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ORIGINAL ARTICLE

Indian Research in Gestational Diabetes Mellitus during the Past Three Decades: A Scientometric Analysis

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Abstract

Background India plays an important role in global research on gestational diabetes mellitus (GDM), but a bibliometric assessment of this research is lacking.

Objective To provide a comprehensive analysis of Indian GDM research during the last 30 years using select bibliometric indicators.

Methods The Scopus international database was used to retrieve publication data, using a defined search strategy. The analysis focused on research output of Indian authors and organizations and their collaborations. The qualitative performance was assessed in terms of relative citation index and citations per paper (CPP).

Results Overall, 100 countries participated in GDM research producing 13,193 publications during 1990–2019. India ranked ninth in global output (1182 publications, 3.1% share) and CPP of 18.6. Only 21.3% of publications had international collaboration and 9.4% were funded. Of the 235 organizations and 544 authors that participated in India's research on GDM, the top 50 organizations and authors contributed 53.8 and 36.4% to national publication share, respectively. The leading productive organizations were AIIMS, New Delhi, KEMH, Pune and PGIMER, Chandigarh, whereas the most productive authors were S. Kalra, V. Seshiah and C.S. Yajnik. Indian Journal of Endocrinology and Metabolism, Journal of Clinical and Diagnostic Research, Journal of Obstetrics and Gynecology of India and Diabetes Research and Clinical Practice were the most productive journals.

Conclusions Indian research on GDM is lagging behind other countries which have a similar disease burden. Increasing national and international collaborations, and active support of national and international funding agencies is urgently required to produce quality research on GDM.

Keywords Gestational diabetes mellitus · Indian publications · Scientometrics · Bibliometrics

Introduction

Gestational diabetes mellitus (GDM) is one of the most common complications of pregnancy and is associated with poor perinatal and maternal-neonatal outcomes, such as increased need for cesarean delivery, fetal macrosomia, risk of development of hypertension and type 2 diabetes (T2D) in the mother, and higher lifetime risk of obesity and T2D in the offspring (1). Worldwide, almost 90% (~18 million) of the 20.4 million women affected by hyperglycemia in pregnancy (HIP) have GDM, according to the recent estimates (1). India has a huge burden of GDM and accounts for approximately 28% of the global population of GDM (2, 3). The prevalence of GDM in some regions of India reaches 41.9%, as compared to an average global prevalence of about 14% live births (1, 4). In several developed countries, GDM

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has emerged as an important area for basic, epidemiological and clinical research due to its implications for morbidity and treatment (5). Despite a dire need to conduct focused research on GDM, India apparently lags behind other countries which have a similar disease burden.

There are a few bibliometric studies on GDM research conducted over the past few years. Brüggmann et al. (6) analyzed global architecture of GDM research and found a disparity in research output between developed and low-resource countries with domination by North-American and Western-European countries. Iftikhar et al. (7) analyzed the 30 most-cited articles on GDM research published during 1946–2018 and found very little contribution of impactful GDM research from developing countries. Another bibliometric study that examined the trends in publications on the associations between genetic polymorphisms and GDM, identified USA as the main contributor to research on GDM-associated genetic factors (8). There is no previous bibliometric assessment of GDM research from India. We therefore planned to conduct a comprehensive review of Indian publication output on GDM over the past three decades.

Materials and Methods

The study examined global and India's research on GDM based on publications covered in Scopus multidisciplinary international database during 1990–2019. The study focused on the following parameters:

1. Publication profile of most productive countries.
2. Characteristics of publications by type and source, publication growth, citation impact, international collaboration and distribution by broad subjects.
3. Publication and citation profile of India's top organizations and authors.
4. Channels of research communication.
5. Bibliographic features of highly cited publications.

The global and Indian publications were identified, retrieved, and downloaded from the Scopus database (http://www.scopus.com) using a defined search strategy. Two sets of keywords (combined by Boolean operators) were used: (i) "diabetes" and (ii) "gestation*" or "pregnancy*" or "maternal" in "Keyword" and "Title" (Article Title) tags of the Scopus database and limiting the search to period "1990–2019," as shown below:

(KEY(diabetes and (gestation* OR pregnancy* OR maternal)) OR TITLE(diabetes and (gestation* OR pregnancy* OR maternal))) AND PUBYEAR > 1989 AND PUBYEAR < 2020.

