

Use of Artificial Pancreas in the Management of Diabetes Mellitus: A Bibliometric Study

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Abstract

Objectives: To describe the trends and characteristics of the worldwide scientific production on the use of artificial pancreas (AP) in the management of diabetes mellitus (DM).

Materials and Methods: Scientific papers published between 2017 and 2022 were retrieved from the Scopus database using relevant keywords. Only original articles, reviews, and short surveys were included. The metadata were exported to the SciVal software for retrieving quantitative data and the main characteristics such as journals, authors, institutions, journal metrics by quartiles, subcategories, and collaborative networks were extracted.

Results: A total of 642 articles were included after applying the inclusion/exclusion criteria: original articles, 489; reviews, 151; and short surveys, 2. The most common type of collaboration was at the national level (38.3%; citations per publication: 22.3; field-weighted citation index [FWCI]: 2.2) followed by international collaboration (29.4%; citations per publication: 19.6; FWCI: 1.94). More than 70% of articles in each year were published in journals listed in Q1. Two journals, *Diabetes Technology and Therapeutics* and *Journal of Diabetes Science and Technology*, accounted for about 22% of all publications. Six of the top 10 universities were from the United States, with The University of Virginia having the most publications ($n = 54$; 59 authors; citations per publication: 38.4; FWCI: 3.73).

Conclusions: The findings of this study highlight that most research on this topic is published in high-quality journals and has a good citation impact. Notably, most research has been conducted in developed countries, thereby indicating the need for research efforts in this field from developing countries.

Keywords: Artificial pancreas, bibliometric analysis, closed loop insulin delivery, diabetes mellitus, diabetes technology, disease management, trends

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INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disease with the main characteristic of increase in glycemia

levels, i.e., hyperglycemia.^[1] The initial symptoms of marked hyperglycemia include polyuria, polydipsia, polyphagia, and weight loss.^[2] However, as the disease

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progresses, symptomatology also involves various organs and systems.^[3] Its pathophysiology relies mainly on the total or partial dysfunction of the pancreas, specifically, in the endocrine function of insulin secretion–absorption.^[1] The two most frequent forms of DM are insulin-dependent (type 1) and non-insulin-dependent (type 2) DM.^[4]

In 2021, the estimated global prevalence of DM among adults (aged 20–79 years) was 10.3% (536.6 million people), and this was projected to increase to 12.2% by 2045.^[5] The effect of complications of DM is an important public health issue that impacts the daily lives of patients, and thus improving its management through research is imperative.^[6,7] Currently, the management of DM mainly focuses on maintaining glycemic control and reducing complications. In recent years, important technological advances have been made, including the use of the artificial pancreas primarily for type 1 DM.^[8,9] This device has a closed-loop mechanism consisting of a glucose sensor, an insulin pump, and a mobile device containing the control algorithm, all wirelessly connected.^[10] Artificial pancreas provides the physiological response of the endocrine pancreas and restores the normal insulin secretion–absorption function and its sensitivity to glucose levels.^[11]

Bibliometrics, a branch of scientometrics, is an analytical, statistical, and quantitative study that is currently being widely applied in the various fields of medical research.^[12] It provides relevant information to researchers to analyze different bibliographic sources and scientific studies related to a specific area of research to determine their academic impact, critical points, and characteristics as well as allows researchers to understand different research methods used in their field of interest.^[13]

While there are several studies and reviews focusing on different scientific perspectives about the use of artificial pancreas in DM,^[14] few bibliometric studies are available regarding the same.^[15] Therefore, the current bibliometric study was conducted with the aim of determining the trends and characteristics of the worldwide scientific production on the use of artificial pancreas in the management of DM.

MATERIALS AND METHODS

Study design

This is a bibliometric study that evaluated all the indexed scientific production on the use of artificial pancreas in DM within the Scopus database.

