



Global Research Trends of Gut Microbiota in Gestational Diabetes Mellitus: A Bibliometric and Visualized Analysis

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ABSTRACT

Objective: Gestational Diabetes Mellitus (GDM) is a metabolic condition that imposes a great economic burden on the global scale and poses great risks to the health of both mothers and babies. Studies on the role of intestinal microbiota in diabetes are remarkable. This study aims to analyze the trends and basic components in studies investigating the relationship between diabetes and intestinal flora.

Methods: Publications on intestinal microbiota in GDM were obtained from the Web of Science Core Collection database (WoS) on February 14, 2024, covering the period from 2009, when the first study on this subject was conducted, to the present. RStudio (Biblioshiny) and VOSviewer (1.6.17) software were used in the bibliometric analysis. Editorial material, reviews, and letters were not included in the study.

Results: A total of 254 articles were obtained in this study. Although the number of publications has been increasing since 2017, the most studies on the subject were conducted in 2022 with 56 scientific articles. Endocrine metabolism is the field with the most publications. The most frequently used terms, as determined by the commonality analysis, are gut microbiota, obesity, and pregnancy.

Conclusions: This is the first bibliometric analysis on gut microbiota in GDM. Studies on gut microbiota in GDM have only been conducted in the last 16 years. Research on GDM and gut microbiota is increasing and attracting more and more attention from researchers. In the future, gut microbiota is expected to remain a central focus in diabetes research.

Keywords: Bibliometric study, gut microbiota, gestational diabetes mellitus

Gestasyonel Diyabet Mellitus'ta Bağırsak Mikrobiyotasının Küresel Araştırma Eğilimleri: Bibliyometrik ve Görselleştirilmiş Analiz

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ÖZET

Amaç: Gestasyonel Diyabet Mellitus (GDM), küresel anlamda büyük ekonomik yük getiren ve hem annelerin hem de bebeklerin sağlığında büyük riskler oluşturan metabolik bir durumdur. Bağırsak mikrobiyotasının diyabetteki rolü üzerine yapılan araştırmalar dikkat çekicidir. Bu çalışma, diyabetin bağırsak florasıyla bağlantısını araştıran araştırmalardaki eğilimleri ve temel bileşenleri analiz etmeyi amaçlamaktadır.

Metot: 14 Şubat 2024'te Web of Science Core Collection veritabanından (WoS) GDM'deki bağırsak mikrobiyotası üzerine yayınlar elde edilerek, bu konudaki ilk çalışmanın yapıldığı 2009 yılından günümüze kadar olan dönemi kapsamaktadır. Bibliyometrik analizde, RStudio (Biblioshiny) ve VOSviewer (1.6.17) yazılımları kullanıldı. Editöryal materyal, derlemeler, mektuplar çalışmaya dahil edilmemiştir.

Bulgular: Bu çalışmada toplam 254 makale elde edildi. Yayın sayısı 2017'den bu yana artış eğilimi gösterse de, konuyla ilgili en fazla çalışma 2022'de 56 bilimsel makale ile yapılmıştır. Endokrin metabolizması en fazla yayın yapan alandır. Ortak varlık analiziyle belirlendiği üzere en sık kullanılan terimler bağırsak mikrobiyotası, obezite ve gebeliktir.

Sonuçlar: Bu, GDM'de bağırsak mikrobiyotası üzerine yapılan ilk bibliyometrik analizdir. GDM'de bağırsak mikrobiyotası üzerine çalışmalar yalnızca son 16 yıldır yürütülmektedir. GDM ve bağırsak mikrobiyotası üzerine yapılan araştırmalar artışta olup araştırmacıların giderek daha fazla ilgisini çekmektedir. İleriye bakıldığında, bağırsak mikrobiyotasının diyabet araştırmaları alanında merkezi bir odak olmaya devam edeceği açıktır.

Anahtar Kelimeler: bibliometric analiz, bağırsak mikrobiyotası, Gestasyonel diyabet

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Introduction

Gestational diabetes mellitus (GDM) is the term for a glucose intolerance that is not noticeable before pregnancy and is identified during the second or third trimester of pregnancy¹. It is an especially prevalent metabolic condition affecting women during pregnancy². Also, approximately 20 million infants are affected by GDM, which is on the rise worldwide and particularly so in low- and middle-income nations³. GDM is linked to poor outcomes for both mothers and infants. After giving birth, mothers with GDM are prone to experience long-term hyperglycaemia or type 2 diabetes⁴. Additionally, preeclampsia, prenatal hypertension, and additional cardiovascular disorders during pregnancy are linked to GDM co-morbidities⁵. It is widely believed that the pathophysiological foundation of GDM arises from an aberrant up-regulation of insulin release in relation to the degree of enhanced insulin resistance that is inherent to pregnancy. Multi-endocrine and neurological pathways combine to regulate glucose, leading to a complicated process⁶. It is commonly recognized that gut dysbiosis affects women who have gestational diabetes mellitus (GDM)⁷. Against this backdrop, we will examine the research on the association between gut microbiota and GDM.

