

Digital Interventions and Artificial Intelligence in Diabetes Management in Last Two Decades: A Bibliometric Analysis on Web of Science

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Abstract. Objectives: To conduct a bibliometric analysis to analyze the landscape of artificial intelligence(AI) in diabetes management in the past two decades. **Methods:** The literatures on AI in diabetes management during 2003 to 2021 were respectively retrieved from Web of Science database. CiteSpace software was applied to perform analysis of frequency distribution and co-occurrence of sub-keyword terms, frequency distribution analysis of reference citations, and analysis of burst detection methods for keyword terms and cited references, in order to create a knowledge map to reveal diabetes management hotspots and cutting-edge directions. **Results:** A total of 1,242 articles on diabetes AI managements were retrieved. The results showed that the number of papers increased year by year, and the number of papers published was the largest in 2019-2021, suggesting that in the field of diabetes management, digital technology was widely adopted in the daily management of diabetes and was conducive in early screening for diabetes complications. In the field of AI in diabetes, various machine learning models including latest deep learning have been proposed and investigated. In the literatures on diabetes digital interventions, the keywords with higher frequency were management, intervention, diabetes, care and blood sugar control. Comparatively, the keywords with the highest frequency in diabetes AI are machine learning, management, diabetes, systems and classification. **Conclusions:** In the future, research trends will focus more on deep learning, mHealth and digital health. AI models with diabetes as comorbidity are still facing certain challenges in terms of system accuracy, validity and confidentiality.

Keywords: Diabetes; Artificial Intelligence; CiteSpace; Bibliometric Analysis.

1. Introduction

Over the past few decades, a growing number of publications have shown that diabetes mellitus (DM) is one of the most common non-communicable chronic diseases, ranking first in the incidence of complications from non-communicable chronic diseases. In 2013, global diabetes statistics showed that about 382 million people worldwide had diabetes, of which type 2 diabetes accounted for 90% [1-4]. Most strikingly, DM prevalence has significantly increased with the aging of the populations [5-9]. Cost is a common obstacle to patient reported self-management and has been shown to reduce compliance and preventive care [10]. Having recognized the global burden of diabetes, we now realize the urgent need for effective intervention. In order to monitor the public-health strategies and design effective future interventions we need reliable global estimates regarding the impact and trend of digital interventions on DM management [11]. However, the lack of prospective interventions and information on DM management limits further research.

Bibliometrics is a quantitative measure in medical literature analysis, which enables researchers to study their main areas of interest in a short period of time by disclosing research hotspots and emerging frontiers based on the approaches of mathematics and statistics [12,13]. At the same time, the theoretical framework and analysis tools of bibliometrics are in the ascendant. It is reported that CiteSpace could perform quantitative analysis of bibliography, covering various contents from data management and data conversion to matrix construction and visualization. In this way, the research hotspot and frontiers can be discovered, and the evolution process of a research field can be illustrated

by drawing a knowledge map [14-18]. The application of bibliometrics to the research area of diabetes digital and AI interventions is worthy. Therefore, this study conducted bibliometric study on the literatures on digital interventions and AI applied in DM management to disclose the research hotspots and emerging trends, thus providing directions for further DM management researches.

2. Materials and Methods

2.1 Data Sources and Search Strategy

The Web of Science core collections (WoSCC) from January 2003 to December 2021 were retrieved and downloaded for relevant articles. TS=(“Diabetes” AND “Artificial intelligence” OR “Machine learning” OR “CDSS” OR “Expert system” OR “Predictive analytics” OR “Clinical prediction models” OR “Hybrid model”) were built up as search equation. In order to ensure the accuracy of data, only the literature types articles and reviews were selected, without any restrictions on language and data categories. After manual retrieval and deduplication, valid documents were obtained. In addition, all the above operations are completed on the same day to avoid deviations caused by daily database updates.

2.2 Data Retrieval and Processing

The literatures were retrieved, extracted and validated. Bibliometric data including complete records and references cited from WoSCC, are downloaded in plain text and exported as complete records, which comply with the software input format.

