

Covid-19 and Type 1 Diabetes: A Scientometric Assessment of Global Publications based on the Scopus Database

Devi Dayal^{1*}, BM Gupta², M Surulinathi³, Pamali Mahasweta Nanda¹

¹Postgraduate Institute of Medical Education and Research, Department of Pediatrics, Chandigarh, INDIA.

²Formerly with CSIR-National Institute of Science, Technology and Development Studies, New Delhi, INDIA.

³Bharathidasan University, Department of Library and Information Science, Tiruchirappalli, Tamil Nadu, INDIA.

ABSTRACT

Background: The Covid-19-related diabetes research is confined mainly to type 2 diabetes. Although type 1 diabetes (T1D) which presents unique challenges in Covid-19, appears to be well-researched, a bibliometric assessment of this research is lacking. **Materials and Methods:** Using a defined search procedure, we identified publications on Covid-19-related T1D research in Elsevier's Scopus database during 2020-2021. The data was analyzed using appropriate bibliometric tools. **Results:** The publications numbered 255 until August 4, 2021. Seventy-three (28.6%) were funded; these received higher average citations than non-funded (19.0 versus 9.8). The share of publications by age group was as follows: adults (36.8%), children (34.9%), adolescents (27.0%), middle-aged (15.7%), and elderly (10.6%). Sixty-nine countries participated; the USA, Italy, and UK led in productivity, whereas Canada, UK, and Italy were the most impactful. Barbara Davis Center, USA, University of Colorado, USA, and King's College London, UK were the most productive, whereas the University of Glasgow, UK, PGIMER-Chandigarh, India, and Barbara Davis Center, USA were the most impactful organizations. USA's Q. Ebekozien and Italy's C. Maffei and R. Schiaffini led in productivity, whereas Italy's A. Avogaro

and India's S. Bhadada and R. Pal led in impact. Diabetes Research and Clinical Practice and Diabetes Care were the leading journals. Only 12 (4.7%) publications were highly-cited. **Conclusion:** Covid-19-related T1D research has primarily been conducted in high-income countries such as the USA, UK, and Italy. There is a need to foster collaboration between high-income and low-income countries for further research to develop better management strategies for worldwide patients with the double scourge of T1D and Covid-19.

Key words: Covid-19, Type 1 Diabetes, Publications, Scientometrics, Bibliometrics, children.

Correspondence

Dr. Devi Dayal,

Professor, Endocrinology and Diabetes Unit, Department of Pediatrics, Advanced Pediatrics Center, Postgraduate Institute of Medical Education and Research, Chandigarh-160012, INDIA.

Email id: drdevidayal@gmail.com

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INTRODUCTION

The coronavirus disease 2019 (Covid-19) pandemic has caused severe devastation throughout the world. The disease is particularly severe in patients with underlying medical conditions such as diabetes, hypertension, obesity, and other co-morbidities.^{1,2} Among patients with diabetes, type 2 diabetes (T2D) in Covid-19 patients has been documented to be associated with the worst outcomes; almost one-fourth of the affected patients die.³ Covid-19 may also affect patients with type 1 diabetes (T1D), but the investigated outcomes have been reported to vary widely among the studied patient populations.⁴ The effects of delayed presentations leading to severe diabetic ketoacidosis (DKA), adoption of telecare for follow-up, and poor metabolic control predisposing to severe illness are well studied in Covid-19-affected patients with T1D.⁵⁻⁷ In addition, the pathophysiological mechanisms linked to adverse clinical outcomes in Covid-19 affected T1D patients are just beginning to get elucidated.⁸ However, several facets of Covid-related T1D are still not well understood. A recent systematic review that included 15 original investigative studies on the association between Covid-19 and T1D reported wide variability in the studied outcomes such as the length of hospital stay, need for hospitalization and intensive care, DKA rates, and severe hypoglycemia.⁴ The authors concluded that further research is still warranted to reach definitive conclusions as the studies conducted so far had several limitations and included heterogeneous patient populations.⁴

To guide further research, a comprehensive assessment of the previously conducted research is mandatory. Such an assessment is done using bibliometric methods that allow the identification of research lacunae, prevailing trends, and hotspots.^{9,10} In addition, bibliometry also helps identify researchers and organizations in a particular research field and thus can facilitate cooperation between them, leading to more impactful research.¹¹ Previous bibliometric studies on Covid-19 concerning diabetes did not include separate analyses on T1D.¹²⁻¹⁵ Additionally, the study spans of recently published scientometric assessments of T1D research were before the onset of the Covid-19 pandemic.¹⁶⁻¹⁸ Hence, a bibliometric evaluation of T1D research in relation to Covid-19 is not available. Thus, the present study was conceived with the aim of providing a comprehensive assessment of Covid-related T1D research.