'Gut microbiota' refers to beneficial microbial populations that have colonized the gastrointestinal (GI) system. The gut microbiota is more prevalent in the distal colon, in particular⁸. The creation of short-chain fatty acids, vitamin synthesis, mucosal barrier function, and food digestion are all supported by the gut microorganisms⁹. Crucially, the gut microbiota's relations with host cells regulate immunological response and host metabolism¹⁰. Furthermore, a growing body of research suggests that the host's native gut microbiota influences intestinal permeability and could be involved in the emergence of a long-lasting, low-grade inflammatory state that aids in the appearance of chronic metabolic disorders¹¹. A population imbalance in the gut microbiota, characterized by a rise in pathogenic bacteria and a reduction in beneficial flora, can lead to a number of underlying health conditions, including neurological disorders, allergy diseases, metabolic syndrome, and some kinds of cancer¹². The connection among microbiota in the intestine, gut dysbiosis, inflammation, obesity, and resistance to insulin during gestation was initially noted by Koren et al¹³.

In recent years, research on the relationship between gut microbiota and GDM has gained popularity. In the past, the only methods available for evaluating the gut microbiota for this purpose were bacteriological culture techniques. However, in more recent times, a variety of sophisticated approaches have started to be employed. These days, the methods that clinicians use include bacterial culture, temperature gradient gel electrophoresis, denaturing gradient gel electrophoresis, fluorescence in situ hybridization, DNA microarrays, terminal restriction fragment length polymorphism, microbiome shotgun sequencing, and cloned 16S rRNA gene sequencing for the direct sequencing of 16S rRNA amplicons¹⁴. Furthermore, the ELISA technique is used to measure the concentrations of different biomolecules that influence intestinal permeability and upset the balance of microbiota¹⁵.

Bibliometric analyses are statistical techniques for conducting quantitative investigations using a general literature database¹⁶. By making predictions about the future frontiers and creating an information map, they may be used to illustrate

how a particular knowledge subject has evolved¹⁷. The literature contains bibliometric analyses of GDM. Nevertheless, there are not any research that particularly look at the gut microbiota in GDM in these types of analyses. The bibliometric study we are now undertaking will contribute the first information to the literature in this regard.

Methods

Data Sources and Search Strategy

The present investigation used a bibliometric analyse approach to examine papers published in the Web of Science (WoS) database on gut microbiota in GDM patients. This study's data was collected from the sub-database of the Science Citation Index Expanded (SCI-E), Emerging Sources Citation Index (ESCI) and Social Science Citation Index (SSCI) sourced from the Web of Science Core Collection (WoS) database on 14.02.2024. The search technique included the search query '(TS=(gestational diabetes mellitus) AND TS=(gut microbiota)', and a Boolean search was conducted. A total of 247 publications were found, but when the exclusion criteria were applied, 243 publications that comprised the study were discovered. The data were examined using Vosviewer (1.6.17) software and RStudio (Biblioshiny)¹⁸.

Inclusion Criteria

The data evaluation was undertaken to span the time frame from 2009, that the first research published in this subject, until now in order to attain a holistic interpretation incorporating keywords, titles, and abstracts. The language of publishing was not differentiated, and only "articles," "reviews," and "early presence" research were chosen.

Exclusion Criteria

The analysis of data was carried out by excluding publications from the research, including proceeding paper, letters, corrections, and editorial materials.

Data Statistics and Indicators

Bibliometric mapping is a visual presentation of scientific literature based on quantitative bibliometric data¹⁹. We used the VOSviewer program, developed by Van Eck and Waltman at the Centre for Science and Technology Research at Leiden University, to construct bibliometric networks to determine the relationships of keywords, authors, institutions and documents. Using Microsoft Excel 2020, the pattern of publication numbers by year was investigated. Diverse nodes in the network graph stand in for diverse factors, including authors, countries, and institutions. The larger the circles, the more frequently publications there are; the circles represent the frequency or quantity of publications. The centrality of a node indicates its location in the knowledge network as well as its effect on other nodes. A high centrality index increases the likelihood that key nodes will form in the network^{20,21}.

Results

Database Overview

Descriptive analyses were conducted utilizing Biblioshiny. The primary data insights are depicted in Figure 1.



Figure 1. Main information

A comprehensive analysis of the study of gut microbiota in GDM encompassed 254 publications from 144 distinct sources (including journals, books, etc.) between 2009 and 2024, sourced from the Web of Science (WoS) database. The rate of publication growth stands at 12.69% annually, with an average document age of 3.66 years. On average, each document receives 27.5 citations. Among the 1288 authors, only 6 have published as single authors. Regarding author collaboration in documents, the prevalence of international co-authorship stands at 18.11%.