The search strategy yielded 37,520 global publications. The search was further refined by countries in "affiliation country tag" one by one to get publication output of top 10 countries including India, as shown below:

(KEY (diabetes and (gestation* or pregnancy* or maternal)) or TITLE (diabetes AND (gestation* or pregnancy* or maternal))) AND PUBYEAR > 1989 AND PUBYEAR < 2020 and (LIMIT-TO (AFFILCOUNTRY, "India")).

The Indian search yielded 1193 records, of which 11 were eliminated as they were found irrelevant, limiting final analysis to 1182 records. The impact of research was assessed by using indices such as citations per paper (CPP), relative citation index (RCI) and h-index (HI). The CPP was derived by dividing citations by publications. The RCI was obtained by dividing the number of citations by the average number of citations that an article usually receives in that particular field. The number thus obtained is then benchmarked against the median Relative Citation Ratio for all NIH-funded papers. H-index or Hirsch index was calculated by counting the number of publications for which an author has been cited by other authors at least that same number of times. Activity index was used for assessing the changes in research activity over time. The study period of 30 years was divided into two 15-year time intervals in order to understand the long-term changes in growth and metrics of publications. Citations to the publications were counted from the date of their publication till May 20, 2019.

Results

Overall Profile of Publications

The number of global and Indian publications on GDM research was 37,520 and 1182, respectively, over 30 years of study period. India's annual output increased from four publications in 1990 to 129 publications in the year 2019, registering 23.2% average growth, higher than that of global publications (7.8%) for the same period. India's 15-year cumulative output increased from 110 publications during 1990–04 to 1072 during 2005–2019, registering 874.5% growth rate, more than three times the global publications growth rate of 241.5% for the same period. India's average share was 3.2% during 1990–1919, which showed an increase from 1.3% during 1990–04 to 3.7% during 2005–2019. India's publications averaged 18.6 citations per paper (CPP) during 1990–19, which increased from 16.6 during 1990–04 to 18.8 during 2005–19 (Table 1).

Only 9.4% (111) of Indian publications were funded, by 75 national and international funding agencies. The funded papers received 9572 citations, averaging 77.2 CPP. The funded papers increased from 1 during 1990–04 to 110 during 2005–2019. The major funding agencies were Indian Council of Medical Research (26 papers), Wellcome Trust,

Table 1 Overall publication profile of Indian and global research in gestational diabetes mellitus during 1990–2019

Year	World	India						
	TP	TP	% World	TC	CPP	ICP	% ICP	FP
1990	373	4	1.1	5	1.2	0	0.0	0
1991	388	4	1.0	21	5.2	0	0.0	0
1992	368	1	0.3	0	0.0	0	0.0	0
1993	437	3	0.7	0	0.0	0	0.0	0
1994	451	4	0.9	37	9.2	0	0.0	0
1995	484	4	0.8	25	6.2	1	25.0	0
1996	446	3	0.7	104	34.7	2	66.6	0
1997	560	4	0.7	18	4.5	0	0.0	0
1998	594	10	1.7	307	30.7	1	10.0	0
1999	527	4	0.8	0	0.0	0	0.0	0
2000	573	8	1.4	108	13.5	0	0.0	0
2001	683	11	1.6	100	9.1	2	18.2	0
2002	761	16	2.1	164	10.3	4	25.0	0
2003	889	17	1.9	203	11.9	1	5.9	1
2004	963	17	1.8	734	43.2	5	29.4	0
2005	1084	17	1.6	439	25.8	5	29.4	0
2006	1197	19	1.6	157	8.3	4	21.0	0
2007	1213	27	2.2	2440	90.4	9	33.3	4
2008	1341	33	2.5	3396	102.9	5	15.1	4
2009	1331	34	2.5	2600	76.5	9	26.5	6
2010	1644	52	3.2	917	17.6	10	19.2	3
2011	1730	66	3.8	1340	20.3	17	25.8	4
2012	1957	85	4.3	1404	16.5	15	17.6	7
2013	2090	70	3.3	787	11.2	9	12.9	6
2014	2205	96	4.3	1223	12.7	17	17.7	10
2015	2441	117	4.8	1330	11.4	21	17.9	6
2016	2589	113	4.4	2930	25.9	28	24.8	9
2017	2460	108	4.4	636	5.9	30	27.8	12
2018	2751	106	3.8	374	3.5	28	26.4	12
2019	2990	129	4.3	232	1.8	29	22.5	27
1990–04	8497	110	1.3	1826	16.6	16	14.6	1
2005–19	29,023	1072	3.7	20,205	18.8	236	22.0	110
1990–19	37,520	1182	3.2	22,031	18.6	252	21.3	111

