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Indian Sickle Cell Disease Research: A Scientometric Assessment of Publications Output During 2008-17

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Abstract

The present study examined 436 Indian publications in Sickle Cell disease, as indexed in Scopus database during 2008-17, with a view to understand their growth rate, global share, citation impact, international collaborative papers share, distribution of publications by broad subjects, productivity and citation profile of top organizations and authors, preferred media of communication and bibliographic characteristics of high cited papers. The Indian publications registered an annual average growth rate of 9.97%, global publication share of 3.80%, international collaborative publication share of 3.80% and citation impact per paper of 10.90. Among 123 countries participating in global Sickle Cell disease research, the top 10 most productive countries global share individually ranged from 2.12% to 46.89%, with USA contributing the largest share of 46.89%, followed by U.K. (9.58%), France (7.23%), Brazil (5.95%), etc. 87.32%. More than 100% share of the cumulative global publication and citation share comes from top 10 countries during 2008-17. Medicine, among seven broad subjects, contributed the largest publications share of 74.31%, followed by biochemistry, genetics & molecular biology (16.51%), pharmacology, toxicology & pharmaceutics (10.55%) and immunology & microbiology (2.29) during 2008-17. Among various 243 organizations and 594 authors contributing to Indian Sickle Cell disease research, the 10 most productive global organizations and authors together contributed 42.89% and 41.28% respectively as their share of global publication output and more than 100% and 23.71% respectively as their share of global citation output during 2008-17. Amongst 423 journal papers (in 192 journals) in Indian Sickle Cell disease research, the top 15 most productive journals contributed 37.59% share of total journal publication output during 2008-17.

Keywords: Sickle cell disease, Indian publications, Scientometrics, Bibliometrics

Abbreviations: SCD: Sickle Cell Disease; WHO: World Health Organization; UN: United Nations

Introduction

Sickle cell disease (SCD) (known also as sickle cell anemia or sickle cell disorder), is an inherited blood disorder and also referred to as a haemoglobinopathy. It is caused by a single misspelling in the DNA instructions for hemoglobin, a protein vital for carrying oxygen in the blood. The disease damages and changes the shape of red blood cells (RBCs). The change in shape is a response to cell deoxygenation. When the oxygen uptake of the cell is low, cells change their shape from a healthy round disk to a crescent, holly leaf or other similarly distorted shape. This shape distortion is referred to as sickling. Hence, the disease is known as sickle cell disease. The sickled cells are rigid, less malleable and stickier than normal, healthy cells, so they consequently may stick to each other and obstruct blood vessels or are not sufficiently malleable and obstruct blood vessels. This obstruction causes harsh and painful complications. Often, these red blood cells will also break down and cause anemia, so we also refer to the disease as sickle cell anemia. Consequent to the breakdown of red blood cells (haemolysis), cell survival may be reduced to as little as twenty days, whereas a normal red blood cell will last anywhere from 110-120 days [1-2]. As a result of this mutation, individuals with SCD experience lifelong complications including anemia, infections, stroke, tissue damage, organ failure, intense painful episodes, and premature death. These debilitating symptoms and the complex treatment needs of people living with SCD often limit their education, career opportunities, and quality of life [2].

Following are the most common types of SCD:

(i) HbSS: People who have this form of SCD inherit two sickle cell genes ("S"), one from each parent. This is commonly called sickle cell anemia and is usually the most severe form of the disease;

(ii) HbSC: People who have this form of SCD inherit a sickle cell gene ("S") from one parent and from the other parent a gene for an abnormal hemoglobin called "C". Hemoglobin is a protein that allows red blood cells to carry oxygen to all parts of the body. This is usually a milder form of SCD and

(iii) HbS beta thalassemia: People who have this form of SCD inherit one sickle cell gene ("S") from one parent and one gene for beta thalassemia, another type of anemia, from the other parent. There are two types of beta thalassemia: "0" and "+". Those with HbS beta 0-thalassemia usually have a severe form of SCD. People with HbS beta +-thalassemia tend to have a milder form of SCD. There also are a few rare types of SCD: HbSD, HbSE and HbSO. People who have these forms of SCD inherit one sickle cell gene ("S") and one gene from an abnormal type of hemoglobin ("D", "E", or "O"). Hemoglobin is a protein that allows red blood cells to carry oxygen to all parts of the body. The severity of these rarer types of SCD varies [3].

