RESEARCH ARTICLE

Exploring the intellectual structure based on co–citation network analysis: A case study of diabetes

Zhibo Zhuang, Penghui Lyu*, Zhimin Zeng

a. School of Public Administration, Sichuan University, Chengdu, China
b. Shenzhen Institute for Advanced Study, University of Electronic Science and Technology of China, Shenzhen, China

ABSTRACT

As the number of diabetics increases worldwide, the amount of research so as to bibliometric research on diabetes is also growing. In order to review the existing research on diabetes from a macro perspective and to remedy the lack of attention given to conference papers, this paper collected a total of 67,104 diabetes-related conference papers on the theme of "diabetes" up to 23 October 2020 in the core collection of Web of Science. Tools for bibliometric analysis include Citespace and VOSviewer and other tools such as Excel and Origin are applied for statistical analysis and visualization of the results. Consequently, publication trend, document co-citation, journal co-citation and author co-citation are analyzed based on these papers, and core documents, journals and authors are identified. This study not only shows the current situation of academic conferences related to diabetes research but also, to a certain extent, reveals the development of the diabetes research situation in the whole field. Meanwhile, this study quantitatively analyzed the intellectual base on diabetes, which can be an illustration of the benefits of bibliometric analysis as a tool in scientific research.

Introduction

Diabetes is caused by a series of metabolic disorders where the patients remain at a high level of blood glucose for a long time. Common causes include insulin secretion defects and impaired biological activities, or a combined result of both. Long-term hyperglycemia leads to dysfunction and chronic injury in various tissues, particularly nerves, blood vessels, heart, kidneys, and eyes (Liu et al., 2021).

The incidence of diabetes has shown a gradual increase in recent years. Thus, both the prevention and treatment of diabetes have become the focus of attention (Li & Ning, 2021). According to the 2021 IDF Global Diabetes Map (10th edition) released by the International Diabetes Federation (IDF) (2021), the global population of adult patients reached 537 million, with a conversion ratio of approximately 10.5%. This indicates that at least one in ten adults has been diagnosed with diabetes. Compared to 2019, a 16% growth (around 74 million) was

* Corresponding Author: lyu@scu.edu.cn

observed in the number of patients, highlighting an astonishing increase in the global prevalence of diabetes. By 2030, the total number of diabetic patients is expected to increase to 643 million (11.3%) globally. This number may further increase to 783 million (12.2%) by 2045 (International Diabetes Federation, 2021).

At the same time, it is estimated that about 44.7% (240 million) of adult patients may be undiagnosed, with over 81% from low-and middle-income countries. Based on geographical regions, the number of patients in 2021 will reach 24 million in Africa, 32 million in Central and South America, 51 million in North America and the Caribbean, 61 million in Europe, 73 million in North Africa and the Middle East, 90 million in Southeast Asia, and 206 million in the Western Pacific. Diabetes has become a prominent public health concern worldwide.

Bibliometric analysis is a statistical method of assessing trends in research activities in a given area over time to provide information for policy development (Koenig, 1982). It is based on numerous text information collection, data mining and quantitative analysis, which can effectively reflect the development status quo of a certain research field, as well as the potential future research trend. These results also play an important role in both future decision-making and public health resource allocation.

The main objective of this study is to review the existing research on diabetes from a macro perspective, utilizing bibliometric analysis tools such as Citespace and VOSviewer. By analyzing a dataset of 67,104 diabetes-related conference papers collected from the core collection of Web of Science, we examine publication trends, document co-citation, journal co-citation, and author co-citation. Furthermore, we identify core documents, journals, and authors in the field of diabetes research, shedding light on the intellectual structure and development of this research domain.

Related Works

At present, bibliometric analysis has obtained increasing popularity in the field of diabetes research. This study reviews a total of 145 papers with the theme of "diabetes" and "bibliometrics" from the Web of Science. After careful evaluation, 20 papers are selected according to relevance. It was found that the research field mainly focused on the following four aspects:

Firstly, bibliometric studies focus on specific types of diabetes. There are four main types of diabetes: type I/II diabetes, gestational diabetes and other types. Type I diabetes occurs mostly in childhood or adolescence since it is caused by the excessive secretion of insulin from pancreas cells that are experiencing autoimmune damage. On the other hand, type II diabetes is more commonly seen in adults. The insulin production capacity is not completely lost, and some patients can even produce more than needed. However, the effect of insulin is rather limited. Gestational diabetes only occurs during pregnancy, which refers to normal glucose metabolism before pregnancy or potential loss of glucose tolerance (Castaño & Eisenbarth, 1990). Lastly, all other types except the above-mentioned three are classified into one category, including diabetes caused by pancreatic and endocrine diseases, diabetes associated with genetic diseases, drug-induced diabetes, etc. Currently, researchers focus on the use of bibliometric tools to study a specific type of diabetes. For example, M. Gupta and Dayal (2020) conducted a research analysis of pediatric type I diabetes from 2000 to 2019. Bibliometric tools were used to identify the characteristics of the most productive and influ-

ential countries, organizations and authors, research trends, and highly cited publications. Geaney et al. (2015) used large-scale data to assess the results of studies on type II diabetes between 1951 and 2012 through bibliometric analysis and density-equalizing maps. Moreover, Ourlad Alzeus G. Tantengco et al. (2021) studied papers on gestational diabetes in Southeast Asian countries from 1975 to 2020 using the WPRIM database, Scopus and Ovid MEDLINE®. Through the analysis of the nation, institution, journal, author, most cited articles, keyword frequency and so on, the current state of gestational diabetes was sorted out in Southeast Asian countries along with VOS viewer software for creating charts.

Secondly, there are bibliometric studies on diabetic complications. Today, diabetes has become the world's third-largest threat to human health after tumors and chronic cardiovascular diseases. The harm of diabetes comes from the long-term poor control of hyperglycemia, which will eventually lead to various acute and chronic complications. These complications can greatly affect the normal function of different organs and tissues. Some researchers focus on analyzing the current situation, future research trends, and hotspots of diabetic complications from the perspective of econometrics. A study on diabetes-specific distress from 2000 to 2018 conducted by Dan Li et al.(2020) analyzed the characteristics of papers, national distribution, research institutions, authors, and journal resources using the WOS and GraphPad Prism 7. At the same time, CiteSpace was used to analyze the frequency and co-occurrence of keywords, frequencies and commonalities of citations, as well as references. Furthermore, common, potential and severe diabetes-specific problems are at the forefront of research (Li et al., 2020). Researchers like Li Xiao focused on diabetic retinopathy. Factors such as the number of publications, highly cited publications, spatial distribution, and co-occurrence keywords were evaluated through collecting and analyzing related papers on this subject from the Web of Science, along with CiteSpace and Microsoft Excel for visualization. It was concluded that optical coherence tomography and risk factors have become a hot topic in recent years. Notably, Chinese medicine has been a hot research topic with increasing interest attracted to its unique advantage of preventing diabetic retinopathy. Therefore, the authors put forward the necessity of combining Chinese and Western medicine to improve the prevention and treatment effects of diabetic retinopathy (Zou & Sun, 2021).

Thirdly, there are bibliometric studies on the treatment of diabetes. The high prevalence of diabetes has aroused increasing interest from the medical community in its prevention methods and techniques. Shen Hui et al. (2021) analyzed the research hot spot of traditional drugs in diabetes treatment. Using a literature review on the application of traditional drugs in diabetes treatment from PubMed, high-frequency MeSH terms were identified through the measurement project co-existing matrix generator, and the results were visualized using gCLUTO software. Finally, a strategic map is generated with the conclusion that antioxidant, hypoglycemic and Chinese medicine monomers are the most promising research keywords. Metformin has good hypoglycemic efficacy and safety and is considered one of the most advanced drugs for the treatment of type II diabetes. Moreover, T-cells play an important role as a potential diagnostic and therapeutic target in the onset of diabetes (Shen et al., 2021). Ye Gao et al. (2017) examined the research trends of diabetes and T-cells between 1997 and 2016 in the WOS and SCI-E databases. The analysis of publication trends using EXCEL 2016, GraphPad Prism 5 and VOSview software concluded that type II diabetes, T-cell immunoglobulin, mucoprotein syllabus and obesity are becoming popular research topics in

this field (Gao et al., 2017).

Last but not least, in addition to the above three types, some researchers carried out diabetes-related bibliometric studies on specific objects. Aamir Raoof Memon, for example, studied the academic journal of the Pakistan Medical Association and collected the published results between 1965 and 2018. They analyzed the number of publications and citations, national distribution, authors, institutions, and impact factors by using the VOSviewer software for visualization. The final summary concluded that from 2013 to 2017, the journal's impact factor increased dramatically from 0.409 to 0.718 with the most common keywords of 'Pakistan', 'diabetes', 'medical students', 'diabetes Mellitus and 'dominant' (Memon, 2019). Xiyan Zhao et al. (2015) identified the 100 most cited scientific reports in diabetes research from the SCI-E database as the WOS core database. They analyzed the key features of these 100 articles, including citation ranking, year of publication, publication journal, research type, H-index, PMC citation, patent reference, country of origin, source of funding, and authors. They also summarized the most influential studies of RCT (randomized controlled trial).