The Annual Publication Distribution Map Index

Figure 2 illustrates the temporal evolution of document growth in the bibliometric analysis of studies concerning gut microbiota in GDM and an increasing global scientific research interest in.

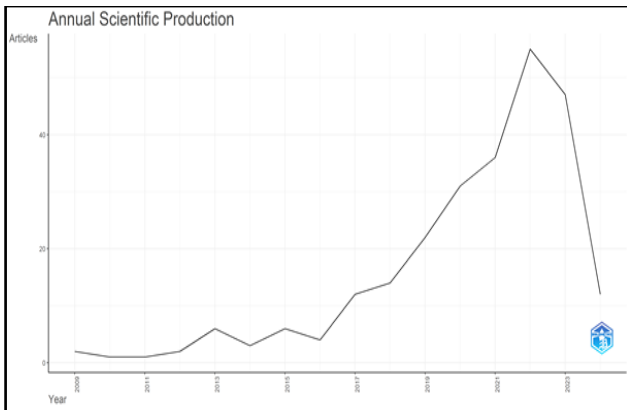


Figure 2. The annual number of published papers

The publication volume has shown an upward trajectory over the years, with 56 papers already published in 2022, 43 in 2023, 38 in 2021, 30 in 2020, 22 in 2019. Notably, the year 2022 experienced the most pronounced surge in gut microbiota in GDM research.

The distribution of research articles on the intestinal microbiota in GDM patients scanned in SCI-E, ESCI and SSCI published in WoS between 2009 and 2024 and their numbers sorted according to the index type they were scanned are shown in Figure 3. There have been 232 SCI-E, 11 ESCI, and 9 SSCI papers published thus far.

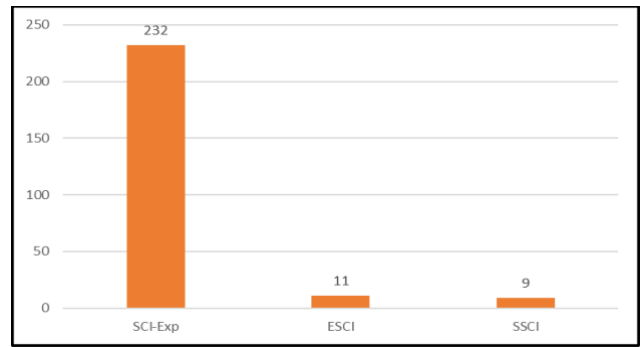


Figure 3. Number of indexes in which publications are scanned

Status of Average Annual Citations

The bibliometric analysis of studies focusing on gut microbiota in GDM included an examination of annual citation trends, as depicted in Figure 4.

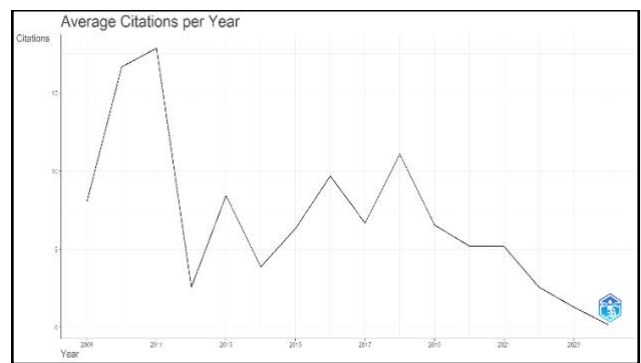


Figure 4. The average citations per year

According to Figure 4, there are differences in the number of citations made by year. While 2011 was the year with the highest number of citations on average, this average tended to decrease as the years progressed.

Sankey Diagram

In the diagram referred to as the "Three-Axis Graph," three parameters (journal, author, and country) have been configured within the program for correlation, and the top performers for each parameter are provided in Figure 5.

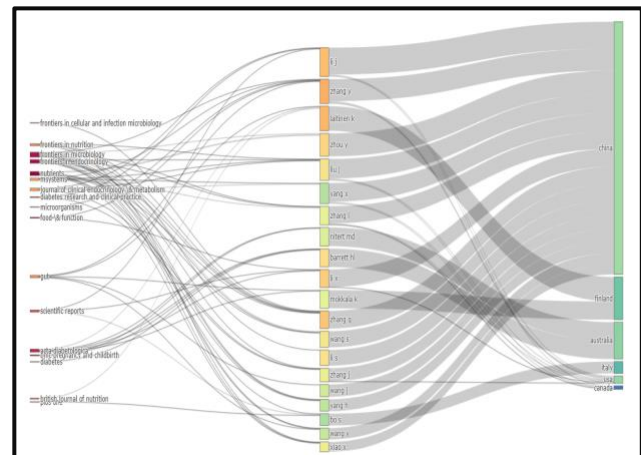


Figure 5. The Sankey diagram for the journal, author and country

In Figure 5, the magnitude of the relationship between parameters is represented by the size of the tiles. The size of the boxes in this diagram signifies the prominence of parameters in

Distribution of Country and Country Based Citation Relationship

In this research area, the most productive countries in Table 1 and the relationship map between the countries in Figure 6 are extracted from the RStudio software. Because there are 42 nations in this category, only the top ten countries in terms of number of publications are considered.