TP Total papers, *TC* Total citations, *CPP* Citations per paper, *ICP* International collaborative papers, *FP* funded papers

UK (19 Papers), Medical Research Council, UK (16 Papers), Bill and Melinda Gates Foundation, USA (15 Papers), and Wellcome Trust-Department of Biotechnology, India Alliance (10 Papers).

Only 21.3% (252) of Indian publications were international collaborative papers (ICP). The ICP share increased from 14.5% during 1990–2004 to 22.0% during 2005–19. The ICPs received 14,429 citations, with an average of 57.3 CPP. UK and USA contributed the largest share in ICPs of 39.5 and 37.6%, respectively, followed by Australia, Denmark, Canada and Pakistan (from 10.6 to 15.6%) and Israel, Italy, Sweden and UAE (from 9.5 to 9.9%). The ICPs share increased for USA, Australia, Israel, Italy, Denmark, Pakistan and UAE (from 3.5 to 26.8%), as against a decrease for Canada, Sweden and UK (from 0.3 to 11.1%) during 1990–2004 and 2005–2019.

The publication types were original articles (63.7%), reviews (19.3%), letters (6.0%), conference papers (3.3%), editorials (2.9%), notes (2.6%), short surveys (0.8%), book chapters (0.5%), erratum (0.2%) and undefined (0.1%).

Topmost Productive Countries

A majority (73%) of publications were produced by the top 10 countries (Table 2). The publication share increased by 0.5% to 5.5% in China, Australia, India, Canada, Spain and

Table 2 Publication output and share of top 10 most productive countries in gestational diabetes mellitus research during 1990–2019

S.no	Country	Number (% share) of global publications		
		1990–2004	2005–2019	1990–2019
1	USA	2537 (29.8)	8123 (28.0)	10,660 (28.4)
2	UK	952 (11.2)	2946 (10.1)	3898 (10.4)
3	Australia	308 (3.6)	1803 (6.2)	2111 (5.6)
4	Canada	269 (3.2)	1640 (5.6)	1909 (5.1)
5	China	57 (0.7)	1797 (6.2)	1854 (4.9)
6	Italy	343 (4.0)	1312 (4.5)	1655 (4.4)
7	Germany	391 (4.6)	1196 (4.1)	1587 (4.2)
8	France	337 (4.0)	975 (3.4)	1312 (3.5)
9	India	110 (1.3)	1072(3.7)	1182 (3.2)
10	Spain	198 (2.3)	940 (3.2)	1138 (3.0)
	Total of 10 countries	5494 (64.7)	21,823 (75.2)	27,317 (72.8)
	World	8497	29,023	37,520

Italy, as against a decrease by 0.5% to 1.0% in Germany, France, UK and USA during 1990–2004 and 2005–2019 (Table 2).

Research Collaboration among Top 10 Countries

All the top 10 countries had discrete collaborative linkages. The top three countries with the largest collaborative linkages (2182, 1619 and 1012) with nine other countries each were USA, UK and Canada. India, France and China showed the least collaborative linkages (384, 651 and 667, respectively). Between two countries, USA–UK registered the highest number of linkages (454), followed by USA–Canada (378) and USA–China (305) (Supplementary Table 1)

Subject-Wise Distribution of Research Output

Of the eight studied subjects, medicine contributed to the largest publication share (79.5%) (Supplementary Table 2). Nursing and medicine registered the highest CPP of 48.3 and 21.4, respectively. The most researched broad subject area was the clinical aspects followed by complications, disease outcomes, and epidemiology (Supplementary Table 3). The research subjects such as treatment and its outcomes, genetics and follow-up were less represented.