To sum up, the bibliometric studies related to diabetes have two main characteristics. Firstly, most efforts were put into research object-related academic papers and scientific reports, while the attention to conference papers was not sufficient. A conference is a formal meeting of scholars that aims to derive innovative ideas and solutions for the research field, and a conference paper gets presented at a conference, where scholars will find other eminent scholars dealing with similar fields of research. So more importance should be attached to this kind of papers. Furthermore, most studies focus on a specific diabetes-related research direction, but rarely analyze the overall development of diabetes from a macro perspective. To fill the gap in the research direction from an innovative perspective, this paper carries out a bibliometric analysis of the 1991-2020 diabetes-related conference papers from the WOS database. It not only shows the current situation of academic conferences related to diabetes research, but also, to a certain extent, reveals the development of the diabetes research situation in the whole field.

This paper tries to make a comprehensive and macroscopic analysis of diabetes research based on conference papers. While existing studies in the field of diabetes research often focus on specific types of diabetes, such as type I or type II diabetes, gestational diabetes, or complications associated with diabetes, this paper takes a broader approach. Furthermore, this paper recognizes the importance of conference papers, which have often received less attention compared to academic papers and scientific reports in previous bibliometric studies. Conferences provide a platform for scholars to present their latest research findings and exchange ideas, making conference papers valuable sources of information. By including conference papers in the analysis, this paper aims to bridge the gap in previous studies and provide a more comprehensive overview of the diabetes research landscape.

Data and Method

To ensure accuracy and mitigate the need for manual data entry resulting from daily database updates, this study focused on collecting a comprehensive dataset of conference papers related to diabetes from the Web of Science core collection. The search query utilized for retrieving these papers was as follows: TS=("diabetes" AND TS=("conference paper" OR "conference proceedings")). This query aimed to identify papers with the term "diabetes" present in their title, abstract, or keywords, and classified as conference papers or conference

proceedings. By employing this search query, a dataset comprising a total of 67,104 papers was retrieved up until October 23, 2020.

Subsequent to the retrieval process, the conference papers were downloaded in HTML text format to facilitate further analysis. To ensure data quality and eliminate duplications, the complete records and reference information of all documents were imported into CiteSpace. Through this procedure, duplicates were successfully identified and removed, resulting in a refined dataset of 67,104 valid records.

For the purpose of bibliometric analysis, several tools were employed, including Citespace and VOSviewer. These tools provided valuable insights for analyzing publication trends, document co-citation, journal co-citation, and author co-citation. Additionally, statistical analysis and data visualization of the results were conducted using Excel and Origin software. To enhance the analysis, the Journal Citation Reports (JCR) database was utilized to obtain relevant information, such as the full journal names and their corresponding impact factors.

Document co-citation analysis played a crucial role in efficiently locating the significant intellectual foundation within the research field. This analysis involved delving into the extensive cited reference information to identify core classical documents. Furthermore, document co-citation analysis allowed researchers to explore the correlation and development context among the documents. It is worth noting that the co-citation strength between two documents reflects their semantic relatedness and is determined by the number of co-citations they receive (Small, 1973).

Journal co-citation analysis provided insights into the correlation between various journals and disciplines. This analysis enabled a deeper understanding of the interrelationships within the journal network and facilitated the quantitative analysis of knowledge distribution and information flow in specific research fields (Hu et al., 2010).

Author co-citation analysis, another powerful tool employed in this study, focused on identifying, tracing, and visualizing the intellectual structure of the academic discipline. This analysis was achieved by assessing the frequency with which works by authors were co-cited with each other in the references of citing documents. Author co-citation analysis played a crucial role in representing implicit knowledge (Bayer et al., 1990).

Results and Discussion

In this part, the result of publication trend, document co-citation, journal co-citation and author co-citation of conference papers from Web of Science are analyzed together by using bibliometric methods.

Publication Trend

The publication outputs of Diabetes research from 1991 to 2020 are shown in Fig. 1. A total of 67,104 articles met the inclusion criteria. It can be observed that from 1991 to 2001, not many researchers paid attention to Diabetes research, so it showed a steady but slow rising trend in this timespan. The number of publications grew exponentially since 2002, with a surging number of 3,685 publications in 2006 alone. Then, a small turning point showed up in 2009, and the growth rate slowed down from 2010 to 2014. Noticeably, the rate started to accelerate again after 2014 and presented a steady high growth trend, indicating that the research on Diabetes has aroused more and more attention.
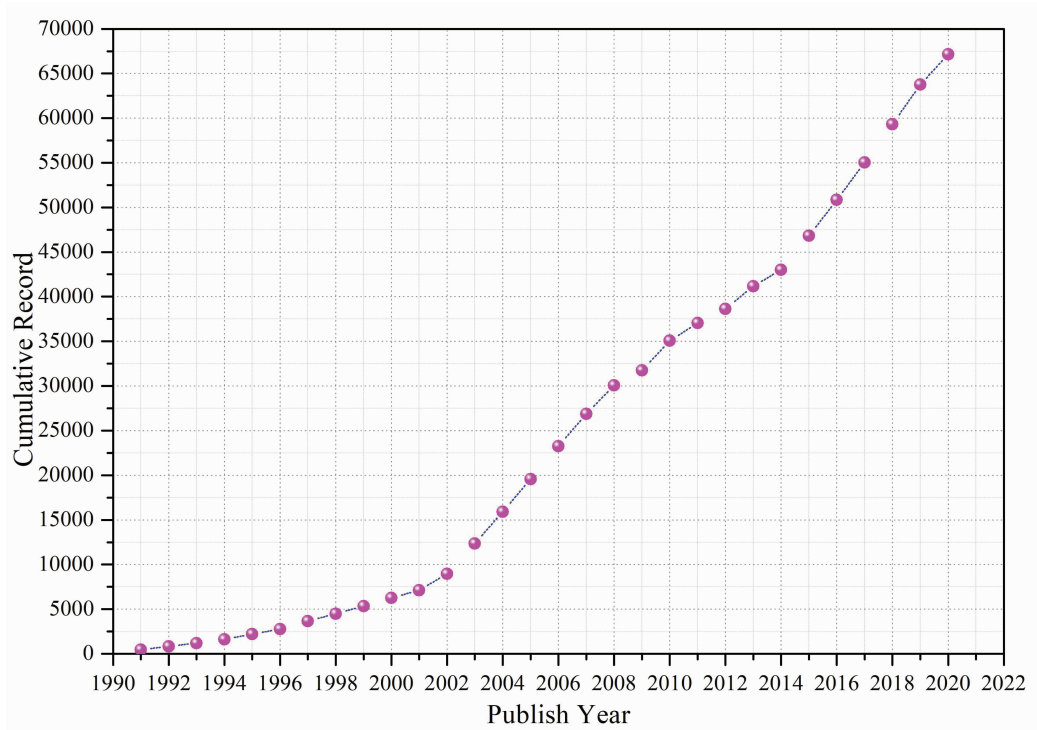
Figure 1 Publication Trend of Diabetes-Related Conference Papers from Web of Science
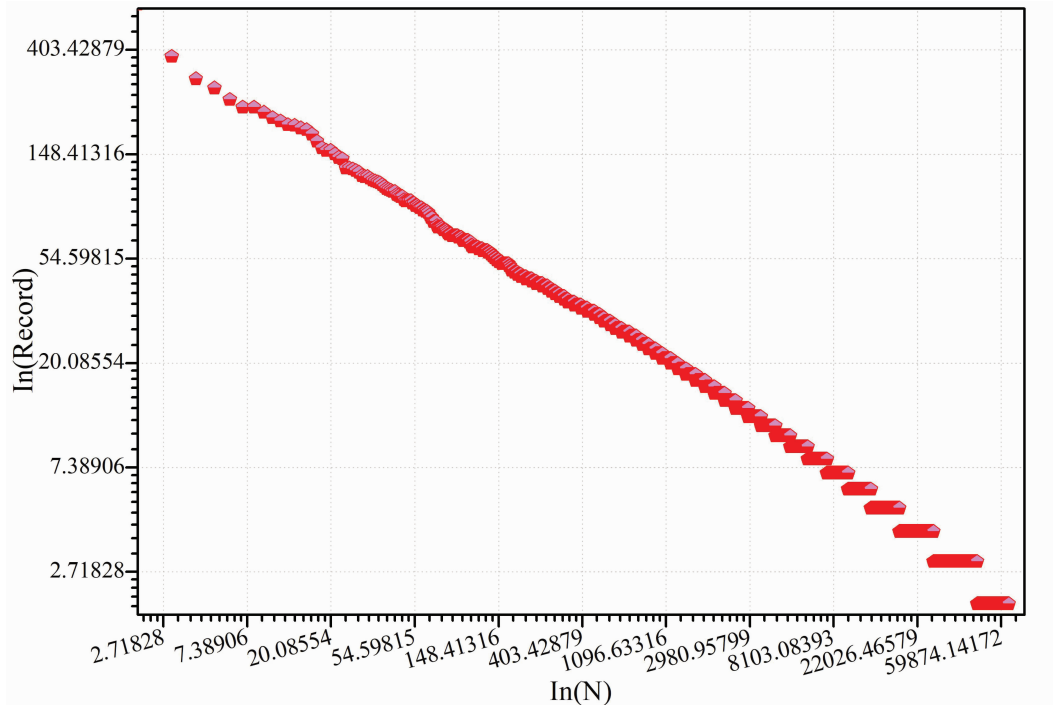
Document Co−citation Analysis

Figure 2 Relationship Map of Rank Order and Document Co-Citation Frequency

This study ranks and labels all the conference papers according to their co-citation frequency from high to low, papers with high co-citation frequency are ranked first, and those with low co-citation frequency are ranked last. These papers are labeled by natural number: the paper with the highest frequency is 1, and the next is 2. By plotting the data on a ln-ln graph, with the axes being ln (N) (N means rank order) and ln (Record) (Record means co-citation frequency), it can be concluded that the plot is relatively linear and the data conform to Power Law. The co-citation frequency of any paper is inversely proportional to its rank in the co-citation frequency figure. It can be seen from Fig. 2 that as the frequency of co-citation increases, the number of such papers decreases, and a great number of papers are in the stage of having low co-citation frequency or zero co-citation frequency, which conform to the Long Tail theory.

