

Research on Congenital Heart Defects: A Bibliometric Assessment of India's Publications during 2000-19

BM Gupta^{1,*}, KK Mueen Ahmed²

ABSTRACT

The paper presents a quantitative and qualitative dimensions of congenital heart defect (CHD) research output in India, based on publications data (1335) indexed in Scopus database during 2000-19. CHD research registered 10.0% growth, averaged 7.07 citations per paper, contributed 3.04% share to the global output and constitute 13.48% share of India's research as international collaborative. CHD research is skewed as top 10 countries account for 83.23% of global output. India ranks as the 10th most productive country in the world. The distribution of CHD research by type of research reveal that Tetralogy of Fallot accounted for the highest share (34.31% share), followed by Aortic Stenosis (30.41%), Atrial Septal Defects (28.16%), Ventricular Septal Defects (26.22%), etc. AIIMS - New Delhi, Amrita Institute of Medical Sciences, Coimbatore and PGIMER - Chandigarh lead the country as the most productive organizations (with 222, 73 and 64 papers). Besides, Amrita Institute of Medical Sciences, Coimbatore (33.88 and 4.79), SCTIMST - Trivandrum (30.73 and 4.35) and Institute of Medical Sciences, BHU, Varanasi (17.20 and 2.43) lead the country as the most impactful organizations in terms of citation per paper and relative citation index. B. Airan, A. Saxena and S. Talwar have been the most productive authors (with 63, 63 and 59 papers) and P. Khairy (16.31 and 2.31), B. Vaidyanathan (14.3 and 2.03) and R.K. Kumar (10.53 and 1.49) have been the most impactful authors. *Indian Heart Journal*, *Annals of Pediatric Cardiology* (84 papers) and *Annals of Cardiac Anaesias* (53 papers) topped the list of most productive journals (with 110, 84 and 53 papers). *International Journal of Cardiology* (18.62), *Catheterization and Cardiovascular Interventions* (16.64) and *Journal of Cardiothoracic and Vascular Anesthesia* (11.65) leads in ranking in terms of citation per paper.

Key words: Congenital Heart Defects, Indian publications, Scientometrics, Bibliometrics.

INTRODUCTION

Congenital heart disease (or defects) (CHD) is defined as a gross structural abnormality of the heart or intrathoracic great vessels that causes significant functional impairment.¹ It simply means that it is a type of birth defect which can involve the walls of the heart, the valves of the heart and the arteries and veins (the large blood vessels) that lead to and from the heart.² The etiology of congenital heart diseases is still elusive. The developmental process of the heart is a tightly regulated process that requires intricate interplay between cardiac transcription factors, several cardiac-specific genes and signaling pathways, which are responsible for early cardiac morphogenesis. Both genetic and environmental factors play essential roles during cardiac development. Gene mutations and some teratogens can interfere with normal development (embryogenesis) of the heart leading to congenital heart defects.³ Studies have also implicated non-hereditary risk factors such as rubella infection, teratogens, maternal age, diabetes mellitus, abnormal hemodynamics use of certain medications or drugs such as alcohol or tobacco, parents being closely related or poor nutritional status or obesity in the

mother, besides having a parent with a congenital heart defect is also a risk factor in causing CHDs.^{3,4}

The most common CHD including left-to-right shunts (atrial septal defect, ventricular septal defect, atrioventricular septal defect, patent ductus arteriosus and others), obstructive lesions (pulmonary stenosis, aortic stenosis and coarctation of aorta) and cyanotic CHD (tetralogy of Fallot, transposition of great arteries, univentricular hearts, total anomalous pulmonary venous connection, Ebstein's anomaly and others).⁵ Congenital heart defects are classified clinically, as cyanotic and acyanotic. Bluish discoloration of mucous membrane clinically characterizes cyanotic heart defects due to an increased level of deoxygenated hemoglobin. Therefore, cyanotic congenital heart defects are regarded as the most severe forms of CHDs.³ Clinical presentations and severity of CHDs depend on their types or sub-types. However, most children with CHDs present with failure to thrive, cough, repeated chest infections, difficulty in breathing, exercise intolerance and bluish discoloration of mucous membranes (cyanosis). Congenital heart defects are

BM Gupta^{1,*}, KK Mueen Ahmed²

¹Formerly with CSIR-, New Delhi, INDIA.

²Phcog.Net, Bengaluru, Karnataka, INDIA.

Correspondence

Dr. BM Gupta,

Formerly with CSIR-, New Delhi-11012, INDIA.

Mobile no: +91-9888378275

Email: bmgupta1@gmail.com

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associated with serious complications such as cognitive impairment and often affect families and individuals both emotionally and financially.^{3,4} Diagnostic and treatment capabilities for congenital heart disease have dramatically improved over the past. Many studies show substantial improvement in survival in developed regions of the world, but the same success rates are not yet seen in developing regions. Despite some improvements in the past two decades, neonates in low-income and middle-income countries (LMICs) with severe forms of congenital heart disease and without access to surgical treatment are more likely to die before their fifth birthday than are those in high income countries. Additional premature mortality might occur secondary to cardiac and pulmonary complications.

