DESIDOC Journal of Library & Information Technology, Vol. 45, No. 2, March 2025, pp. 123-130, DOI : 10.14429/djlit.20408

High Cited Papers in Type 1 Diabetes Mellitus Immunotherapy: A Bibliometric Analysis of Global Publications During 1996-2023

Raju Vaishya[~*], B.M. Gupta[#], S.M. Dhawan[$], Yogendra Singh[^] and Jivesh Bansal[!]
[~]*Indraprastha Apollo Hospitals, Sarita Vihar, New Delhi – 110 076, India*
[#]*Formerly with CSIR-NISTADS, Pusa, New Delhi – 110 012, India*
[$]*Formerly with CSIR-NPL, Pusa, New Delhi – 110 012, India*
[^]*Swami Rama Himalayan University, Dehradun – 248 016, India*
[!]*Panjab University, A.C. Joshi Library, Chandigarh – 160014, India*
[*]*Email: raju.vaishya@gmail.com*

ABSTRACT

The performance of global research in immunotherapy for type 1 diabetes mellitus (T1DM) was bibliometrically examined using 112 High-Cited Papers (HCPs) indexed in the Scopus database from 2016 to 2023. The HCPs were cited between 80 and 1019 times, with an average citation of 205.54. The lead country, institution, author, and journal were identified as the USA, University of California San Francisco, J.A. Bluestone, and Diabetes, respectively. Switzerland, Brigham and Women's Hospital, USA, Q. Tang, and Annual Review of Immunology were found to be the most impactful countries, institutions, authors, and journals. The most frequent keywords were immunotherapy, insulin-dependent diabetes mellitus, and type 1 diabetes mellitus. It was observed that immunotherapy for T1DM as a research area has gained attention in global literature during the past decade from various countries and institutions. The research environment has predominantly been influenced by developed countries of North America and Western Europe. It is recommended to undertake large-scale randomised controlled trials and foster research partnerships between developed and developing nations to ensure long-term sustainability and a broader impact, globally.

Keywords: Immunotherapy; Type 1 diabetes; High-cited publications; Citations; Collaboration

1. INTRODUCTION

Type 1 diabetes mellitus or T1DM is recognised as a complex autoimmune condition characterised by the destruction of pancreatic β cells through a T-cell-mediated mechanism, which ultimately leads to a complete lack of insulin and elevated blood glucose levels. Because acute and chronic complications lead to significant morbidity and mortality[1]. Among people in the age group 20-79 years, the Diabetic Mellitus (DM) global prevalence was 10.5 %, constituting 536.6 million people in 2021. About 10 % proportion of DM prevalence was accounted for by TIDM, according to Diabetes Atlas from the International Diabetes Federation (IDF)[2-3]. TIDM is considered a disease with a high burden, and huge social, health, and economic consequences and often leads to liability and death, consequently, it needs a high national priority for nations suffering the most[4]. Recent decades have seen remarkable advancements in treatment options for T1DM. These include the development of novel insulin analogues, smart insulins, oral and weekly insulin formulations, artificial pancreas systems, sustainable human β-cell replacement therapies, and targeted immune interventions aimed at preserving β-cell functionality[5-6].

Received : 18 July 2024, Revised : 12 November 2024
Accepted : 02 December 2024, Online published : 27 February 2025

For managing and controlling TIDM through prevention, delay and reversal, novel immunotherapy approaches have been developed by scholars more recently. These approaches help in the reduction of the functional loss of β cells by suppressing the autoimmune assault on the β cells of T and B cells[7-8].

Previous scholars have studied the inhibition of β-cell destruction and made efforts to partially restore islet function with a temporary curative effect[9-10]. Consequently, researchers redirected their focus towards the creation of specialised immunotherapeutic agents and novel delivery methods, resulting in enhanced response rates and a decrease in overall toxicity and immune suppression[11-13]. The existing literature on T1DM immunotherapy categorizes approaches into three main types: (i) T-cell-targeted therapies, (ii) therapies aimed at CD4+ regulatory T cells (Tregs), and (iii) dendritic cell-targeted therapies. The literature suggests that multiple or combination therapies should be used, as these are expected to provide simultaneous or synergistic effects to effectively address the autoimmune processes in patients[14-15].

In current advanced delivery strategies, nanoparticles, liposomes, plasmids, engineered microorganisms, and microneedles are utilised: (i) for the development of localised on-demand delivery of drugs, and cell factors, and (ii) the antibodies to minimise toxicity in vivo. For

dampening the immune response and inducing immune tolerance, multiple therapies have been introduced and tested with a substantial number of interventions although indicate positive results, but so far only partially or transiently in a small proportion of participants[8,16].

Bibliometric analysis is a quantitative method of citation and content analysis for scholarly literature, aimed to understand the:(i) research status, trends, and characteristics of specific disciplines, (ii) describe patterns of publications, (iii) evaluate the activities of participating countries, organisations, authors and journals and (iv) examine and visualise influences and the relationships among participating players within a given field or across various fields[17].