Organizations such as the World Health Organization (WHO) and United Nations (UN) have recognized SCD as a global health issue. In 2006, the World Health Assembly passed a resolution recognizing SCD as a public health priority and called on countries to tackle the disease. This resolution was also adopted by the United Nations in 2009. In countries with poor public health systems and high levels of poverty, SCD remains a major killer of infants and children, similar to other diseases like malaria and HIV/AIDS. In resource-poor countries, 90 percent of children with SCD do not survive to adulthood. And the problem is growing; by 2050 the number of people with SCD is expected to increase by about 30 percent globally. Some middle-income countries are making advancements in both early diagnosis and management of SCD [2].

Globally it is estimated that, SCD occurs in approximately 300,000 births annually. Prevalence of sickle cell trait varies greatly between different regions but reaches levels as high as 40 percent in some areas of sub-Saharan Africa, eastern Saudi Arabia, and central India. In resource-poor countries more than 90 percent of children with SCD do not survive to adulthood. SCD is most prevalent in malaria endemic parts of the world, primarily Africa, the Middle East and South Asia. SCD has a high prevalence in India, especially in the central and western regions. Approximately 20 percent of children with SCD die by the age of two [2].

In India, the National Guideline on Hemoglobinopathies was released by the National Health Mission in 2017. This guideline aims at improving the treatment and management of patients with SCD by providing free blood transfusions, iron chelation medicines and other interventions in all government hospitals and state-run health centers. Such policies are a positive step for improving the life quality of patients. The Disability Act 2016 also provides legal protection for SCD patients including access to education and employment [4].

Literature review

There is no specific bibliometric study on Sickle Cell disease output both at national and international level. However, there are few quantitative studies focusing on overall blood diseases. Among such studies, Daneshmand, Forouzandeh, Azadi and Cheraghzadeh Dezfuli [5] examined quantitative and qualitative evaluation of hematological research output in five Islamic countries; Iran, Turkey, Malaysia, Saudi Arabia and Egypt; which have the most scientific productions from 1996-2013. Gupta [6] analyzed the heredity blood disorders research output, using Scopus database during 2002-11 on different parameters including the global publications share and citation quality of top 10 leading countries, India's growth, citation impact, share of international collaborative papers, contribution of major collaborative partner countries, contribution of various subject fields and by type of heredity blood disorder, pattern of research communication in most productive journals, productivity and citation profile of top Indian institutions and authors and characteristics of high cited papers. Bansal, Bansal and Gupta [7] examined the Indian research output consisting of 717 publications on "iron deficiency anemia" as covered in Scopus database during 2006-15. Different parameters including publication growth, citation impact, share of international collaborative papers and identification of major international collaborative partners, global rank and share of India amongst the top 20 most productive countries, productivity and citation impact of leading Indian institutes and authors, medium of communication in most productive journals.

Objectives

Based on publications covered and indexed in Scopus database, the present study analyses the Indian Sickle Cell disease research during 2008-17. In particular, the study analyses the growth rate in Indian publications, its global and international collaborative publication share and citation impact per paper; its broad distribution of output by broad subject areas; its leading organizations and authors, in terms of publication output and citation impact and its leading medium of communication, particularly the most productive journals.

Methodology

Several quantitative and qualitative bibiometric indicators have been used in this study to measure the performance of Indian Sickle Cell disease research. The basic publication data for the present study was retrieved and downloaded from the Scopus database (http://www.scopus.com) for 10 years during 2008-17. For retrieving publication data from the Scopus database, the authors have used the Keyword "Sickle Cell*"in "Keyword" tag or ''Article Title'' tag and further restricting the search to the period 2008-17 in "date range tag" for searching the global publication data on Sickle Cell research and this becomes the main search string. When the main search string with restricted to individual top 10 most productive country names (including India) in "country tag", the publication data on the individual country in Sickle Cell research obtained. The Indian search string is further refined, as provided in Scopus database, by restricting to "subject area tag", "country tag", "source title tag", "journal title name" and "affiliation tag", to get information on the distribution of publications by subject, collaborating

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countries, author-wise, organization-wise and journal-wise, etc. For citation data, citations to publications were also collected from the date of publication till 1 June 2018.