The congenital heart defects (CHDs) are the most frequent congenital anomalies and affect a large number of newborns accounting for a high proportion of infant mortality worldwide. There are regional differences in the prevalence and distribution pattern of CHDs. Globally, twenty-eight percentage of all major congenital anomalies consist of heart defects and along with neural tube defects they account for two-thirds of all congenital malformations.¹ The birth prevalence of CHD is reported to be 8-12/1000 live births. Considering a rate of 9/1000, about 1.35 million babies are born with CHD each year globally.⁶

Considering a birth prevalence as 9/1000, the estimated number of children born with CHD every year in India approximates 240,000, posing a tremendous challenge for the families, society and health care system. About one-fifth of these suffer from critical heart disease requiring early intervention. The currently available care for these children is grossly inadequate. There are over 60 centers that cater to children with congenital heart disease; majority are in southern states of India. Most of babies born with congenital heart disease in most populous states of India, such as Uttar Pradesh and Bihar, do not receive the care they deserve. Improving care of children with congenital heart disease is an uphill task, but needs to be addressed.⁶

A number of guidelines are available for the management of congenital heart diseases (CHD) from infancy to adult life. However, these guidelines are for patients living in high-income countries. Separate guidelines, applicable to Indian children, are required when recommending an intervention for CHD, as often these patients present late in the course of the disease and may have coexisting morbidities and malnutrition. Guidelines emerged following expert deliberations at the National Consensus Meeting on Management of Congenital Heart Diseases in India, held on August 10 and 11, 2018, at the All India Institute of Medical Sciences. These evidence-based guidelines aims at (i) indications and optimal timing of intervention in common CHD; (ii) follow-up protocols for patients who have undergone cardiac surgery/catheter interventions for CHD; and (iii) indications for use of pacemakers in children. Evidence-based recommendations are provided for indications and timing of intervention in common CHD. In addition, protocols for follow-up of postsurgical patients are also described, disease wise. Guidelines are also given on indications for implantation of permanent pacemakers in children.⁵

Literature Review

Bibliometric/scientometric studies related to analysis of "Congenital Heart Disease/defects" covering publications and patents, are only few. Amongst the existing studies, Farhat,, Abdul-Sater, Obeid, Arabi Diab, Masri, Al Hales, Nemer and Bitar⁷ made a bibliometric assessment and compared the contribution of the Arab countries (530 articles) with that of the United States (12936 articles) and Europe (12260 articles), in congenital heart disease using MEDLINE, PubMed and Scopus databases. Basic research relating to genetics and animal models of CHD is emerging sparsely in the Arab world, with few articles published in

high-impact-factor journals. The Arab world research output in the field of CHD per capita is substantially low, estimated to be 29 times less than in developed countries. Despite the minimal increase in published research articles, most of the research relating to CHD continues to be far from innovative. Regional collaborations with international linkage are starting to evolve. The research facilities in the Arab countries need to increase substantially in research and infrastructure funding to keep up with the pace of research in developing countries. Hsieh, Chiu, Lee *et al.*⁸ made a bibliometric analysis of Patent Ductus Arteriosus (PDA) treatment research, including intravenous injection of indomethacin and surgery using Science Citation Index (SCI) during 1991-2002. The publication pattern concerning authorship, collaboration, original countries, citation frequency, document type, language of publication, distribution of journals, page count and the most frequently cited papers were performed. The results indicated that either treatment was not the recent emphasis of PDA research. van Doren, Brida, Gatzoulis *et al.*⁹ examine quantum and factors associated with female representation in 35118 global CHD publications during 2006-15. It observed that 25.0% of all authors were female and women constituted for 30.2% and 20.8% of all first and senior authorship positions with great geographic heterogeneity. Significant predictors of female first authorship on logistic regression analysis were country gross domestic product, human development index, gender inequality index and a female senior author ($p < 0.0001$ for all). Conclusions While modest improvement in female authorship over time was noted, women remain underrepresented in contemporary academic CHD

In view of non-availability of any bibliometric study on congenital heart defects publications at national level and India being contributing to largest share of newborns and infants in global mortality, we decided to carry out the present study. The study aims to examine the qualitative and qualitative aspects of India's overall research output in the area of congenital heart defects as indexed in Scopus database during 2000-19. In particular, the study focuses and analyses: global research output in terms of publications growth and global share of top 10 most productive countries, congenital heart defects (CHD) research in India in terms of publications growth, its distribution by document and source types, broad subject areas and type of congenital heart defects, CHD research in India in terms of citation impact and describe bibliographic features of highly-cited papers and top 20 most productive organizations and authors and top 20 journals for research communications.

MATERIALS AND METHODS

In order to undertake a study of India's contribution in the congenital heart defects research, data on publications was sourced from the Scopus database (<http://www.scopus.com>) covering 20-year period 2000-19. A set of keywords such as "congenital heart anomaly" or "congenital heart defect" or "congenital heart disease" or "congenital heart malformation" or "hypoplastic heart syndrome" or "Obstructive heart defects" or "Septal heart defects" or "Cyanotic heart defects" were used in "Keyword tag" as well as in "Article Title tag" (joined by Boolean operator "OR") simultaneously and restricted the output to period "2000-19" to get global publication data (consisting of 43888 records). The above described search strategy was refined by country of publication (including India) to get publication output data on top 10 countries. India's publication output comprised of 1335 records. The search strategy for obtaining India's output was further refined to get statistics on India's output by subject, collaborating country, organization, author and journal. Citations to publications were counted from date of their publication till 9 May 2020. Separate search strategies were formulated to get data on various types of congenital heart defects. A complete counting method,

wherein every contributing author or organization covered in multiple authorship papers was fully counted and used.