The response of regulating agencies and the medical community while evaluating new immunotherapies for TIDM generallyignores to look into the heterogeneous nature of T1D and varied differences in the immune status of children and adults. Therefore, they suggest the need for documenting literature in this area utilizing bibliometric methods, besides undertaking systematic reviews from time to time[18].

Currently, bibliometrics methods are utilised by various scholars to analyse research status, hot topics, and trends in the application of "immunotherapy for cancer"[19-20], and "immunotherapy for inflammatory bowel disease"[21], etc.

Because of the absence of such a bibliometric study for Type 1 diabetes literature, we decided to undertake the present study aiming to make a bibliometric assessment of the literature on"Immunotherapy for Type 1 Diabetes". The study examined the:(i) overall growth and citation profile; (ii) distribution of publications by document type, research type, study design and population age group; (iii) identify important participating players, such as countries, organisations and authors and study their productivity, citation impact and collaborative linkages through bibliometric indicators and visual methods, (iv) identify the significant keywords and the focused subject areas, using co-occurrence analysis, (iii) the important media of communication, and (iv) the characteristics of top 15 HCPs.

2. METHODOLOGY

The literature on immunotherapy and Type 1 diabetes was searched with appropriate keywords using the Scopus database from January 1, 1996, to December 31, 2023, on 10.2.2024. The detailed search strategy utilised in this study is shown below. A total of 1197 documents were identified and these were sorted by decreasing the order of citations leaving only 112 documents having received 80 or more citations. The 112 high-cited papers were selected for detailed analysis. The extracted data for each downloaded publication included various bibliographical features, such as title (source), author, country, organisation, serial, citation received, keywords, publication date and other related information, which were exported for final analysis. MS Excel was used for descriptive statistical analysis of the research output. For carrying out the co-authorship, co-occurrence and co-citation analysis, VOS viewer software[22] was used.

(KEY (type 1 diabetes OR diabetes, AND type 1) AND KEY (immunotherapy)) AND PUBYEAR > 1995 AND PUBYEAR < 2024 AND PUBYEAR > 1995 AND PUBYEAR < 2024

3. FINDINGS

3.1 Overview

The global search on "Immunotherapy for Type 1 Diabetes" yielded 1197 papers during a span of 28 years from 1996 to 2023. From 1197 papers, 112 (9.36 %) were identified as having received 80 to 1019 citations and together registered 23021 citations, averaging 205.54 citations per paper (CPP). These 112 papers are assumed as high-cited papers (HCPs). The 112 HCPs depict uneven distribution: 17 papers fall in the citation range 80-96, 88 in the citation range 100-490, and 7 papers in the citation range 615-1019. The annual growth in 112 HCPs showed fluctuating growth and decline, with maximum papers (n=11 and 8 each) published in 2011 and 2012-2013. Considering cumulative five-year growth, the contribution has first increased from 14 (1996-2002) to 41 (2003-09) and then decreased to 32 and 25 during 2010-16 and 2017-23.

By document types, 57 (50.89 %) and 50 (44.64 %) appeared as articles & reviews in 112 HCPs, followed by short surveys (3 and 2.68%) and note & conference papers (1 and 0.89 % each). By research type, pathophysiology and treatment(with 13.39 % share each) contributed the most, followed by clinical studies (10.71 % share), epidemiology and genetics (5.36% share each), risk factor (3.57% share), and complications (2.68 %). By research design, 28 (25.0 %) and 12 (10.71 %) HCPs were involved in clinical trials and randomised controlled trials. Among population age groups, the major focus was on children& adolescents (n=17), followed by middle-aged (n=9), adults (n=8) and aged (n=3).

External funding from various international agencies was indicated in sixty-five (58.04 %) out of 112 HCPs. They collectively received 14250 citations, averaging 219.23 CPP. National Institute of Diabetes and Digestive and Kidney Diseases, USA supported funded research led to the highest number of publications (n=24), followed by the National Institute of Health, USA (n=22), National Institute of Allergy and Infectious Diseases, USA (n=18), National Cancer Institute, USA and Juvenile Diabetes Research Foundation International (n=4 each), etc.

Thirty-nine (34.82 %) of the 112 HCPs indicated their participation in international collaboration. They collectively received 6865 citations, averaging 176.03 CPP. Among 39 international collaborative papers,the USA took the lead by publishing 33 papers, followed by the U.K. and Netherlands (n=10 each), France (n=7), Germany and Sweden (n=4 each), etc.

3.2 Geographical Distribution of HCPs

The top 10 countries out of 25 participated in 112 HCPs and individually contributed 3 to 82 papers. They collectively contributed 145 papers and 28107 citations, which account for more than 100 % share each in total papers and citations. Considering the top 10 countries: (i) Two countries, namely the USA (n=82) and the U.K. (n=15) contributed more than the average publication productivity (11.2), and (ii) Two countries, namely Switzerland (339.67 and 1.653) and the USA (220.61 and 1.073) achieved citation impact (CPP and RCI) more than their average values (193.84 and 0.943). The share of ICPs in the national output of the top 10 countries varied from 40.0 % to 100.0 %, with an average of 53.79 %.