Database

The Scopus database (Elsevier, USA) was used to collect relevant metadata for this study. Scopus was chosen because it covers journals that have been accepted following an assessment, thereby indicating adequate quality, and its breadth of coverage is more than most other widely accepted databases. In addition, it is an effective support tool for keyword searches and citation analysis.^[16,17] Further, SciVal (Elsevier, USA), a Scopus-compatible data analysis software, was used as it can help quantitatively analyze the collaboration rate, authors, institutions, the number of citations per publication, impact by quartile, h-index, Field-Weighted Citation Impact (FWCI), Source Normalized Impact per Paper (SNIP), and collaborative network associations of this research.

Search strategy

The relevant scientific papers published from 2017 to 2022 were retrieved from the Scopus database. Initially, we extracted the keywords from the MeSH thesaurus and Embase, including their various iterations, to devise the final search formula. The final search was performed on May 3, 2023. Only the following types of manuscripts were considered: original articles, reviews, and short surveys. Conference papers, notes, editorials, book chapters, letters to editor, books, and conference reviews were excluded. The results obtained from the search were exported onto Microsoft Excel spreadsheets using the Scival tool, which allowed full access to the research data, in addition to processing and extraction of results. The total population of metadata obtained in the search strategy was checked for validity by manually reviewing each of the included papers to avoid selection bias.

The following search formula was used: TITLE-ABS-KEY (“Diabetes Mellitus Insulin-Dependent” OR “Diabetes Mellitus Insulin Dependent” OR “Insulin-Dependent Diabetes Mellitus” OR “Diabetes Mellitus Juvenile-Onset” OR “Diabetes Mellitus Juvenile Onset” OR “Juvenile-Onset Diabetes Mellitus” OR “Juvenile-Onset Diabetes” OR “Diabetes Juvenile-Onset” OR “Juvenile Onset Diabetes” OR “Diabetes Mellitus Sudden-Onset” OR “Diabetes Mellitus Sudden Onset” OR “Sudden-Onset Diabetes Mellitus” OR “Type 1 Diabetes Mellitus” OR “Diabetes Mellitus Insulin-Dependent 1” OR “Insulin-Dependent Diabetes Mellitus 1” OR “Insulin Dependent Diabetes Mellitus 1” OR “Type 1 Diabetes” OR “Diabetes Type 1” OR “Diabetes Mellitus Type I” OR “Diabetes Autoimmune” OR “Autoimmune Diabetes” OR “Diabetes Mellitus Brittle” OR “Brittle Diabetes Mellitus” OR “Diabetes Mellitus Ketosis-Prone” OR “Diabetes Mellitus Ketosis Prone”

OR “Ketosis-Prone Diabetes Mellitus” OR “Brittle diabetes” OR “Insulin dependent” OR “juvenile onset diabetes” OR “juvenile diabetes” OR “ketoacidotic diabetes”) AND TITLE-ABS-KEY (“Artificial Pancreas” OR “Pancreas Artificial” OR “Artificial Organs” OR “Organs Artificial”) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017)).

Bibliometric indicators

Bibliometric indicators of collaboration were analyzed, including collaboration, authors, and universities, classifying each publication depending on the type of collaboration based on their affiliation information as (a) international collaboration; (b) national collaboration; (c) institutional collaboration; or (d) single authorship. Likewise, production indicators were analyzed using the number of citations and most productive publications per journal, authors, universities, and subcategories that publish scientific studies on DM and artificial pancreas. Finally, impact indicators were analyzed. The FWCI was used for this study, which measures the ratio between the total number of citations received by the denominator result and the total number of citations that would be expected according to the average for the subject field.^[16-20] Another indicator used was SNIP, which is a metric that intrinsically accounts for field-specific differences in citation practices.^[8,19] We also used the h-index^[18] and CiteScore.^[21,22]

Data analysis

The data were downloaded as a.csv file from the Scopus database and then exported to Microsoft Excel for the creation of the tables and graphs. For a better deepening of the data analysis, the.csv file was exported to SciVal (Elsevier, USA).