(KEY("congenital heart anomaly" or "congenital heart defect" or "congenital heart disease" or "congenital heart malformation" or "hypoplastic heart syndrome" or "Obstructive heart defects" or "Septal heart defects" or "Cyanotic heart defects") OR TITLE ("congenital heart anomaly" or "congenital heart defect" or "congenital heart disease" or "congenital heart malformation" or "hypoplastic heart syndrome" or "Obstructive heart defects" or "Septal heart defects" or "Cyanotic heart defects")) AND PUBYEAR > 1999 AND PUBYEAR < 2020 AND (LIMIT-TO (AFFILCOUNTRY,"India"))

Analysis

Publication Growth

The global and Indian research output in field of "Congenital Heart Defects" (CHD) in 20 years was 43888 and 1335 publications during 2000-19, an average of 2194.4 and 66.75 publications per year. India registered 10.0% growth compared to 6.64% by the world. India's absolute growth between 2000-09 and 2010-19 was 147.66% compared to 79.40% by the world. India contributed 3.04% share to global output in 20 years; its 10-year global publications share surged from 2.44% (2000-09) to 3.37% (2010-19). In the field of CHD research, India's citation impact on a 20-year window averaged to 7.07 citations per paper (CPP) and its 10-year citation impact dropped from 9.17 CPP to 6.22

CPP during 2000-09 to 2010-19. Only 55 out 1335 India's publications are observed to be funded by national and international funding agencies. These 55 funded papers received 3680 citations, averaging 66.91 citations per paper (Table 1). Of the total publications, 75.13% appeared as articles, 9.44% as reviews, 6.74% as letters, 3.52% as notes, 2.47% as conference papers, 0.67% as short surveys and 1.87% as editorials and 0.67% as book chapters.

Top Ten Most Productive Countries

In all, 162 countries participated in global Congenital Heart Defects (CHD) research. The distribution of CHD research across participating countries was uneven. For instance, 68 countries published 1-10 papers, 40 published 11-50 papers, 8 published 51-100 papers, 27 published 101-500 papers, 6 published 601-1000, 12 published 1001-3698 papers and 1 published 15705.

Bulk of the global research output (83.23%) in the field was contributed by top 10 most productive countries alone, which increased from 78.10% to 86.08% during 2000-09 to 2010-19. USA is in the leadership position in the world ranking, accounting for 35.78% global publications share and other 9 countries has been in single digit ranging between 3.04% and 8.43%. India ranked at 10th position, with global share of 3.04%. The global publication share increased in China, USA, India, Canada and Netherlands (from 0.48% to 5.52%), as against decrease in Italy, France,

Table 1: Annual and Cumulative Publications on "Congenital Heart Defects (CHD) in India during 2000-19.

Publication Year	Global Publications (TP)	Indian Publications						
		TP	TC	CPP	%TP	ICP	%ICP	FP
2000	1006	31	264	8.52	3.08	2	6.45	
2001	1131	33	277	8.39	2.92	1	3.03	
2002	1312	32	464	14.50	2.44	3	9.38	
2003	1438	22	319	14.50	1.53	2	9.09	
2004	1518	33	209	6.33	2.17	7	21.21	
2005	1715	52	605	11.63	3.03	2	3.85	3
2006	1902	29	264	9.10	1.52	4	13.79	1
2007	1759	42	283	6.74	2.39	2	4.76	
2008	1907	57	470	8.25	2.99	8	14.04	1
2009	2020	53	365	6.89	2.62	8	15.09	
2010	2231	72	517	7.18	3.23	6	8.33	1
2011	2346	67	446	6.66	2.86	4	5.97	11
2012	2361	86	368	4.28	3.64	12	13.95	1
2013	2633	79	2156	27.29	3.00	13	16.46	1
2014	2908	100	497	4.97	3.44	13	13.00	2
2015	2838	114	626	5.49	4.02	14	12.28	3
2016	2979	108	394	3.65	3.63	14	12.96	4
2017	3198	113	530	4.69	3.53	18	15.93	6
2018	3371	108	286	2.65	3.20	20	18.52	17
2019	3315	104	96	0.92	3.14	27	25.96	9
2000-09	15708	384	3520	9.17	2.44	39	10.16	5
2010-19	28180	951	5916	6.22	3.37	141	14.83	55
2000-19	43888	1335	9436	7.07	3.04	180	13.48	

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; ICP=International Collaborative Papers

Japan, U.K. and Germany (from 0.13% to 1.95%) during 2000-09 to 2010-19 (Table 2).