The top 10 countries collaborative intensity, measured by total link strength (TLS) varied from 2 to 44, with a maximum (of 44TLS) reported by the USA (n=44 TLS), followed by the Netherlands (n=18 TLS), U.K. (n=17 TLS), Sweden (n=9 TLS), etc. In terms of country-to-country collaboration linkages, the maximum bilateral collaborative links(9) were reported by country pair "USA - U.K", followed by USA-Netherlands" (n=8), "USA-France"(n=6), "U.K.–Netherlands"(n=5), etc. The extent of collaborative linkages among top countries is reflected in the collaborative network map, indicated in Fig. 1.

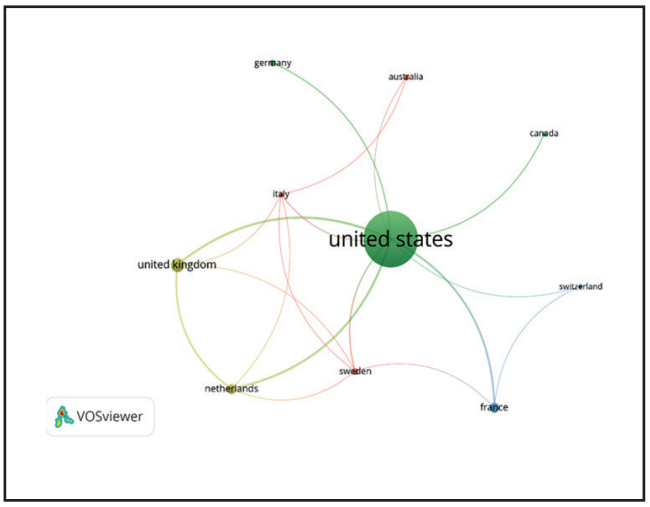


Figure 1. Collaborative network map of top 10 countires.

3.3 Leading Authors

The top 24 authors out of 596 participated in 112 HCPs and individually contributed 3 to 15 papers. They collectively contributed 111 papers and 26816 citations, which constitute 99.11 % and more than 100.0 % share respectively in global publications and citations. The 18 authors among the top 24 had their affiliations in the USA, followed by 2 from the U.K., and 1 each from Australia, Canada and the Netherlands.

Among the top 24 authors: (i) Five authors, namely J.A. Bluestone (USA)(n=15), K.C.Herold (USA)(n=12), M. Peakman (UK)(n=11), B.O. Roep (n=10)(Netherlands)(n=10) and Q. Tang (USA) (n=5)contributed more than average productivity (4.625), and (ii) Seven authors, namely Q. Tang (USA)(446.2 and 2.17), H.L. Weiner (USA)(406.33 and 1.98), M.S. Anderson (USA)(400 and 1.95), J.H. Buckner (USA)(383.67 and 1.87) and S.A. Long (USA)(382 and 1.86)registered citation impact (CPP and RCI) more than their values (241.59 and 1.18). The top 24 authors' share of ICPs in their national output varied from 0.0 % to 100.0 %, with an average of 50.45 %.

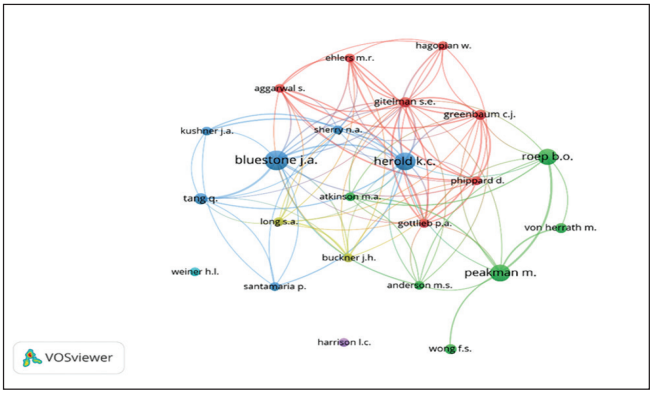


Figure 2. Network of 24 authors (Software Vosviewer; n=>3).

The top 24 authors' collaborative intensity, measured by total link strength (TLS) varied from 0 to 40, with a maximum (of 40 TLS) reported by J.A. Bluestone, followed by K.C. Herold (n=39 TLS)), C.J. Greenbaum (n=35 TLS)), S. E.Gitelman (n=34 TLS)), etc. The maximum bilateral collaborative links (n=5) in terms of author-to-author collaboration linkages, were reported by the author pairs "J.A. Bluestone and Q. Tang" and "M. Peakman. and B.O. Roep", followed by author pairs "J.A. Bluestone and K.C. Herold" (n=4) and "B.O. Roep and M.A. Atkinson" (n=4 each), etc. A collaborative network map of the top 24 authors is shown in Fig. 2, where these authors are classified into six clusters.

3.4 Leading Organisations

The top 21 organisations out of 452 participated in 112 HCPs and individually contributed 3 to 18 papers. They collectively contributed 134 papers and 28172 citations, which account for more than 100.0 % share each, respectively in global publications and citations. The 13 out of the top 21 organisations originated from the USA, followed by 5 from France, 2 from the UK and 1 from the Netherlands.

