Original Article



# Relationship between periodontitis and diabetes: a bibliometrics analysis

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**Background:** Diabetes and periodontitis are common chronic diseases, and the pathogeneses of the 2 diseases both involve chronic inflammation. The presence of either of the 2 diseases increases the risk of the other, while the treatment of 1 can reduce the risk of the other. This study sought to summarize the current status of research in this field via a bibliometric analysis.

**Methods:** The Science Citation Index Expanded (SCI-E) database was searched to retrieve relevant articles using the following search terms: "periodontitis" and "diabetes". Citespace software was used to analyze the search results, including the number of citations, the distribution of the countries, institutions, and journals that published the articles, the distribution of the authors, and the use of keywords in the articles.

**Results:** A total of 2,151 articles, with 63,668 citations, were included in the analysis. The top 5 countries in terms of the number of published papers were the United States (US), China, Brazil, Japan, and the United Kingdom (UK), and the top 5 institutions in terms of the number of published papers were Columbia University, Sichuan University, the University of North Carolina, the University of Sao Paulo, and the University of Guarulhos. The top 5 authors in terms of the number of published papers were Loos, Park, Han, Wang, and Offenbacher. There was little cooperation overall. The top 3 journals in terms of the most published related articles were all periodontal disease-related journals. After periodontitis and diabetes, the most frequently used keywords were inflammation, and risk.

**Conclusions:** More and more studies have been conducted on diabetes and periodontitis, and the current research mainly focuses on the treatment and management of these 2 diseases.

**Keywords:** Periodontitis; diabetes; inflammation; bibliometrics

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## Introduction

Diabetes and periodontitis are common chronic diseases with complex pathogeneses. Research has shown that diabetes is widespread worldwide (1). In 2019, 463 million people had diabetes worldwide, and the prevalence has shown a marked increase in the past 25 years (1-3). Diabetes can reduce life expectancy and increase the risk of cardiovascular disease, kidney disease, and malignancy (2). Thus, the active prevention and treatment of diabetes are of great clinical significance.

Worldwide, the vast majority of people suffer from varying degrees of periodontal disease, including gingivitis and periodontitis (4). Epidemiological studies have shown that the prevalence of periodontitis in low-, lower-middle-, upper-middle- and high-income countries is 28.7%,

10%, 42.5%, and 43.7%, respectively. The prevalence of periodontitis is higher in elderly patients (4,5). In the United States (US), the prevalence of periodontitis among people aged over 65 years was the lowest in Utah (62.3%) and New Hampshire (62.6%), and the highest in New Mexico, Hawaii, and the District of Columbia (all >70%) (5). Periodontitis is associated with a variety of diseases and can increase the risk of cardiovascular disease, diabetes, cancer, and more (6-8).

A previous study has found a bidirectional relationship between diabetes and periodontitis (9). Notably, diabetes is a major risk factor for periodontitis (10). Patients with diabetes have a 2–3 times increased risk of developing periodontitis compared to patients without diabetes (11). In the general population, patients with periodontitis have higher fasting blood glucose levels and hemoglobin A1C (HbA1c) levels than non-periodontitis patients (12). Additionally, severe periodontitis increases the risk of developing diabetes (9). Conversely, in diabetic patients, periodontitis is closely related to blood glucose levels, glycosylated hemoglobin levels, and complications (13).

As the above research results indicate, extensive research has been conducted on the relationship between diabetes and periodontitis, especially in terms of the underlying mechanisms and interventions. However, the current research situation is not very clear. A bibliometrics analysis refers to a statistical analysis of the relevant research literature in a specific field or topic via the adoption of a certain retrieval strategy. Different from other studies focused on some specific points, bibliometrics analysis reveals the general status of the related research in the chosen field or topic, the changes over time, and provides researchers with relatively macro information. It helps researchers to grasp the progress trends and focus areas of related research, to establish research directions, and explore new research priorities. This study adopted a bibliometrics method to analyze the overall status of research related to diabetes and periodontitis.

## Methods

### *Database*

Bibliometrics research mostly uses the Science Citation Index Expanded (SCI-E) database in the Web of Science Core Collection (WOSCC) as the data source for retrieval. The database was founded by the American Institute for Scientific Information in 1957, and contains the articles and citation information for more than 8,000 important journals. The SCI-E database is an important citation retrieval tool, and an important resource for metrology research and scientific research evaluation.

### *Search strategy*

In this study, a "topic" search strategy was adopted, and the search terms were "periodontitis" and "diabetes". There was no restriction on the publication time of the articles, and the last retrieval date was 2021-10-29.

### *Data collection*

After the literature search was completed, all the records of the search results and the cited references were exported in plain-text format to generate source files for the analysis. The source files were analyzed using Citespace software. The content of the analysis included the annual distribution of the articles, the annual distribution of the article citations, the distributions of the institutions and countries of the articles, the distribution of the authors of the articles, the cooperation between countries, institutions and authors, the journal distribution of the articles, and the use of keywords in the articles.

### *Statistical analysis*

This study mainly used the number and percentage to describe the indicators statistically. No difference analyses were conducted; thus, there was no need to establish a test level.