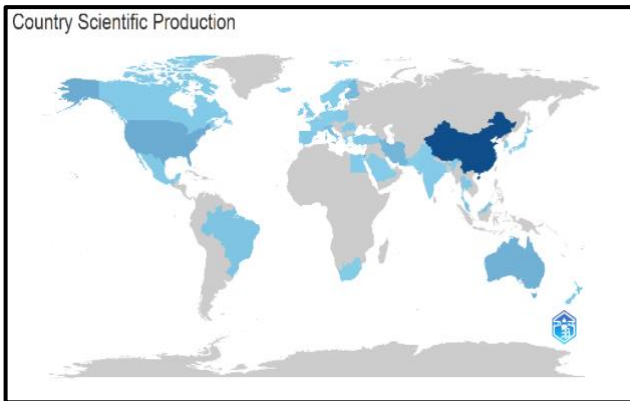


Figure 6. Country scientific production.

On the map, the colours navy blue, blue and grey mean the country that broadcasts the most, the country that broadcasts less and the country that does not broadcast, respectively.

Table 1. Most productive countries

Country	Article	Total Citation
CHINA	513	1779
USA	129	896
AUSTRALIA	108	690
IRAN	93	410
ISRAEL	82	96
FINLAND	77	777
DENMARK	68	333
ITALY	62	362
MALAYSIA	48	112
BRAZIL	40	226

the literature. Notably, the foremost journal is "Frontiers in Microbiology," helmed by leading author "Zhang Y.," with China emerging as the leading country in the field.

The ten countries that collaborate the most by several documents are shown in Table 2. The world cooperation map for these values are shown in Figure 7.

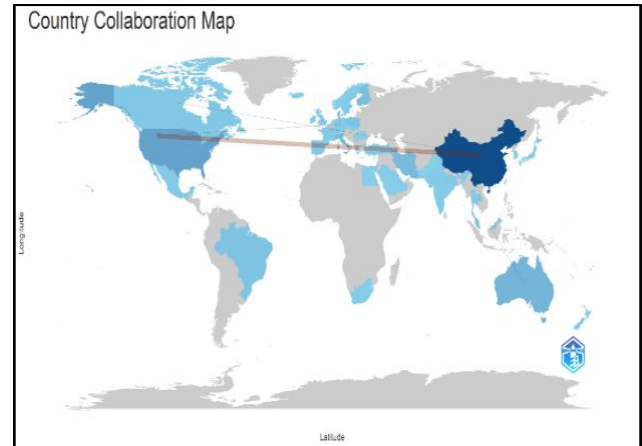


Figure 7. Country based collaboration map

China-USA ranks first with 10 documents among the countries with the most cooperation

Table 2. Number of documents from the 10 most cooperating countries.

From	To	Frequency
CHINA	USA	10
AUSTRALIA	MALAYSIA	2
CHINA	CANADA	2
CHINA	SINGAPORE	2
DENMARK	GERMANY	2
USA	GERMANY	2
AUSTRALIA	NEW ZEALAND	1
AUSTRALIA	SWEDEN	1
AUSTRALIA	UNITED KINGDOM	1
BRAZIL	FRANCE	1

Most Published Authors Institutions and Their Collaborations

According to the data in figure 8, the Chinese Academy of Medicine and the University of Turku in Finland are the two universities where scientists who produce the most academic publications on the gut microbiota in patients with GDM work or are funded (11 papers). In second place are Nanjing Medical University, Peking Union Medical College, Peking University and University of Queensland (10 studies). In third place is Royal Brisbane Women's Hospital with 9 studies.

Most Cited Document and Author Citation Relationship

The most cited document refers to the research article/paper that has accumulated the highest number of total citations from other scholarly works. In other words, it's the paper that has been referenced the most by other researchers and accordingly received the highest cumulative

number of citations. The ten most cited documents are presented in Table 3.

Citation relationship based on the author are analysed in Figure 9, and "Effects and Mechanisms of Probiotics, Prebiotics, Synbiotics, and Postbiotics on Metabolic Diseases Targeting Gut Microbiota: A Narrative Review" published by Li, Zhu, Gan et al. in 2021²², and Hasain, Mokhtar Kamaruddin et al.'s 2020 work "Gut Microbiota and Gestational Diabetes Mellitus: A Review of Host-Hut Microbiota Interactions and Their Therapeutic Potential"²³ had the most cited publications with 89 citations. The paper "Diet-Gut Microbiota Interactions and Gestational Diabetes Mellitus (GDM)" published by Ponzo, Fedele, Goitre et al.²⁴ in 2019 comes in second with 73 citations. Liu, Pan, Lv et al.'s 2019 paper "Alterations of Gut Microbiota and Blood Lipidome in Gestational Diabetes Mellitus with Hyperlipidaemia"²⁵ has 64 citations and is the third most cited study.