Most Productive Organizations

Of the 235 organizations that participated in India's GDM research, 190 organizations published 1–5 papers each, 93 organizations 6–10 papers each, 38 organizations 11–20 papers each, 12 organizations 21–50 papers each and 2 organizations 51–96 papers each. The productivity of top 50 organizations varied from 11 to 96 publications per organization; together they contributed 53.8% (636) to India's publications share and 49.9% (22) citations share (Table 3). Nine organizations registered their publication output above the group average (24.3), while seven registered their CPP and RCI above the group average of 17.3 and 0.9, respectively (Table 3).

Institutional Collaboration among Top Organizations

Four organizations that registered the highest collaboration linkages were Bharti Hospital-Karnal, AIIMS-New Delhi, GMCH-Chandigarh and MDF-Chennai (SupplementaryTable 4).

Most Productive and Impactful Authors

Five hundred and forty-four authors participated in India's GDM research; 335, 158, 43, 7 and 1 authors published 1–5, 5–10, 11–20, 21–50 and 54 papers each, respectively. Six registered their publications output above the group average of 17.2, while nine authors had their CPP and RCI above the group average of 12.1 and 0.6, respectively (Table 4).

Collaboration between Authors

Among the top 15 authors, the highest collaboration linkages were by V. Mohan, S. Kalra, R.M. Anjana and Y. Gupta, while C.S. Yajnik and A. Ramachandran recorded the least linkages (Supplementary Table 5).

Medium of Research Communication

A majority of research on GDM (98.1%, 1169 papers) appeared in 224 journals, the rest (< 2%) as books or book series. One hundred and eighty journals published 1–5 papers each, 20 published 6–10 papers each, 16 published 11–20 papers each and 8 published 21–46 papers each. The top 25 most productive journals accounted for 41.2% share research output, which increased from 38.5% to 41.4% between 1990–2004 and 2005–2019 (Table 5).

Discussion

Our analysis revealed that the volume of Indian research on GDM is far less as compared to several other countries which have a similar disease burden. Although some improvement was noted during the second 15-year period, there is still a wide gap between Indian share of global publications and the disease burden (3.2% for 28% of GDM burden). Research on GDM is a highly organized activity

Table 3 Topmost productive and most impactful Indian organizations in gestational diabetes research

S.no	Organization	TP	TC	CPP	HI	ICP	ICP (%)	RCI
Most productive organizations								
1	All India Institute of Medical Sciences (AIIMS), New Delhi	96	2804	29.21	16	13	13.54	1.57
2	Bharti Hospital, Karnal	60	229	3.82	10	12	20.00	0.20
3	King Edward Memorial Hospital (KEMH), Pune	53	2766	52.19	22	20	37.74	2.80
4	Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh	39	932	23.90	12	2	5.13	1.28
5	Madras Diabetes Foundation (MDF), Chennai	37	520	14.05	13	19	51.35	0.75
6	Christian Medical College (CMC), Vellore	33	252	7.64	10	5	15.15	0.41
7	Government Medical College and Hospital (GMCH), Chandigarh	31	125	4.03	6	0	0.00	0.22
8	Jawaharlal Institute of Postgraduate Medical Education and Research [JIPMER], Pondicherry	28	250	8.93	10	1	3.57	0.48
Most impactful organizations								
1	King Edward Memorial Hospital (KEMH), Pune	53	2766	52.19	22	20	37.74	2.80
2	Dr V. Seshiah Diabetes Care and Research Institute (DVSDCRI), Chennai	12	460	38.33	9	2	16.67	2.06
3	Diabetes Research Center (DRC), Chennai	11	359	32.64	7	4	36.36	1.75
4	All India Institute of Medical Sciences (AIIMS), New Delhi	96	2804	29.21	16	13	13.54	1.57
5	Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh	39	932	23.90	12	2	5.13	1.28
6	National Institute of Nutrition (NIN), Hyderabad	11	225	20.45	5	6	54.55	1.10
7	Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPIMS), Lucknow	13	244	18.77	6	2	15.38	1.01
8	Sher-i-Kashmir Institute of Medical Sciences (SKIMS), Srinagar	13	214	16.46	6	0	0.00	0.88