## Results

### *General information*

A total of 2,151 articles were included in the analysis, and these articles were cited 63,668 times, with an average of 29.6 citations per article, and an h-index of 115. Among these articles, there were 1,731 original articles, 335 reviews, 38 proceedings papers, 34 meeting abstracts, 31 editorial materials, 27 online first publications, 11 letters, 5 reprints, 2 book chapters, 2 corrections, 1 news article, 1 note, and 1 retraction (see *Table 1*). The number of papers published each year generally showed a gradual growth trend (see *Figure 1*), and the number of citations of these articles also showed a significant trend of increasing year by year (see *Figure 2*).

**Table 1** Article type

| Article type | Records | % of 2,151 |
|---|---|---|
| Article | 1,731 | 80.47 |
| Review | 335 | 15.57 |
| Proceedings paper | 38 | 1.77 |
| Meeting abstract | 34 | 1.58 |
| Editorial material | 31 | 1.44 |
| Online first | 27 | 1.26 |
| Letter | 11 | 0.51 |
| Reprint | 5 | 0.23 |
| Book chapter | 2 | 0.09 |
| Correction | 2 | 0.09 |
| News article | 1 | 0.05 |
| Note | 1 | 0.05 |
| Retraction | 1 | 0.05 |

Among the 2,151 articles, 68 articles were classified as repeated publications; thus, in this table, the total number of articles is 2,219 articles.

### *Countries and institutions*

CiteSpace V software was used to analyze the country and institutional information of the literature sources, and generate a visualization map. The number of network nodes in the country visualization map (see *Figure 3*) was 96; that is, 96 countries were listed in the documents. The number of connections between the nodes was 451; that is, the number of times that any 2 of the countries appeared in a document at the same time was 451; these results provide insights into the cooperation between countries. Similarly, in the institutional visualization map (see *Figure 4*), the number of network nodes was 591; that is, a total of 591 research institutions were involved in research in this field, and there were 1,087 collaborations (E) among them.

The statistical results also showed that the top 5 countries in terms of the number of publications were the US, China, Brazil, Japan, and the United Kingdom (UK) (see *Table 2*). The index reflecting the cooperation between a country and other countries was the centrality score, and the top 5 countries in terms of cooperation were the US, the UK, Germany, Italy, and Brazil (see *Table 3*). The top