High citation analysis is to sort all the conference papers according to their citation frequency and screen out the papers with the highest citation frequency. By analyzing the content, author and publishing time of these papers, the deep-seated reasons for their high citation frequency may thus be sorted out. As is shown in Table 1, the top 30 diabetes-related conference papers with the highest citation frequency are presented. Most papers were published before 2000, which indicates before stepping into the 21st century, people had already developed a rough understanding of diabetes. Among the top 30 papers, the most cited one is *The Effect of Intensive Treatment of Diabetes on The Development and Progression of Long-Term Complications in Insulin-Dependent Diabetes-Mellitus*, issued in 1993 written by SHAMOON H. The paper is to examine whether intensive treatment to maintain blood glucose concentrations close to the normal range could decrease the frequency and severity of long-term microvascular and neurologic complications, as the complications may cause major morbidity and mortality in patients with insulin-dependent diabetes mellitus (Shamoon et al., 1993). This paper paves the way for future research on the treatment of diabetes and its complications. Some papers with high citation frequency are marked yellow, indicating that they also have a high co-citation frequency (shown in Fig. 3), and are the intellectual base of the diabetes research field.

Table 1 Top 30 Diabetes-Related Conference Papers with the Highest Citation Frequency

Rank	Records	Cited References (Author, Year, Journal, DOI)
1	928	Shamoon H, 1993, New Engl J Med, V329, P977, DOI 10.1056/nejm199309303291401
2	625	Turner RC, 1998, Lancet, V352, P837, DOI 10.1016/s0140–6736(98)07019–6
3	379	Reaven GM, 1988, Diabetes, V37, P1595, DOI 10.2337/diabetes.37.12.1595
4	306	Cleeman JI, 2001, JAMA –J AM MED ASSOC, V285, P2486, DOI 10.1001/jama. 285.19.2486
5	280	Knowler WC, 2002, New Engl J Med, V346, P393, DOI 10.1056/NEJMoa012512
6	251	Wild S, 2004, DIABETES CARE, V27, P1047, DOI 10.2337/diacare.27.5.1047
7	233	Gavin JR, 1997, DIABETES CARE, V20, P1183
8	233	Stearne MR, 1998, BMJ–BRIT MED J, V317, P703
9	222	Haffner SM, 1998, NEW ENGL J MED, V339, P229, DOI 10.1056/NEJM1998 07233390404
10	211	STAMLER J, 1993, DIABETES CARE, V16, P434, DOI 10.2337/diacare.16.2.434
11	204	Tuomilehto J, 2001, NEW ENGL J MED, V344, P1343, DOI 10.1056/NEJM2001 05033441801

| Rank	Records	Cited References (Author, Year, Journal, DOI)
12	197	LEWIS EJ, 1993, NEW ENGL J MED, V329, P1456, DOI 10.1056/NEJM199311113292004
13	196	Turner RC, 1998, LANCET, V352, P854, DOI 10.1016/s0140−6736(98)07037−8
14	191	MATTHEWS DR, 1985, DIABETOLOGIA, V28, P412, DOI 10.1007/BF00280883
15	188	Stratton IM, 2000, BMJ−BRIT MED J, V321, P405, DOI 10.1136/bmj.321.7258.405
16	180	Alberti KGMM, 1998, DIABETIC MED, V15, P539, DOI 10.1002/(SICI)1096−9136(199807)15:7<539::AID−DIA668>3.0.CO;2−S
17	168	Hovorka R, 2004, PHYSIOL MEAS, V25, P905, DOI 10.1088/0967−3334/25/4/010
18	158	Brenner BM, 2001, NEW ENGL J MED, V345, P861, DOI 10.1056/NEJMoa011161
19	154	OHKUBO Y, 1995, DIABETES RES CLIN PR, V28, P103, DOI 10.1016/0168−8227(95)01064−K
20	154	Shapiro AMJ, 2000, NEW ENGL J MED, V343, P230, DOI 10.1056/NEJM200007273430401
21	149	Chobanian AV, 2003, HYPERTENSION, V42, P1206, DOI 10.1161/01.HYP.0000107251.49515.c2
22	144	King H, 1998, DIABETES CARE, V21, P1414, DOI 10.2337/diacare.21.9.1414
23	142	Lewis EJ, 2001, NEW ENGL J MED, V345, P851, DOI 10.1056/NEJMoa011303
24	130	Hansson L, 1998, LANCET, V351, P1755, DOI 10.1016/S0140−6736(98)04311−6
25	130	PEDERSEN TR, 1994, LANCET, V344, P1383
26	129	HALES CN, 1992, DIABETOLOGIA, V35, P595, DOI 10.1007/BF00400248
27	127	Yusuf S, 2000, NEW ENGL J MED, V342, P145
28	125	Brownlee M, 2001, NATURE, V414, P813, DOI 10.1038/414813a
29	121	BERGMAN RN, 1981, J CLIN INVEST, V68, P1456, DOI 10.1172/JCI110398
30	120	DEFRONZO RA, 1991, DIABETES CARE, V14, P173, DOI 10.2337/diacare.14.3.173
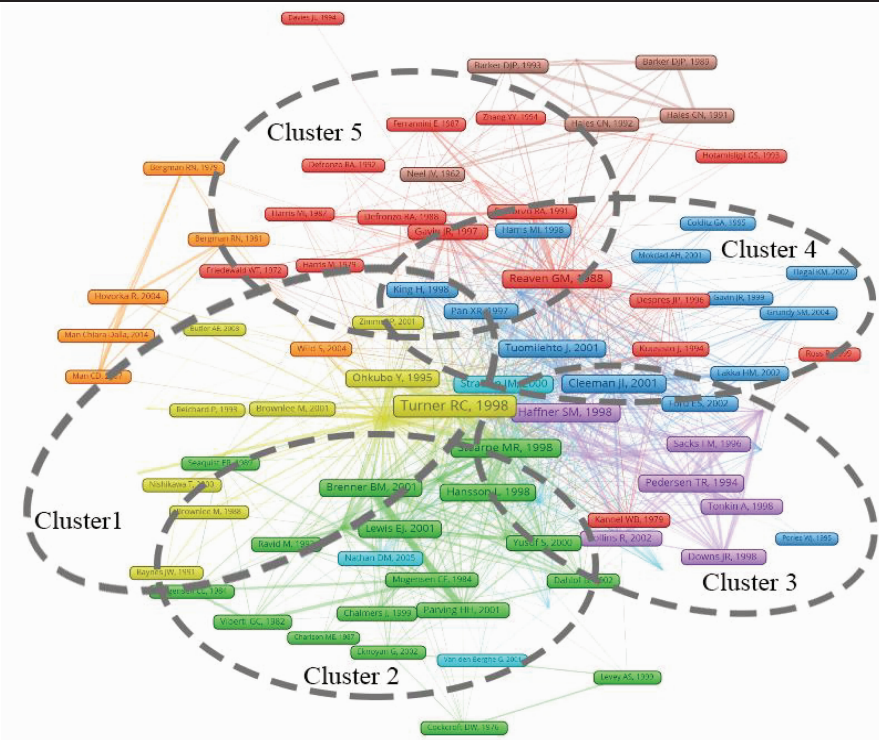
Figure 3 Reference Co-citation Network of Diabetes-related Conference Papers

It is shown in Fig. 3 that the paper named *Intensive blood-glucose control with sulphony-lureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes* (*UKPDS 33*) written by Turner RC in 1998 is the largest node in the network, indicating that it owns the highest co-citation frequency and could be the foundation and core document in the research field of diabetes. 67 pages in Lancet were devoted to this research, which lasted 10 years, and took 3867 newly diagnosed patients with type 2 diabetes at a median age of 54 years (IQR 48-60 years) as objects of observation. It makes a useful contribution to answering questions about the effectiveness of strict glucose control and the treatment of any associated hypertension. As shown in Fig. 3, documents related to diabetes are divided into five categories: cluster 1 (yellow), cluster 2 (green), cluster 3 (purple), cluster 4 (dark blue) and cluster 5 (red). And the detailed information such as the author, publish year, journal, and title of the documents in the clusters are listed in Table 2.