RESULTS

Proportion of collaboration

A total of 897 articles were retrieved in the initial search, of which 255 articles were excluded because the article type did not meet the inclusion criteria. Therefore, 642 articles were included in the final analysis: original articles, 489; reviews, 151; and short surveys, 2 [Figure 1]. The most common type of collaboration was at the national level (38.3%; citations per publication: 22.3; FWCI: 2.2), followed by international collaboration (29.4%; citations per publication: 19.6; FWCI: 1.94), and only institutional collaboration (26.0%; citations per publication: 16.3; FWCI: 1.2); [Table 1].

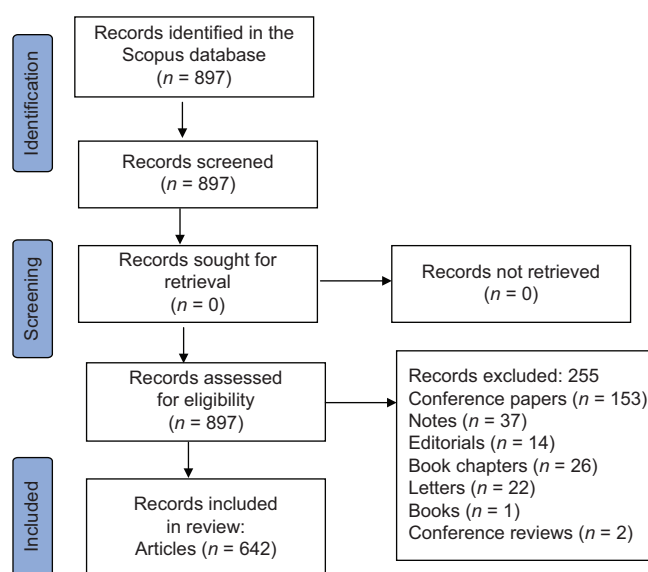


Figure 1: Flow diagram detailing the search

Table 1: Scholarly output of diabetes mellitus and artificial pancreas according to collaborations

Metric	Scholarly output (%)	Citations per publication	FWCI
International collaboration	189 (29.4)	19.6	1.94
Only national collaboration	246 (38.3)	22.3	2.2
Only institutional collaboration	167 (26.0)	16.3	1.2
Single authorship (no collaboration)	37 (5.8)	21.7	1.05

FWCI – Field-Weighted Citation Impact

Top 10 most productive journals

The highest number of publications were in *Diabetes Technology and Therapeutics* (79 publications and 378 authors; citations per publication: 26; SNIP: 1.969), followed by *Journal of Diabetes Science and Technology* (65 publications and 291 authors; citations per publication: 15.7; SNIP: 1.064). These two journals collectively accounted for about 22% of all publications. All other top 10 journals are listed in Table 2.

Publications by journal quartile

When analyzed by quartile, most articles were published in journals placed in Q1; the year-on-year growth was also highest in this quartile (from 69 manuscripts in 2017 to 83 manuscripts in 2018), and overall, there was a steady number of articles published in this quartile over the studied period. Notably, >70% of articles in all studied years were published in journals listed in Q1. Less than 10 manuscripts were published in Q4 throughout the 5-year studied period (range: 0–8 publications). These data show the dynamics of the publications according to the quartile of the journal [Figure 2].

Top 10 universities

The Top 10 universities accounted for more than half of all publications in this field ($n = 358$; 55.8%). The largest

number of contributors to this field came from authors affiliated to The University of Virginia, with 54 manuscripts and 59 authors (citations per publication: 38.4; FWCI: 3.73), and Stanford University, with 47 manuscripts and 35 authors (citations per publication: 48.7; FWCI: 6.34). Notably, 6 of the top 10 universities were from the United States, of which 4 were in the top 5 [Table 3].