TP Total publications, *TC* Total citations, *CPP* Citations per paper, *ICP* International collaborative papers, *RCI* relative citation index

Table 4 Most productive and impactful authors in gestational diabetes research

S.no	Author	Affiliation	TP	TC	CPP	HI	ICP	ICP (%)	RCI
Most productive authors									
1	S. Kalra	Bharti Hospital, Karnal	54	210	3.9	9	12	22.2	0.2
2	V. Seshiah	DVSDCRI, Chennai	42	778	18.5	15	13	30.9	0.9
3	C.S. Yajnik	KEMH, Pune	35	416	11.9	12	15	42.8	0.6
4	V. Mohan	MDRF, Chennai	35	416	11.9	12	15	42.8	0.6
5	Y. Gupta	AIIMS, New Delhi	32	129	4.0	6	4	12.5	0.2
6	B. Kalra	Bharti Hospital, Karnal	24	90	3.7	5	0	0.00	0.2
7	R.M. Anjana	MDRF, Chennai	17	264	15.5	9	11	64.7	0.8
8	M.S. Balaji	DVSDCRI, Chennai	17	506	29.8	10	4	23.5	1.6
Most impactful authors									
1	H. Divakar	Divakar's Speciality Hospital, Bangalore	8	279	34.8	4	6	75.0	1.8
2	A. Ramachandran	DRC, Chennai	15	481	32.1	9	4	26.7	1.7
3	M.S. Balaji	DVSDCRI, Chennai	17	506	29.8	10	4	23.5	1.6
4	C. Snehalatha	DRC, Chennai	11	317	28.8	7	3	27.3	1.5
5	V. Seshiah	DVSDCRI, Chennai	42	778	18.5	15	13	30.9	0.9
6	R.M. Anjana	MDRF, Chennai	17	264	15.5	9	11	64.7	0.8
7	R. Unnikrishnan	MDRF, Chennai	13	181	13.9	8	7	53.8	0.7
8	R. Agarwal	AIIMS, New Delhi	7	87	12.4	5	0	0.00	0.6

TP Total publications, *TC* Total citations, *CPP* Citations per paper, *ICP* International collaborative papers, *RCI* relative citation index

that requires large investments and commitment by national governments and research funding agencies (9). Such support is apparently lacking in India due partly to the need for investment in urgent public health issues of national priority such as control of communicable disease and scarcity of resources (10). The large funding support available in the resourceful countries explains why there is a huge disparity in terms of GDM research output between developed and

Table 5 Most productive and most impactful journals in gestational diabetes research during 1990–2019

S.no	Journal	Number of papers			TC	CPP
		1990–04	2005–19	1990–19	1990–2019	
Most productive journals						
1	Indian Journal of Endocrinology and Metabolism	0	46	46	221	4.8
2	Journal of Clinical and Diagnostic Research	0	41	41	223	5.4
3	Journal of Obstetrics and Gynecology of India	0	37	37	107	2.9
4	Diabetes Research and Clinical Practice	5	27	32	765	23.9
5	Journal of Association of Physicians of India	8	22	30	431	14.4
6	Journal of Pakistan Medical Association	0	29	29	68	2.3
7	Journal of South Asian Federation of Obstetrics and Gynaecology	0	27	27	24	0.9
8	Journal of Indian Medical Association	12	14	26	84	3.2
Most impactful journals						
1	The Lancet	0	8	8	6392	799.0
2	Diabetes Care	1	14	15	629	41.9
3	Diabetic Medicine	4	7	11	426	38.7
4	International Journal of Gynecology and Obstetrics	0	15	15	450	30.0
5	Diabetologia	1	10	11	311	28.3
6	Diabetes Research and Clinical Practice	5	27	32	765	23.9
7	Indian Journal of Medical Research	2	19	21	450	21.4
8	Journal of Association of Physicians of India	8	22	30	431	14.4

TP Total publications, *TC* Total citations, *CPP* Citations per paper

low-resource countries (6). For similar reasons, the quality of Indian GDM research also lags behind developed countries. The quality of research in terms of CPP showed only a marginal improvement from 16.6 to 18.8 during the two time intervals of the study and was probably attributable to an increase in the international collaboration from 14.6 to 22.0% and the number of funded publications. The CPP of funded and collaborative publications was almost 4–5 times higher than the average CPP of all publications. It is well known that funded and collaborative research is associated with better publication impact (10). Indeed, collaborative efforts and fostering of research endeavors have been suggested for overcoming the research disparities between resourceful and resource-poor nations (6).