MATERIALS AND METHODS

The published data on T1D related to Covid-19 until August 4, 2021, was identified, retrieved, and downloaded from the Scopus database (<https://www.scopus.com>). We used a defined search strategy similar to our previous scientometric studies.¹⁹⁻²¹ The keywords and the details of the search string are as given below:

(Title ("Covid 19" or "2019 novel coronavirus" or "coronavirus 2019" or "coronavirus disease 2019" or "2019-novel CoV" or "2019 ncov" or covid 2019 or covid19 or "corona virus 2019" or ncov-2019 or ncov2019 or "nCoV 2019" or 2019-ncov or covid-19 or "Severe acute respiratory

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syndrome coronavirus 2” or “SARS-CoV-2”) or Key (“Covid 19” or “2019 novel coronavirus” or “coronavirus 2019” or “coronavirus disease 2019” or “2019-novel CoV” OR “2019 ncov” or covid 2019 or covid19 or “corona virus 2019” or ncov-2019 or ncov2019 or “nCoV 2019” or 2019-ncov or covid-19 or “Severe acute respiratory syndrome coronavirus 2” or “SARS-CoV-2”) and key (diabet*) and (“Type 1 diabet*” or “Diabet*, Type 1”) and (Limit-To (Exact Keyword,”Insulin Dependent Diabetes Mellitus”) or Limit-To (Exact Keyword,”Diabetes Mellitus, Type 1”) or Limit-To (Exact Keyword,”Type 1 Diabetes”).

The quantitative assessment of research productivity was shown as the number of publications. For qualitative assessment, we used indicators such as citations per paper (CPP), relative citation index (RCI), and *h*-index (HI). Citations were counted from the date of publication till August 4, 2021. Any publication with more than 50 citations was considered a highly cited publication (HCP). The bibliometrix and VOSviewer software were also utilized for analyzing and visualizing the networks between authors, countries, institutions, and co-occurrence of keywords.

RESULTS

The general profile of publications

The global research on T1D-related Covid-19 consisted of 255 publications (138 and 117 during 2020 and 2021, respectively) until August 4, 2021. These publications were cited 2509 times with an average of 9.8 CPP. Only 73 (28.6%) were funded; these received a higher average (19.0) and total (1388) citations. The major funding agencies included Novo Nordisk (15 papers), National Institute of Health, USA (14 papers), Eli Lilly and Company (13 papers), Juvenile Diabetes Research Foundation, USA (11 papers), and Medtronic (10 papers).

The share of original articles, reviews, letters, notes, editorials, and book chapters/surveys was 61.5%, 16.4%, 9.4%, 7.8%, 3.9%, and 0.4%, respectively. The focus of almost half (49.0%) of publications was clinical aspects followed by complications (31.8%), treatment (26.7%), epidemiology (20.8%), risk factors (20.0%), pathophysiology (13.3%), and genetics (2.7%). Studies on risk factors received the highest impact (average CPP 24.8), whereas those on treatment were the least impactful (11.0). The subject-wise distribution of publications revealed that Medicine accounted for the largest share (92.1%), followed by Biochemistry, Genetics and Molecular Biology (41.1%), Immunology and Microbiology (3.1%), and Pharmacology, Toxicology and Pharmaceutics (1.9%). In terms of impact, publications on Biochemistry, Genetics and Molecular Biology registered the highest average CPP of 15.4 and Immunology and Microbiology the lowest (3.1). The share of publications by age group of the studied population was as follows: adults (36.9%), children (34.9%), adolescents (27.0%), middle-aged (15.7%), and elderly (10.6%).

We figured out 46 significant keywords with a frequency of appearance varying from 33 to 255, which indicated the research trends on this theme (Figure 1).

Top countries in productivity and impact

The research on Covid-19-related T1D was reported from 69 countries; 60 of these contributed 1-10 papers each, five countries 11-20 papers each, and four contributed 21-68 publications each. The top 10 countries contributed 95.7% of publications; their relative contribution is shown in Table 1. Countries with CPP and RCI higher than the group average of 10.5 and 1.0, respectively, were more impactful than others (Table 1).

