

ORIGINAL ARTICLE

KNOWLEDGE MAPPING OF PHARMACOECONOMIC ON DIABETES MELLITUS RESEARCH BASED ON SCOPUS DATABASE: A BIBLIOMETRIC ANALYSIS

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Background: Every year, there are more people diagnosed with diabetes mellitus (DM). There is no bibliometric report on this subject despite the publication on the pharmacology of diabetes mellitus. In order to do this, this study will conduct a bibliometric analysis of the literature on the pharmaco-economic analysis of diabetes therapy. **Methods:** To find a bibliographic database of primary research on the subject, the Scopus database was searched for articles containing the terms "pharmacoeconomic searched for articles containing the terms "pharmacoeconomic" OR "cost effectiveness analysis" OR "cost minimization analysis" OR "cost benefit analysis" OR "cost utility analysis" AND "diabetes mellitus" on May 5, 2023. A total of sixty-three documents ranging from 1978 to 2023 have been selected. Utilizing VOSviewer 1.6.19, the data was evaluated. **Results:** The most significant nations, universities, sources, journals, and authors are, in order of influence: the United Kingdom, Beijing University, Diabetes Care Journal, PharmacoEconomics Journal, and Vijan (United States). A therapy model that is applied with high effectiveness but low cost can be determined by doing a pharmacoeconomic study of all aspects of diabetes mellitus management. Cost-effectiveness and cost-utility are the two most important and varied aspects of this subject. **Conclusion:** By utilising pharmacoeconomic analysis, our results improve research collaboration and pinpoint the knowledge gaps required for applications in the management of diabetes mellitus.

Keywords: Pharmacoeconomic; Diabetes mellitus; Bibliometric; Scopus; VOSviewer

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INTRODUCTION

Diabetes mellitus (DM) is becoming more common worldwide, becoming an increasingly profound health burden, and indicating a significant increase in the population suffering from diabetes throughout the world.^{1,2} These data reflect the fact that diabetes has become an urgent global pandemic with a significant impact on public health care systems and economies.^{3,4} Considering the increasing prevalence, prevention efforts, education, and management of diabetes mellitus are becoming increasingly important in efforts to address these challenges.^{5,6} According to a study by Liu *et al.* (2020)⁷, the cost of treating diabetes mellitus continues to rise worldwide. They investigated data from a number of countries and found that the total cost of diabetes treatment has gone through a significant increase in recent years. Factors contributing include increased drug prices, the cost of routine care, and the cost of complicated care.^{8–10}

Furthermore, a study by Seuring *et al.* (2015)¹¹ explored the financial impact that those with type 2 diabetes suffered and discovered that people with diabetes who have type 2 experienced a higher financial burden than those who did not suffer from diabetes. This burden is mainly related to drugs and health care.^{12,13} These results underline the significance of financial considerations when

it comes to managing diabetes because it requires such a high cost.¹⁴ Pharma-economics in diabetes mellitus is an increasingly important area in health research, which focuses on the cost-benefit analysis of various diabetes-related treatment strategies and interventions.^{15–17} Pharmacoeconomic analysis provides critical insights into the effectiveness of using medical resources in the control of diabetes by evaluating the short and long-term costs of various therapeutic options, monitoring technologies, and prevention programmes.^{18,19} Pharmacoeconomics helps policymakers and health practitioners make informed and sustainable decisions to improve the clinical outcomes of diabetic patients while mitigating the financial burden on the healthcare system.^{20,21} With the increasing financial pressure on the healthcare system, pharmacoeconomic research on diabetes mellitus has become increasingly relevant in helping to provide affordable and high-quality care for individuals living with the disease.²²

Many scientific publications are recorded as original research on pharmaco-economics for the treatment of diabetes mellitus. For example, two articles report the cost assessment of DM treatment.^{23,24} There haven't been any bibliometric solutions to this problem, though. In order to advance research, a bibliometric analysis of pharmaco-economics in DM was carried out.

According to Bamel *et al.* (2020)²⁵ and Yeung *et al.* (2018)²⁶, a subject known as bibliometric analysis combines management (assessments of authors, institutions, and sources based on literature) and theoretical (assessments of the literature to look at the level of understanding in certain areas) elements. Results from bibliometric studies on management issues aid in the development of new policies, assist funding organisations and policymakers in setting financial priorities, and foster greater partnerships in research.²⁷ Additionally, bibliometric analyses of theoretical elements aid in understanding past and present patterns in publication in particular domains.²⁵ Thus, this work correlates earlier research on the subject, advises further study, and presents a fresh way to quantitative analyses of the pharmaco-economics of diabetes mellitus.