India's International Collaboration

The share of international collaborative papers (180) in India's total output (1335) was 13.48% during 2000-19, which increased from 10.16% during 2000-09 to 14.83% during 2010-19. The 180 international collaborative papers spread over 100 countries have received 6587 citation, averaging 36.59 citations per paper. India's collaboration with the USA was the largest (51.11% of India's ICP output), followed by U.K. and Canada (24.44% and 22.78%) and for other 7 countries it varied from 10.56% to 18.33% during 2000-19 (Table 3).

Subject-Wise Distribution of India's Research Output

Medicine research in India intersected with 3 disciplines (as identified in Scopus database classification). Of these, medicine has been the most favored subject areas in CHD research pursuits (with 92.88% publications share), followed by biochemistry, genetics and molecular biology (7.79%) and pharmacology, toxicology and pharmaceuticals (2.47%). Research activity index in all subjects of increased in biochemistry, genetics and molecular biology (from 27.47 to 129.58) and pharmacology, toxicology and pharmaceuticals (from 42.14 to 123.36), as

against decrease in medicine (from 105.14 to 97.93) between 2000-09 and 2010-19. Medicine recorded the highest citation impact per paper of 9.09 and pharmacology, toxicology and pharmaceuticals the least (7.55) during 2000-19 (Table 4).

Distribution of Publications by Type Heart Defects

In all, CHD are classified under two types: Hydroplasia and Obstructive defects. The obstructive defects are further classified as ventricular outflow tract obstruction, septal defects and cyanotic defects. The above two type of defects are further classified under 15 subcategories as shown in Table 5. Under various subcategories of CHD, the largest contribution has been made by Tetralogy of Fallout (458 papers, 34.31%), followed by Aortic Stenosis (406 papers, 30.41%), Atrial Septal Defects (376 papers, 27.55%), Ventricular Septal Defects (350 papers, 26.22%), Transposition of the Great Vessels (204 papers, 15.28%), Tricuspid Atresia (86 papers, 6.44%), etc.

India's Top 25 Most Productive Organizations

In all, 431 organizations participated in Indian research on CHD during 2000-19, of which 303 organizations published 1-5 papers each, 76 organizations published 6-10 papers each, 45 organizations 11-20 papers each, 4 organizations 21-50 papers each, 2 organizations 51-100

Table 2: Congenital Heart Defects: Top 10 Most Productive Countries during 2000-19.

S.No	Name of the Country	Number of Papers			Share of Papers		
		2000-09	2010-19	2000-19	2000-09	2010-19	2000-19
1	USA	5286	10419	15705	33.65	36.97	35.78
2	U.K.	1369	2329	3698	8.72	8.26	8.43
3	Germany	1200	1604	2804	7.64	5.69	6.39
4	China	438	2341	2779	2.79	8.31	6.33
5	Canada	824	1730	2554	5.25	6.14	5.82
6	Italy	825	1443	2268	5.25	5.12	5.17
7	Japan	748	1249	1997	4.76	4.43	4.55
8	Netherlands	575	1166	1741	3.66	4.14	3.97
9	France	619	1026	1645	3.94	3.64	3.75
10	India	384	951	1335	2.44	3.37	3.04
	Total	12268	24258	36526	78.10	86.08	83.23
	World	15708	28180	43888			

Table 3: India' International Collaboration with Top 10 Countries in CHD Research during 2000-19.

S.No.	Collaborative Country	International Collaborative Papers (ICP)			Share of ICP		
		2000-09	2010-19	2000-19	2000-09	2010-19	2000-19
1	USA	12	80	92	30.77	56.74	51.11
2	U.K.	5	39	44	12.82	27.66	24.44
3	Canada	4	37	41	10.26	26.24	22.78
4	Australia	2	31	33	5.13	21.99	18.33
5	Italy	3	26	29	7.69	18.44	16.11
6	France	2	26	28	5.13	18.44	15.56
7	Netherlands	0	25	25	0.00	17.73	13.89
8	Switzerland	0	25	25	0.00	17.73	13.89
9	Argentina	0	22	22	0.00	15.60	12.22
10	Japan	2	17	19	5.13	12.06	10.56
	Total India's ICP output	39	141	180			

papers each and 1 organization 222 papers. The productivity of top 25 most productive organizations varied from 11 to 222 publications per organization; together they contributed 60.75% (811) Indian publications share and 89.95% (8488) Indian citations share during 2000-09. Table 6 lists top 10 most productive and top 10 most impactful organizations.

Six organizations registered their publications output above their group average (32.44): AIIMS - New Delhi (222 papers), Amrita Institute of Medical Sciences, Coimbatore (73 papers), PGIMER - Chandigarh (64 papers), SCTIMST- Trivandrum (52 papers), Sri Jayadeva Institute of Cardiovascular Sciences and Research (SJICSR), Bangalore (48 papers) and Fortis Escort Heart Institute and Research Centre (FEHIEC), Delhi (42 papers) (Table 6).

Four organizations registered their citations per paper and relative citation index above the group average (10.47 and 1.48) of all

organizations: Amrita Institute of Medical Sciences (AIMS), Coimbatore (33.88 and 4.79), SCTIMST - Trivandrum (30.73 and 4.35), Institute of Medical Sciences (IMS), BHU, Varanasi (17.20 and 2.43) and G.B. Pant Hospital, Delhi (11.33 and 1.60) (Table 6).