(KEY(Sickle cell*) OR TITLE(Sickle cell*)) AND PUBYEAR > 2007 AND PUBYEAR < 2018 AND (LIMIT-TO (AFFILCOUNTRY,"India"))

Analysis

The world has published 11487 and 436 global and Indian publications on Sickle Cell disease research in 10 years during 2008-17, which increased from 988 to 1198 (global) and 21 to 31 (Indian) publications in the year 2008 to the year 2017, registering annual average growth rates of 2.38% and 9.97%. The cumulative growth of global and Indian publications on Sickle Cell disease research increased from 5239 to 6248 and 168 to 268 publications from 2008-12 to 2013-17, witnessing a growth rate of 19.26% and 59.52%%. The global publication share of Indian output was 3.80% during 2008-17, which increased from 3.21% to 4.29% from 2008-12 to 2013-17. The average citation per publication (CPP) registered by global and Indian publications on Sickle Cell disease research were 12.48 and 10.90 during 2008-17, which decreased from 19.52 to 6.58 in global publications and increased from 4.88 to 14.68 CPP in Indian publications from 2008-12 to 2013-17 (Table 1). Of the total Indian publications, 68.81% (300) appeared as articles, 13.07% (57) as reviews, 10.09 (44) as letters, 2.98% (13) as conference papers, 1.83% (8) as editorials, 1.61% (7) as notes, 1.38% (6) as book chapters and 0.23% (1) as short survey.

Table 1: World and Indian Research Output on Sickle Cell Disease Research: Growth and Citation Impact, 2008-17.

Publication Period	World			India					
	TP	TC	CPP	TP	TC	CPP	ICP	%ICP	%TP
2008	988	20384	20.63	21	92	4.38	0	0.00	2.13
2009	946	19969	21.11	25	138	5.52	2	8.00	2.64
2010	1067	21230	19.90	29	162	5.59	3	10.34	2.72
2011	1103	21257	19.27	36	198	5.50	3	8.33	3.26
2012	1135	19408	17.10	57	230	4.04	2	3.51	5.02
2013	1155	14447	12.51	58	1326	22.86	6	10.34	5.02
2014	1242	11582	9.33	54	186	3.44	8	14.81	4.35
2015	1300	8786	6.76	53	1603	30.25	7	13.21	4.08
2016	1353	5067	3.75	70	744	10.63	16	22.86	5.17
2017	1198	1238	1.03	33	74	2.24	8	24.24	2.75
2008-12	5239	102248	19.52	168	820	4.88	10	5.95	3.21
2013-17	6248	41120	6.58	268	3933	14.68	45	16.79	4.29
2008-17	11487	143368	12.48	436	4753	10.90	55	12.61	3.80
TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper									

Global publication share & citation impact of top 10 most productive countries

The global Sickle Cell disease research output originated in 123 countries during 2008-17, of which 47 countries contributed 1-10 papers each, 41 countries 11-50 papers each, 16 countries 51-100 papers each, 17 countries 101-500 papers each and 2 countries 1100-5386 papers each during 2008-17. Table 2 lists the output of top 10 most productive countries in Sickle Cell disease research during 2008-17. The cumulative publication and citation share of 10 most productive countries in Sickle Cell disease research was 87.32% and more than 100% of the world publication and citations output during 2008-17. Individually, the global publication share of these 10 countries varied from 2.12% to 46.89% during 2008-17, with highest publication share (46.89%) coming from USA, followed by U.K. (9.58%), France (7.23%), Brazil (5.95%) and other 6 countries from 2.12% to 3.80% during 2008-17.The global publication share showed increase in USA, Brazil, India, Italy and Canada (from 0.14% to 3.53%), as against decrease in U.K., France, Nigeria, Germany and Netherlands (from 0.13% to 0.77%). Five out of 10 countries have scored relative citation index more than the average of 1.58: Germany (2.70), Netherlands (2.27), Canada (2.25), Italy (1.85) and U.K. (1.60) during 2008-17.

Table 2: Publication Output, Global Publication Share & International Collaborative Publications of Top 10 Most Productive Countries in Sickle Cell Disease Research during 2008-17.