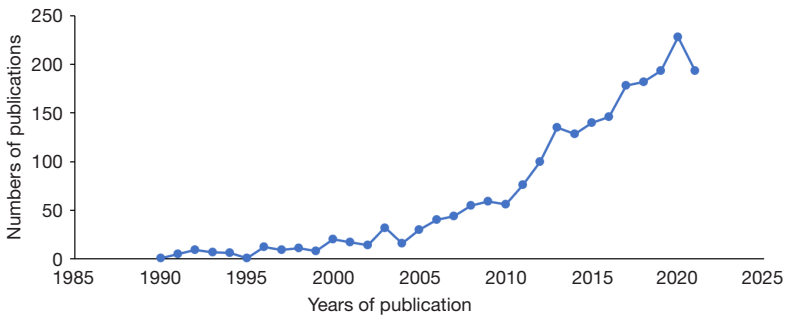


**Figure 1** Annual changes in the number of articles published.

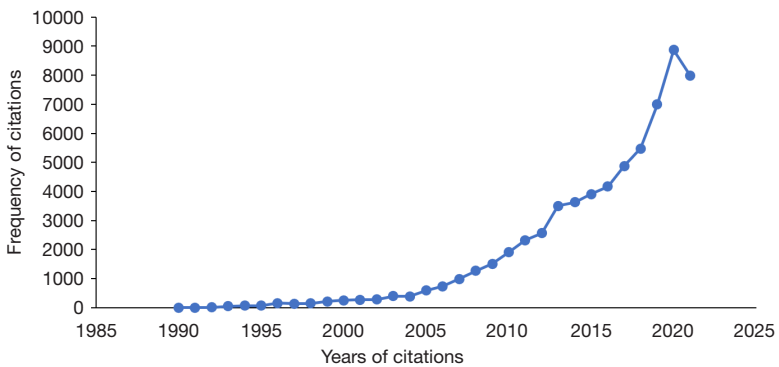


**Figure 2** Annual trends in citations.


**Figure 3** Country visualization map.

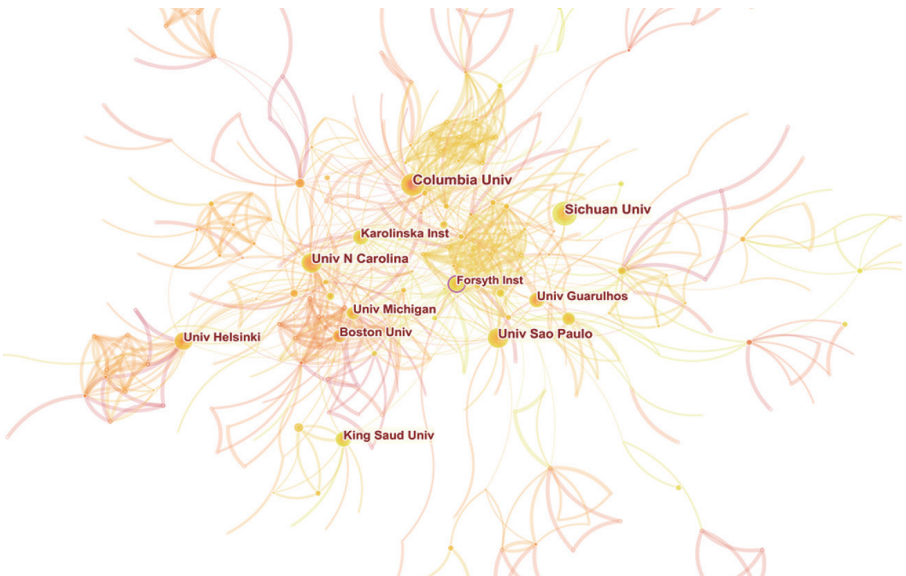


**Figure 4** Institutional visualization map.

5 institutions in terms of the number of publications were Columbia University, Sichuan University, the University of North Carolina, the University of Sao Paulo, and the University of Guarulhos (see *Table 4*). The Forsyth Institution and the University of North Carolina (see *Table 5*) were the only institutions with a centrality score >0.10.

### *Authors*

CiteSpace V software was used to analyze the author information for the articles, and the results showed that the top 5 authors in terms of the number of article publications were Loos, Park, Han, Wang, and Offenbacher (see *Table 6*). As the author cooperation visualization map shows, there was a certain degree of cooperation among some authors, but cooperation was relatively scattered, which suggests that this kind of cooperation was mostly limited to the same research institution or team (see *Figure 5*). This was consistent with the low centrality scores of the authors. The analysis showed that only 3 authors had a score of 0.01

**Table 2** Top 10 countries by posts

| Rank | Countries | Frequency |
|---|---|---|
| 1 | USA | 563 |
| 2 | China | 260 |
| 3 | Brazil | 213 |
| 4 | Japan | 170 |
| 5 | England | 118 |
| 6 | Germany | 110 |
| 7 | South Korea | 105 |
| 8 | Turkey | 92 |
| 9 | Italy | 91 |
| 10 | India | 77 |

USA, United States of America.

**Table 3** Top 10 countries by centrality

| Rank | Countries | Centrality |
|---|---|---|
| 1 | USA | 0.63 |
| 2 | England | 0.15 |
| 3 | Germany | 0.10 |
| 4 | Italy | 0.10 |
| 5 | Brazil | 0.08 |
| 6 | Serbia | 0.08 |
| 7 | Slovakia | 0.07 |
| 8 | China | 0.06 |
| 9 | Saudi Arabia | 0.06 |
| 10 | France | 0.06 |

USA, United States of America.

**Table 4** Top 10 institutions by publishing volume

| Rank | Institutions | Frequency |
|---|---|---|
| 1 | Columbia University | 52 |
| 2 | Sichuan University | 43 |
| 3 | University of North Carolina | 37 |
| 4 | University of Sao Paulo | 37 |
| 5 | University of Guarulhos | 33 |
| 6 | University of Michigan | 32 |
| 7 | University of Helsinki | 32 |
| 8 | Karolinska Institution | 31 |
| 9 | King Saud University | 30 |
| 10 | Boston University | 30 |

**Table 5** Top 10 institutions by centrality

| Rank | Institutions | Centrality |
|---|---|---|
| 1 | Forsyth Institution | 0.11 |
| 2 | Univ N Carolina | 0.10 |
| 3 | Columbia Univ | 0.08 |
| 4 | Tokyo Med and Dent Univ | 0.08 |
| 5 | Univ Michigan | 0.07 |
| 6 | Univ Minnesota | 0.07 |
| 7 | Univ Helsinki | 0.06 |
| 8 | Univ Washington | 0.06 |
| 9 | Univ Sao Paulo | 0.05 |
| 10 | Karolinska Inst | 0.05 |

(Loos, Park, and Offenbacher), and all the other authors had a centrality score <0.01. The top 5 co-cited authors were Lalla, Loe, Mealey, Preshaw, and Taylor (see *Table 7*). The author with the highest co-citation centrality score was Salvi (see *Table 8*). The co-citation visualization map showed that the citations were broadly linked, which suggests that the links between the studies were relatively close (see *Figure 6*).

### *Journals*

The 2,151 articles included in this study were published in 561 journals, of which 12 journals published >20 articles each in this field (see *Table 9*), amounting to a total of 911 journal articles, and accounting for 42.35% of the total articles published (see *Table 10*). These 12 journals were all dental professional journals. The top 3 journals that published the most related articles were periodontal disease-related journals (see *Table 9*). The most cited journals were also mainly dental journals, and the authoritative diabetes professional journal (*Diabetes Care*), and the top journal *Lancet* were also cited frequently (see *Table 10*), but the journals with the higher citation centrality values were mainly basic research journals, such as *Biochemical*

*and Biophysical Research Communications*, *Oral Microbiology Immunology*, *J Biological Chemistry* and *Science* (see *Table 11*).