Institutional Collaboration among Top 15 Most Productive Organizations

Amongst top 15 most productive organizations, PGIMER-Chandigarh leads in collaboration linkages (38), followed by AIIMS - New Delhi (33 linkages), AIMS - Coimbatore and SCTIMST-Trivandrum (23 linkages each), etc. The collaboration between KEMH - Pune and SGSMC - Mumbai was the strongest with 10 linkages, followed by PGIMER-Chandigarh and SPGIMER-Lucknow (6 linkages), AIMS - Coimbatore and SCTIMST - Trivandrum (6 linkages), etc. (Table 7).

Table 4: Subject-Wise Breakup of Indian Publications in "Congenital Heart Defects" during 2000-19.

S.No	Subject*	Number of Papers (TP)			Activity Index		TC	CPP	%TP
		2000-09	2010-19	2000-19	2000-09	2010-19			
1	Medicine	375	865	1240	105.14	97.93	11271	9.09	92.88
2	Biochemistry, Genetics and Molecular Biology	8	96	104	26.74	129.58	924	8.88	7.79
3	Pharmacology, Toxicology and Pharmaceutics	4	29	33	42.14	123.36	249	7.55	2.47
		384	951	1335	100.00	100.00			

• There is overlapping of literature covered under various subjects

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper

Table 5: Distribution of India's papers on CHD by type of Heart Defects during 2000-19.

S.No	Type of Heart Defects	Number of Papers			Share of Papers			TC	CPP
		2000-09	2010-19	2000-19	2000-09	2010-19	2000-19		
1	Hydroplasia								
1.1	Hypoplastic Left Heart Syndrome	12	39	51	3.13	4.10	3.82	291	5.71
1.2	Hypoplastic Left Heart Syndrome	5	16	21	1.30	1.68	1.57	126	6.00
2.	Ventricular Outflow Track Obstruction								
2.1	Pulmonic Stenosis	1	3	4	0.26	0.32	0.30	61	15.25
2.2	Aortic Stenosis	102	304	406	26.56	31.97	30.41	1429	3.52
2.3	Coarctation of the Aorta	0	2	2	0.00	0.21	0.15	14	7.00
2.4	Bicuspid Aortic Valve Stenosis	4	40	44	1.04	4.21	3.30	113	2.57
2.5	Subaortic Stenosis	3	11	14	0.78	1.16	1.05	33	2.36
3.	Septal Defects								
3.1	Ventricular Septal Defects	83	267	350	21.61	28.08	26.22	1554	4.44
3.2	Atrial Septal Defects	114	262	376	29.69	27.55	28.16	1425	3.79
3.3	Probe Patent Foramen Ovale	0	1	1	0.00	0.11	0.07	7	7.00
4.0	Cyanotic Defects								
4.1	Truncus Arteriosus	5	29	34	1.30	3.05	2.55	51	1.50
4.2	Total Anomalous Pulmonary Venous Connection	7	26	33	1.82	2.73	2.47	44	1.33
4.3	Tetralogy of Fallot	134	324	458	34.90	34.07	34.31	2010	4.39
4.4	Transposition of the Great Vessels	49	155	204	12.76	16.30	15.28	788	3.86
4.5	Tricuspid Atresia	23	63	86	5.99	6.62	6.44	378	4.40
		384	951	1335					

Table 6: Top 10 Most Productive and Top 10 Most Impactful Organizations in CHD in India during 2000-19.

S.No	Name of the Organization	TP	TC	CPP	HI	ICP	%ICP	RCI
1	Amrita Institute of Medical Sciences (AIMS), Coimbatore	73	2473	33.88	17	23	31.51	4.79
2	Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum	52	1598	30.73	11	9	17.31	4.35
3	Institute of Medical Sciences (IMS), BHU, Varanasi	15	258	17.2	5	2	13.33	2.43
4	G.B.Pant Hospital, Delhi	18	204	11.33	6	1	5.56	1.6
5	Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPIMS), Lucknow	22	207	9.41	7	0	0	1.33
6	King Edward Memorial Hospital (Kem Hospital), Pune	23	214	9.3	8	1	4.35	1.32
7	Seth Gordhandas Sunderdas Medical College (SGSMC), Mumbai	20	182	9.1	9	3	15	1.29
8	University of Mysore	14	111	7.93	6	2	14.29	1.12
9	All India Institute of Medical Sciences (AIIMS), New Delhi	222	1754	7.90	22	22	9.91	1.12
10	Christian Medical College (CMC), Vellore	15	116	7.73	5	3	20	1.09
11	Fortis Escort Heart Institute and Research Centre (FEHIEC), Delhi	42	244	5.81	7	5	11.9	0.82
12	Institute of Cardiovascular Diseases (ICD), Chennai	19	102	5.37	6	1	5.26	0.76
13	Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh	64	267	4.17	10	2	3.13	0.59
14	Sri Jayadeva Institute of Cardiovascular Sciences and Research (SJICSR), Bangalore	48	150	3.13	5	3	6.25	0.44

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

Table 7: Institutional Collaboration among Top 15 Productive Indian Organizations in CHD during 2000-19.