2.3 Criteria for Included Publications

The criteria for literature inclusion were as follows: (1) The range of period between 2003 to 2021; (2) Publications indexed by WoSCC; (3) Only indexed articles were selected; (4) no restrictions on language and data categories.

2.4 Statistical Analysis

The WoSCC toolkit was applied to analyze general characteristics of the included literatures, including year, country, institute, author, language, and journal resource, while CiteSpace (version:5.3.R3) was adopted for visual analysis. The parameter of Time Span was set from January 2003 to December 2021, and the time division took one year as a unit. For the term source parameter, we selected the title, abstract, author keywords, and supplementary keywords. For the node types, we selected countries/institutions, co-citations between authors and authors, journal co-citations, keywords, and literature co-citations. The top 50 keywords with the highest frequency in each year were screened out, with co-occurrence analysis was performed on countries/institutions, author-author co-citations, journal co-citations, and keywords. Furthermore, cluster analysis was conducted on document co-citations, by selecting the display mode as timeline view, the connection strength as Cosine, the range as With Slices, and the data deletion standard "Top N" as 50. Then, the system was run on the input data until the graph changes stop. The control panel was used to adjust the node size, node label size, node display number, and connection transparency. Once the "node" was right clicked, the node details could be viewed to know the specific information of the country/institution, author, author co-citation, journal co-citation, keywords, and literature. The size of the nodes could affect the number or frequency of postings, and different colors of nodes and lines represented different times. Purple circles represent centrality, and nodes with greater centrality are usually regarded as key points in the network. In addition, the keywords were clustered and analyzed according to the terms extracted from the article.

3. Results

3.1 The Growth and Trend of Publications

The total amount of publication outputs reflected the research hotspot in the retrieved field to some extent. The study included 1,242 AI relevant publications on DM from WoSCC ranged between 2003 to 2021. The results showed there were few publications before 2016 (less than 50), and the overall number of publications was on the rise, reaching the highest in 2021 (381).

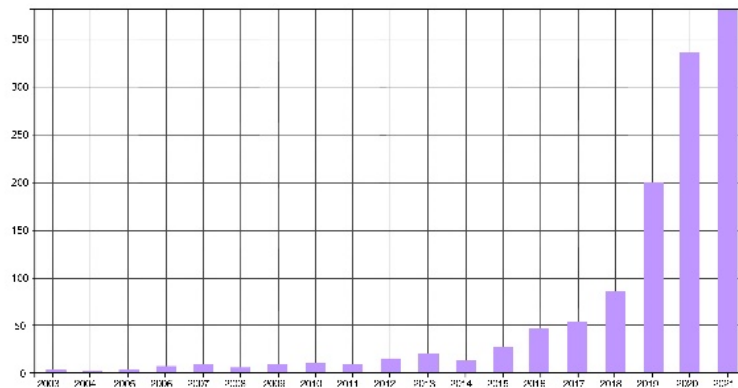


Figure 1. The annual quantities of publications from 2003 to 2021.

3.2 Keyword Frequency Distribution and Co-occurrence Analysis

Count	Centrality	Year	Keywords
308	0.01	2003	management
295	0.01	2003	intervention
195	0.08	2003	diabete
186	0.06	2003	care
145	0.06	2004	glycemic control
131	0.02	2003	outcm
130	0.06	2003	adult
125	0.06	2003	diabetes mellitus
121	0.03	2003	mellitus
119	0.04	2004	prevalence
118	0.03	2004	health
106	0.03	2003	self management
100	0.04	2005	prevention
96	0.03	2003	education
93	0.04	2004	risk
93	0.04	2004	adherence
92	0.01	2011	self-management
89	0.04	2003	physical activity
84	0.04	2003	metaanalysis
80	0.05	2004	risk factor
79	0.03	2005	primary care
79	0.06	2004	disease
78	0.06	2003	type 2 diabete
77	0.04	2004	mortality
73	0.09	2004	program