### *Keywords*

CiteSpace V software was used to generate a keyword co-occurrence map (see *Figure* 7). There were 369 nodes in the figure; that is, in the 2,151 articles, 369 keywords were used (see *Figure* 7). There were 1,757 connections between the nodes in the graph; that is, 2 of the keywords appeared 1,757 times in a document at the same time (see *Figure* 7). In addition to periodontitis and diabetes, the most frequently used terms were inflammation and risk (see *Table 12*). The keywords with the highest centrality scores were diabetes mellitus and periodontal disease, and other keywords with high scores included necrosis factor alpha and bacteria (see *Table 13*). CiteSpace was also used to conduct a burst analysis of the keywords with a high frequency (see *Figures 8-10*), and the results showed that the use of hot keywords changed over time.

**Table 6** Top 10 authors by number of publications

| Rank | Authors | Frequency |
|---|---|---|
| 1 | Bruno G. Loos | 15 |
| 2 | Junbeom Park | 13 |
| 3 | Kyungdo Han | 13 |
| 4 | Qi Wang | 12 |
| 5 | Steven Offenbacher | 11 |
| 6 | Fawad Javed | 10 |
| 7 | Zohaib Akram | 10 |
| 8 | Yuichi Izumi | 10 |
| 9 | Evanthia Lalla | 10 |
| 10 | Philip M. Preshaw | 9 |

## Discussion

In this study, an overview of the general situation of the literature in this field was obtained by analyzing the research articles in the related fields of periodontitis and diabetes. We found that the number of articles published in this field was small until 2005, but the number of articles published in this field has increased significantly since 2005, and the frequency of article citations has increased significantly since 2004. Overall, research in this field began to increase significantly around 2004–2005.

In terms of the countries to which the authors belong, the US has published the most articles, and the US has the highest centrality score, indicating that the US has a higher level of co-operation. China ranks 2nd in terms of the number of published articles, and 8th in terms

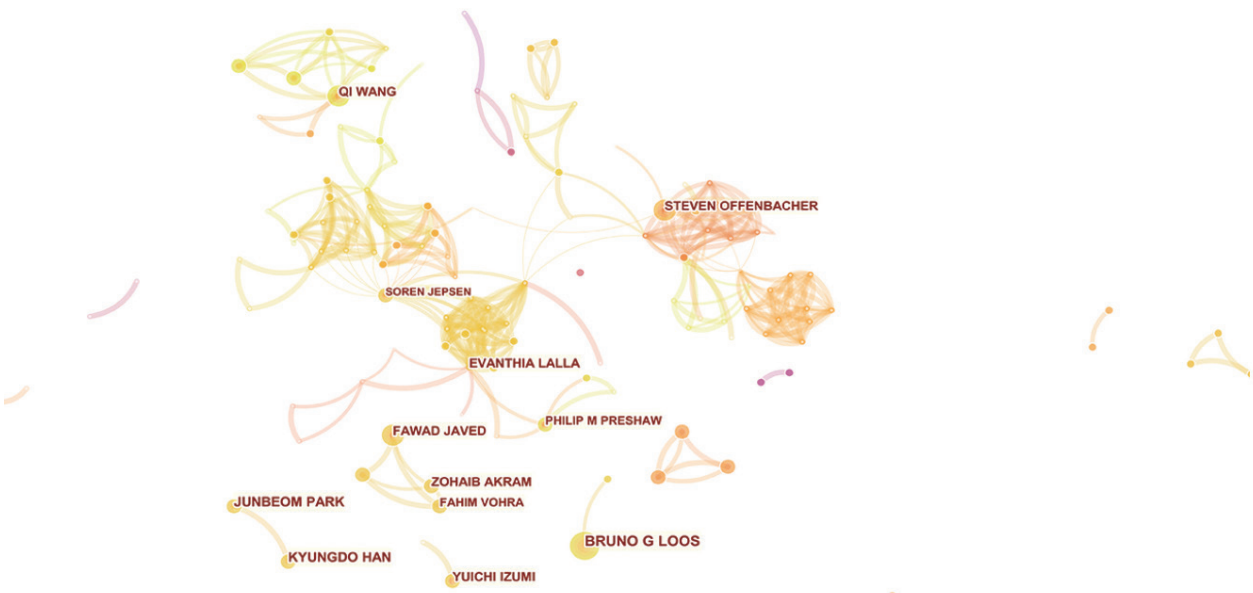


**Figure 5** Author co-authored visualization map.

**Table 7** Top 5 authors with total citations

| Rank | Authors | Frequency |
|---|---|---|
| 1 | Lalla E | 420 |
| 2 | Loe H | 413 |
| 3 | Mealey BL | 384 |
| 4 | Preshaw PM | 300 |
| 5 | Taylor GW | 291 |

**Table 8** Top 10 centrally cited authors

| Rank | Authors | Centrality |
|---|---|---|
| 1 | Salvi GE | 0.18 |
| 2 | Genco RJ | 0.16 |
| 3 | Cianciola LJ | 0.14 |
| 4 | Tervonen T | 0.13 |
| 5 | Grossi SG | 0.12 |
| 6 | Offenbacher S | 0.12 |
| 7 | Cutler CW | 0.12 |
| 8 | Tonetti MS | 0.10 |
| 9 | Lalla E | 0.09 |
| 10 | Loe H | 0.09 |

