortcomings of collaborative measures with techniques used in social network analysis. More often scientific collaborations are analyzed by the simple count of records retrieved from bibliographical databases. Application of techniques of network analysis research on co – authorship enables in to focus the collaboration behavior among scientists and structural level of collaborations.

Chromosome anomaly is a sub – field of genetics in medicine. Thischaracteristic may reflected in the results of study. Collaborative measures in chromosome anomalies reveals increasing trend of solo research, and a large research groups research. Network of co – authorship for chromosome anomalies are greatly influenced by the very few scientists. It might show the phenomenon of unjustified hyper – authorship. The death rate among the new bourns due to chromosome anomalies are increasing drastically but the research productivity in this field is fluctuating. Policy makers, Research and Development centers and other organization must address the issues to develop healthier nation. The present focuses on co – authorship pattern alone but a complete scientometrics analysis using network analysis techniques on research output of chromosome anomalies study is essential in this present situation.

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