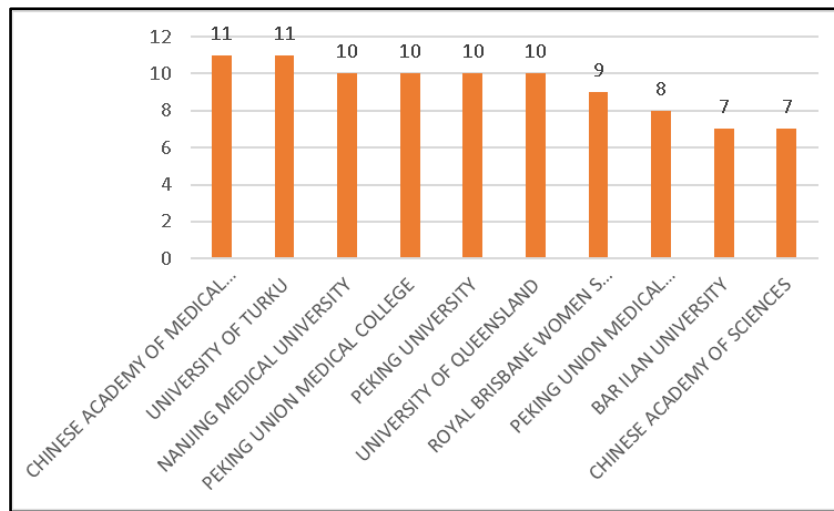


Figure 8. Institutions of the most published authors

Table 3. Most cited documents

Paper	DOI	TC	TC per Year	Normalized TC
Catalano Pm, 2011, Am J Obstet Gynecol	10.1016/j.ajog.2010.11.039	250	17,86	1,00
Luoto R, 2010, Br J Nutr	10.1017/S0007114509993898	250	16,67	1,00
Crusell Mkw, 2018, Microbiome	10.1186/s40168-018-0472-x	246	35,14	3,17
Wang J, 2018, Gut	10.1136/gutjnl-2018-315988	246	35,14	3,17
Laitinen K, 2009, Br J Nutr	10.1017/S0007114508111461	243	15,19	1,88
Cho Ce, 2013, Am J Obstet Gynecol	10.1016/j.ajog.2012.08.009	208	17,33	2,05
Gomez-Arango Lf, 2016, Diabetes	10.2337/db16-0278	191	21,22	2,19
Hu J, 2013, Plos One	10.1371/journal.pone.0078257	172	14,33	1,70
Wesolowski Sr, 2017, Nat Rev Gastro. Hepatol	10.1038/nrgastro.2016.160	142	17,75	2,66
Ferrocino I, 2018, Sci Rep	10.1038/s41598-018-30735-9	139	19,86	1,79

(TC: total citations)

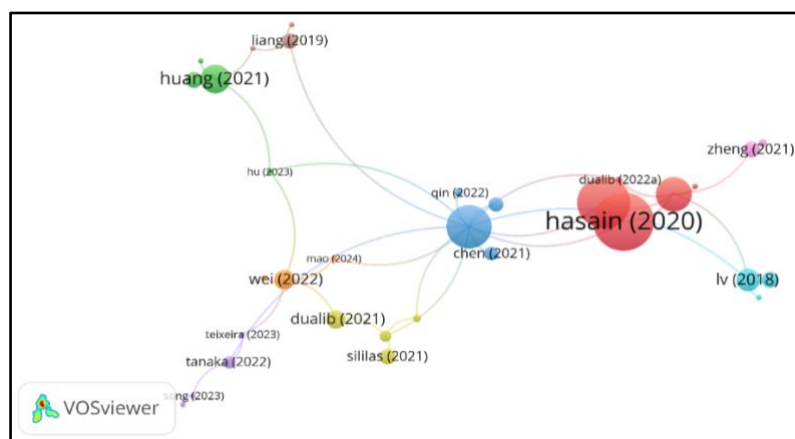


Figure 9. Citation relationship based on the author

Most Cited Local Sources

Examining the most cited local sources that publish research on gut microbiota in patients with GDM reveals that, that Diabetes Care has the highest number of citations (587) followed by Plos One (516), Nutrients (439), Nature (417), and SCI Re-UK (363) (Figure 10).

Sources Dynamics

If the dynamics of the resources are examined over the years, 'Scientific Reports' and 'Nutrients' started to conduct the first studies on this subject for the first time in 2009, and the number of studies started to increase as of 2017 and peaked with the beginning of 2024 (Figure 11).

Academic Research Categories

When academic articles published in WOS are classified into research fields, the top five are Endocrinology Metabolism, Nutrition Dietetics, Microbiology, Gynaecology, and Biochemistry-Molecular Biology (Table 4).