Of the top 21 organisations: (i) Nine organisations, namely University of California, San Francisco, USA (n=18), Yale School of Medicine, USA (n=14), Leiden Univ. Med. Center, Netherlands (n=10), Harvard Med. School, USA (n=9), Benaroya Res. Inst. at Virginia Mason, USA (n=8), etc. contributed more than average publication productivity (5.33), and (ii) Six organisations, namely Brigham and Women's Hospital, USA (315.83 and 1.54), University of California, San Francisco, USA (302.33 and 1.47), Harvard Med. School, USA(258 and 1.26), Benaroya Research Institute at Virginia

Mason, USA (255.13 and 1.24) and CNRS, France (213 and 1.04) registered citation impact (CPP and RCI) more than the average values (210.24 and 1.02). The top 21 organisations' share of ICPs in their national output varied from 0.0 % to 100.0 %, with an average of 53.49 %.

The Total Link Strength (TLS) of the top 21 organisations varied from 13 to 161, with maximum (161 TLS) reported by University of California, San Francisco, USA., followed by Yale School of Medicine, USA (112 TLS), King's College, London, U.K. (89 TLS), etc. In terms of organisation-to-organisation collaboration linkages, the maximum bilateral collaborative linkages (n=7) were reported by organisations pair "University of California, San Francisco, USA and Benaroya Research Institute at Virginia Mason, USA", followed by "University of California, San Francisco, USA and Yale School of Medicine, USA", "Leiden Univ. Med.Center, Netherlands and City of Hope Med. Centre, USA" (n=5 each), etc. A collaborative network map of the top 21 organisations is presented in Fig. 3, where they are presented in three clusters.

3.5 Leading Journals

The top 20 journals out of 58 participated in 112 HCPs and individually contributed 3 to 13 papers. They collectively published 74 papers and 17082 citations, which constitute 66.07 % and 74.20 % share each respectively of the global publications and citations.

The highest number of papers published in this area was from the *Diabetes* (n=13), followed by *Journal of Experimental Medicine* (n=8) and *Clinical and Experimental Immunology* (n = 7), *Journal of Autoimmunity, Journal of Immunology* and *The Lancet Diabetes and Endocrinology* (n=4) each.

By citations per paper (CPP), the leading impactful journals were: *Annual Review of Immunology* (657.0 CPP), followed by *Immunological Reviews* (475.0 CPP), *Science Translational Medi*cine(424.5 CPP), *Journal of Experimental Medicine* (401.13 CPP), *Diabetes Care*(264.33CPP), *Proceedings of the National Academy of Sciences of the United States of America* (260.67 CPP), *Nature Medicine* (239.670 CPP) and *Nature Reviews Immunology* (238.5 CPP).

By impact factor, the leading journals were: the *American Journal of Transplantation* (n=2) (IF=53.44), *Diabetologia* (n=2) (IF=53.106), *Proceedings of the National Academy of Sciences of the United States of America* (n=3) 9IF=44.5), *The Lancet Diabetes and Endocrinology* (n=4) (IF=40.5), *Clinical and Experimental Immunology* (n=7) (IF= 32.4), *Journal of Autoimmunity* (n=4) (IF= 29) and *Nature Medicine* (n=3) (IF=28.527).

3.6 Significant Keywords

The keywords reflect the core and focus of a paper. Among 112 HCPs, a total of 2279 keywords appeared having a frequency of occurrence from 1 to 99. The top important keywords, measured by the frequency of occurrences, were as follows: Immunotherapy (n=99), insulin-dependent diabetes mellitus (n=87), diabetes mellitus - type 1(n=85), autoimmunity (n=46), autoimmune disease (n=45), immunology (n=36), pancreas islet beta cell (n=36) and immunological tolerance (n=31).

The 330 among 2279 keywords appeared 4 or more times and from them 73 important keywords were identified and selected for co-occurrence analysis, undertaken using VOS viewer software. The software classified the 73 keywords into four clusters, reflecting different priority themes (Fig. 4).

The main keywords (along with the frequency of their occurrences) included in these four clusters are shown as follows:

Cluster 1. autoimmune disease (45), immunological tolerance (n=31), regulatory t lymphocyte (n=31), cd4+ t lymphocyte (n=23), adoptive transfer (n=20), gamma interferon(n=19), immune tolerance (n=18), interleukin 2 (n=17), cytokine production (n=16), etc.

Cluster 2: Immunotherapy (n=99), insulin dependent diabetes mellitus (n=87), diabetes mellitus, type 1 (n=85), Autoimmunity (n=46), pancreas islet beta cell-2 (n=36), interleukin-2 (n=17), Autoantibody (n=15), islets of langerhans (n=13), etc.;

Cluster 3: c peptide (n=20), immunomodulation (n=15), insulin-secreting cells (n=15), monoclonal antibody cd3 (n=12), Rapamycin (n=12), Rituximab (n=12), insulin treatment (n=11), Proinsulin (n=10), glutamate decarboxylase 65(n=9), Teplizumab (n=8), etc

Cluster 4: Immunology (n=36), immune response(n=19), Inflammation (n=19), Metabolism (n=19), cd8+ t lymphocyte (n=16), monoclonal antibody (n=12), non-insulin dependent diabetes mellitus (n=12), cancer immuno-therapy (n=11), Hyperglycemia(n=10), etc.