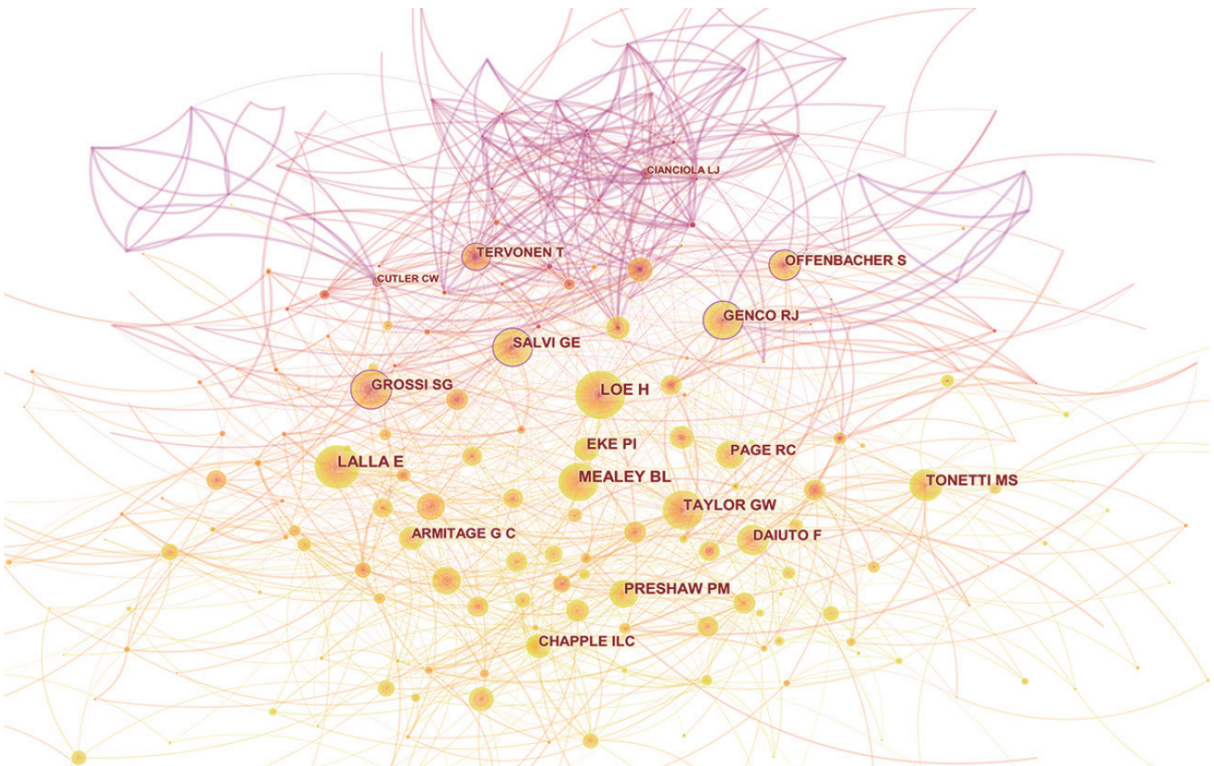


**Figure 6** Author co-citation visualization map.

of its centrality score, which suggests that there were fewer collaborative studies in China. In terms of the authors' institutions, Columbia University in the US published the most articles, but the Forsyth Institution at Harvard University, which is a world-renowned dental research institution, had the highest centrality score. The author analysis showed that Loos from the University of Amsterdam in the Netherlands published the most articles. However, the centrality scores of the authors were all low, and there was few cross-institution and cross-country

**Table 9** Top 12 journals with the most publications

| Journals | Records | % of 2,151 |
|---|---|---|
| *Journal of Periodontology* | 289 | 13.44 |
| *Journal of Clinical Periodontology* | 190 | 8.83 |
| *Journal of Periodontal Research* | 112 | 5.21 |
| *Journal of Dental Research* | 62 | 2.88 |
| *PLoS One* | 45 | 2.09 |
| *Archives of Oral Biology* | 37 | 1.72 |
| *Clinical Oral Investigations* | 36 | 1.67 |
| *BMC Oral Health* | 35 | 1.63 |
| *Oral Diseases* | 31 | 1.44 |
| *Periodontology 2000* | 30 | 1.39 |
| *Journal of Endodontics* | 23 | 1.07 |
| *Scientific Reports* | 21 | 0.98 |

**Table 10** Top 10 most cited journals

| Rank | Journals | Frequency |
|---|---|---|
| 1 | *Journal of Periodontology* | 1,833 |
| 2 | *Journal of Clinical Periodontology* | 1,697 |
| 3 | *Journal of Dental Research* | 1,342 |
| 4 | *Journal of Periodontal Research* | 1,138 |
| 5 | *Periodontology 2000* | 1,065 |
| 6 | *Diabetes Care* | 981 |
| 7 | *Ann Periodontology* | 825 |
| 8 | *Journal of American Dentist Association* | 650 |
| 9 | *PLoS One* | 577 |
| 10 | *Lancet* | 539 |