MATERIAL AND METHODS

Using the Scopus database, the materials on pharmaco-economics for DM were found. The dataset, which is extensive and suitable for analysis using bibliometrics^{25,28,29}, covers a wide range of scholarly literature. The Scopus database was searched for articles containing the terms "pharmacoeconomic" OR "cost effectiveness analysis" OR "cost minimization analysis" OR "cost benefit analysis" OR "cost utility analysis" AND "diabetes mellitus" on May 5, 2023 (Figure 1). The authors utilized these concepts in scientific articles' titles, abstracts, and keywords. The complete text that complied with the inclusion and exclusion criteria was evaluated. Literature from the Scopus database, primary studies (original articles and reviews), English language content, and issues related to pharmaco-economics for diabetes mellitus were the inclusion criteria. According to Arifah *et al.* (2021)³⁰, the removal criteria included irrelevant terms like the preceding article, incomplete and skewed information, being inaccessible, and duplication. The MarvinSketch programme was used to create some sketches of discovered chemical structures.

The procedure of analysis and data extraction is shown in Figure 1. The appropriate documents were imported into VOSviewer 1.6.19 as ".CSV" files to perform bibliometric analysis.³¹ This programme assessed publishing trends, influential nations, organisations, sources, networks of authors and bibliographical coupling, networks of documents and co-citations, networks of keyword co-occurrence, and overlay.³⁰ A word or phrase is represented by the bubble map visualisation.³² Additionally, the size of the bubbles and the space between them showed, respectively, the frequency of the words and their occurrence together.^{26,33}

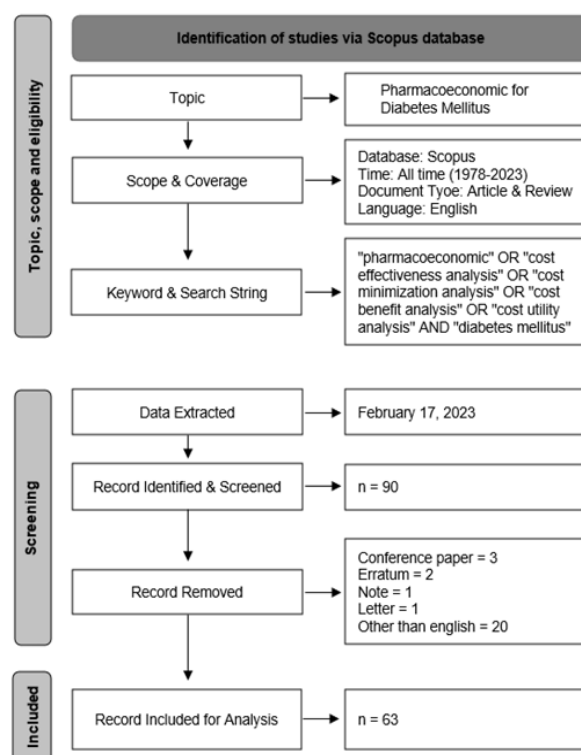


Figure-1: Procedures for Conducting Searches

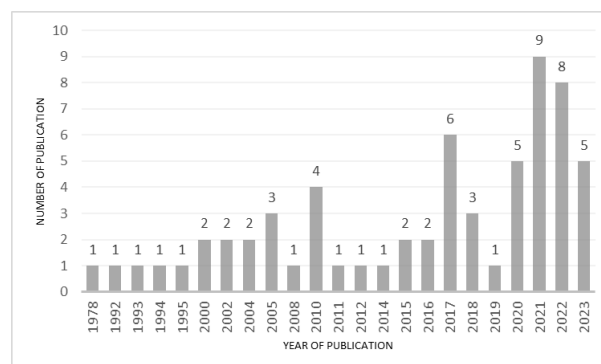


Figure-2: Trends in Pharmacoeconomic publication in diabetes mellitus therapy

RESULT AND DISCUSSION

The articles, which included 51 sources and 160 writers from 63 chosen pieces, were published between 1978 and 2023. The earliest article was "Importance of outpatient supervision in the prognosis of juvenile diabetes mellitus: A cost-benefit analysis," and it appeared in the Journal of Diabetes Care in 1978 (Figure-2). Additionally, 2021 had the most publications, with nine items appearing in print. There are several research projects related to cost-effectiveness analysis in diabetes management. The data obtained describes trends in health economics research focusing on various aspects of the

management of the disease from 1978 to 2023.