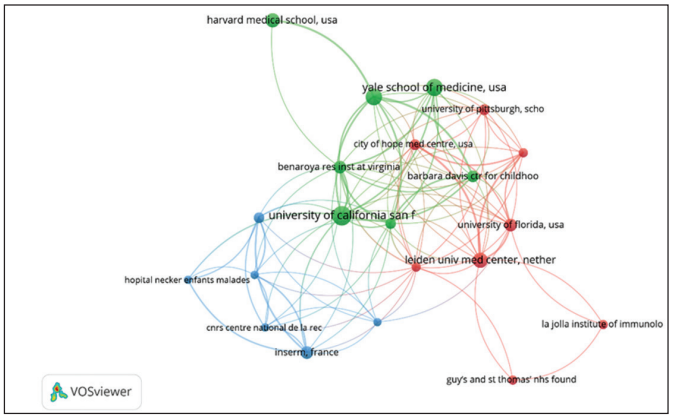


Figure 3. Collaboration network of 21 top institutions (Software Vosviewer; n=>3).

3.7 Top High-Cited Papers (HCPs)

The top 15 among the top 112 HCPs were published between 1996 and 2018, having citation frequency from 310 to 1019. They were published in 11 medical journals (with IF varying from 8.7 to 53.44): Three articles in the *Journal of Experimental Medicine* (IF = 15.3), 2 articles each in *Annual Review of Immunology* (IF=28.527) and *Immunological Reviews* (IF=8.7) and 1 paper each

in *Nature Medicine* (IF=53.44), *Lancet Diabetes & Endocrinology* (IF=44.5), *Nature Reviews Immunology* (IF=40.5), *Circulation* (IF=37.8), etc.

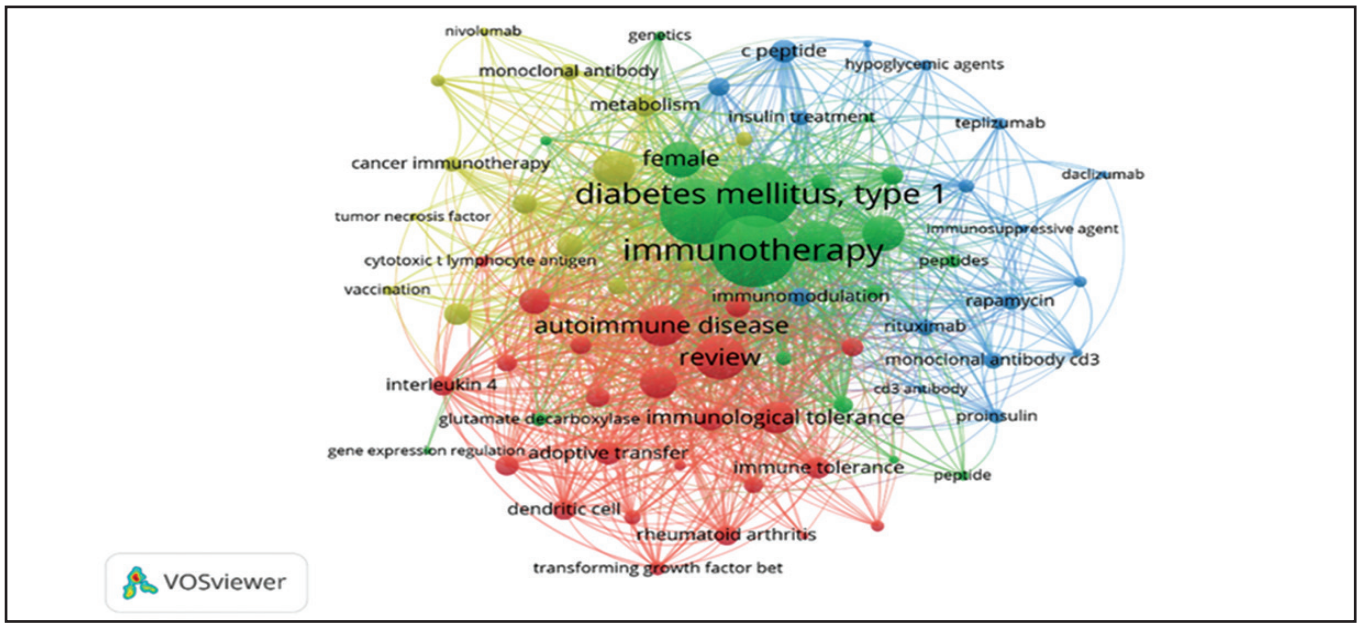
Eleven of the top 15 HCPs were published with externally funded support of national and international agencies: (i), 5 publications with the support of the National Institute of Diabetes and Digestive and Kidney Diseases, (ii) 4 publications with the support of the National Institute of Allergy and Infectious Diseases (iii) 3 publications from the support of National Institute of Health etc. Six of the 15 HCPs were involved in clinical trials.