The average collaboration between the top 10 countries was 35.2% (range, 21.4%–66.6%). The largest collaborative linkages (22, 15, and 14) occurred between the USA, UK, and India. The country pairs that collaborated the most were the USA–India (6 times), the USA–Australia (4 times), and the USA–UK (3 times) (Figure 2).



Figure 1: WordCloud showing co-occurrence and importance of significant keywords in Covid-19 research concerning type 1 diabetes.

Table 1: Most productive countries in research on type 1 diabetes concerning Covid-19.

S. no.	Country	TP	TC	CPP	HI	ICP	%ICP	RCI	% TP
1	United States	68	365	5.4	9	21	30.9	0.6	26.7
2	Italy	42	582	13.9	11	9	21.4	1.4	16.5
3	U.K.	36	615	17.1	11	13	36.1	1.7	14.1
4	India	26	219	8.4	7	8	30.8	0.9	10.2
5	Germany	15	259	17.3	7	10	66.7	1.8	5.9
6	Spain	13	93	7.2	5	3	23.1	0.7	5.1
7	France	12	65	5.4	5	5	41.7	0.6	4.7
8	Australia	11	65	5.9	5	7	63.6	0.6	4.3
9	Canada	11	240	21.8	5	4	36.4	2.2	4.3
10	Brazil	10	81	4.1	5	6	30.0	0.4	3.9

Abbreviations: TP, total papers; TC, total citations; CPP, citations per paper; ICP, international collaborative papers; HI, h-Index; RCI, relative citation index.

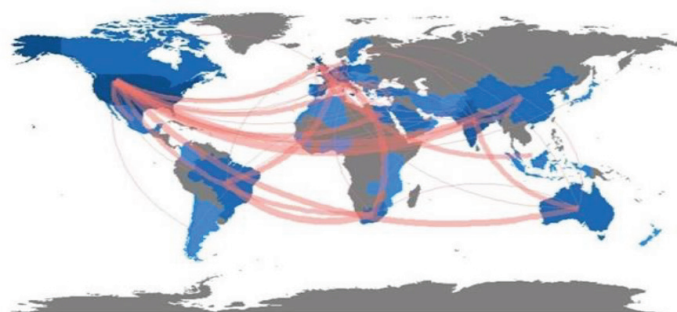


Figure 2: Collaboration map of countries. The thickness of the connecting lines represent the value of countries in collaboration.

Productive and influential organizations

Only six of the 258 participating organizations contributed 6-8 publications each; 89 contributed only one paper each, 67 organizations two papers each, 54 organizations three papers each, 29 organizations four

Table 2: Most productive and most impactful organizations in research on type 1 diabetes concerning Covid-19.

S.No.	Organization	TP	TC	CPP	HI	ICP	% ICP	RCI
Most productive organizations								
1	Barbara Davis Center for Childhood Diabetes, USA	8	142	17.8	4	1	12.5	1.8
2	University of Colorado Anschutz Medical Campus, USA	8	142	17.8	4	1	12.5	1.8
3	King's College London, U.K.	7	68	9.7	5	4	57.1	1.0
4	T1D Exchange, Boston, USA	6	51	8.5	4	0	0.0	0.9
5	Icahn School of Medicine at Mount Sinai, USA	6	37	6.2	4	2	33.3	0.6
6	University of California, San Francisco, USA	6	14	2.3	3	1	16.7	0.2
7	PGIMER-Chandigarh	5	92	18.4	4	0	0.0	1.9
8	Universita degli Studi di Padova, Italy	5	78	15.6	3	0	0.0	1.6
9	INSERM, France	5	23	4.6	3	2	40.0	0.5
10	University of Glasgow, U.K.	5	397	79.4	5	0	0.0	8.1
Most impactful organizations								
1	University of Glasgow, U.K.	5	397	79.4	5	0	0.0	8.1
2	PGIMER-Chandigarh	5	92	18.4	4	0	0.0	1.9
3	Barbara Davis Center for Childhood Diabetes, USA	8	142	17.8	4	1	12.5	1.8
4	University of Colorado Anschutz Medical Campus, USA	8	142	17.8	4	1	12.5	1.8
5	Universita degli Studi di Padova, Italy	5	78	15.6	3	0	0.0	1.6
6	University of Washington, USA	5	68	13.6	3	1	20.0	1.4
7	IRCCS Ospedale Pediatrico Bambino Gesù, Italy	5	66	13.2	4	2	40.0	1.3
8	King's College London, U.K.	7	68	9.7	5	4	57.1	1.0
9	T1D Exchange, Boston, USA	6	51	8.5	4	0	0.0	0.9
10	Icahn School of Medicine at Mount Sinai, USA	6	37	6.2	4	2	33.3	0.6

Abbreviations: TP, total papers; TC, total citations; CPP, citations per paper; ICP, international collaborative papers; HI, *h*-Index; RCI, relative citation index

papers each, and 21 organizations five papers each. Table 2 lists the top 10 most productive and most impactful organizations. The inter-organization collaborations are shown in Figure 3.