Top 10 authors

The highest number of contributions was from Bruce A. Buckingham, with 37 publications (citations per publication: 53.1; FWCI: 5.46; and h-index: 65), followed by Roman Hovorka, with 33 publications (most recent publication being in 2022) (citations per publication: 37.5; FWCI: 4.22; and h-index: 56). All other top 10 authors are listed in Table 4.

Top subject categories

The majority of the publications on the use of artificial pancreas in the management of DM were in the subject areas of medicine (68.7%), engineering (35.1%), and computer science (17.1%) [Figure 3].

Keyword analysis

The analysis of the selected keywords revealed that the most commonly used term was “artificial pancreas,” which has maintained a steady number of publications over the studied period, with an average of 98 publications per year. This was followed by the keyword “insulin dependent diabetes mellitus”, which had the highest number of publications in 2020 ($n = 105$) and lowest in 2017 ($n = 83$). Other terms such as “hypoglycemia”, “closed loop

Table 2: Top 10 journals with highest number of publications

Scopus source	Publications	Authors	Citations per publication	SNIP	Cite score 2021	SJR
<i>Diabetes Technology and Therapeutics</i>	79	378	26	1.969	10.3	2.66
<i>Journal of Diabetes Science and Technology</i>	65	291	15.7	1.064	7.1	1.142
<i>Diabetes, Obesity and Metabolism</i>	19	139	23.6	1.51	12.1	2.356
<i>Diabetic Medicine</i>	16	88	19.5	1.444	6.7	1.405
<i>IEEE Transactions on Biomedical Engineering</i>	15	64	23	1.835	9.4	1.298
<i>Sensors</i>	14	54	14.6	1.42	6.4	0.803
<i>Diabetes Care</i>	13	115	38.6	5.042	27.7	6.528
<i>IEEE Journal of Biomedical and Health Informatics</i>	13	57	23.2	2.274	10.9	1.799
<i>Biomedical Signal Processing and Control</i>	11	40	21.7	1.855	6.9	1.211
<i>Journal of Process Control</i>	10	48	18	1.602	7.6	1.131

SNIP – Source-normalized impact per paper; SJR – Scientific Journal Ranking

Table 3: Top 10 universities with highest number of publications

Institution	Country/region	Scholarly output	Authors	Citations per publication	FWCI
University of Virginia	United States of America	54	59	38.4	3.73
Stanford University	United States of America	47	35	48.7	6.34
Harvard University	United States of America	45	41	37.9	4.21
University of Colorado Denver	United States of America	39	26	36.4	3.88
University of Cambridge	United Kingdom	36	22	36.5	3.94
University of Colorado Anschutz Medical Campus	United States of America	36	26	48.3	5.2
McGill University	Canada	27	34	19.1	1.46
University of Padua	Italy	26	21	31.1	2.49
Centro de Investigación Biomédica en Red	Spain	26	19	11.4	0.98
Illinois Institute of Technology	United States of America	22	14	26	1.78

FWCI – Field-weighted citation impact

Table 4: Top 10 authors with highest number of publications

Name	Scholarly output	Most recent publication	Citations	Citations per publication	FWCI	H-index
Buckingham, Bruce A	37	2022	1966	53.1	5.46	65
Hovorka, Roman	33	2022	1237	37.5	4.22	56
Dassau, Eyal	30	2022	1227	40.9	3.85	46
Forlenza, Gregory P	29	2022	1661	57.3	6.2	33
Breton, Marc D	28	2022	957	34.2	3.25	38
Doyle, Francis Joseph Iii	23	2022	1076	46.8	4.42	72
Cinar, Ali	22	2022	571	26	1.78	37
Messer, Laurel	20	2022	871	43.6	4.23	34
Ly, Trang T	20	2021	935	46.8	4.45	32
Haidar, Ahmad	20	2021	400	20	1.72	28

FWCI – Field-weighted citation impact

systems” and “blood glucose monitoring” show variations in the number of publications over the years but remain areas of interest [Figure 4].