S.No	Country Name	Number of Papers			Share of Papers			TC	CPP	ICP	%ICP	RCI
1	USA	2356	3030	5386	44.97	48.5	46.89	87453	16.24	991	18.4	1.3
2	U.K.	512	588	1100	9.77	9.41	9.58	21993	19.99	620	56.36	1.6
3	France	401	430	831	7.65	6.88	7.23	12586	15.15	342	41.16	1.21

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4	Brazil	288	396	684	5.5	6.34	5.95	8047	11.76	126	18.42	0.94
5	India	168	268	436	3.21	4.29	3.8	4753	10.9	55	12.61	0.87
6	Nigeria	192	202	394	3.66	3.23	3.43	3943	10.01	104	26.4	0.8
7	Italy	163	203	366	3.11	3.25	3.19	8463	23.12	151	41.26	1.85
8	Canada	136	208	344	2.6	3.33	2.99	9650	28.05	196	56.98	2.25
9	Germany	116	130	246	2.21	2.08	2.14	8283	33.67	143	58.13	2.7
10	Netherlands	120	123	243	2.29	1.97	2.12	6892	28.36	121	49.79	2.27
	Total	4452	5578	10030	84.98	89.28	87.32	172063		2849	28.4	
	World Total	5239	6248	11487				143368	12.48			1

International collaboration

The share of international collaborative papers in India's research output in Sickle Cell disease output was 12.61% during 2008-17, which increased from 5.95% during 2008-12 to 16.79% during 2003-17. USA tops the list with 52.73% share in India's international collaborative papers, followed by Saudi Arabia (24.45%), U.K. (23.64%), Jamaica and Singapore (14.55% each), Germany and Malaysia (12.73% each), Canada, Italy and Spain (10.91% each) during 2008-17. The share of international collaborative papers increased in 9 countries (from 1.11% to 18.89%), but decreased in U.K. by 7.78% from 2008-12 to 2013-17 (Table 3).

Table 3: Share of Most Significant Foreign Countries in India's International Collaborative Papers in Sickle Cell Disease Research during 2008-17.

S. No	Collaborative Country	Number of International Collaborative Papers (ICP)			Share of International Collaborative Papers		
		2008-12	2013-17	2008-17	2008-12	2013-17	2008-17
1	USA	4	25	29	40.00	55.56	52.73
2	Saudi Arabia	1	13	14	10.00	28.89	25.45
3	U.K.	3	10	13	30.00	22.22	23.64
4	Jamaica	1	7	8	10.00	15.56	14.55
5	Singapore	1	7	8	10.00	15.56	14.55
6	Germany	1	6	7	10.00	13.33	12.73
7	Malaysia	1	6	7	10.00	13.33	12.73
8	Canada	1	5	6	10.00	11.11	10.91
9	Italy	1	5	6	10.00	11.11	10.91
10	Spain	0	6	6	0.00	13.33	10.91
	Total of India	10	45	55			

Subject-wise distribution of research output

As per the Scopus database classification, the Indian Sickle Cell disease research output is distributed across four sub-fields during 2008-17. Among sub-fields, medicine registered the highest publications share (74.31%), followed by biochemistry, genetics & molecular biology (16.51%), pharmacology, toxicology & pharmaceutics (10.55%) and immunology & microbiology (2.29) during 2008-17. The publication activity, as seen through activity index from 2008-12 to 2013-17, witnessed decrease in medicine (from 105.73 to 96.41), biochemistry, genetics & molecular biology (from 104.53 to 97.16) and immunology & microbiology (from 129.76 to 81.340) as against increase in pharmacology, toxicology & pharmaceutics (from 78.99 to 113.17) from 2008-12 to 2013-17. Medicine registered the highest citation per paper of 13.87 among four subjects, followed by biochemistry, genetics & molecular biology (5.38), pharmacology, toxicology & pharmaceutics (3.04) and immunology & microbiology (3.0) during 2008-17 (Table 4).

Table 4: Subject-Wise Breakup of Global Publications in Sickle Cell Disease Research during 2008-17.