The top 15 publications (8 articles and 7 reviews) have the participation of a single institution (zero collaboration) in 5 papers, while 9 (6 and 3 papers each) other papers involve national collaboration and international collaboration The 15 top HCPs involve the participation of 91 authors affiliated to 35 institutions, involving major participation from the USA with 14 papers, France in 2 papers and Brazil and Switzerland in 1 paper each. The first most-cited paper is authored by Q.Tang, K.J. Henriksen, *et al* .entitled "In vitro-expanded antigen-specific regulatory T cells suppress autoimmune diabetes" and published in the *Journal of Experimental Medicine* in 2004 (received 1019 citations).

treatment of cancer and inflammatory bowel disease, yet there has been no such study for type 1 diabetes to describe the research trends. Keeping the need to study literature on new treatment methods for T1DM, thus, we performed the current study.

Our study identified the 112 HCPs for T1DM immunotherapy research (involving 596 authors affiliated with 452 organisations in 25 countries and published in 58 journals) from the Scopus database and examined the publications output, indicated strong and weak subject areas, and suggested frontiers areas in this field, which may help the existing scholars to quickly learn the current developments and identify future frontiers areas in the field. The study also identified, studied and visualised the most active journals, most-cited papers and the important countries, institutions and authors, and the strength of collaboration linkages among important research players, countries, organisations and authors.

The USA had the strongest influence both in productivity and citation impact, with 73.21 % of total publications originating from the institutions in that country, whereas the other important countries like the UK (13.39 %), France and the Netherlands (8.93% each) contributed the remaining papers alone or most in collaboration with the USA. The most collaborative countries were the USA and the UK, which have 44 and 17 collaborative



Figue 4. Network of 73 significant keywords (Software Vosviwer; n =>4).

4. DISCUSSION

Although T1DM has a high global disease burden, it is also very well-researched as reflected in its high research productivity and proportional research output. Immunotherapy, from the past decade, is fast emerging as an important treatment method for various diseases, such as cancer, inflammatory bowel disease, T1DM, etc. Because of the global importance of immunotherapy as a treatment method, few scholars undertook bibliometric studies in applying immunotherapy methods for the

links with 27 and 5 countries each. Because of major research contributions coming from the USA, the top three external funding agencies publications also came from the USA: National Institute of Diabetes and Digestive and Kidney Diseases, USA (n=24), National Institute of Health, USA (n=22) and National Institute of Allergy and Infectious Diseases, USA (n=18).

The core authors and organisations in any field can be identified through bibliometric analysis which may provide information on potential collaborations for

future researchers. Since the USA, U.K. and France are the top-ranking countries in publications output, therefore among the top 21 organisations, 13 came from the USA [University of California, San Francisco, USA (n=18), Yale School of Medicine, USA (n=14), Harvard Medical School, USA (n=9), Benaroya Research Institute at Virginia Mason, USA (n=8) and University of Florida, USA(n=7), etc], 5 from France [INSERM, France (n=7), University of Paris Cite, France (n=5), CNRS, France (n=3), etc.] and and 2 from U.K. [King's College London, U.K. (n=5) and University of Bristol, U.K. (n=3)].

Similarly, of the top 24 authors, 18 were from the USA and 2 from the U.K. Among USA, the most prominent authors were: J.A. Bluestone (n=15), K.C. Herold (n=12), Q. Tang (n=5), S.E. Gitelman and M. Von Herrath (n=4 each) etc] and U.K. [M. Peakman (n=11) and F.S. Wong (n=4)]. The comparative higher research productivity of the USA, U.K. and France was based on extensive infrastructure and huge scientific resources committed to research in this area leading to their better performance and results.

The identification of core and productive journals generally guides scientists in day-to-day information access and manuscript submission. Of the 58 journals that participated, *The Diabetes* was the most frequent journal, with 13 publications, followed by the *Journal of Experimental Medicine* and *Clinical and Experimental Immunology*, with 8 and 7 publications. Other top journals include the *Journal of Autoimmunity*, *Journal of Immunology* and *The Lancet Diabetes* and *Endocrinology*, with 4 publications each.

Eight of the top 15 HCPs were published before 2008 because more citations could be accumulated as time passed. However, the exceptional paper published in *Endocrine Reviews* in 2018 by L. S. Chang, R. Barroso-Sousa, et al.is considered a more significant work "Endocrine toxicity of cancer immunotherapy targeting immune checkpoints" registering 313 citations.

Of all 2279 keywords in this area, 73 out of the top 330 keywords (occurred 4 or more times) were identified and co-occurrence analyses were undertaken, which presented them into four different clusters and themes.

To measure the effectiveness of any treatment or intervention, clinical trials (CTs) and randomised controlled trials (RCTs) are valuable. In our data, a striking lack of CTs and RCTs on immunotherapy for T1DM was observed; only 25.0 % (28) and 10.71 % (12) were CTs and RCTs.