S.No	Name of the Organization	Number of Collaborative Linkages	Total Collaborative Linkages
1	AIIMS - New Delhi	2(5), 3(6), 4(6), 5(3), 6(3), 7(3), 11(1), 12(3), 15(3)	33(9)
2	AIMS - Coimbatore	1(5), 3(2), 4(6), 5(3), 6(3), 14(1), 15(3)	23(7)
3	PGIMER - Chandigarh	1(6), 4(4), 5(2), 6(2), 7(6), 12(3), 15(2)	38(7)
4	SCTIMST - Trivandrum	1(6), 2(6), 3(4), 5(2), 6(2), 13(1), 15(2)	23(7)
5	SJICSR - Bangalore	1(3), 2(3), 3(2), 4(2), 6(2), 7(1), 15(2)	15(7)
6	FEHIEC - Delhi	1(3), 2(3), 3(2), 4(2), 5(2), 7(1), 13(2), 15(2)	17(8)
7	SGPIMS - Lucknow	1(3), 3(6), 12(3)	12(3)
8	KEMH - Pune	1(3), 5(1), 9(15)	19(3)
9	SGSMC - Mumbai	1(1), 5(1), 8(15)	17(3)
10	ICD - Chennai		
11	JIPMER - Pondicherry	1(1), 13(1)	2(2)
12	CMC - Vellore	1(3), 3(3)	6(2)
13	G.B.Pant Hospital, Delhi	4(1), 6(2), 11(1)	4(3)
14	KMC - Manipal	2(1)	1(1)
15	Sir Ganga Ram Hospital, New Delhi	1(3), 2(3), 3(2), 4(2), 5(2)	11(5)

India's Top 25 Most Productive Authors

397 authors participated in Indian research on CHD during 2000-19, of which 397 authors published 1-5 paper each, 65 authors 6-10 papers each, 35 authors 11-20 papers each, 6 authors 21-50 papers each and 5 authors 51-63 papers each and 1 author 58 papers. The research productivity of top 25 most productive authors varied from 11 to 63

publications per author. Together they contributed 50.04% (668) Indian publications share and 48.27% (4555) Indian citations share during 2009-18. Table 8 gives detailed scientometric profile of top 10 most productive and top 10 most impactful authors.

- Seven of top 25 authors registered their publications output above the group average of 26.72: B. Airan and A. Saxena (63 papers each),

S. Talwar (59 papers), S.S. Kothari (56 papers), S.K. Choudhury (51 papers), R.K. Kumar (43 papers) and R. Juneja (35 papers);

- Twelve of top 25 authors registered their citation per paper and relative citation index above the group average (6.83 and 0.96) of all authors: P. Khairy (16.31 and 2.31), B. Vaidyanathan (14.3 and

2.03), R.K. Kumar (10.53 and 1.49), U. Kiran (9.65 and 1.37), A. Saxena (9.54 and 1.35), S. Shrivastava (8.55 and 1.21), S. Chauhan (8.33 and 1.18), A. Bhan (8.24 and 1.16), R. Juneja (7.60 and 1.07), N.B. Ramachandra (7.55 and 1.07), S.S. Kothari (7.20 and 1.02) and R. Sharma (7.19 and 1.02).

Table 8: Top 10 Most Productive and Top 10 Most Impactful Indian Authors in CHD during 2000-19.

S.No	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP	RCI
1	P. Khairy	Fortis Escort Heart Institute and Research Centre (FEHIEC), Delhi	13	212	16.31	6	0	0	2.31
2	B.Vaidyanathan	AIMS – Coimbatore	13	187	14.38	8	3	23.08	2.03
3	R.K. Kumar	AIMS-Coimbatore	43	453	10.53	12	15	34.88	1.49
4	U. Kiran	AIIMS – New Delhi	23	222	9.65	8	0	0	1.36
5	A. Saxena	AIIMS-New Delhi	63	601	9.54	13	7	11.11	1.35
6	S. Shrivastava	Fortis Escort Heart Institute and Research Centre (FEHIEC), Delhi	11	94	8.55	3	0	0	1.21
7	S. Chauhan	AIIMS – New Delhi	21	175	8.33	7	1	4.76	1.18
8	A. Bhan	AIIMS – New Delhi	17	140	8.24	7	1	5.88	1.17
9	R. Juneja	AIIMS – New Delhi	35	266	7.6	11	2	5.71	1.07
10	N.B. Ramachandra	University of Mysore	11	83	7.55	6	0	0	1.07
11	S.S. Kothari	AIIMS – New Delhi	56	403	7.2	10	4	7.14	1.02
12	R. Sharma	AIIMS – New Delhi	26	187	7.19	8	2	7.69	1.02
13	S.K. Choudhury	AIIMS – New Delhi	51	278	5.45	8	2	3.92	0.77
14	S. Talwar	AIIMS – New Delhi	59	258	4.37	8	4	6.78	0.62
15	B. Airan	AIIMS-New Delhi	63	269	4.27	8	4	6.35	0.60

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

Table 9: Collaboration among Top 15 Productive Indian Authors in CHD during 2000-19.