**Table 11** Top 10 journals cited by centrality

| Rank | Journals | Centrality |
|---|---|---|
| 1 | *Biochemical and Biophysical Research Communications* | 0.10 |
| 2 | *Oral Microbiology and Immunology* | 0.08 |
| 3 | *Journal of Biological Chemistry* | 0.07 |
| 4 | *Science* | 0.07 |
| 5 | *Journal of Oral Pathology and Medicine* | 0.07 |
| 6 | *American Journal of Medicine* | 0.07 |
| 7 | *Infection And Immunity* | 0.06 |
| 8 | *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* | 0.06 |
| 9 | *American Journal of Pathology* | 0.06 |
| 10 | *Nature* | 0.05 |

collaborations. The journal analysis showed that the main journals in this field were periodontal disease-related journals, but some highly cited articles had been published in related basic research journals. The results of the keyword analysis showed that in addition to periodontitis and diabetes, inflammation, risk, bacterial infection, were also research hotspots, and there have been some changes in research hotspots in recent years.

At present, a consensus has been reached on the relationship between periodontitis and diabetes. Periodontitis is a chronic inflammation in which microbial dysbiosis in dental plaque leads to a chronic, damaging inflammatory response (13). Periodontitis is almost incurable due to the openness of the oral cavity, frequent use, and repeated stay stimulation of various substances, and thus requires lifelong management, including reasonable treatment, the control of oral hygiene, and a reduction in related risk factors (14). The long-term, reasonable, and effective treatment of periodontitis can reduce the risk of diabetes and blood sugar levels. In a meta-analysis of diabetic patients, Simpson *et al.* found that the treatment of periodontal disease significantly reduced the level of glycated hemoglobin in both type 1 and type 2 diabetes (15). Subsequent meta-analyses with further updates revealed similar results, but also found that at least 6 months of professional periodontal treatment was required to achieve improvement (16). In a further meta-analysis, Madianos found that periodontal treatment significantly reduced the glycated hemoglobin levels in diabetic patients after 3 months, but the decrease was weakened at 6 months (17). Further, in a meta-analysis, Zhang *et al.* concluded that periodontitis increased the risk of diabetic microangiopathy in patients with type 2 diabetes mellitus (18).

Similarly, diabetes has a significant effect on periodontitis. Chronic inflammation may be the main mechanism linking diabetes and periodontitis (19). A large number of studies have suggested that diabetes also has a mechanism of chronic inflammation (11,12). The average circulating expression level of tumor necrosis factor in diabetic patients