5. STRENGTH AND LIMITATIONS

Examining research trends in the application of immunotherapy to T1DM over 28 years, was the first attempt by present authors, to bibliometrically assess global literature. This study aims to look into the current research landscape in the field, creating a better understanding of its evolution. Furthermore, The cluster analysis of important keywords may also assist existing scholars in understanding upcoming and existing sub-fields, ultimately serving as a valuable resource for future research projects.

However, this study had its limitations too. First, we searched only the Scopus database. The lack of complementary data from other bibliographical and citation databases (such as WoS), in this study may lead to a partially incomplete analysis of the data. In Scopus, the content coverage breadth, the search analysis tools sophistication, the citations volume, and the funding sources diversity are regarded as comparatively more intense and extensive compared to PubMed or Web of Science. A significant number of the majority of bibliometric surveys utilise only a single bibliometric database, but still, they successfully meet the objectives. As a result, we have utilised only one database, namely Scopus for our study.

The study using analytical tools and visualisation software provides an overview of the field for scholars, policy-makers, funding agencies, participating organisations and countries to develop valuable collaborations among themselves and help provide links to the funding agencies which can support future research.

6. CONCLUSION

Our study provides a comprehensive analysis of research in type 1 diabetes immunotherapy, effectively recognising the contributions made by important and core authors, institutions, scientific journals and research types identified through significant keywords. The study indicates that high-income countries like North America and Western Europe presently constitute the core landscape of research. It is essential to advocate for the implementation of large-scale randomised controlled trials and to promote research partnerships between developed and developing countries. This is to ensure a sustained and significant impact, globally, through external funding from developed countries' agencies. Given the high burden of type 1 diabetes, immunotherapy continues to remain an important research area for the treatment of type 1 diabetes.

REFERENCES

1. Di Meglio, L.A.; Evans-Molina, C. & Oram, R.A. Type 1 diabetes. *Lancet*, 2018, **391**. 2449-2462. doi: 10.1016/S0140-6736 (18)31320-5
2. Sun, H.; Saeedi, P.; *et al.* IDF Diabetes atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res. Clin. Pract.*, 2022, **183**, 109119. doi: 10.1016/j.diabres.2021.109119
3. Patterson, C.C.; Karuranga, S. *et al.* Worldwide estimates of incidence, prevalence and mortality of type 1 diabetes in children and adolescents. Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res. Clin. Pract.*, 2019, **157**, 107842. doi: 10.1016/j.diabres.2019.107842