More and more research related to cost-benefit analysis is being done over time. This reflects increasing attention to economic health issues related to diabetes mellitus. This research includes various types of therapies, testing, and diabetes management programmes, such as drug use, pharmaceutical interventions, and patient education. Besides, there are variations in the coverage of research topics. The research covers various aspects of diabetes management, ranging from pharmacological treatment to patient education and monitoring. It shows the complexity of diabetes and the efforts to find the most effective and cost-effective solution. Research related to pharmaco-economics in DM in its development also reaches to the type of therapy that is evaluated. Over time, research has evolved from conventional drugs to newer treatment options like dipeptidyl peptidase-4 inhibitors (DPP-4) and SGLT-2 (Sodium-Glucose Cotransporter 2). This reflects a change in the ever-evolving approach to diabetes treatment.

The pharmaco-economic research on DM includes analysis from multiple viewpoints, including the patient's perspective, the national health care system, and the pharmaco-social perspective. This suggests that the researchers are trying to understand the economic impact from a variety of perspectives. Several more recent studies (for example, 2020–2023) explore the use of digital technology and more innovative treatment models in diabetes management, such as digital education programmes and the usage of sensors. It reflects a global trend towards the use of technology in health care. These trends reflect growing efforts to find effective and cost-effective solutions for diabetes mellitus management and how these approaches evolve over time.

Table 1 presents information based on the number of quotations and top authors based on the "Cites" column for a number of pharmaco-economically related studies on diabetes mellitus. From this table, it can be concluded that the study with the highest number of quotes is a highly recognised work in the medical literature related to diabetes. The study, entitled "Cost-utility Analysis of Screening Intervals for Diabetic Retinopathy in Patients with Type 2 Diabetes Mellitus, was written by Vijan in 2000. It implies that this study has significantly influenced how diabetic retinopathy is managed. Meanwhile, other studies in this table also have a fairly high number of quotations, reflecting important contributions to research and economic analysis related to diabetes mellitus. These studies describe various aspects of diabetes management, including cost-benefit analysis, drug evaluation, and testing strategies. This quote reflects the importance of this research in the creation of clinical recommendations and diabetes-related health care policies.

Pharmaco-economics on DM was investigated

in 63 studies from 37 countries. The second-largest contributor after Europe is Asia (Table 1). According to the quantity of publications, the UK had the most influence.

One hundred fifty-four institutions and organisations are involved in pharmaco-economic research on diabetes mellitus, according to institutional contributions in the 63 articles. The most renowned university was Peking University (China), but the University of Michigan (US) had the highest number of publications cited among the top 10 institutions (Table 1). The majority of the institutions that contributed were in the United States.

The pharmaco-economic data on DM help researchers submit their work to publishers and discover a viable publisher. Only two of the 51 sources had three papers each. With three publications, 215 citations, and an average of 35.83 citations per publication, "Diabetes Care" and "PharmacoEconomics" published the most.

An author analysis of a subject area explains patterns of scholarly collaboration and the concept of scholarly collaboration while also identifying academics who have made significant contributions to a study area.^{25,34,35} One hundred fifty-eight writers researched the pharmaco-economics of DM using a bibliometric analysis of 63 chosen articles.

Deng, J and Chien, C have the most total link strength with 10 links. Academics, organisations, and nations will offer advice on how to foster and develop research collaboration for the benefit of other academics.³⁰ Additionally, author-based bibliographic coupling was created. According to this research, two writers referenced related articles in their works.³⁶ Similar topics in the examined articles are suggested by a strong bibliographical coupling strength.³⁷ Because fractional counting is more accurate than full counting and has fewer common misunderstandings, we used it in this analysis.³⁸ Each piece was equal to one because they were all the same weight.²⁵ Then, we combined different author names that were the same by using a thesaurus.³⁰ We needed one document for every writer, so there were, but this wasn't enough to create a co-citation network (Figure 3). Only 14 authors had the most connections, even though 63 authors met the one-document requirement. So, using 110 linkages and the required minimum document number, we computed a total link strength of 63. This network's size reveals the author's internal coupling intensity, which suggests that their reference lists are comparable. For clusters containing the largest node, the author's name is used. Our bibliographical coupling network's findings are displayed, which found four clusters. Clusters 1 (red-coloured), 2 (green-coloured), 3 (blue-coloured), and 4 (yellow-coloured) were close to each other and were chaired by Annemnas L, Davies M.J, Dunn C.J, and Men P, for cluster 1; thus, Capel M, Fariman S.A, Jiang Y, and

Nosrati M, chaired clusters 2. Chien C, Hu S, Morales C, and Ruan Z chaired clusters 3; thus, Chaikittisophon K, and Men P, chaired clusters 4.