Cluster 1 is themed on "blood-glucose and diabetes" which includes mechanisms underlying the hyperglycemic damage on vascular endothelial cells, the hyperglycemia-induced vascular damage process, the effect of blood-glucose on diabetic microvascular disease and macrovascular complications etc. (Baynes, 1991; Brownlee, 2001; Nishikawa et al., 2000; UK Prospective Diabetes Study Group [UKPDS], 1998; Ohkubo et al., 1995). Cluster 2 focuses on "blood pressure and diabetes", which includes the effect of tight control of blood pressure on macrovascular and microvascular complications in patients with type 2 diabetes, the benefits of lowering the diastolic blood pressure and the dose of aspirin in patients with hypertension, ramipril's (hypotensive drug) effect on reducing the rates of death, myocardial infarction, and stroke, etc. (Brenner et al., 2001; Haffner et al., 1998; Hansson et al., 1998; Yusuf et al., 2000; Lewis et al., 2001). Cluster 3 is themed on "coronary disease and diabetes" (Long-term hyperglycemia in patients with diabetes will lead to coronary heart disease, and many patients with coronary heart disease are also accompanied by abnormal blood glucose metabolism or diabetes), including MRC/BHF cardioprotective studies with Simvastatin to lower cholesterol, the benefit of cholesterol-lowering therapy to the majority of patients with coronary disease who have average cholesterol levels, etc. (Downs et al., 1998; Haffner, 1998; Heart Protection Study Collaborative Group, 2002; Pedersen, 1994; Sacks et al., 1996). Cluster 4 consists relatively macro and predictive studies, including projections of 1995-2025 global burden of diabetes, the prevalence of the metabolic syndrome among US adults, the role insulin resistance played in human disease, etc. (Expert Panel on Detection, 2001; Ford et al., 2002; King et al., 1998; Pan et al., 1997; Tuomilehto et al., 2001) Cluster 5 emphasizes "insulin resistance", which includes the role insulin resistance plays in human-disease, the research on impaired glucose-tolerance in United-States population aged 20-74 etc. (Després et al., 1996; Harris et al., 1987; Reaven, 1988)

Table 2   Document Co-citation Clusters

Cluster	Author	Publish Year	Journal	Title
Cluster 1	Turner RC	1998	Lancet	Intensive blood –glucose control with sulphony-lureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33)
	Ohkubo Y	1995	Diabetes Research and Clinical Practice	Intensive insulin therapy prevents the progression of diabetic microvascular complications in Japanese patients with non –insulin –dependent diabetes–mellitus – a randomized prospective 6–year study

Cluster	Author	Publish Year	Journal	Title
Cluster 1	Brownlee M	2001	Nature	Biochemistry and molecular cell biology of diabetic complications
	Nishikawa T	2000	Nature	Normalizing mitochondrial superoxide production blocks three pathways of hyperglycaemic damage
	Baynes JW	1991	Diabetes	Role of oxidative stress in the development of complications in diabetes
Cluster 2	Stearne MR	1998	BMJ –British Medical Journal	Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38
	Brenner BM	2001	New England Journal of Medicine	Effects of losartan on renal and cardiovascular outcomes in patients with type 2 diabetes and nephropathy
	Hansson L	1998	Lancet	Effects of intensive blood–pressure lowering and low –dose aspirin in patients with hypertension: principal results of the hypertension optimal treatment (HOT) randomised trial
	Lewis EJ	2001	New England Journal of Medicine	Renoprotective effect of the angiotensin–receptor antagonist irbesartan in patients with nephropathy due to type 2 diabetes
	Yusuf S	2000	New England Journal of Medicine	Effects of an angiotensin–converting–enzyme inhibitor, ramipril, on cardiovascular events in high–risk patients
Cluster 3	Haffner SM	1998	New England Journal of Medicine	Mortality from coronary heart disease in subjects with type 2 diabetes and in nondiabetic subjects with and without prior myocardial infarction
	Sacks FM	1996	New England Journal of Medicine	The effect of pravastatin on coronary events after myocardial infarction in patients with average cholesterol levels
	Pedersen TR	1994	Lancet	Randomized trial of cholesterol–lowering in 4444 patients with coronary –heart –disease – the Scandinavian simvastatin survival study (4S)
	Collins R	2002	Lancet	MRC/BHF Heart Protection Study of cholesterol lowering with simvastatin in 20536 high–risk individuals: a randomised placebo–controlled trial
	Downs JR	1998	Jama –Journal of The American Medical Association	Primary prevention of acute coronary events with lovastatin in men and women with average cholesterol levels – Results of AFCAPS/TexCAPS
Cluster 4	Cleeman JI	2001	Jama –Journal of The American Medical Association	Executive summary of the Third Report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III)
	Tuomilehto J	2001	New England Journal of Medicine	Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance.
	Ford ES	2002	Jama –Journal of The American Medical Association	Prevalence of the metabolic syndrome among US adults – Findings from the Third National Health and Nutrition Examination Survey

Cluster	Author	Publish Year	Journal	Title
Cluster 4	Pan XR	1997	Diabetes Care	Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance – The Da Qing IGT and diabetes study
	King H	1998	Diabetes Care	Global burden of diabetes, 1995–2025 – Prevalence, numerical estimates, and projections
Cluster 5	Reaven GM	1988	Diabetes	Role of insulin resistance in human–disease
	Harris MI	1987	Diabetes	Prevalence of diabetes and impaired glucose – tolerance and plasma–glucose levels in United–States population aged 20–74 yr
	Despres JP	1996	New England Journal of Medicine	Hyperinsulinemia as an independent risk factor for ischemic heart disease

Journal Co–citation Analysis

It is can be seen from Table 3 that *New Engl J Med (New England Journal of Medicine), Diabetes Care, Diabetes* and *Lancet* received the top 4 citation count, indicating the importance of these 4 journals in the field of diabetes. *New England Journal of Medicine* is a journal of Medicine, General & Internal. It aims to publish the best research and information at the intersection of biomedical science and clinical practice and to present this information in understandable, clinically useful formats that inform health care practice and improve patient outcomes, and the impact factor of which in 2020 was 91.253. *DIABETES CARE* is a journal for the health care practitioner that is intended to increase knowledge, stimulate research, and promote better management of people with diabetes, whose impact factor in 2020 was 19.112. *DIABETES* covers research about the physiology and pathophysiology of diabetes mellitus including any aspect of laboratory, animal or human research and its impact factor in 2020 was 9.461. *The Lancet* began as an independent, international weekly general medical journal founded in 1823 and has strived to make science widely available so that medicine can serve and transform society, and positively impact the lives of people. Its impact factor in 2020 was 79.323.

Table 3 Top 20 Diabetes-related Journals with the Highest Citation Frequency

Rank	Records	Cited Journal
1	8,318	New Engl J Med
2	8,098	Diabetes Care
3	7,558	Diabetes
4	6,284	Lancet
5	5,991	Diabetologia
6	4,810	JAMA–J Am Med Assoc
7	4,361	J Clin Invest
8	4,071	Circulation
9	3,409	P Natl Acad Sci USA
10	3,204	Nature
11	3,159	J Clin Endocr Metab

Rank	Records	Cited Journal
12	3,093	Diabetic Med
13	2,991	Ann Intern Med
14	2,979	J Biol Chem
15	2,771	Science
16	2,494	Arch Intern Med
17	2,260	Brit Med J
18	2,179	Metabolism
19	2,118	Kidney Int
20	2,010	BMJ–Brit Med J

Figure 4 Journal Co-citation Network of Diabetes-related Conference Pap

As shown in Fig. 4, journals related to diabetes are divided into four categories. As for other categories, there's little significance during their clustering distribution, so the following illustrations will concentrate on the four main categories: cluster 1 (red), cluster 2 (dark blue), cluster 3 (yellow) and cluster 4 (green). And the detailed information such as the abbreviation, full name and category of the journals in the clusters are listed in Table 4. Cluster 1 represents journals in the field of biochemistry, molecular biology as well as cell biology, which explores the pathology of diabetes from a relatively microscopic perspective, such as cytology and genetics. This cluster plays the most important role in diabetes research. Cluster 2

represents journals in the field of surgery, including peripheral vascular disease and transplant techniques. Cluster 3 represents journals in the field of medicine, general, internal and public health which is aligned with the humanities to a certain extent. Cluster 4 represents journals in the field of physiology, endocrinology and metabolism. *Diabetes, Lancet and New. Engl. J. Med.* are located at the center of the whole network and have the largest node among them all, which means these three journals have the highest co-citation frequency and are of vital significance in diabetes research.

Diabetes, Lancet and *New. Engl. J. Med.* are closely linked with *P. Natl. Acad. Sci. USA.* and Nature, which probably indicates the overlaps of their content scope. *P. Natl. Acad. Sci. USA.* and *Nature* are journals of multidisciplinary science, including multiple fields and subjects such as diabetes research.