4. Huang, M.; Chen, W., *et al.* Advanced delivery strategies for immunotherapy in type I diabetes mellitus. *BioDrugs.*, 2023, **37**, 331–352. doi: 10.1007/s40259-023-00594-6
5. Drucker, D.J. Transforming type 1 diabetes: The next wave of innovation. *Diabetologia.,* 2021, **64**(5), 1059–1065. doi: 10.1007/s00125-021-05396-5
6. Paul, M.; Dayal, D.; Bhansali, A.; Dhaliwal, L. & Sachdeva, N. *In* vitro assessment of cord blood-derived proinsulin-specific regulatory T cells for cellular therapy in type 1 diabetes. *Cytotherapy*, 2018, **20**, 1355–1370. doi: 10.1016/j.jcyt.2018.09.004
7. Bradley, C.A. Immunotherapy: PDL1 restoration reverses T1DM. *Nat Rev Endocrinol*., 2018, **14**(1). doi: 10.1038/nrendo.2017.165
8. Cabello-Olmo. M.; Araña, M.; Radichev, I.; Smith, P.; Huarte, E. & Barajas, M. New insights into immunotherapy strategies for treating autoimmune diabetes. *Int. J. Mol. Sci*., 2019, **20**(19), 4789. doi: 10.3390/ijms20194789
9. Katsarou, A.; Gudbjornsdottir, S., *et al.* Type 1 diabetes mellitus. *Nat. Rev. Dis. Primers.,* 2017, **3**, 17016. doi: 10.1038/nrdp.2017.16
10. Atkinson, M.A.; Roep, B.O., *et al.* The challenge of modulating beta-cell autoimmunity in type 1 diabetes. *Lancet Diabetes Endocrinol*., 2019, **7**, 52–64. doi: 10.1016/S2213-8587(18)30112-8
11. Roep, B.O.; Wheeler, D.C.S., *et al.* Antigen-based immune modulation therapy for type 1 diabetes: The era of precision medicine. *Lancet Diabetes Endocrinol*., 2019, **7**, 65–74. doi: 10.1016/S2213-8587(18)30109-8.
12. Zhang, X.; Kang, Y., *et al.* Engineered PD-L1-expressing platelets reverse new-onset type 1 diabetes. *Adv. Mater*., 2020, **32**, e1907692. doi: 10.1002/adma.201907692
13. Herold, K.C.; Bundy, B.N., *et al.* Type 1 Diabetes TrialNet Study. G. An anti-CD3 antibody, teplizumab, in relatives at risk for type 1 diabetes. *N. Engl. J . Med*., 2019, **381**, 603–113. doi: 10.1056/NEJMoa1902226
14. Ni, Q.; Pham, N.B.; Meng, W.S.; Zhu, G. & Chen, X. Advances in immunotherapy of type I diabetes. *Adv. Drug Deliv. Rev*., 2019, **139**, 83–91. doi: 10.1016/j.addr.2018.12.003
15. Vallianou, N.G.; Stratigou, T.; Geladari, E.; Tessier, C.M.; Mantzoros, C.S. & Dalamaga, M. Diabetes type 1: Can it be treated as an autoimmune disorder? *Rev Endocr Metab Disord.,* 2021, **22**, 859–876. doi: 10.1007/s11154-021-09642-4
16. Eleanor, McDermid. How far has immunotherapy for type 1 diabetes progressed? 20.5.22 https://diabetes.medicinematters.com/immunotherapy/diabetes-prevention/how-far-has-immunotherapy-for-type-1-diabetes-progressed/20417114
17. University of Maryland Libraries. Research Guides. Library Resources and Research. Bibliometrics and Altmetrics: Measuring the Impact of Knowledge. 13 February 2024. (accessed on 27 July 2024) https://lib.guides.umd.edu/bibliometrics/bibliometrics#:~:text=Bibliometrics%2C%20or%20research%20impact%2C%20is,is%20cited%20by%20other%20resources (accessed on 27 July 2024)
18. Shen, J.; Shen, H.; Ke, L.; Chen, J.; Dang, X.; Liu, B. & Hua, Y. Knowledge mapping of immunotherapy for hepatocellular carcinoma: A bibliometric study. *Front Immunol*., 2022, **13,** 815575. doi: 10.3389/fimmu.2022.815575
19. Ji, Wang.; Gong, Zhengpeng. & Yu, Ming. Bibliometric study on the knowledge graph of immunotherapy for head and neck cancer. *Front Oncol.*, 2023, **13**, 942777. doi: 10.3389/fonc.2023.942777
20. Sur, D.; Lungulescu, C., *et al.* Immunotherapy-related publications in colorectal cancer: A bibliometric analysis. *Healthcare*, 2021, **10**(1), 75. doi: 10.3390/healthcare10010075.
21. Xiong, J.Q.; Fu, Y.F., et al. Global research trends of immunotherapy and biotherapy for inflammatory bowel disease: A bibliometric analysis from 2002 to 2021. BioMed EngOnLine., 2022, **21**, 42. doi: 10.1186/s12938-022-01011-9
22 Welcome to VOSviewer. https://www.vosviewer.com/ (accessed on 21 May 2024)

CONTRIBUTORS

Prof. Raju Vaishya (MS, MCh, FRCA, FACS) is a distinguished orthopaedic surgeon and joint replacement specialist with over 38 years of experience, working at Indraprastha Apollo Hospitals, New Delhi. He impressive educational background includes an MBBS degree (Gold Medalist), MS (Orth), MCh (Orth), FRCS (London), and FACS (USA). He is a prolific researcher and author with over 800 publications in national and international orthopaedic journals.
He has contributed towards conceptulisation, literature search, manuscript writing, editing and final approval.

Dr. B.M. Gupta retired as Scientist G from CSIR-NISTADS (2008) and worked later as Emeritus Scientist, CSIR (2009-13). He holds a PhD from Karnatak University, Dharwad (1990), a Fellow of the Society for Information Science (2007), Fulbright Fellowship of the USEFI (1989). Currently, editorial board member of 6 Indian journals, coordinated 6 special issues in bibliometric studies and published more than 400 papers (with 166 indexed in the Scopus database) in the LIS field in national and international journals.
He has contributed towards manuscript preparation, conceived the study, data collection, literature analysis, analysis and final approval of the manuscript.

Dr. S.M. Dhawan retired as a Senior Principal Scientist in 2005 from CSIR- NPL, Delhi. He holds an MLIS from the University of New York, USA anda PhD from the University of Delhi in LIS. His expertise spans Bibliometrics, Digital library services, and Special libraries including participating in numerous research

projects in bibliometrics/scientometrics and authoring several research papers in the field in national and international journals**.** He has contributed towards manuscript preparation, data analysis and editing, and final approval.

Prof. Yogendra Singh worked as a Scientist in DRDO and retired as an Institute Librarian at IIT Roorkee. He is presently working as a University Librarian and Professor (LIM) at Swami Rama Himalayan University, Dehradun.
His expertise spans ICT applications in libraries, Bibliometrics and social network analysis applications and published more than 35 papers in various areas of LIS. He had contributed towards manuscript preparation through data collection, curation, visualisation, final approval.

Dr. Jivesh Bansal worked as Deputy Librarian from July 2018 and also served as University Librarian (I/C) from April 2019 to June 2022 in Punjab University, Chandigarh. He holds a PhD from Panjab University (2013) and his expertise spans ICT in libraries, Bibliometrics and user services and published more than 15 papers in national and international journals.
He has contributed towards manuscript preparation through data collection, literature analysis, and final approval.