Internationally, GDM research is accorded high priority by identifying important research areas for future studies (11). Several unresolved issues such as poorly defined GDM diagnostic criteria, benefit of early diagnosis and treatment on the risk of adverse outcomes, incomplete understanding of medical management, especially the uncertainty of long-term outcomes of comparative use of insulin, metformin, and glyburide, have been identified by researchers in the developed countries (5, 12). Additionally, phenotypic heterogeneity in GDM, and novel and individualized treatment approaches appear certain to be researched in the future (12). In the Indian context, there are several additional challenges identified for GDM research (13). For example, the reasons why Indian women have several fold higher risk of developing GDM as compared to Caucasian women are not fully known (14). Also, the reasons for wide variations in regional prevalence of GDM are yet to be elucidated (2). Although the differences in diagnostic criteria accounting for the regional differences is beginning to get studied, such studies are needed on a nationwide scale (15, 16). Indeed, Indian authors have raised concerns about the lack of consensus on approaches for screening, diagnosis, and treatment of GDM across the country (13). Authors have also highlighted the need of building capacities and capabilities and conducting qualitative research to overcome the current and future challenges of GDM (13). Our analysis also identified that several subject areas such as the treatment and its outcomes, genetics and follow-up of GDM are less well researched. These are crucial subjects for future research and may help improve outcomes in Indian patients of GDM.

For improving the quantity and quality of GDM research, a collective and sustained effort by all the major stakeholders viz. Indian government, research organizations, professional bodies and researchers is needed (13). The financial support for conducting high-quality research needs to be provided by the Indian government through various funding agencies. Research organizations such as the Indian Council of Medical Research (ICMR) and Department of Science and Technology (DST) should prioritize GDM research and formulate strategies similar to countries with high GDM burden, which run several programs for prevention of GDM (12, 17). A national task force for GDM supervised by ICMR or

DST can identify priority research areas and guide research. India also needs to increase its international collaboration in GDM research through organizations such as Public Health Foundation of India, DBT-Wellcome India Alliance and World Diabetes Foundation (18, 19). Professional bodies such as Federation of Obstetric and Gynaecological Societies of India, Research Society for Study of Diabetes in India, Endocrine Society of India, National Neonatology Forum and Indian Society for Pediatric and Adolescent Endocrinology need to support GDM research similar to their counterparts in other countries, and because of a common interest in GDM-related maternal and offspring outcomes.

Our bibliometric analysis has some limitations. The search was limited to only Scopus database due to its much larger content coverage, search analysis tools and funding information as compared to other medical literature databases such as PubMed and Web of Science (20, 21). Secondly, all the Indian publications related to GDM were probably not captured despite standardizing the author names and resolving the issue of synonyms or homonyms in author names by using other specific fields such as affiliations, similar to our previous bibliometric analyses (22, 23). Searching the other databases simultaneously has been suggested for an improved data capturing, but the data retrieval may still remain incomplete due to an underrepresentation of publications from developing countries in international databases (24). Despite these limitations, we could identify the major gaps in the Indian GDM research and quantify the publication output in this area which may help the planners and policymakers to develop focused programs for future GDM research.

Conclusion

The Indian research output in GDM lags behind other countries which have a similar disease burden. To improve the quantity and quality of GDM research, there is a need for high-quality intra- and inter-country collaborative research by Indian researchers, professional bodies and research organizations with sufficient financial support by the national government. The sustained improvement in quality of research may translate into better maternal and offspring outcomes for women who suffer from GDM.

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Compliance with ethical standards

Conflict of interest None.

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