S. No	Subject*	Number of Papers (TP)			Activity Index		Total Citations	CPP	%TP
		2008-12	2013-17	2008-17	2008-12	2013-17	2008-17		
1	Medicine	132	192	324	105.73	96.41	4493	13.87	74.31
2	Biochemistry, Genetics & Molecular Biology	29	43	72	104.53	97.16	387	5.38	16.51
3	Pharmacology, Toxicology & Pharmaceutics	14	32	46	78.99	113.17	140	3.04	10.55

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4	Immunology & Microbiology	5	5	10	129.76	81.34	30	3.00	2.29
	Indian Output	168	268	436					
*CPP=Citation per Paper									

Distribution of papers by population age groups

On classifying Indian publications on Sickle Cell disease research, it was observed that the largest share of papers were devoted to Children's (34.63%), followed by adolescents (26.15%), adults (9.63%) and aged (7.34%) during 2008-17. The share of papers decreased in case of children's (from 36.90% to 33.21%) and adolescents (from 27.38% to 25.37%), as against increase in adults (from 7.14% to 11.19%) and aged (From 4.76% to 8.96%) from 2008-12 to 2013-17 (Table 5).

Table 5: Classification of Indian Research Output in Sickle Cell Disease by Population Age Groups, 2008-17.

S.No	Populatio Age Group	Number of Papers			Share of Papers		
		2008-12	2013-17	2008-17	2008-12	2013-17	2008-17
1	Children's	62	89	151	36.90	33.21	34.63
2	Adolescents	46	68	114	27.38	25.37	26.15
3	Adults	12	30	42	7.14	11.19	9.63
4	Aged	8	24	32	4.76	8.96	7.34
	Total of India	168	268	436			

Significant keywords

Around 45 significant keywords have been identified from the literature, which point to possible trends in Indian Sickle Cell disease research. These keywords are listed in Table 6 in the decreasing order of the frequency of occurrence during 2007-16.

Table 6: Significant Keywords in Literature on Indian Sickle Cell Disease Research during 2007-16.

S.No.	Name of Keyword	Frequency	S.No.	Name of Keyword	Frequency
1	Sickle Cell Anemia	315	24	Hemoglobin E	26
2	Sickle Cell Trait	88	25	Hemoglobin A2	25
3	Hemoglobin	83	26	Genetic Variability	23
4	Sickle Cell Disease	76	27	Jaundice	24
5	Beta Thalassemia	72	28	Iron Deficiency Anemia	21
6	High Performance Liquid Chromatography	66	29	Acute Chest Syndrome	20
7	Hemoglobin F	62	30	Sickle Hemoglobin	20
8	Hemoglobin S	62	31	Abnormal Hemoglobin	20
9	Hemoglobinopathy	62	32	NMR Imaging	20
10	Hemoglobin Blood Level	51	33	Avascular Necrosis	19
11	Genetics	49	34	Diabetes Mellitus	19
12	Thalassemia	49	35	Pregnancy	18
13	Heterozygote	48	36	Pathology	17
14	Anemia	47	37	Alpha Thalassemia	16
15	Sickle Cell Beta Thalassemia	46	38	Computer-Assisted Tomography	16
16	Blood Transfusion	43	39	Hemolytic Anemia	13
17	Genotype	42	40	Hypertension	13
18	Hydroxyurea	41	41	Plasmodium Falciparum	13
19	Electrophoresis	37	42	Hemolysis	12
20	Fever	33	43	Hepatomegaly	12
21	Sickle Cell	33	44	Antioxidants	11
22	Heterozygosity	28	45	Genetic Disorder	11
23	Malaria	27			

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Profile of top 10 most productive organizations

243 organizations participated in Indian Sickle Cell disease research, of which 226 organizations contributed 1-5 papers each, 7 organizations 6-10 papers each, 6 organizations 11-20 papers each, 3 organizations 21-30 papers each and 1 organization 31 papers. The productivity of 10 most productive organizations in Indian Sickle Cell disease research varied from 11 to 31 publications and together contributed 42.89% (187 publications) publication share and more than 100% (5287) citation share to its cumulative publications output during 2008-17. The scientometric profile of these 10 organizations is presented in Table 7.

a) Four organizations have registered higher publications output than the group average of 18.7: Institute of Haematology, Mumbai (31 papers), Government Medical College, Nagpur (29 papers), All India Institute of Medical Sciences, New Delhi (28 papers) and Pt. J.N.M. Medical College, Raipur (22 papers) during 2008-17.

b) Two organizations have registered more than the average citation per publication (28.27) Postgraduate Institute of Medical Education & Research, Chandigarh (183.17) and All India Institute of Medical Sciences, New Delhi (81.43) during 2008-17.

c) Three organizations have achieved more than the average share of international collaborative publications (14.40%): Postgraduate Institute of Medical Education & Research, Chandigarh (50.0%), All India Institute of Medical Sciences, New Delhi (35.71%) and Pt. J.N.M.Medical College, Raipur (27.27%) during 2008-17.

d) Two organizations have registered the relative citation index more than average (2.59): Postgraduate Institute of Medical Education & Research, Chandigarh (16.80) and All India Institute of Medical Sciences, New Delhi (7.47) during 2008-17.