Trend Topics

Trending topics about the gut microbiota in GDM, literature from 2009 to 2024 by year are given in Table 5.

During the first quarter of 2017, second quarter of 2020, and third quarter of 2022, the dominant trending theme was "gut microbiota." Then, the trend topic "pregnancy" came to the fore in the first quarter of 2020, the second quarter of 2021 and the last quarter of 2022. "Gut microbiota", "pregnancy" and "obesity" continue to be the most talked about topics in this field. The developed keyword TreeMap is shown in Figure 12.

Common Presence Analysis

Using the VOSviewer software, the technique of "Common presence analysis" has been employed to incorporate keywords with distinct colours corresponding to the publication year (Figure 13). The colours of items are based on the duration elapsed since their publication. The average (yellow) publication year for recently introduced terms is 2023 for the analysis performed in this paper. Figure 13 illustrates the timeframe spanning from 2020 to 2023, represented by the progression of blue-green-yellow colours.

While terms such as "gut microbiome", "16 rRNA sequencing", "neonate", problems", and "oral microbiota" were most commonly used in 2020 and 2021, "gestational diabetes mellitus", "pregnancy", "obesity", "probiotics" had become popular as of the second half of 2021. After 2023, the keywords "hormone metabolism," "metabolic biomarker," and "behaviour change techniques" began to appear often in academic publications.

Thematic Analysis

Using author-defined keywords, a thematic investigation of gut microbiota in GDM publications was undertaken, employing bibliometric methods. The network representation in Figure 14 reveals a bifurcation of gut microbiota in GDM studies into four thematic clusters.

These encompass investigations concerning "gestational diabetes" within the overarching or fundamental theme of literature, and examinations of "intestinal microbiome" within a more specific domain.