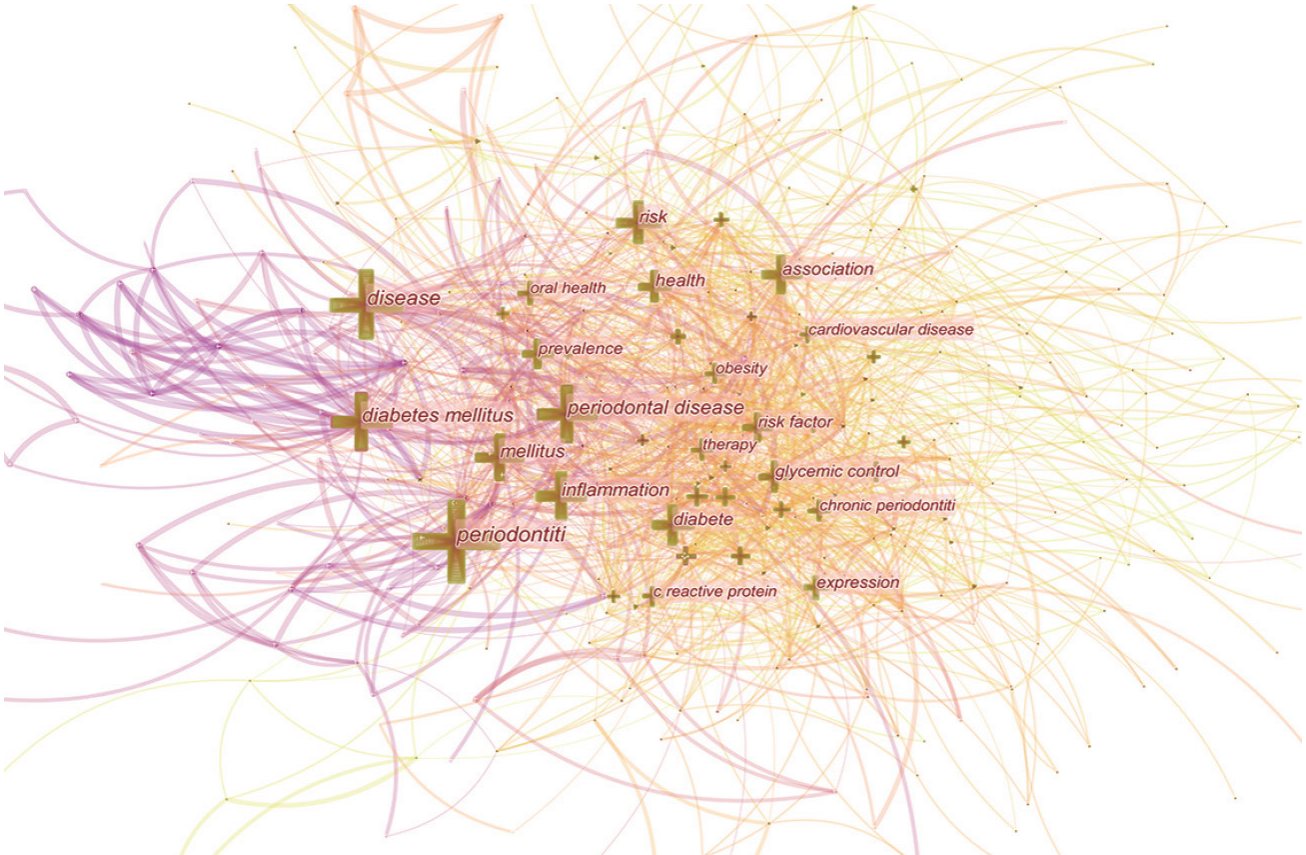


**Figure 7** Keyword co-occurrence graph.

**Table 12** Top 5 keywords by frequency

| Rank | Keywords | Frequency |
|---|---|---|
| 1 | Periodontitis | 978 |
| 2 | Disease | 704 |
| 3 | Diabetes mellitus | 632 |
| 4 | Periodontal disease | 478 |
| 5 | Inflammation | 410 |

**Table 13** Top 5 keywords by centrality

| Rank | Keywords | Centrality |
|---|---|---|
| 1 | Diabetes mellitus | 0.21 |
| 2 | Periodontal disease | 0.14 |
| 3 | Porphyromonas gingivalis | 0.11 |
| 4 | Attachment lo | 0.09 |
| 5 | Disease | 0.08 |

is higher than that in non-diabetic patients, and the level of inflammation in various tissues is also higher than that in the general population (20,21). Similarly, the level of inflammation in the periodontal tissue of diabetic patients was also significantly increased, and mainly manifested in the increased expression of local inflammatory factors, resulting in increased vascular permeability and increased inflammatory cell infiltration (19,22,23). Lowering glycemic therapy reduces the inflammatory load or inhibits inflammatory activity in diabetic patients (24,25). In turn, the treatment of periodontitis also significantly reduces the level of systemic inflammation in diabetic patients (26).

This study had a number of limitations. First, as a data source, the SCI-E database mainly includes documents in English, and a few other languages with English abstracts; thus, the unlisted documents in Chinese, Japanese and other languages could not be retrieved, which reduced the number of relevant documents. Indeed, the actual number

Top 25 Keywords with the Strongest Citation Bursts

| Keywords | Year | Strength | Begin | End | 1990–2021 |
|---|---|---|---|---|---|
| Dependent diabetes mellitus | 1990 | 18.43 | 1991 | 2010 | |
| Actinobacillus actinomycetemcomitans | 1990 | 11.88 | 1991 | 2007 | |
| Adult periodontitis | 1990 | 11.11 | 1991 | 2008 | |
| Children | 1990 | 9.78 | 1992 | 2008 | |
| Attachment lo | 1990 | 8.53 | 1993 | 2011 | |
| Periodontal disease | 1990 | 6.49 | 1995 | 2007 | |
| Necrosis factor alpha | 1990 | 11.33 | 1997 | 2012 | |
| Early onset periodontitis | 1990 | 8.98 | 1998 | 2005 | |
| Cigarette smoking | 1990 | 6.29 | 1998 | 2006 | |
| Coronary heart disease | 1990 | 6.91 | 2000 | 2006 | |
| Alveolar bone lo | 1990 | 6.85 | 2001 | 2008 | |
| Risk factor | 1990 | 10.79 | 2002 | 2007 | |
| Metabolic control | 1990 | 10.26 | 2002 | 2011 | |
| Infection | 1990 | 8.03 | 2003 | 2009 | |
| Glycemic control | 1990 | 5.98 | 2010 | 2012 | |
| Hba1c | 1990 | 6.86 | 2011 | 2015 | |
| National health | 1990 | 7.39 | 2016 | 2018 | |
| Global burden | 1990 | 9.03 | 2017 | 2021 | |
| Nutrition examination survey | 1990 | 6.71 | 2017 | 2018 | |
| Classification | 1990 | 12.11 | 2018 | 2021 | |
| Consensus report | 1990 | 14.46 | 2019 | 2021 | |
| Update | 1990 | 10.11 | 2019 | 2021 | |
| Peri implant disease | 1990 | 8.47 | 2019 | 2021 | |
| Workshop | 1990 | 7.41 | 2019 | 2021 | |
| Activation | 1990 | 5.79 | 2019 | 2021 | |

**Figure 8** Top 25 keywords with the strongest citation bursts. Red lines indicate that the years when keyword was used frequently. Green lines indicate the years when the keyword was not used frequently between 1990–2021.