Table 7: Scientometric Profile of Top 10 Most Productive Organizations in Indian Sickle Cell Disease Research during 2008-17.

S.No	Name of the Organization	TP	TC	CPP	HI	ICP	%ICP	RCI
1	Institute of Haematology, Mumbai	31	231	7.45	9	0	0	0.68
2	Government Medical College, Nagpur	29	196	6.76	9	4	13.79	0.62
3	All India Institute of Medical Sciences, New Delhi	28	2280	81.43	8	10	35.71	7.47
4	Pt. J.N.M.Medical College, Raipur	22	88	4.00	5	6	27.27	0.37
5	King Edward Memorial Hospital, Mumbai	14	85	6.07	5	1	7.14	0.56
6	Regional Medical Research Centre, ICMR, Bhubaneswar	14	76	5.43	5	0	0	0.50
7	Awadhesh Pratap Singh University, Rewa	13	45	3.46	4	0	0	0.32
8	VSS Medical College & Hospital, Burla, Orissa	13	80	6.15	6	0	0	0.56
9	Postgraduate Institute of Medical Education & Research, Chandigarh	12	2198	183.17	6	6	50	16.80
10	Datta Megha Institute of Medical Sciences, Nagpur	11	8	0.73	2	0	0	0.07
	Total of 10 organizations	187	5287	28.27	59	27	14.4	2.59
	Total of India	436	4753	10.90				1.00
	Share of top 10 organizations in India's total	42.89	111.24					

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index

Profile of top 10 most productive authors

594 authors participated in Indian Sickle Cell disease research, of which 518 authors contributed 1-5 papers each, 59 authors 6-10 papers each, 16 authors 11-20 papers each and 1 author 27 papers. The productivity of 15 most productive authors in Indian Sickle Cell disease research varied from 11 to 34 publications and together contributed 41.28% (180 publications) publication share and 23.71% (1127) citation share to its cumulative publications output during 2008-17. The scientometric profile of these 10 authors is presented in Table 8.

a) Three authors have registered higher publications output than the group average of 18.0: R.B. Colatz (34 papers), K. Ghosh (29 papers) and P.K. Patra (24 papers) during 2008-17.

b) Six authors receiving comparatively higher average citation per publication were: D. Jain (10.0), A.H. Nadkarni (8.36), D.K. Patel (7.42), R.B. Colatz (7.41) and K. Ghosh (7.38) during 2008-17.

c) Two authors have achieved more than the average share of international collaborative publications (7.22) of all authors: P.K. Patra (29.17%) and D. Jain (11.76%) during 2008-17.

d) Five authors receiving comparatively higher relative citation index: D. Jain (0.92), A.H. Nadkarni (0.77), D.K. Patel, R.B. Colatz and K. Ghosh during 2008-17.

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Table 8: Top 10 Most Productive Authors in Indian Sickle Cell Disease Research, 2008-17.

S. No	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP	RCI
1	R.B. Colatz	Institute of Haematology, Mumbai	34	252	7.41	10	2	5.88	0.68
2	K. Ghosh	Institute of Haematology, Mumbai	29	214	7.38	8	2	6.9	0.68
3	P.K. Patra	Pt. J.N.M.Medical College, Raipur	24	94	3.92	5	7	29.17	0.36
4	D.Jain	Government Medical College, Nagpur	17	170	10	8	2	11.76	0.92
5	R. Saxena	All India Institute of Medical Sciences, New Delhi	15	50	3.33	5	0	0	0.31
6	S. Patel	VSS Medical College & Hospital, Burla, Orissa	14	89	6.36	6	0	0	0.58
7	R.S. Balgir	Regional Medical Research Centre, ICMR, Bhubaneswar	12	36	3	4	0	0	0.28
8	R.M. Mishra	Awadhesh Pratap Singh University, Rewa	12	41	3.42	4	0	0	0.31
9	D.K. Patel	VSS Medical College & Hospital, Burla, Orissa	12	89	7.42	6	0	0	0.68
10	A.H. Nadkarni	Institute of Haematology, Mumbai	11	92	8.36	6	0	0	0.77
		Total of 10 authors	180	1127	6.26	6.2	13	7.22	0.57
		Total of the World	436	4753	10.9				
		Share of 10 authors in World output	41.28	23.71	0.57				
TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index									