Figure 2. Keyword-term frequency list

Researchers have to select professional terms carefully and accurately to ensure keywords can reflect research hotspots. We integrated keywords and terms as bibliometrics research objects to ensure that analysis cover more main points of diabetes in the field of AI applications domain. CiteSpace was performed to illustrate timeline view and to analyze references cited frequently. The parameters of CiteSpace were configured as follows: time slicing (from 2003 to 2021, one year per slice), node types (term and keyword), selection criteria (top 30), and visualization (cluster view-static, merged network). The top 5 keyword terms on diabetes AI were listed as follows: “machine learning”, “management”, “diabetes”, “system” and “classification”. While the values of modularity

Q and mean silhouette were 0.4933 (>0.3) and 0.7526 (>0.7). intelligence for diabetic retinopathy screening: a review. Eye (London, England), 2020, 34(3):451–460.

3.3 References-cited Frequency Distribution Analysis

References cited are defined as a core ingredient of the bibliometrics research. CiteSpace was performed well to analyze frequency references cited and to illustrate reference-cited cluster and timeline (Figure 3). The top 5 keyword terms on diabetes AI were listed as follows: “health information technology”, “machine learning”, “diabetes care”, “deep learning” and “electronic clinical reminder.”

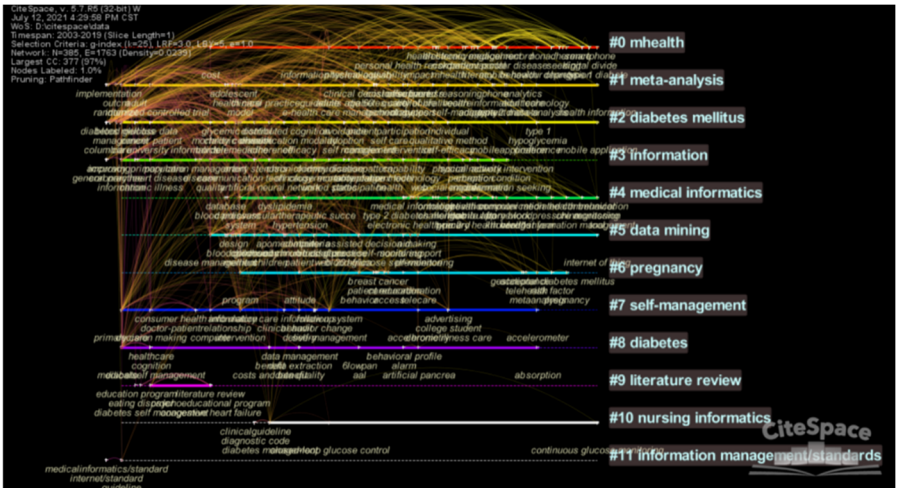


Figure 3. Keywords/terms co-occurrence timeline map

3.4 Bursts for Keyword Terms and References

Keyword terms with the strongest citation bursts was considered as indicators of research advanced or rising trends over a period of time. Figure 4 presented the top 18 keyword terms with strong frequency bursts, and the red bars mean some keywords cited frequently, and the green bars were keywords cited infrequently. The keyword, telemedicine, has continuously been reported on relevant papers from 2003 to 2017, which surged in 2016 to 2017, reflecting that telemedicine was a hot emerging field in recent years.