Most prolific and influential authors

Three hundred fifty-seven authors participated unevenly in global research on Covid-19 and T1D; 185 contributed only one publication each, 134 two papers each, 28 three papers each, seven four papers each, and only three published five papers each. The relative productivity and impact of the top authors are shown in Table 3. The leading authors had an extensive collaboration in research; P.E. Verwei, M. Blaize, and A. Fakkar had the largest number of collaborative linkages (12, 11, and 11). The collaboration networking between top authors is depicted in Figure 4.

Leading journals

Only one of the 255 publications on Covid-19 and T1D research is published as book series, and the rest are published in 99 journals. Table 4 lists the leading journals in productivity and influence.

Highly cited publications

Only 12 (4.7%) publications were HCPs; these received 53 to 220 citations each, and their cumulative and average citations were 1270 and 105.8, respectively. Six were published as original articles, four as reviews, and one each as letter and note. Italy contributed three HCPs, Canada, Germany, and the UK contributed two each, while Hong Kong, India, South Korea, and the USA contributed one HCP each. Forty-three organizations and 64 authors participated in 12 HCPs, seven as collaborative and five as non-collaborative publications. Of the nine journals



Figure 3: Collaboration network of organizations in Covid-19-related type 1 diabetes research. The box size and text dimension depict the degree value in collaboration.

that published HCPs, The Lancet Diabetes and Endocrinology and Diabetes Technology and Therapeutics published three and two papers, respectively. Diabetes Care, Diabetes Research and Clinical Practice, Diabetes Therapy, Endocrinology Reviews, JAMA - Journal of the American Medical Association, Molecular Metabolism, and Nature Reviews Endocrinology published one HCP each.

DISCUSSION

The global response to Covid-19 has been centered on clinical research. The speed of clinical research and its publication have been unprecedented

Table 3: The most prolific and influential authors in type 1 diabetes research related to Covid-19.

S.No.	Author	Affiliation	TP	TC	CPP	HI	ICP	%ICP	RCI
Most Prolific authors									
1	Q.Ebekozien	TID Exchange, USA	5	14	2.8	3	0	0.0	0.3
2	C.Maffeis	Aziencia Ospedaliera Universitaria Integrata Verona, Italy	5	45	9.0	3	0	0.0	0.9
3	R.Schiaffini	IRCCS Ospedale Pediatrico Bambina, Italy	5	66	13.2	4	2	40.0	1.3
4	G.T. Alonso	TID Exchange, USA	4	47	11.8	3	0	0.0	1.2
5	S.K.Bhadada	PGIMER Chandigarh, India	4	84	21.0	3	0	0.0	2.1
6	R.Pal	PGIMER Chandigarh, India	4	84	21.0	3	0	0.0	2.1
7	M.P. Gallagher	TID Exchange, USA	4	47	11.8	3	0	0.0	1.2
8	I.B.Hirsch	Barbara Davis Center for Childhood Diabetes, USA	4	72	18.0	4	1	25.0	1.8
9	B.Ngongo	International Diabetes Foundation, Belgium	4	26	6.5	2	4	100.0	0.7
10	I.Rabbone	Universita degli Studi del Piemonte Orientale Amedeo, Italy	4	42	10.5	2	0	0.0	1.1
Most influential authors									
1	A.Avogaro	Universita degli Studi di Padova, Italy	3	76	25.3	3	0	0.0	2.6
2	S.K.Bhadada	PGIMER Chandigarh, India	4	84	21.0	3	0	0.0	2.1
3	R.Pal	PGIMER Chandigarh, India	4	84	21.0	3	0	0.0	2.1
4	I.B.Hirsch	Barbara Davis Center for Childhood Diabetes, USA	4	72	18.0	4	1	25.0	1.8
5	R.Schiaffini	IRCCS Ospedale Pediatrico Bambina, Italy	5	66	13.2	4	2	40.0	1.3
6	G.T. Alonso	TID Exchange, USA	4	47	11.8	3	0	0.0	1.2
7	I.Rabbone	Universita degli Studi del Piemonte Orientale Amedeo, Italy	4	42	10.5	2	0	0.0	1.1
8	C.Maffeis	Aziencia Ospedaliera Universitaria Integrata Verona, Italy	5	45	9.0	3	0	0.0	0.9
9	M.T.U.Barone	International Diabetes Foundation, Belgium	3	24	8.0	2	3	100.0	0.8
10	B.Ngongo	International Diabetes Foundation, Belgium	4	26	6.5	2	4	100.0	0.7