Medium of communication

192 journals participated in 423 journal papers in Indian Sickle Cell disease research, of which 177 journals contributed 1-5 papers each, 10 journals 6-10 papers each, 4 journals 11-20 papers each, and 1 journal 24 papers. The 15 most productive journals in Indian Sickle Cell disease research contributed from 6 to 24 papers and together contributed 37.59% share (159 papers) to the Indian journal publication output during 2008-17. The publication share of these top 15 most productive journals increased from 34.13% to 39.84% from 2008-12 to 2013-17. The most productive journal (with 24 papers) was *Journal of Clinical & Diagnostic Research, followed by Indian Journal of Pediatrics* (19 papers), *Hemoglobin* (16 papers), *Indian Journal of Hematology & Blood Transfusion* (14 papers), *Indian Journal of Medical Research* (11 papers), *Indian Journal of Human Genetics and Indian Journal of Pharma & Bio Sciences* (9 papers each), etc. during 2008-17 (Table 9).

Table 9: List of Top 15 Most Productive Journals in Indian Sickle Cell Disease Research during 2008-17.

S.No	Name of the Journal	Number of Papers		
		2008-12	2013-17	2008-17
1	Journal of Clinical & Diagnostic Research	5	19	24
2	Indian Journal of Pediatrics	11	8	19
3	Hemoglobin	7	9	16
4	Indian Journal of Hematology & Blood Transfusion	1	13	14
5	Indian Journal of Medical Research	3	8	11
6	Indian Journal of Human Genetics	7	2	9
7	Indian Journal of Pharma & Bio Sciences	1	8	9
8	Blood Cell Molecules & Diseases	2	6	8
9	Journal of Association of Physicians of India	4	4	8
10	Mediterranean Journal of Hematology & Infectious Diseases	0	8	8
11	Anthropologist	6	1	7
12	Indian Journal of Clinical Biochemistry	5	2	7
13	Indian Journal of Pediatrics	3	4	7

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14	Indian Journal of Laboratory Hematology	1	5	6
15	Indian Journal of Pharmaceutical Sciences Review & Research	1	5	6
	Total of 15 Journals	57	102	159
	Total of India	167	256	423
	Share of 15 journals in Indian journal output	34.13	39.84	37.59

Summary

436 Indian publications on Sickle Cell disease research were published during 2008-17, as indexed in Scopus database, constituting 3.80% share of global publications (11487). The global publication share of Indian output increased from 3.21% to 4.29% from 2008-12 to 2013-17. The Indian publications increased from 21 to 33 from the year 2008 to the year 2017, registering 9.97% growth per annum. Their cumulative Indian publication output on Sickle Cell disease research increased from 168 to 268, witnessing a growth of 59.51% from 2008-12 to 2013-17. The citation impact per paper of Indian publications in Sickle Cell disease was averaged to 10.90 during 2008-17, however, increasing from 4.88 during 2008-12 to 14.68 during 2013-17. The international collaborative papers share in India's research output on Sickle Cell disease output was 12.61% during 2008-17, which increased from 5.95% during 2008-12 to 16.79% during 2003-17. USA tops the list among international collaborative partners of India with 52.73% share, followed by Saudi Arabia (24.45%), U.K. (23.64%), Jamaica and Singapore (14.55% each), Germany and Malaysia (12.73% each), Canada, Italy and Spain (10.91% each) during 2008-17. The share of international collaborative papers increase in all countries (from 1.11% to 18.89%), except that of U.K., where it decreased by 7.78% from 2008-12 to 2013-17.

About 123 countries participated in global Sickle Cell disease research output, of which the top 10 countries individually contributed global publication from 2.12% to 46.89% during 2008-17 and together contributed 87.32% share and more than 100% share of the world publication and citations output during 2008-17. Among top 10 countries, USA contributed the largest global publication share of 46.89%, followed by U.K. (9.58%), France (7.23%), Brazil (5.95%) and other 6 countries from 2.12% to 3.80% during 2008-17. The global publication share showed increase in USA, Brazil, India, Italy and Canada (from 0.14% to 3.53%), as against decrease in U.K., France, Nigeria, Germany and Netherlands (from 0.13% to 0.77%). Five out of 10 countries have scored relative citation index more than the average of 1.58: Germany (2.70), Netherlands (2.27), Canada (2.25), Italy (1.85) and U.K. (1.60) during 2008-17.