Table 4 .Journal Co-citation Clusters

Cluster	Abbreviation	Full Name	Category
Cluster 1	Diabetes	/	Endocrinology & Metabolism–SCIE
	Nature	/	Multidisciplinary Sciences–SCIE
	P Natl Acad Sci USA	Proceedings of the National Academy of Sciences of The United States of America	Multidisciplinary Sciences–SCIE
	J Biol Chem	Journal of Biological Chemistry	Biochemistry & Molecular Biology–SCIE
	Biochem Bioph Res Co	Biochemical and Biophysical Research Communications	Biochemistry & Molecular Biology–SCIE
	Biochem J	Biochemical Journal	Biochemistry & Molecular Biology–SCIE
	Febs Lett	Febs Letters	Biochemistry & Molecular Biology–SCIE Cell Biology–SCIE Biophysics–SCIE
	Faseb J	Faseb Journal	Biochemistry & Molecular Biology–SCIE Cell Biology–SCIE Biology–SCIE
	Cell	/	Biochemistry & Molecular Biology–SCIE Cell Biology–SCIE
	Nat Med	Nature Medicine	Biochemistry & Molecular Biology–SCIE Cell Biology–SCIE Medicine, Research & Experimental–SCIE
	Ann NY Acad Sci	Annals of The New York Academy of Sciences	Multidisciplinary Sciences–SCIE
	J Immunol	Journal of Immunology	Immunology–SCIE
	Biochemistry–US	/	Biochemistry & Molecular Biology–SCIE
	J Exp Med	Journal of Experimental Medicine	Medicine, Research & Experimental–SCIE Immunology – SCIE
	Biochim Biophys Acta	Biochimica Et Biophysica Acta	Biochemistry & Molecular Biology–SCIE Biophysics – SCIE
	Free Radical Bio Med	Free Radical Biology and Medicine	Biochemistry & Molecular Biology–SCIE Endocrinology & Metabolism–SCIE
	Am J Pathol	American Journal of Pathology	Pathology–SCIE
	Nat Genet	Nature Genetics	Genetics & Heredity–SCIE
	Am J Hum Genet	American Journal of Human Genetics	Genetics & Heredity–SCIE

Cluster	Abbreviation	Full Name	Category
Cluster 2	New Engl J Med	New England Journal of Medicine	Medicine, General & Internal–SCIE
	Kidney Int	Kidney International	Urology & Nephrology–SCIE
	J Am Soc Nephrol	Journal of the American Society of Nephrology	Urology & Nephrology–SCIE
	Am J Kidney Dis	American Journal of Kidney Diseases	Urology & Nephrology–SCIE
	Transplantation	/	Transplantation–SCIE Surgery–SCIE Immunology–SCIE
	Ann Surg	Annals of Surgery	Surgery–SCIE
	Arch Surg–Chicago	Archives of Surgery	Surgery–SCIE
	J Vasc Surg	Journal of Vascular Surgery	Peripheral Vascular Disease–SCIE Surgery–SCIE
	Surgery	/	Surgery–SCIE
	Am J Surg	American Journal of Surgery	Surgery–SCIE
	Am J Transplant	American Journal of Transplantation	Transplantation–SCIE Surgery–SCIE
	Transpl P	Transplantation Proceedings	Transplantation–SCIE Surgery–SCIE Immunology–SCIE
	Transplant P		
Cluster 3	Lancet	/	Medicine, General & Internal–SCIE
	Ann Intern Med	Annals of Internal Medicine	Medicine, General & Internal–SCIE
	Brit Med J	British Medical Journal	Medicine, General & Internal–SCIE
	Arch Intern Med	Archives of Internal Medicine	Medicine, General & Internal–SCIE
	Am J Med	American Journal of Medicine	Medicine, General & Internal–SCIE
	J Intern Med	Journal of Internal Medicine	Medicine, General & Internal–SCIE
	J Am Geriatr Soc	Journal of the American Geriatrics Society	Gerontology–SSCI Geriatrics & Gerontology–SCIE
	J Clin Epidemiol	Journal of Clinical Epidemiology	Public, Environmental & Occupational Health–SCIE Health Care Sciences & Services–SCIE
	Am J Public Health	American Journal of Public Health	Public, Environmental & Occupational Health–SSCI Public, Environmental & Occupational Health–SCIE
	Int J Epidemiol	International Journal of Epidemiology	Public, Environmental & Occupational Health–SCIE
Cluster 4	J Clin Endocr Metab	Journal of Clinical Endocrinology & Metabolism	Endocrinology & Metabolism–SCIE
	Am J Physiol	American Journal of Physiology	Physiology–SCIE
	Endocrinology	/	Endocrinology & Metabolism–SCIE
	Am J Physiol–Endoc M	American Journal of Physiology–Endocrinology and Metabolism	Physiology–SCIE Endocrinology & Metabolism–SCIE

Cluster	Abbreviation	Full Name	Category
Cluster 4	Horm Metab Res	Hormone and Metabolic Research	Endocrinology & Metabolism–SCIE
	Endocr Rev	Endocrine Reviews	Endocrinology & Metabolism–SCIE
	J Appl Physiol	Journal of Applied Physiology	Physiology–SCIE Sport Sciences–SCIE
	Life Sci	Life Sciences	Pharmacology & Pharmacy–SCIE Medicine, Research & Experimental–SCIE
	J Physiol–London	Journal of Physiology –London	Physiology–SCIE Neurosciences–SCIE
	Physiol Rev	Physiological Reviews	Physiology–SCIE

Author Co–citation Analysis
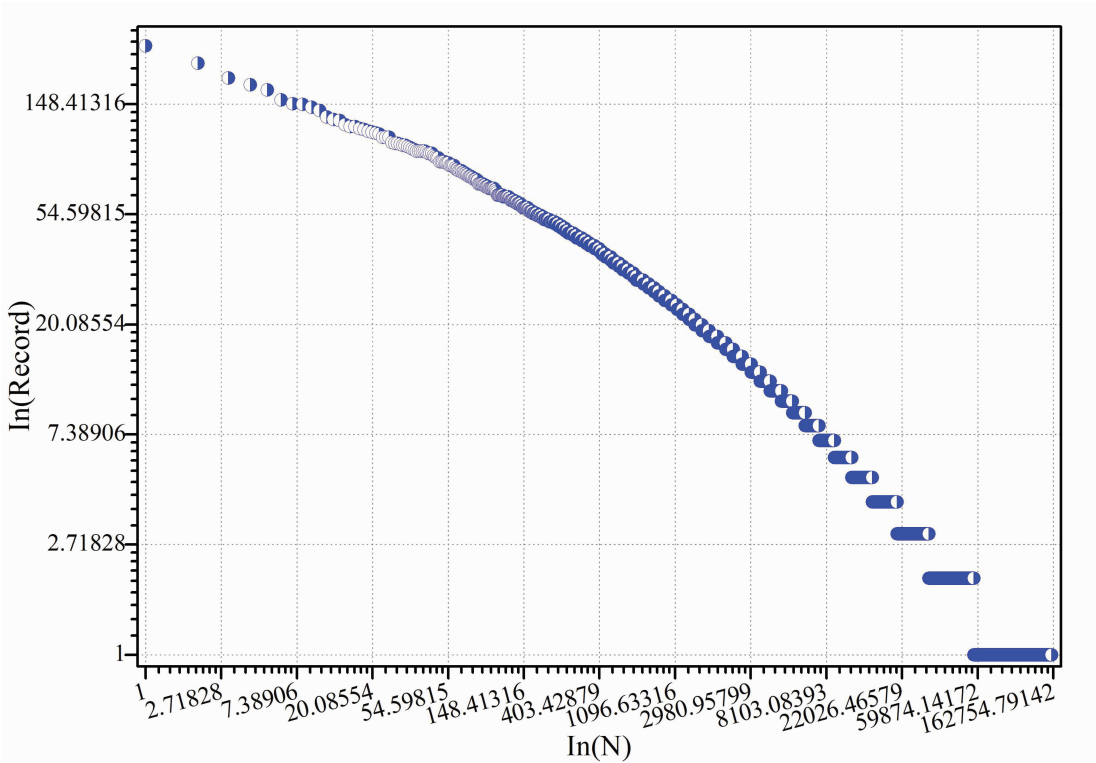
Figure 5 Relationship Map of rank order and author co-citation frequency

This study ranks and labels all the authors according to their co-citation frequency from high to low, papers with high co-citation frequency are ranked first, and those with low co-citation frequency are ranked last. These authors are labeled by natural number: the author with the highest frequency is 1 and the next is 2. By plotting the data on a ln-ln graph, with the axes being ln (N) (N means rank order) and ln (Record) (Record means co-citation frequency), it can come to a conclusion that the plot is relatively linear and the data conform to Power law. The co-citation frequency of any author is inversely proportional to its rank or-