To determine which documents were the most influential, the authors counted all the citations made to each one. The analysis identified the 24 articles with the most citations-more than 10. McEwan P. attained the highest citation with 34 citations and 463 total strong links. The second and third were written by Valentine W.J. (33 citations and 369 total link strength) and Palmer A.J. (21 citations and 252 total link strength). Analysis of cost benefit, cost utility, and cost effectiveness was covered in the three most influential articles. To evaluate scientific understanding and the expansion of research trends, we conducted a co-citation network analysis.³⁹ When two documents are cocited, a co-citation network is formed.^{25,40} Two documents are strongly related if other documents frequently cite them.^{25,40} Co-citation is a measure of the degree of resemblance in meaning between two or more texts and the relationships between their citations, with more co-citations indicating semantic closeness.⁴⁰ To explore the works of influential scholars, this study developed a co-citation network.²⁵ In its visualisation, this methodology also revealed spatial information for the most-cited publications.²⁵ In the analysis, counting in fractions was used, much like the bibliographic coupling network. Only 24 of the 3,895 items that satisfied the requirement for a minimum of ten citations of a referenced reference were connected to the network. A minimum of ten citations was our requirement, and 24 documents met it. In order to investigate this network, the authors therefore employed one minimal citation (Figure 5). Three clusters were created within the network, with 112, 137, and 108 citations in each of them. Cluster 1 is coloured red, cluster 2 is green, and cluster 3 is blue.

The network and overlay for keyword co-occurrences can be used to identify research areas that are receiving a lot of attention as well as to provide quick, accurate, and useful ideas that can be repeated in the principal branches of study.^{25,41} Prospective keywords and network co-occurrence edges were depicted as nodes in the visualisation.⁴¹ As a result of our use of fractional counting, according to Vargas-Quesada *et al.* (2017)⁴², it normalised link weights, produced more accurate results, and revealed network structure. All keywords were chosen since there are three choices for an analytical unit in this analysis: author keywords, indexed keywords, and all keywords. While indexed keywords interpret the contents, author keywords use natural language to characterise the author's subject matter.⁴² Author keywords are effective for examining the domain-specific knowledge landscape in bibliometric research; however, they could be biased because some scientists employ specific keywords to boost the visibility of their research.^{42,43} Additionally, according to Vargas-Quesada

et al. (2017)⁴², indexed keywords provide thorough visualisations of document contents and aid in the visualisation of article content. Therefore, the authors used the thesaurus to filter out keyword repetitions before basing our construction on all keywords (author and indexed keywords).³⁰ Six hundred eighty-four keywords from 63 articles were displayed in this network visualisation. As a result, the authors picked five keywords as the cut-off, and 74 keywords satisfied the condition. Its representation, though, was extremely dense and overlapping. According to Bamel *et al.* (2020)²⁵, dimensions of the nodes and the distance between them show the frequency with which keywords are used (Figure 5A). A node overlap also illustrates the frequency with which specific phrases co-occur in the network.²⁵ This analysis has three clusters, according to the visualisations.

The keyword's frequency of use was reflected in the node size (Figure 5B). Purple nodes were used around or before 2010, purple-blue nodes were used around 2012, blue-green nodes were used around 2014, green nodes were used around 2018, and yellow nodes were used around or after 2020, respectively. Some keywords, including patient compliance, cost of illness, priority journal, mass screening, pregnancy, United Kingdom, and clinical trial, occurred around 2010. Whereas keywords such as cost-benefit analysis, glucose, adolescent, health care cost, female, adult, and aged appeared around 2012. Moreover, keywords used around 2014 involved cost effectiveness, non-insulin dependent, human, economic, quality adjusted 1, insulin, and metformin. Whereas around 2018, drug cost, hypoglycaemic agent, models-economic, sensitivity analysis, drug efficacy, monotherapy, and economic evaluation Furthermore, around 2020, cost effectiveness, diabetic patient, body mass, cohort analysis, clinical outcome, haemoglobin blood 1, insulin glargine, and antidiabetic agents were used. This history of studies indicates that the pharmacoEconomics of DM have expanded, starting with patient compliance and the cost of illness.