1	B. Airan	AIIMS-New Delhi	2(27),3(42), 4(30), 5(42), 7(17), 8(9), 9(1), 10(3), 11(14), 12(11), 14(9), 15(5)	210(12)
2	A. Saxena	AIIMS-New Delhi	1(27), 3(18), 4(31), 5(21), 6(2), 7(28), 8(13), 9(1), 10(2), 11(16), 12(9), 14(12), 15(7),	185(13)
3	S. Talwar	AIIMS – New Delhi	1(42), 2(18), 4(18), 5(41), 7(12), 8(5), 9(3), 10(5), 11(4), 12(2), 14(2), 15(8)	160(12)
4	S.S. Kothari	AIIMS – New Delhi	1(30), 2(31), 3(18), 4(20), 6(1), 7(21), 8(12), 9(1), 10(2), 11(16), 12(13), 14(13), 15(7)	185(13)
5	S.K. Choudhury	AIIMS – New Delhi	1(42), 2(21), 3(41), 4(20), 7(14), 8(8), 9(4), 10(2), 11(11), 12(1), 14(8), 15(5)	177(12)
6	R.K. Kumar	AIMS-Coimbatore	2(2), 3(2), 4(1)	5(3)
7	R. Juneja	AIIMS – New Delhi	1(17), 2(28), 3(12), 4(21), 5(14), 8(7), 9(2), 10(2), 11(7), 12(2), 14(8), 15(6),	126(12)
8	R. Sharma	AIIMS – New Delhi	1(9), 2(13), 3(5), 4(12), 5(8), 7(7),9(1), 11(12), 12(5), 14(15), 15(1)	88(10)
9	U. Kiran	AIIMS – New Delhi	1(1), 2(1), 3(3), 4(1), 5(4), 7(2), 8(1), 10(7), 11(1), 12(1), 14(1)	23(11)
10	S. Chauhan	AIIMS – New Delhi	1(2), 2(2), 3(5), 4(2), 5(2), 7(2), 9(7), 11(1), 12(2), 15(1)	26(10)
11	P. Venugopal	AIIMS – New Delhi	1(14), 2(16), 3(4), 4(16), 5(11), 7(7), 8(12), 9(1), 11(1), 12(10)	93(10)
12	U.K. Chowdhury	AIIMS – New Delhi	1(11), 2(9), 3(2), 4(13), 5(1), 7(2), 8(5), 9(1), 10(2), 11(10), 14(12)	59(11)
13	K.M. Cherian	International Institute of Cardio Thoracic and Vascular Disease		
14	A. Bhan	AIIMS – New Delhi	1(9), 2(12), 3(2), 4(13), 5(8), 7(8), 8(15), 9(1), 12(12)	80(9)
15	S.K. Gupta	AIIMS – New Delhi	1(5), 2(7), 3(8), 4(7), 5(5), 7(6), 8(1), 10(1)	40(8)

Table 10: Top 10 Most Productive and Top 10 Most Impactful Journals in CHD during 2000-19.

S.No	Name of the Journal	Number of Papers			TC	CPP
		2000-09	2010-19	2000-19	2000-19	2000-19
1	International Journal of Cardiology	6	7	13	242	18.62
2	Catheterization and Cardiovascular Interventions	10	12	22	366	16.64
3	Journal of Cardiothoracic and Vascular Anesthesia	13	13	26	303	11.65
4	Pediatric Cardiology	14	11	25	244	9.76
5	Indian Journal of Pediatrics	29	23	52	386	7.42
6	Heart Lung and Circulation	7	4	11	69	6.27
7	Indian Pediatrics	18	27	45	265	5.89
8	Congenital Heart Disease	5	12	17	100	5.88
9	Annals of Thoracic Surgery	9	12	21	121	5.76
10	Cardiology in the Young	10	28	38	185	4.87
11	Indian Heart Journal	68	42	110	503	4.57
12	Annals of Pediatric Cardiology	4	80	84	344	4.1
13	Annals of Cardiac Anaesias	6	47	53	184	3.47
14	Asian Cardiovascular and Thoracic Annals	12	22	34	103	3.03
15	BMJ Case Reports	0	26	26	17	0.65

Collaboration among top 15 authors

Amongst top 15 most productive authors, B. Airan (AIIMS) leads in collaboration linkages (210), followed by A. Saxena and S.S. Kothari (AIIMS) (185 linkages each), S.K.Choudhury (AIIMS) (177 linkages each), etc. The collaboration between A. Airan and S. Talwar and B. Airan and S.K. Choudhury was the strongest with 42 linkages each, followed by S. Talwar and S.K. Choudhury (AIIMS) (41 linkages), A. Saxena and S.S. Chudhury (AIIMS) (31 linkages), etc. (Table 9).