der in the co-citation frequency figure. It can be seen from Fig. 5 that as the frequency of co-citation increases, the number of such authors decreases. And the authors who own large quantities of co-citation frequency only account for a small part of the field but in effect, they are the most important influencers. Relatively, the papers cited in small quantities account for most of the field, which conforms to the "eighty-twenty" rule.
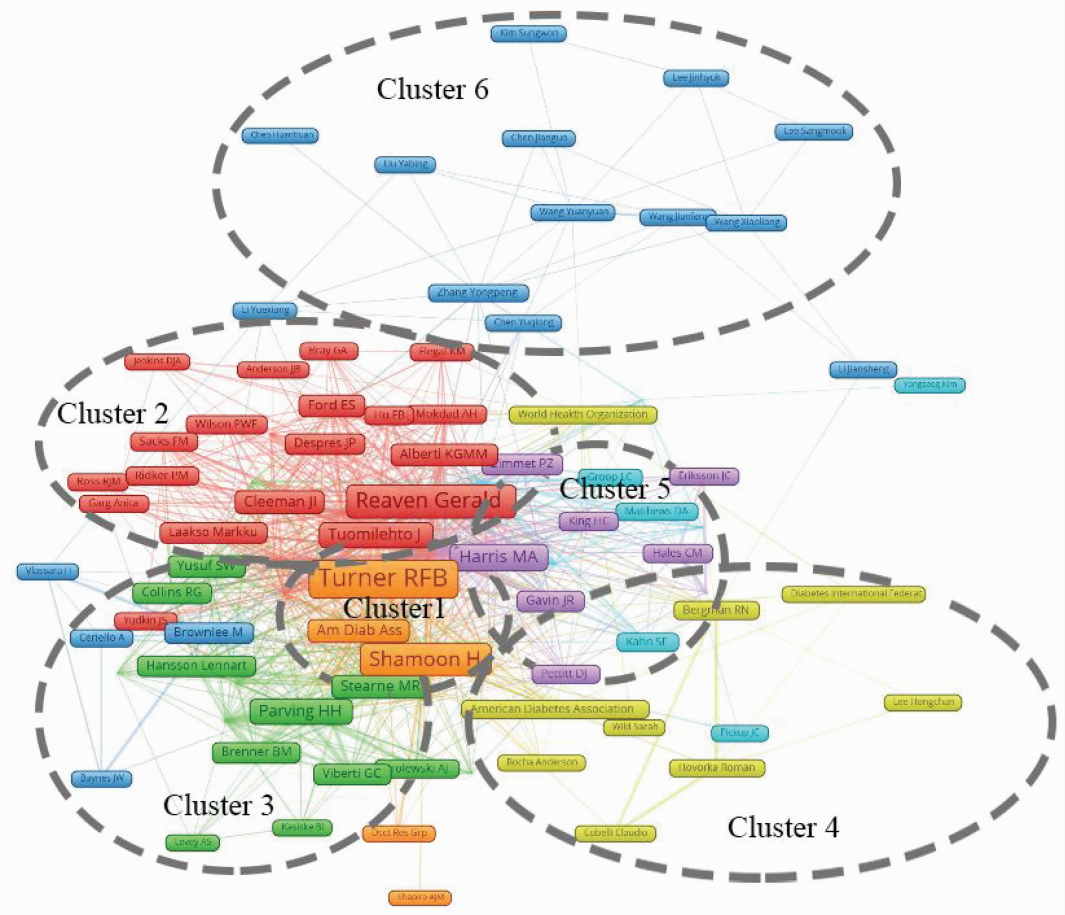

Figure 6 Author Co-citation Network of Diabets-related Conference Papers

As shown in Fig. 6, authors related to diabetes research are divided into six clusters: cluster 1 (orange), cluster 2 (red), cluster 3 (green), cluster 4 (yellow), cluster 5 (purple) and cluster 6 (dark blue) and are listed in Table 5. Turner RFB, Reaven Gerald, Tuomilehto J, and Harris MA are at the center of the whole network, whose diabetes research results have the highest co-citation frequency. Their research mostly quested for the behavioral mechanism of diabetes, which lead the field of diabetes research into both the Science Technology discipline and Life Sciences Biomedicine discipline.

Cluster 1 includes authors of great importance in diabetes research. Turner RFB (Robin F. B., professor in Michael Smith Labs, University of British Columbia) is an expert in molecular biology, biotechnology, and applied microbiology, who focuses on the micro-mechanism of diabetes. Am Diab Ass [American Diabetes Association] mostly publishes their research re-

sults in Diabetes Care. Shamoon H's (professor in Albert Einstein College of Medicine) major research interests are clinical chemistry, and clinical endocrinology. The main research fields of this cluster are the biochemistry mechanism of diabetes.

Authors of cluster 2 are Reaven Gerald, Tuomilehto J, Alberti KGMM, Cleeman JI and other experts. Reaven Gerald (professor in Div Cardiovasc Med, Stanford University) plays an important role in the metabolism and pharmacology of diabetes. Tuomilehto, Jaakko O. (professor in Dept Med, University of Helsinki, Finland) major research interests in geriatrics gerontology of diabetes, which related greatly to the elderly. George Alberti, Kurt (expert in Imperial College London) research interests focus on the epidemiology and family studies of diabetes, which take the family background into consideration. Cleeman, James I (professor in Ctr Qual Improvement & Patient Safety, Agency for Healthcare Research & Quality) critical care medicine of diabetes. It can be seen that the main research fields of this cluster are public environmental occupational health, and general internal medicine of diabetes.

Authors of cluster 3 are Parving HH, Yusuf SW, Collins RG, Brenner BM and other experts. Parving, Hans-Henrik (professor in Rigshospitalet, University of Copenhagen, Denmark) focus on health care sciences services and economic factors of diabetes. Yusuf, Syed Wamique (professor of UTMD Anderson Cancer Center) pays attention to the oncology of diabetes, which relates to the cancer. Collins, Richard George (from Florida Museum Nat Hist) and Brenner, Bruce M. (from Florida Atlantic University) major research interests are nephrology and medicine of diabetes. The experts of green clustering are mostly major in factors causing cancer and medicine study of diabetes.

Authors of cluster 4 are World Health Organization, Bergman RN (from Cedars Sinai Medical Center), Wild Sarah (from University of Edinburgh, Scotland) and others. Their research mostly take place in the field of Pharmacology, human health medical science and policy, which is correlative of cluster 5.

Authors of cluster 5 are Harris MA, Zimmet PZ, Gavin JR, King HC and other experts. The major research interests of Harris, Michael A. (professor of Dept Chem Engn & Mat Sci, University of Minnesota System) are not only the endocrinology metabolism of diabetes, but also its psychology developmental outcomes. Zimmet, Paul Z (professor of Cent Clin Sch, Monash University) major research interests are endocrinology metabolism, in accordance with harris, and nutrition dietetics in dealing with diabetes, in accordance with King, Hee Chang (professor of Coll Nat Sci, Seoul National University SNU, South Korea). Gavin, James R. (professor of Sch Med, Emory University) major research interests are health policy services about diabetes. To summarize, the experts of this cluster are mostly major in psychology and health care sciences services.

Authors of cluster 6 are Ceriello A (from IRCCS Multimedica, Italy), Zhang Yongpeng (from Inst Tradit Chinese Med, Hebei North University, China), Li Yuexiang (from Coll Chem, Nanchang University, China) and other experts. It is worth mentioning that many well-known Chinese scholars appear in this cluster. They mostly major in cell biology, which is correlative of cluster 3, and in psychiatry, which is correlative of cluster 2.

Table 5 Author Co-citation Clusters

Cluster	Author	Country	Author's full name	Institution	Research fields	Topic of the highest Contribution
	Turner RFB	Canada	Turner, Robin F. B.	University of British Columbia Michael Smith Labs	Chemistry·Physics and Astronomy·Biochemistry, Genetics and Molecular Biology·Engineering·Materials Science·Immunology and Microbiology·Environmental Science·Chemical Engineering·Medicine·Energy·Computer Science·Social Sciences·Neuroscience·Agricultural and Biological Sciences·Health Professions·Mathematics·Pharmacology, Toxicology and Pharmaceutics	Cancer; Raman Spectroscopy; Labels; Blood Preservation; Citrate Phosphate Dextrose; Hemolysis; Wavelength; Semiconductor Lasers; Iteratively Reweighted Least Squares
Cluster 1	Am Diab Ass	USA	American Diabetes Association	Diabetes Care	Human Medicine	
	Shamoon H	USA	Shamoon, Harry	Albert Einstein College of Medicine	Medicine·Biochemistry,Genetics and Molecular Biology·Agricultural and Biological Sciences·Nursing·Neuroscience·Mathematics·Health Professions·Pharmacology, Toxicology and Pharmaceutics·Chemical Engineering·Social Sciences·Decision Sciences	Hypoglycemia; Patient with Type 1 Diabetes; Insulin Dependent Diabetes Mellitus; Impaired Glucose Tolerance; Non–Insulin Dependent Diabetes Mellitus; Diabetes Mellitus; Aryldialkylphosphatase; Arylesterase, Oxidative Stress;
Cluster 2	Reaven Gerald	USA	Reaven Gerald	Stanford University Div Cardiovasc Med	Medicine·Biochemistry, Genetics and Molecular Biology·Nursing·Agricultural and Biological Sciences·Pharmacology, Toxicology and Pharmaceutics·Immunology and Microbiology·Neuroscience·Health Professions·Multidisciplinary·Psychology·Arts and Humanities·Chemistry·Physics and Astronomy·Environmental Science·Mathematics·Computer Science·Dentistry·Earth and Planetary Sciences	Blood Glucose; Insulin Resistance; Acanthosis Nigricans; High Density Lipoprotein Cholesterol; Insulin Resistance; Lipid Accumulation Product; Metabolic Syndrome; Pioglitazone; Impaired Glucose Tolerance