With the increasing number of people suffering from diabetes mellitus worldwide, pharmacoeconomic research has played an essential function in aiding policymakers and health professionals make wise decisions regarding resource allocation and treatment options. The study entitled "Cost-utility Analysis of Screening Intervals for Diabetic Retinopathy in Patients with Type 2 Diabetes Mellitus" was published in JAMA in 2000 and had 231 quotations as a first-rate penalty, with the most quotes written by Vijan *et al.* This study deals with cost-benefit analysis in the context of type 2 diabetics checking for diabetic retinopathy. With a very high number of quotes, this study shows the importance of monitoring diabetic retinopathy in disease management. The second and third places, respectively,

are occupied by research that raises important issues in the pharmacoeconomy of diabetes. The study "Screening for Type 2 Diabetes Mellitus: A Cost-Effectiveness Analysis" by Hoerger in 2004, published in the Annals of Internal Medicine, discussed the cost-benefit analysis of type 2 diabetes screening. Meanwhile, Elixhauser's 1993 "Cost-benefit analysis of preconception care for women with established diabetes mellitus," published in Diabetes Care, reviewed the economic benefits of care provided to diabetic mothers before conception. Both studies reflect growing concern in exploring the value of different diabetes management techniques management and prevention, as well as describing the important role of pharmacoeconomics in guiding clinical decisions and policies related to diabetes mellitus.

By showing the conceptual and procedural framework built around a timeline that we can use in a variety of situations, the new study advances the previously mentioned research problem. The analysis examined publication trends, the most influential countries, publishers, and institutions, as well as the most significant publications. Based on the author and co-citation networks of the most significant articles, a bibliographical coupling network is also used in this study to look at how the researchers built upon one another's knowledge. A keyword co-occurrence network and overlay are also used to look at how knowledge has developed over time. The last few decades, pharmacoeconomic research on diabetes has focused on

the cost-benefit analysis of various treatment strategies. These studies help identify the most effective therapies for regulating blood sugar levels and limiting diabetic complications. It allows healthcare providers and policymakers to make better decisions about choosing appropriate care.

Technological developments have also played a crucial role in the pharmacoeconomic research on diabetes. The use of digital blood sugar monitors, continuous infusion insulin therapy, and more innovative drugs has been the focus of research. These studies attempt to measure the economic impact of the use of advanced technology in diabetes management, including initial costs, long-term savings, and clinical benefits. Pharmacoeconomic research is also increasingly highlighting issues related to diabetes treatment in specific population groups. This includes research on diabetes management in pregnant mothers with gestational diabetes, those suffering from severe renal dysfunction associated with diabetes, and patients with type 1 diabetes requiring intensive therapy.

Pharmacoeconomic research also receives growing attention in evaluating the cost-effectiveness of intervention programmes involving community pharmacists or public health services in diabetes management. This approach aims to increase patient understanding and support in managing their diabetes, with a positive impact on clinical and economic outcomes.

Table-1: Top 10 most cited documents on pharmacoeconomic for DM research (1978–2023)

Rank	Cites	Authors	Title	Source	Type	DOI
1	231	Vijan 2000 ⁴⁴	Cost-utility Analysis of screening intervals for diabetic retinopathy in patients with type 2 diabetes mellitus	JAMA	Article	10.1001/jama.283.7.889
2	141	Hoerger 2004 ⁴⁵	Screening for Type 2 Diabetes Mellitus: A Cost-Effectiveness Analysis	Annals of Internal Medicine	Article	10.7326/0003-4819-140-9-200405040-00008
3	82	Elixhauser 1993 ⁴⁶	Cost-benefit analysis of preconception care for women with established diabetes mellitus	Diabetes Care	Article	10.2337/diacare.16.8.1146
4	74	Starostina 1994 ⁴⁷	Effectiveness and cost-benefit analysis of intensive treatment and teaching programmes for Type 1 (insulin-dependent) diabetes mellitus in Moscow-blood glucose versus urine glucose self-monitoring	Diabetologia: Clinical and Experimental Diabetes and Metabolism	Article	10.1007/s001250050089
5	43	Davies 2012 ⁴⁸	Cost-utility analysis of liraglutide compared with sulphonylurea or sitagliptin, all as add-on to metformin monotherapy in Type2 diabetes mellitus	Diabetic Medicine	Article	10.1111/j.1464-5491.2011.03429.x
6	42	Plosker 2004 ⁴⁹	Repaglinide: A pharmacoeconomic review of its use in type 2 diabetes mellitus	PharmacoEconomics	Review	10.2165/00019053-200422060-00005
7	39	Foster 2000 ⁵⁰	Glipizide: A review of the pharmacoeconomic implications of the extended-release formulation in type 2 diabetes mellitus	PharmacoEconomics	Review	10.2165/00019053-200018030-00008
8	36	Nicholson 2005 ⁵¹	Screening for gestational diabetes mellitus: A decision and cost-effectiveness analysis of four screening strategies	Diabetes Care	Article	10.2337/diacare.28.6.1482
9	29	Poncet 2002 ⁵²	Cost-effectiveness analysis of gestational diabetes mellitus screening in France	European Journal of Obstetrics and Gynecology and Reproductive Biology	Article	10.1016/S0301-2115(02)00042-8
10	29	Shao 2017 ⁵³	Cost-effectiveness analysis of dapagliflozin versus glimepiride as monotherapy in a Chinese population with type 2 diabetes mellitus	Current Medical Research and Opinion	Article	10.1080/03007995.2016.1257978