DISCUSSION

DM is one of the most common diseases worldwide, and thus one of the most researched topics across different health specialties. In recent years, important technological advances have been made in the management of DM. The use of artificial pancreas in the management of DM is one such advancement.^[12] This bibliometric study identified the characteristics of the worldwide scientific production on DM and artificial pancreas in the past 5 years.

The current bibliometric study only included original articles, reviews, and short surveys that were available in Scopus. A study by Jabali *et al.*^[15] on a similar topic also included manuscript types such as letters to the editor, conference papers, and books; however, these article types are generally considered informal literature given that these are not peer-reviewed publications, and thus were excluded from the current study. Other bibliometric studies have either only analyzed DM or artificial pancreas as their main area of interest and have also included manuscripts such as

letters to the editor, conference papers, and notes/books/editorials.^[23,24]

In terms of collaboration, national-level collaborations were found to be the most common. This may be indicative of certain countries having a higher degree of research focus toward understanding the use of artificial pancreas for the management of DM. In general, international collaboration has been found to generate greater impact at the indicator level in multiple disciplines including in medicine and biotechnology.^[25-27] Nonetheless, in the current study, it was found that studies with only national-level collaboration had better citations per manuscript and FWCI compared with studies with international collaboration. This study found that two journals, namely, *Diabetes Technology and Therapeutics* and *Journal of Diabetes Science and Technology*, accounted for about 22% of all publications in this field. This is unsurprising given that these are leading journals in this field of interest.^[15]

All the top 10 universities with the most publications were from developed countries, with the majority being from the United States. Of these, The University of Virginia had the most publications. In contrast, other similar bibliometric analysis found that the University of Padua was the most productive institution;^[15] this university was only ranked eighth in the current study. These differences could likely be due to timeframe and manuscript type differences between the two studies. Specifically, while the current study was not able to provide specific bibliometric data pertaining to Peru, a previous bibliometric study of DM studies in Peru demonstrated that many national universities publish on this topic, with the highest scientific production being from the Universidad Peruana Cayetano Heredia.^[25]

The present study also identified the subcategories within the area of medicine with the highest scientific contribution to research on the management of DM with artificial pancreas. Nonetheless, Health Informatics and Pediatrics gaining relevance in this field may likely be due to the