Medicine, contributed the largest publications share of 74.31% in Indian Sickle Cell disease research, followed by biochemistry, genetics & molecular biology (16.51%), pharmacology, toxicology & pharmaceutics (10.55%) and immunology & microbiology (2.29) during 2008-17. As per the Scopus database classification, the Indian Sickle Cell disease research output is distributed across sfour sub-fields during 2008-17. The publication activity showed decrease in medicine, biochemistry, genetics & molecular biology and immunology & microbiology, as against increase in pharmacology, toxicology & pharmaceutics from 2008-12 to 2013-17. Among four subjects, medicine registered the highest citation per paper of 13.87 among four subjects, followed by biochemistry, genetics & molecular biology (5.38), pharmacology, toxicology & pharmaceutics (3.04) and immunology & microbiology (3.0) during 2008-17. Children's, among population age group, become the main focus of Sickle Cell disease research and accounts for highest publication share of 34.63% during 2008-17, followed by adolescents (26.15%), adults (9.63%) and aged (7.34%) during 2008-17. The share of papers decreased in children's (from 36.90% to 33.21%) and adolescents (from 27.38% to 25.37%), as against increase in adults (from 7.14% to 11.19%) and aged (from 4.76% to 8.96%) from 2008-12 to 2013-17.

Amongst 243 organizations and 594 authors contributing to Indian Sickle Cell disease research, the 10 most productive global organizations and authors together contributed 42.89% and 41.28% respectively as their share of global publication output and more than 100% and 23.71% respectively as their share of global citation output during 2008-17. The leading organizations in research productivity were: Institute of Haematology, Mumbai (31 papers), Government Medical College, Nagpur (29 papers), All India Institute of Medical Sciences, New Delhi (28 papers) and Pt. J.N.M. Medical College, Raipur (22 papers) during 2008-17. The leading organizations in terms of citation impact per paper were: Postgraduate Institute of Medical Education & Research, Chandigarh (183.17) and All India Institute of Medical Sciences, New Delhi (81.43) during 2008-17.

Journal of Clinical & Diagnostic Research was the most productive journal (with 24 papers) in Indian Sickle Cell disease research output, followed by Indian Journal of Pediatrics (19 papers), Hemoglobin (16 papers), Indian Journal of Hematology & Blood Transfusion (14 papers), Indian Journal of Medical Research (11 papers), Indian Journal of Human Genetics and Indian Journal of Pharma & Bio Sciences (9 papers each), etc. during 2008-17. Among the 423 journal papers (in 192 journals) in Sickle Cell disease research, the top 15 most productive journals contributed 37.59% share of total journal publication output during 2008-17, which increased from 34.13% to 39.84% from 2008-12 to 2013-17.

Conclusion

Conclude that there is enormous opportunity to improve the state of present SCD by taking actions to address unmet needs. There is need for us to address existing disparities by increasing

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access to diagnostic and therapeutic interventions and providing comprehensive care and appropriate support services to people living with SCD. Emerging therapies and promising new insights in the treatment of SCD represent a significant step toward improving outcomes and reducing the treatment burden for affected children and adults.

Alleviating the pain and suffering caused by this disease, as well as the socioeconomic costs, is entirely within our grasp. Although conquering SCD is doable, it requires a well-orchestrated plan and a coordinated effort from a range of partners including government agencies, patient advocacy organizations, health care providers, public health organizations, researchers, foundations, pharmaceutical and biotech companies, and other stakeholders.

In an effort to advance a forward-looking and comprehensive agenda that will make a significant difference, a group of SCD researchers, clinicians, individuals with the disease and policymakers have come together to develop an organized approach to improving outcomes for people with SCD. From these meetings, four priority areas were identified- Access to Care, Training and Professional Education, Research and Clinical Trials, and Global Issues Related to SCD. Such steps will help the global collective efforts toward ultimately advancing SCD care, early diagnosis, treatment and research.

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