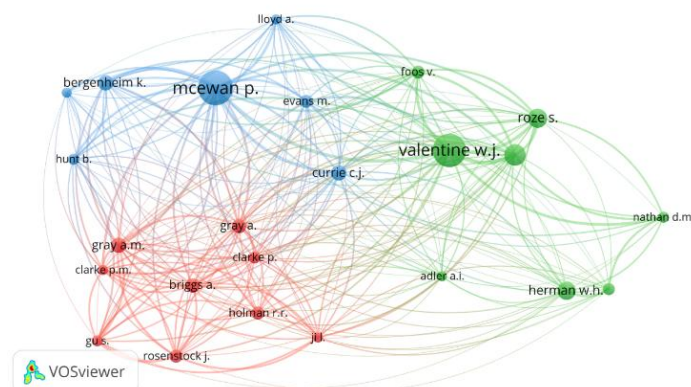


Figure-4: Co-citation network of cited references

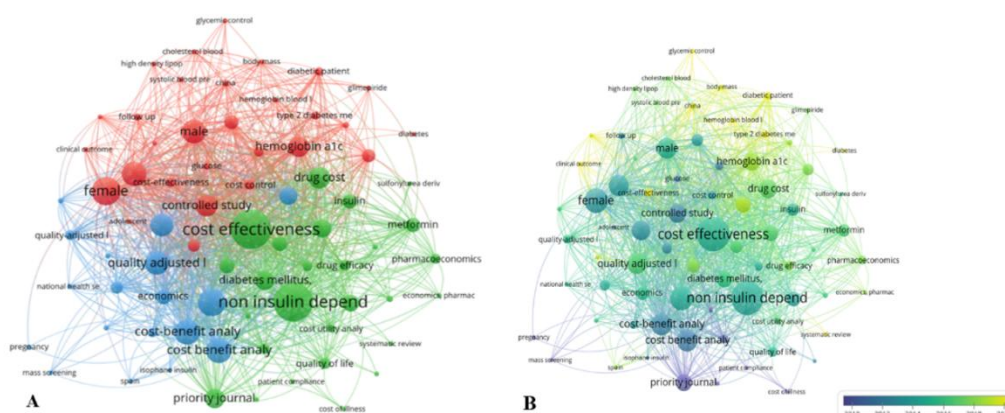


Figure-5: (A) keyword co-occurrence network, (B) keyword co-occurrence overlay with a timeline

CONCLUSION

These studies cover various aspects of diabetes management, from the cost-benefit analysis of therapies to the impact assessment of medical technology and public health care. The quantity of publications varied from 1978 to 2023. The analysis determined which nation was the most productive (United Kingdom), institution (Peking University, China), source (Diabetes Care; Pharmacoeconomics), and author (Vijan *et al.*, who are affiliated with the University of Michigan, Ann Arbor, US). Basic studies on the pharmacoeconomics of diabetes mellitus were displayed using data from the most prominent publications based on significant papers, co-citation networks, author-based bibliographical coupling networks, keyword co-occurrence networks, and overlays.

AUTHORS' CONTRIBUTIONS

M. Fiqri Zulpadly is responsible for the following tasks: conceptualization, methodology, formal analysis, data curation, writing the initial draught, writing the review and editing, and project management. Heru Sasongko: Supervision and

Composition. Dian Eka Ermawati: Evaluation, and Editing The final manuscript has been read by all authors and is their approval.

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