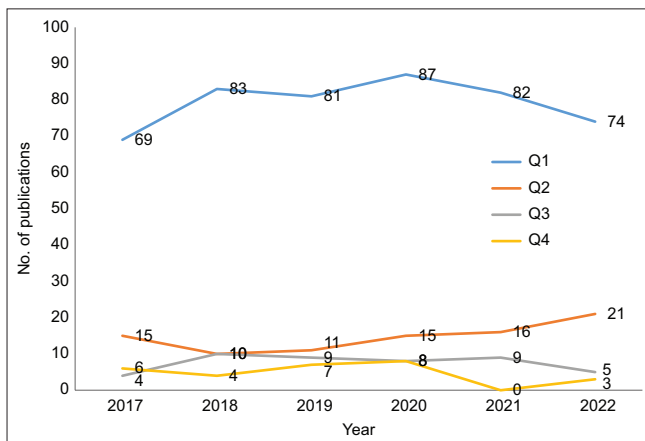


Figure 2: Publications per journal quartile by CiteScore Percentile

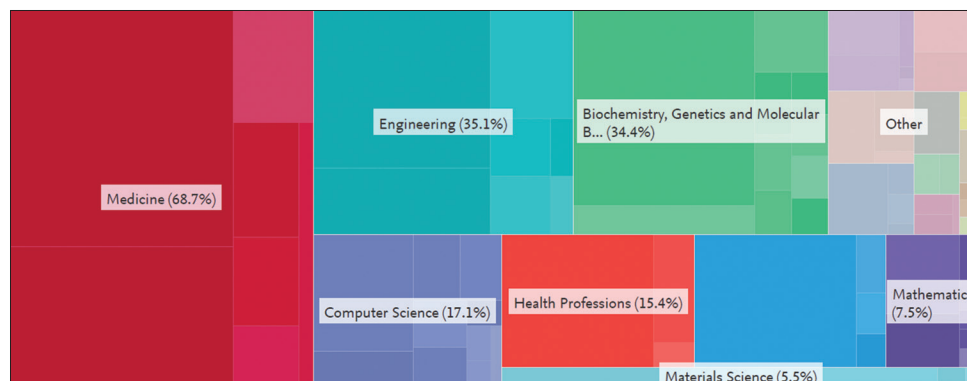


Figure 3: Top subcategories in scholarly output about diabetes mellitus and artificial pancreas

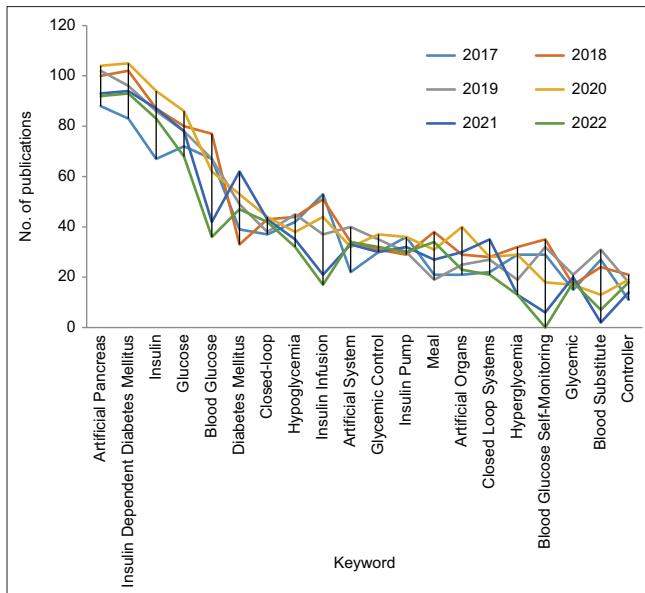


Figure 4: Analysis of the most used keywords about diabetes mellitus and artificial pancreas

positive impact that the treatment with artificial pancreas has on pediatrics with type 1 DM.^[26]

Strengths and limitations

A strength of this study was that it only included manuscript types that generally undergo the peer review process and that extensive keyword combinations were used for retrieving the relevant data. In addition, relevant specialized impact indicators such as SNIP, FWCI, h-index, and CiteScore were used to improve the level of the results.

The main limitation of the study was that only the Scopus database was used; the use of other databases such as Web of Science, EMBASE, and PubMed could have in the retrieval of additional manuscripts.

CONCLUSIONS

This study found that national-level collaborations were most common in the field of artificial pancreas and DM in the 5-year period between 2017 and 2022, and that two journals account for nearly one-fourth of all publications in this field. Further, a large majority of the articles were published in journals placed in Q1 in Scopus, indicating the high-quality of research carried out in this field. Notably, all the top 10 universities with the most publications were from developed countries. These results provide valuable insights to researchers, institutions, and policymakers, improving the understanding of the research landscape and trends in this field.

Ethical consideration

This bibliometric study has no ethical implications because it uses data openly available in the Scopus database.

Peer review

This article was peer-reviewed by two independent and anonymous reviewers.

Data availability statement

The data that support the findings of this study are openly available in Scopus at <https://www.scopus.com/>.

Author contributions

Conceptualization: E.M-G, R.L-B; Methodology: J.B-O, F.M-T, A.M-D, J.A; Data analysis: J.B-O, F.M-T, A.M-D; Writing—original draft preparation: E.M-G, R.L-B; Writing – review and editing: J.B-O, F.M-T, A.M-D, J.A.

All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

There are no conflicts of interest.

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