Medium of Research Communication

Nearly 99.03% (1322) of CHD research in India appeared in 209 journals, 0.60% (8) in conference proceedings, 0.22% (3) in book series and 0.15% (2) as books. Of the 209 journals (reporting 1325 articles), 184 published 1-5 papers each, 13 published 6-10 papers each, 9 published 11-20 papers each, 11 published 21-50 papers each, 2 published 51-100 papers each and 1 published 110 papers each during 2000-19. The top 25 most productive journals accounted for 55.60% of total Indian output in journals during 2000-19, The 10-year output in journals decreased from 62.66% to 52.72% between 2000-09 and 2010-19. *Indian Heart Journal* was the topmost productive journal (with 110 papers) in reporting Indian research in the field of CHD research, followed by *Annals of Pediatric Cardiology* (84 papers), *Annals of Cardiac Anaesias* (53 papers), *Indian Journal of Pediatrics* (52 papers) and *Indian Pediatrics* (45 papers) during 2000-19. In terms of citation per paper, *International Journal of Cardiology* leads in ranking (18.62), followed by *Catheterization and Cardiovascular Interventions* (16.64), *Journal of Cardiothoracic and Vascular Anesthesia* (11.65), *Pediatric Cardiology* (9.76) and *Indian Journal of Pediatrics* (7.42) (Table 10)

CONCLUSION

This paper analyzes India research in the domain of "Congenital Heart Defects" (CHD) based on few bibliometric indicators covering 20-year (2000-19) published research. During the 20 year period, CHD research by India registered a 10.0% average annual growth, contributed 3.04% share to global output, averaged citation impact of 7.07 citations per paper and only 55 papers are funded by funding agencies. About 180

(13.45%) India's publications on CHD were involved in international collaboration during 2000-19, which increased from from 10.16% (39) during 2000-09 to 14.83% (141) during 2010-19. In all, 162 countries contributed to global CHD research (43888 publications). The top 10 most productive countries in the world alone accounted for 83.23% bulk share to global publications output in the subject. USA is in the leadership position in the world ranking (with 35.781% share). India ranks 10th most productive country in the world with 3.04% share. The global publication share of other 8 amongst top 10 counties has been in single digit ranging between 3.75% and 8.43%. The share of global publication increased in China, USA, India, Canada and Netherlands (from 0.48% to 5.52%), as against decrease in Italy, France, Japan, U.K. and Germany (from 0.13% to 1.95%) during 2000-09 to 2010-19

Medicine has been the preferred subjects in CHD research (with 92.88% publications share). Amongst the type of CHD research, "Tetralogy of Fallot" (458 papers, 34.31%) contributed the largest publication output and share, followed by Aortic Stenosis (406 papers, 30.41%), Atrial Septal Defects (376 papers), Ventricular Septal Defects (350 papers, 26.22%), Transposition of the Great Vessels (204 papers, 15.28%), Tricuspid Atresia (86 papers, 6.44%), etc

The distribution of India research in CHD by participating organizations is skewed. The top 25 organizations (out of total 431) contributed contributed 60.75% (811) Indian publications share and 89.95% (8488) Indian citations share during 2000-09, respectively during the period. AIIMS - New Delhi (222 papers), Amrita Institute of Medical Sciences, Coimbatore (73 papers), PGIMER - Chandigarh (64 papers) and SCTIMST- Trivandrum (52 papers) have been the most productive research organizations in the country. The organizations leading in terms of citation per paper and relative citation index were: Amrita Institute of Medical Sciences (AIMS), Coimbatore (33.88 and 4.79), SCTIMST - Trivandrum(30.73 and 4.35), Institute of Medical Sciences (IMS), BHU, Varanasi (17.20 and 2.43) and G.B.Pant Hospital, Delhi (11.33 and 1.60)

The distribution of India research by participating authors is highly scattered. The top 25 authors (out of total 397) across India contributed 50.04% (668) Indian publications share and 48.27% (4555) Indian citations shar respectively during the period. B. Airan and A. Saxena (63 papers each), S. Talwar (59 papers) and S.S. Kothari (56 papers)

have been the most productive authors. The authors leading in terms of citation per paper and relative citation index were: P.Khairy (16.31 and 2.31), B. Vaidyanathan (14.3 and 2.03), R.K. Kumar (10.53 and 1.49), U. Kiran (9.65 and 1.37) and A. Saxena (9.54 and 1.35).

Indian Heart Journal was the topmost productive journal (with 110 papers) in reporting Indian research in the field of CHD research, followed by Annals of Pediatric Cardiology (84 papers), Annals of Cardiac Anaesthesia (53 papers), Indian Journal of Pediatrics (52 papers) and Indian Pediatrics (45 papers) are the top five most popular journals in the subject. International Journal of Cardiology leads in ranking (18.62) in terms of citation per paper, followed by Catheterization and Cardiovascular Interventions (16.64), Journal of Cardiothoracic and Vascular Anesthesia (11.65), Pediatric Cardiology (9.76) and Indian Journal of Pediatrics (7.42)

Conclude that pediatric cardiac care in India is still in its infancy. We have no data on congenital heart disease (CHD) prevalence at birth or on proportional mortality from CHD. The resources are not only limited but also are at times improperly utilized. There are very few specialized pediatric cardiology training programs, those that are, are concentrated in certain regions of India and are often imparted through combined adult and pediatric programs. The existing number of trained personnel for pediatric cardiology and pediatric cardiac surgery is inadequate. Above all there is no national policy for pediatric heart care. Increasing awareness of the problem amongst the pediatricians through CMEs, seminars, symposia is likely to be most helpful in early diagnosis and timely referral of cases. Training programs exclusively dedicated to

pediatric cardiology and pediatric cardiac surgery need to be established in centres with good standards of pediatric cardiac care.⁶

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