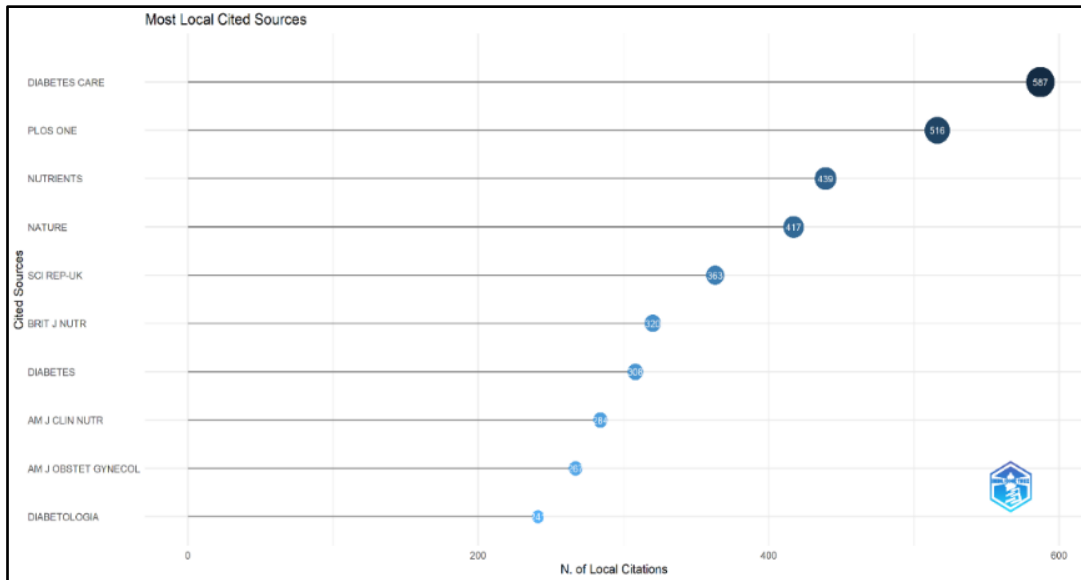


Figure 10. Most local cited sources

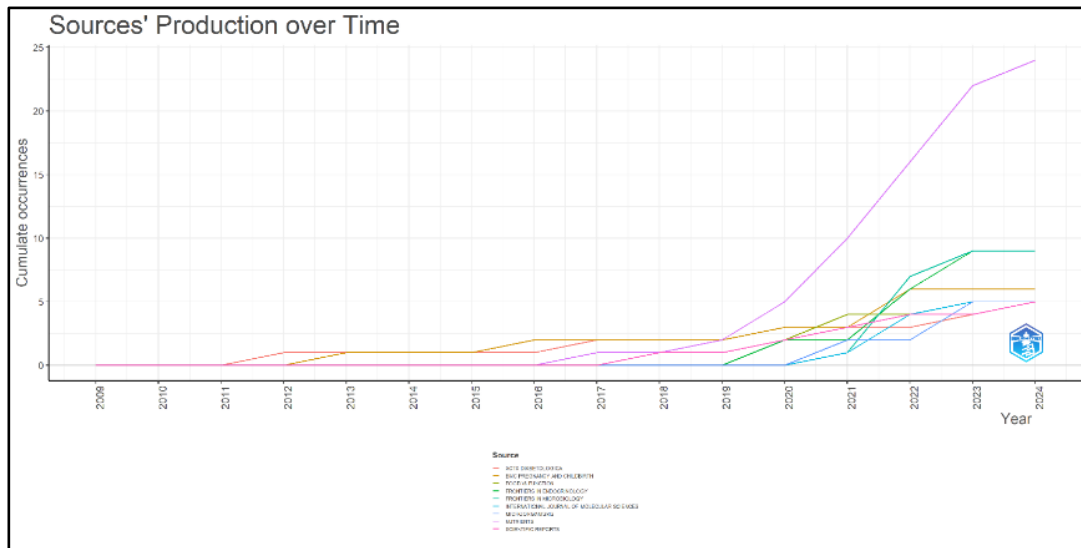


Figure 11. Sources' production over time

Table 4. The number of papers published by academic categories

Research categories	Number of papers
Endocrinology Metabolism	52
Nutrition Dietetics	44
Microbiology	34
Obstetrics and Gynaecology	24
Biochemistry and Molecular Biology	21
Food Science Technology	12
Research Experimental Medicine	12
General Internal Medicine	11
Chemistry	9
Science Technology Other Topics	9

Table 5: Trending topics by year

item	freq	year_q1	year_med	year_q3
pregnant-women	17	2018	2019	2022
oxidative stress	13	2018	2019	2022
birth-weight	6	2018	2019	2020
gut microbiota	86	2017	2020	2022
obesity	63	2018	2020	2022
gestational diabetes-mellitus	34	2018	2020	2023
pregnancy	71	2020	2021	2022
double-blind	50	2018	2021	2022
association	35	2019	2021	2022
risk	37	2019	2022	2023