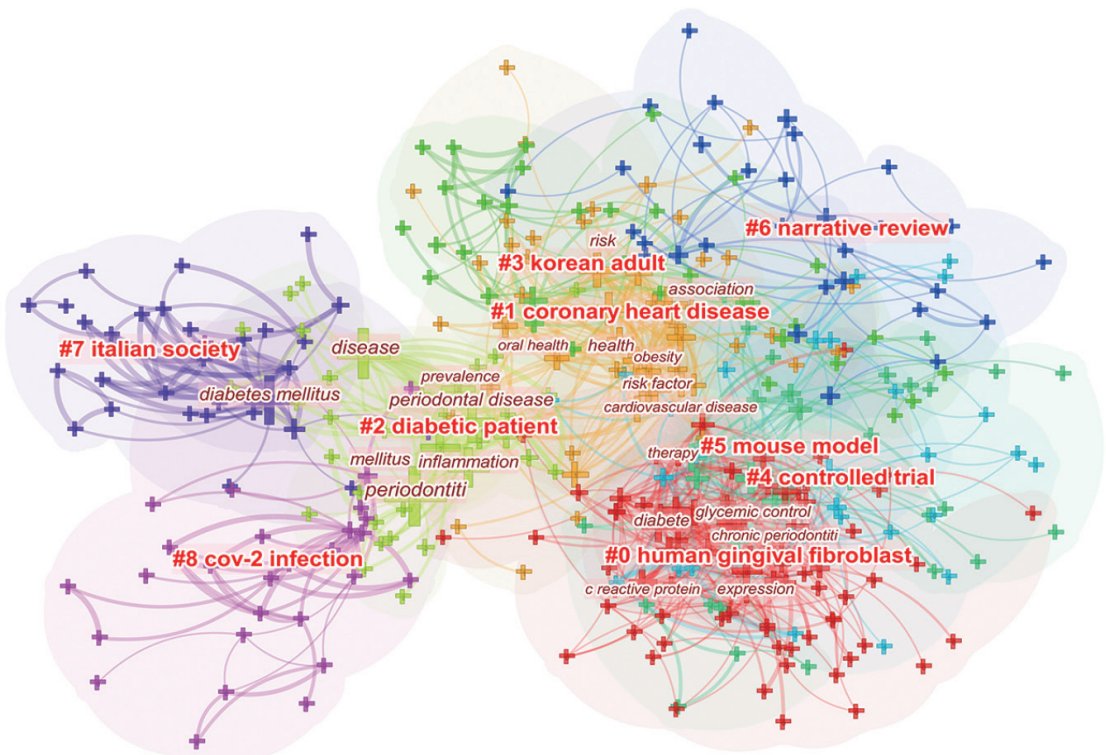


**Figure 9** Cluster graph of keywords.

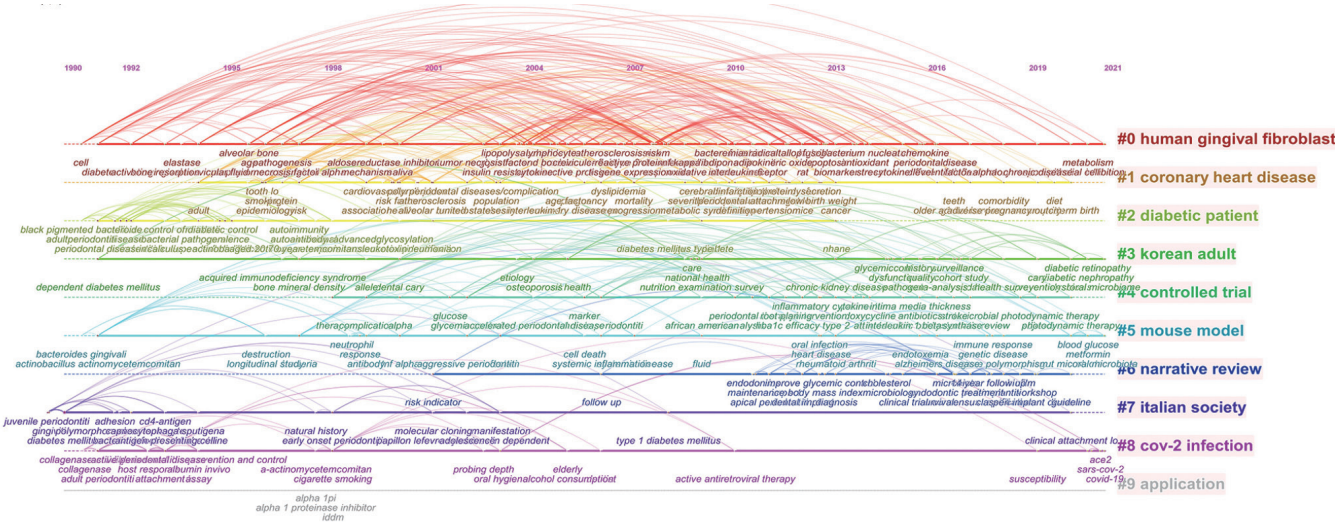


**Figure 10** Timeline cluster graph of keywords.

of literatures may have been significantly underestimated, and some important research results may have been missed.

## Acknowledgments

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## Footnote

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1067/coif). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.



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