Abbreviations: TP, total papers; TC, total citations; CPP, citations per paper; ICP, international collaborative papers; HI, *h*-Index; RCI, relative citation index.

**Figure 4:** Collaboration network of authors.

in several countries.²² High-income North-American and Western European countries appear to have taken the lead in conducting research on Covid-19.¹³ The research on the major co-morbidities related to Covid-19, such as diabetes, obesity, and hypertension, also appears to have been dominated by the same countries.^{12,23} Our study also found that even the Covid-19-related T1D research landscape is dominated by the USA, UK, and Italy. This is understandable as similarities in the relative distribution of research productivity over time allow these countries to form stable and productive research clusters.²⁴ In addition,

the geographical proximity and funding opportunities in high-income countries lead to more impactful research.²⁴

In contrast, research funding and the governmental commitment to research are much lower in low-income countries.²⁴ The economic fallout and the urgent need to allocate resources for Covid-19 in the low- and middle-income countries also meant little funding was available for original Covid-19 research.²⁵ Among the low- or low-middle-income economies, only India managed to be included in the top five countries in the Covid-19-related T1D research. However, India's productivity was only a little more than one-third of that of the USA despite the T1D disease burden being almost equal to that of the USA.²⁶ In this regard, the Indian institutions with high-volume T1D practice need to enhance their productivity.²⁷⁻²⁹ Also, centers actively engaged in pediatric T1D research prior to the Covid-19 pandemic need to plan research strategies for a possible future Covid-19 wave that may adversely affect children with T1D.³⁰⁻³³

An important finding of our study was the relatively less attention received by the Covid-19-related T1D research compared to other endocrine disorders during the same time span. The number of publications on diabetes (all types), thyroid, and vitamin D deficiency in relation to the Covid-19 was 762, 599, and 435, respectively.^{15,34,35} In addition, studies on pathophysiology, which is considered crucial for understanding the

Table 4: Most productive and influential journals in type 1 diabetes research related to Covid-19.

S.No.	Journal	TP	TC	CPP
1	Diabetes Research and Clinical Practice	29	309	10.7*
2	Diabetes Care	14	314	22.4*
3	Diabetes and Metabolic Syndrome: Clinical Research and Reviews	12	93	7.8
4	Journal of Diabetes Science and Technology	12	47	3.9
5	Diabetes Technology and Therapeutics	11	176	16.0*
6	Diabetic Medicine	11	78	7.1
7	Acta Diabetologica	9	41	4.6
8	Frontiers in Immunology	6	12	2.0
9	Diabetes Therapy	5	77	15.4*
10	Lancet Diabetes and Endocrinology	5	601	120.2*
11	Pediatric Diabetes	5	26	5.2
12	International Journal of Diabetes in Developing Countries	4	8	2.0
13	Journal of Pediatric Endocrinology and Metabolism	4	8	2.0
14	Primary Care Diabetes	4	8	2.0
15	Acta Biomedica	3	4	1.3

*more impactful than others

Abbreviations: TP, total papers; TC, total citations; CPP, citations per paper.

mechanisms of disease severity and outcome, were only 3.3%. These gaps in research need to be considered during further research in this field.

Some limitations of our bibliometric assessment need discussion. The evaluation is based on the publication output retrieved from a single database, i.e., Scopus; its choice was based on its extensive content coverage and citation accuracy.³⁶ Although most bibliometric studies are based on single databases; such a strategy may miss some publications or citations.³⁷ At the same time, even as using multiple databases may improve the number of records, the discrepancies in the retrievable data do not allow drawing uniform conclusions.³⁸

CONCLUSION

The research on T1D in relation to Covid-19 is currently led by high-income countries such as the USA, UK, and Italy. For developing better management strategies in the future for such patients worldwide, there is a need for enhancing collaboration between high-income and low-and middle-income countries. Further research should also focus on the pathophysiological aspects of T1D concerning Covid-19.

CONFLICT OF INTEREST

The authors declare no conflict of interest

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