Cluster	Author	Country	Author´s full name	Institution	Research fields	Topic of the highest Contribution
	Tuomilehto J	Finland	Tuomilehto, Jaakko O.	University of Helsinki Dept Med	Geriatrics Gerontology Public Environmental Occupational Health Medicine·Biochemistry,Genetics and Molecular Biology·Nursing·Neuroscience·Agricultural and Biological Sciences·Immunology and Microbiology·Pharmacology, Toxicology and Pharmaceutics·Multidisciplinary·Psychology·Social Sciences·Mathematics·Decision Sciences·Chemistry·Health Professions·Environmental Science·Computer Science·Physics and Astronomy·Economics, Econometrics and Finance·Chemical Engineering·Engineering·Dentistry	Impaired Glucose Tolerance; Non–Insulin Dependent Diabetes Mellitus; Diabetes Mellitus; Adipose Tissues; Adipocytes; Inflammation; Transcription Factor 7; Single Nucleotide Polymorphism; Gestational Diabetes
Cluster 2	Laakso Markku	Finland	Laakso, Marku	It?–Suomen yliopisto, Kuopio, Finland	Medicine·Biochemistry, Genetics and Molecular Biology·Agricultural and Biological Sciences·Neuroscience·Nursing·Multidisciplinary·Chemistry·Physics and Astronomy·Pharmacology, Toxicology and Pharmaceutics·Immunology and Microbiology·Health Professions·Psychology·Mathematics·Computer Science·Arts and Humanities·Social Sciences·Decision Sciences·Veterinary	Multifactorial Inheritance; Summary Statistic; Single Nucleotide Polymorphism; Transcription Factor 7; Single Nucleotide Polymorphism; Gestational Diabetes; Biomarkers; Acylcarnitine; Metabolomics
	Despres JP	Canada	Després, Jean Piérre	Université Laval, Quebec, Canada	Medicine·Biochemistry, Genetics and Molecular Biology·Agricultural and Biological Sciences·Nursing·Health Professions·Pharmacology, Toxicology and Pharmaceutics·Mathematics·Neuroscience·Psychology·Multidisciplinary·Social Sciences·Decision Sciences·Engineering·Chemistry·Dentistry·Environmental Science	Intra–Abdominal Fat; Abdominal Subcutaneous Fat; Obesity; Calcification of Aortic Valve; Aortic Valve Calcification; Tricuspid Valve Disease; Obesity; Added Sugars; Fructose
	Hu FB	USA	Hu, Frank B.	Harvard T.H. Chan School of Public Health, Boston, U-nited States	Medicine·Biochemistry, Genetics and Molecular Biology·Nursing·Agricultural and Biological Sciences·Neuroscience·Multidisciplinary·Environmental Science·Psychology·Chemistry·Immunology and Microbiology·Social Sciences·Physics and Astronomy·Dentistry·Health Professions·Engineering·Pharmacology, Toxicology and Pharmaceutics·Arts and Humanities·Computer Science·Mathematics·Decision Sciences	Biomarkers; Acylcarnitine; Metabolomics;Cross–Sectional Studies; Nutritional Adequacy; DASH Diet; Dairy Consumption; Cardiovascular Disease; Yoghurt

Cluster	Author	Country	Author's full name	Institution	Research fields	Topic of the highest Contribution
	Mokdad AH	USA	Mokdad, Ali H.I.	Institute for Health Metrics and Evaluation, Seattle, United States	Medicine·Biochemistry, Genetics and Molecular Biology·Social Sciences·Agricultural and Biological Sciences·Nursing·Immunology and Microbiology·Multidisciplinary·Psychology·Health Professions·Neuroscience·Arts and Humanities·Environmental Science·Dentistry·Pharmacology, Toxicology and Pharmaceutics	Global Burden of Disease; Disability–Adjusted Life Year; Disability Weights; National Burden; Territories; Disease; Prediabetes; Dexmedetomidine; Correlation
Cluster 2	Wilson PWF	USA	Wilson, Peter W.F.	Atlanta VA Medical Center, Decatur, United States	Medicine·Biochemistry, Genetics and Molecular Biology·Nursing·Agricultural and Biological Sciences·Immunology and Microbiology·Neuroscience·Mathematics·Dentistry·Health Professions·Pharmacology, Toxicology and Pharmaceutics·Social Sciences·Computer Science·Physics and Astronomy	Hypoglycemia; Patient with Type 2 Diabetes; Non Insulin Dependent Diabetes Mellitus; Coronary Vessels; Calcification; Ethnic Studies; Cardiovascular Disease; Alirocumab; Familial Hypercholesterolemia
	Parving HH	Denmark	Parving, Hans – Henrik	University of Copenhagen Rigshospitalet	Medicine·Biochemistry, Genetics and Molecular Biology·Nursing·Pharmacology, Toxicology and Pharmaceutics·Agricultural and Biological Sciences·Health Professions·Immunology and Microbiology·Multidisciplinary·Neuroscience·Chemistry	Kidney; Endothelin–1; Endothelin Receptor Antagonists; Renin Angiotensin Aldosterone System; Angiotensin Receptor Antagonists; Chronic Kidney Failure; Hypoglycemia; Patient with Type 1 Diabetes; Insulin Dependent Diabetes Mellitus
Cluster 3	Yusuf SW	USA	Yusuf, Wamique Syed	UTMD Anderson Cancer Center Cardiol	Medicine·Biochemistry, Genetics and Molecular Biology·Nursing·Pharmacology, Toxicology and Pharmaceutics·Neuroscience·Chemistry·Health Professions·Agricultural and Biological Sciences·Chemical Engineering·Materials Science·Psychology	Radiotherapy; Carotid Stenosis; Intensity Modulated Radiation Therapy; Carcinoid Heart Disease; Carcinoid Tumor; Carcinoid Syndrome; Anthracyclines; Cardiotoxicity; Doxorubicin
	Brenner BM	USA	Brenner, Bruce M.	Florida Atlantic University Charles E Schmidt Coll Med	Biochemistry, Genetics and Molecular Biology·Medicine·Agricultural and Biological Sciences·Environmental Science·Neuroscience·Social Sciences	Parental Leave; Internship and Residency; Surgeon; Aberrant Crypt Foci; Azoxymethane; Animals

Cluster	Author	Country	Author's full	Institution	Research fields	Topic of the highest Contribution
Cluster 3	Viberti GC	England	Viberti, Giancarlo	Guy's Hospital, London, United Kingdom	Medicine · Biochemistry, Genetics and Molecular Biology · Agricultural and Biological Sciences · Nursing · Mathematics · Pharmacology, Toxicology and Pharmaceutics · Multidisciplinary · Dentistry · Decision Sciences · Environmental Science	Antihypertensive Agents; Thiazides; Hypertension; Renin Angiotensin Aldosterone System; Angiotensin Receptor Antagonists; Chronic Kidney Failure; Impaired Glucose Tolerance; Non Insulin Dependent Diabetes Mellitus; Diabetes Mellitus
	Hansson Lennart	Sweden	Hansson, Lennart O.	Uppsala Universitet, Uppsala, Sweden	Medicine · Biochemistry, Genetics and Molecular Biology · Pharmacology, Toxicology and Pharmaceutics · Nursing · Decision Sciences · Mathematics · Chemistry · Environmental Science	
Cluster 4	World Health Organization	Switzerland	World Health Organization,	Organisation Mondiale de la Santé, Geneva, Switzerland	Medicine · Environmental Science · Immunology and Microbiology · Biochemistry, Genetics and Molecular Biology · Veterinary · Agricultural and Biological Sciences · Materials Science	Immunization Programs; Immunostimulation; Vaccines; Human Poliovirus 1; Oral Poliomyelitis Vaccine; Poliomyelitis; Dengue; Antibody–Dependent Enhancement; Flavivirus
	Bergman RN	USA	Bergman, Richard N.	Cedars Sinai Medical Center Diabet & Obes Res Inst	Medicine · Biochemistry, Genetics and Molecular Biology · Nursing · Agricultural and Biological Sciences · Chemistry · Computer Science · Multidisciplinary · Engineering · Physics and Astronomy · Chemical Engineering · Mathematics · Neuroscience · Social Sciences · Psychology · Health Professions · Pharmacology, Toxicology and Pharmaceutics · Decision Sciences · Materials Science · Veterinary	Insulin Secretion; Glucose Tolerance Tests; Glucose; Blood Glucose; Insulin Resistance; Acanthosis Nigricans; Transcription Factor 7; Single Nucleotide Polymorphism; Gestational Diabetes
	Wild Sarah	Scotland	Wild, Sarah Helen	University of Edinburgh Coll Med & Vet Med	Medicine · Biochemistry, Genetics and Molecular Biology · Agricultural and Biological Sciences · Nursing · Multidisciplinary · Neuroscience · Chemistry · Physics and Astronomy · Social Sciences · Chemical Engineering · Engineering · Immunology and Microbiology · Dentistry	Non–Insulin Dependent Diabetes Mellitus; Socioeconomic Position; Period Prevalence; Insulin Dependent Diabetes Mellitus; Patient with Type 1 Diabetes; Member 1 Small Inducible Cytokine Subfamily E; Fatty Liver; Proton Density (Concentration); Keratin–18