Top 18 Keywords with the Strongest Citation Bursts

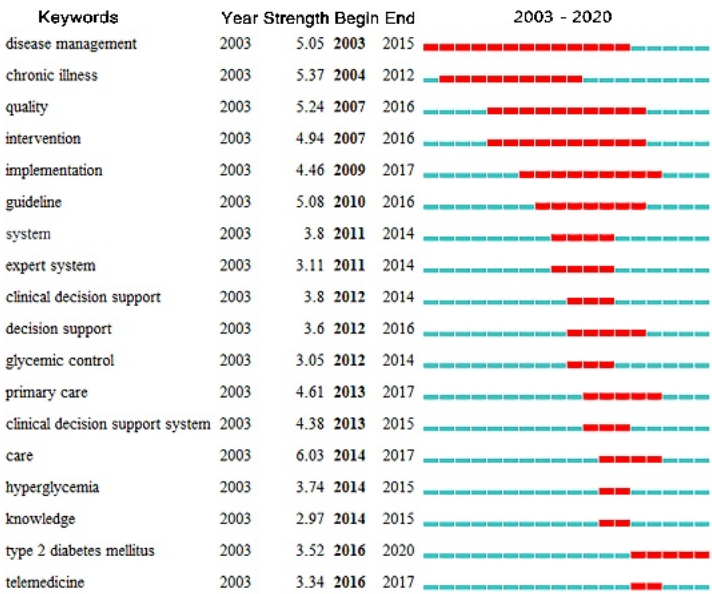


Figure 4. Keyword terms with the strongest citation bursts from 2003 to 2021.

4. Discussion

AI is the developmental stage of the digital interventions for diabetes management. As our analysis illustrated, “AI in diabetes” in the WoSCC has also exploded in recent years, from less than 50 in 2016 to 381 in 2021. The increasing incidence of diabetes has an impact on a wider population, which has prompted people to constantly discuss the research on the management and intervention of AI in diabetes, suggesting that the development trend of AI applications in DM management has become inevitable. AI digital intervention is an extremely suitable solution for diabetes management and has been investigated a lot [19, 20]. When patients’ information is collected through the digitalized device, the AI is used to match the healthy living solution and to recommend better follow-up diabetes management in a high efficiency and individualization manner [21-23]. It can be seen that diabetes information management and AI are closely related to diabetes prevention and treatment.

As our bibliometric study indicated, insulin therapy and drug therapy topped the list in terms of keyword frequency, suggesting that AI may also play a role in drug and new treatments for diabetes. Intelligent medical care, which integrates AI and Internet, can provide good solutions to these problems, and has gained wide attention [24]. Digital technology is widely used in the daily management of diabetes with AI. The developed "mobile intelligent diabetes management system" analyzed patients' health information and generated a personalized diabetes self-management plan through AI and sending previous patient data such as blood sugar, hemoglobin glyc level and complications to the cloud. In addition, digital therapeutics (DTx) has been proposed to effectively assist in diabetes management like drug treatment. DTx can alert patients to take medication or receive insulin injection promptly, and to analyze drug adherence data, shared by health care professionals or other important people. More complex applications may receive data from an automatic insulin pen recording doses at injection or from a digital drug cassette indicating the time of medication. Although initial prototypes of both are already available, development of integrated applications is ongoing. In addition, DTx can also comprehensively calculate the price, side effects and hobbies of patients, give each item different weight to each project, and give drug prescription in combination with the diabetes medication strategy at home and abroad. With the development of machine learning techniques, AI models have been applied into diabetes researches. More and more AI prediction models such as support vector machine (SVM), decision tree, etc, have been utilized. For instance, SVM based on the China Health and Nutrition Survey database achieved 94.2% accuracy rate and 93.9% recall rate. There are also genomic data trained models with area under the ROC curve of diabetes of 0.89 by analyzing single nucleotide polymorphisms. These AI models are less traumatic and highly accessible and are available to each healthy person on mobile phones or other portable devices, effectively improving the screening willingness of the general population and also developing screening programs for high-risk populations [25-27]. It can be seen that the frequency of DL keywords is very high, and the emerging algorithms such as DL are becoming AI models in the field of DM management.

There are also some limitations in this study. Firstly, the literatures retrieved in this study originated only from the WoSCC database, missing a few studies included in other literature databases. Secondly, the knowledge map analysis only reflects the research hotspots and development trends in this field on the whole, and the specific hotspots such as mobile intervention and DTx are not discussed in depth, so more investigations are worth to be conducted. Nevertheless, compared to the traditional reviews and summaries in DM management, this bibliometric are basically consistent with them while providing worthy suggestions and insights.

5. Conclusion

To conclude, publication outputs of the application of AI in diabetes management have been rising over last two decades. More researchers show their interest in this fresh and promising field and some hotspots such as mobile medicine, telemedicine, deep learning, and DTx are of great significance for future research.

Acknowledgments

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