Cluster	Author	Country	Author´s full	Institution	Research fields	Topic of the highest Contribution
	Harris MA	USA	Harris, Michael A.	University of Minnesota System Dept Chem Engn & Mat Sci	Medicine·Psychology·Biochemistry, Genetics and Molecular Biology·Nursing·Chemical Engineering·Engineering·Decision Sciences· Mathematics·Health Professions	Insulin Dependent Diabetes Mellitus; Glycemic Control; Quality of Life; Children with Medical Complexity; Health Care Need; Medicaid; Self–Management; Diabetes Mellitus; Glycemic Control
	Zimmet PZ	Australia	Zimmet, Paul Z	Monash University Cent Clin Sch	Medicine·Biochemistry, Genetics and Molecular Biology· Nursing·Agricultural and Biological Sciences·Immunology and Microbiology· Pharmacology, Toxicology and Pharmaceutics· Neuroscience·Health Professions·Arts and Humanities·Energy·Environmental Science· Multidisciplinary·Mathematics·Chemical Engineering·Social Sciences·Psychology· Decision Sciences	Impaired Glucose Tolerance; Non–Insulin Dependent Diabetes Mellitus; Diabetes Mellitus; Radiological Findings; Clinical Features; COVID–19; Gestational Diabetes; Pregnancy Diabetes Mellitus; Non–Insulin Dependent Diabetes Mellitus
Cluster 5	Gavin JR	USA	Gavin, James R.	Emory University Sch Med	Medicine·Biochemistry, Genetics and Molecular Biology·Nursing·Pharmacology, Toxicology and Pharmaceutics·Multidisciplinary·Health Professions·Neuroscience·Chemistry· Agricultural and Biological Sciences·Chemical Engineering·Environmental Science·Immunology and Microbiology	Glucose; Hypoglycemia; Insulin Dependent Diabetes Mellitus; Diabetes Mellitus; Liraglutide; Declaration; Diabetic Neuropathies; Pregabalin; Diabetes Mellitus
	Pettitt DJ	USA	Pettitt, David Dj	Kaiser Permanente, CA, United States	Medicine·Biochemistry, Genetics and Molecular Biology·Nursing·Immunology and Microbiology· Agricultural and Biological Sciences·Social Sciences·Dentistry·Psychology·Health Professions·Environmental Science· Pharmacology, Toxicology and Pharmaceutics	Blood Glucose; Insulin Resistance; Acanthosis Nigricans; Insulin Dependent Diabetes Mellitus; Patient with Type 1 Diabetes; Member 1 Small Inducible Cytokine Subfamily E; Glucose; Hypoglycemia; Insulin Dependent Diabetes Mellitus

Cluster	Author	Country	Author´s full name	Institution	Research fields	Topic of the highest Contribution
	Ceriello A	Italy	Ceriello, Antonio	IRCCS Multimedica	Medicine·Biochemistry, Genetics and Molecular Biology·Nursing·Agricultural and Biological Sciences·Pharmacology, Toxicology and Pharmaceutics·Chemical Engineering·Health Professions·Chemistry·Engineering·Neuroscience·Multidisciplinary·Social Sciences·Immunology and Microbiology·Computer Science·Dentistry	Dipeptidyl Peptidase IV Inhibitor; Linagliptin; Cardiovascular Disease; Antidiabetic Agent; Empagliflozin; Electron Microprobe Analysis; Non–Insulin Dependent Diabetes Mellitus; Glomerulus Filtration Rate; Diabetic Nephropathies
	Zhang Yongpeng	China	Zhang, Yongpeng	Hebei North University Inst Tradit Chinese Med	Engineering·Computer Science·Mathematics·Environmental Science·Physics and Astronomy·Decision Sciences·Chemical Engineering·Social Sciences	Interval Time–Varying Delay; Integral Inequality; Linear Matrix Inequality; Social Segregation; Emigration and Immigration; Settlement Patterns; University Teacher; Professional Development; Academic Staff
Cluster 6	Chen Yuqiong	China	Chen, Yuqiong	Huazhong Agricultural University, Wuhan, China	Agricultural and Biological Sciences·Chemistry·Biochemistry, Genetics and Molecular Biology·Pharmacology, Toxicology and Pharmaceutics·Environmental Science·Medicine·Dentistry·Chemical Engineering·Social Sciences·Health Professions·Nursing·Immunology and Microbiology	Camellia Sinensis; Theaflavins; Linalool Oxide; Flavanols; White Tea; Antioxidant; Fluorides; Pollution; Euphausia Superba
	Li Yuexiang	China	Li, Yuexiang	Nanchang University Coll Chem	Materials Science·Chemistry·Chemical Engineering·Energy·Physics and Astronomy·Engineering·Environmental Science·Biochemistry, Genetics and Molecular Biology·Medicine·Multidisciplinary·Earth and Planetary Sciences·Arts and Humanities	Water; Hydrophobicity; Aerogels; Cyanogen; Graphitic Carbon Nitride; Photocatalysts; Catalyst; Cobalt Phosphide; Water Splitting
	Wang yuanyuan	China	Wang, Yuanyuan	Fudan University, Shanghai, China	Computer Science·Medicine·Engineering·Physics and Astronomy·Biochemistry, Genetics and Molecular Biology·Materials Science·Health Professions·Chemical Engineering·Mathematics·Chemistry·Neuroscience·Arts and Humanities·Agricultural and Biological Sciences·Energy·Decision Sciences·Social Sciences·Multidisciplinary	Synthetic Apertures; Beamforming; Ultrasound; Texture Analysis; Cancer; Fluorodeoxyglucose F 18; Object Detection; Deep Learning; IOU

Conclusion

As the number of diabetics increases worldwide, the amount of research so as to bibliometric research on diabetes is also growing, which mainly focus on specific diabetes, diabetes complications, and diabetes treatment. However, in current bibliometric research, most efforts are put into academic papers and scientific reports, while the attention to conference papers is not sufficient. And most research just focus on a specific diabetes-related research direction, but rarely analyze from a macro perspective. Therefore, the bibliometric research in this paper analyzes the conference papers published in the field of diabetes from 1991-2020 in order to fill the research gap.

The analysis of the publication trend indicates that diabetes-related research has been receiving strong attention from researchers. Meanwhile, the results of Document Co-citation Analysis can be concluded that several papers such as *Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33)* and *Role of insulin resistance in human-disease* have both high citation and co-citation frequency, are crucial papers in the field of diabetes. The paper named Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33) written by Turner RC in 1998 is also the largest node in the network, indicating that it owns the highest co-citation frequency and could be the foundation and core document in the research field of diabetes. They can be regarded as the intellectual base of diabetes research. The knowledge contained in them has been shared in the whole discipline. The existing diabetes conference papers mainly focus on topics of blood-glucose and diabetes, blood pressure and diabetes, coronary disease and diabetes and insulin resistance. In addition, the Journal Co-citation Analysis shows that Diabetes, Lancet and New. Engl. J. Med. are located at the center of the whole co-citation network and have the largest node among all, this also indicates that the research on diabetes has been extended to the whole field of medicine and various related extension fields. Finally, the Author Co-citation Analysis shows that a small number of researchers have had a critical impact on the entire field of research, while the majority of researchers have been obscure and unknown. Turner RFB, Reaven Gerald, Tuomilehto J, Harris MA are at the center of the co-citation network, whose diabetes research results have provided an important intellectual base for diabetes research.

Moreover, conference papers, as observed in this study, have been an area of limited attention in the current bibliometric research landscape. Most efforts have been focused on academic papers and scientific reports. However, this analysis demonstrates that conference papers play a crucial role in disseminating knowledge and advancing research within the field of diabetes. Conference papers, along with other types of papers, contribute to the dissemination of knowledge, form the intellectual base of the field, and foster interdisciplinary collaboration. Understanding the specific effects and contributions of conference papers in relation to other types of papers can further enrich bibliometric research and inform future studies in the field of diabetes.

Based on the analysis conducted in this study, several suggestions can be made: Firstly, fostering interdisciplinary collaboration among researchers from various fields is essential. Encouraging collaboration between endocrinologists, geneticists, nutritionists, and public health experts can lead to innovative approaches and cross-pollination of ideas. This interdisciplinary collaboration can contribute to novel insights and advancements in understanding

and managing diabetes.

Additionally, it is important to explore emerging research areas within the field of diabetes. Identifying and analyzing emerging trends such as digital health technologies, personalized medicine, or the role of microbiota in diabetes can provide valuable insights and enable researchers to stay at the forefront of advancements in the field. This proactive approach to identifying emerging research areas will contribute to the development of innovative solutions for diabetes prevention, treatment, and management.

Furthermore, it is essential to consider the societal impact of diabetes research. Evaluating the translation of research findings into clinical practice, policy development, and patient outcomes can shed light on the practical implications of diabetes research. Understanding the real-world impact of research efforts will help prioritize areas of study that have the greatest potential for improving diabetes prevention, management, and overall public health.

Lastly, supplementing quantitative bibliometric analysis with qualitative approaches can provide a deeper understanding of the motivations, challenges, and perspectives of researchers in the field of diabetes. Incorporating qualitative methods such as interviews or surveys can uncover factors that influence research directions, collaborations, and knowledge dissemination. This mixed-methods approach will enrich the analysis and provide valuable insights into the human aspects of diabetes research.

However, since diabetes-related papers are so widely distributed, it is very challenging to conduct completely thorough investigation, there are still many high-quality papers that have not been analyzed, such as those written in non-English languages. If given the chance to collect all the diabetes literatures in the world, the bibliometrics results may be of more comprehensive. Moreover, this article hasn't taken enough consideration into gender issues that sometimes citations are gendered, and women's research is under recognized. This will lead to the fact that bibliometrics are permeated with subtle or implicit biases which ultimately lead to gender disparities, analysis that rely on bibliometrics do not capture a full or accurate picture. Given the current limitation of conditions, this article is still incomplete. However, the authors believe that the results of this study can still provide some useful information for future diabetes research and help to solve the problem at an early date.

Acknowledgement

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