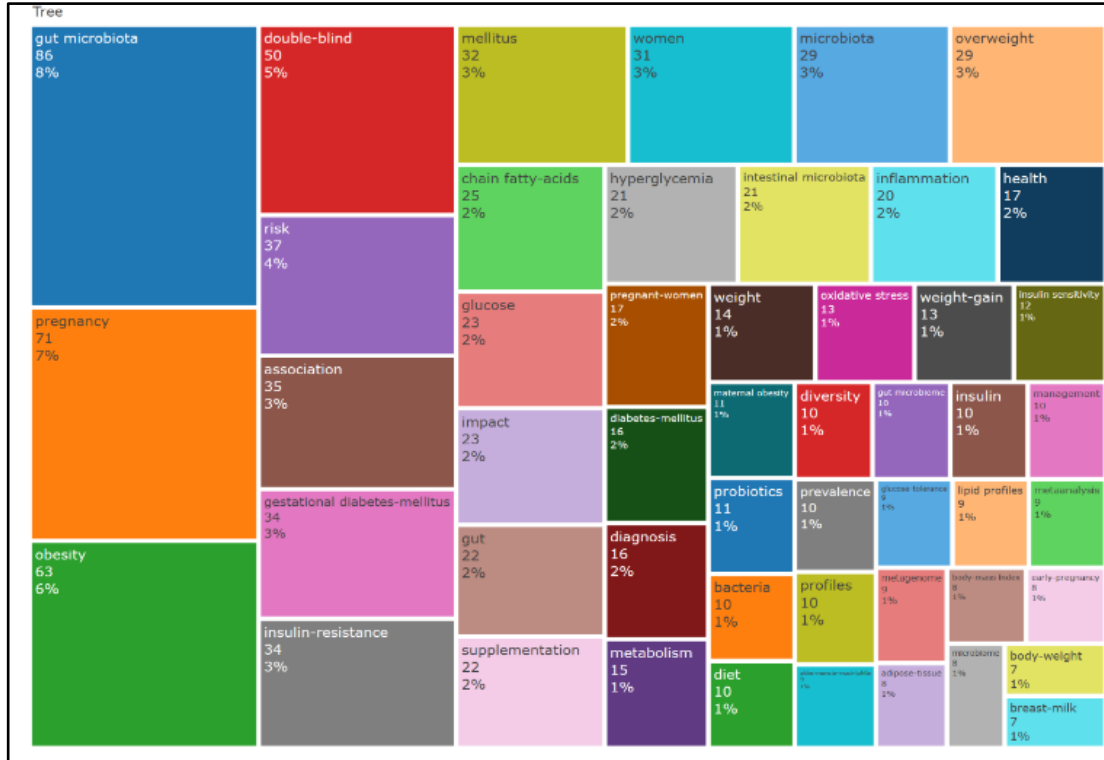


Figure 12. TreeMap of keywords

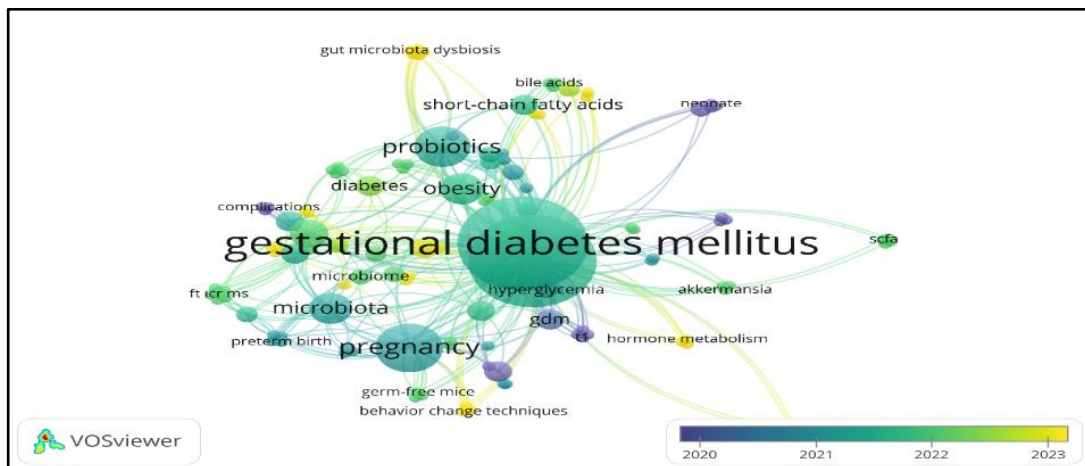


Figure 13. Common asset analysis

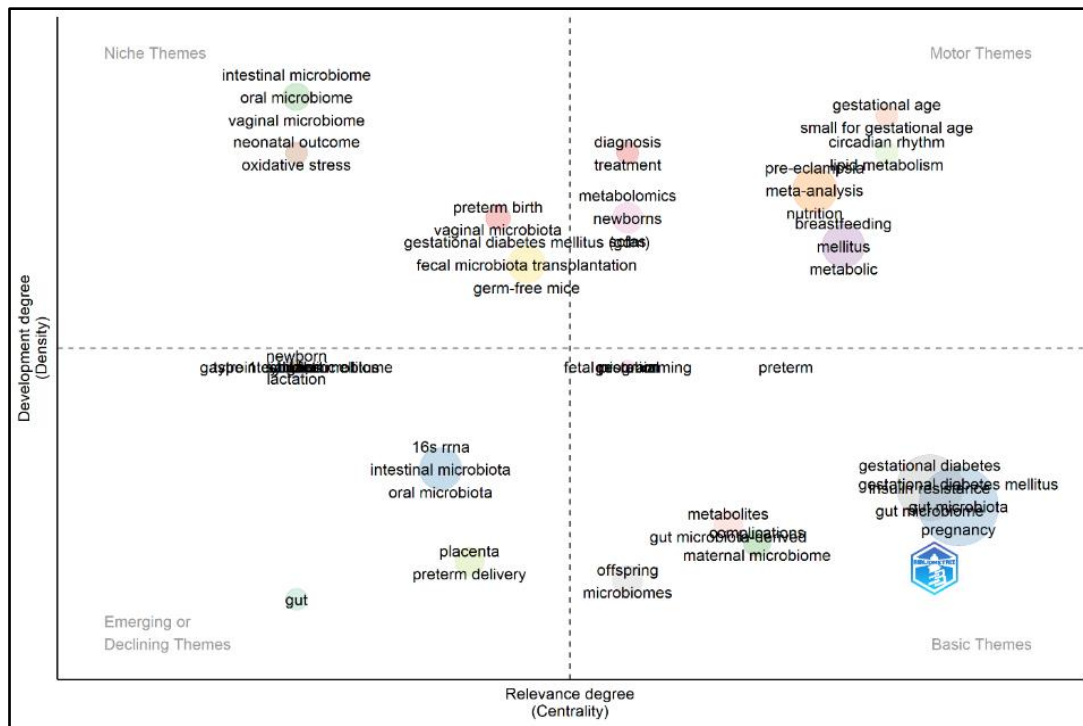


Figure 14. Thematic analysis based on keywords.

Discussion

As the volume of scientific literature is increasing rapidly, researchers resort to bibliometric analysis tools to identify trends in research areas, identify keywords, and understand interdisciplinary relationships. The current bibliometric analysis research is one of the first in the literature to investigate the gut microbiota in GDM. This study, which aims to systematically examine studies on gut microbiota in patients diagnosed with GDM, looked at various topics such as author profile, co-citation status, research areas of the examined publications, journals in which the studies were published, and the results were presented. Our findings indicate that GDM and gut microbiota is a rapidly expanding topic with huge promise. There is no question that this study topic represents a significant step into the future, and we are confident that GDM and gut microbiota will keep evolving. The trend is likely to raise worldwide consciousness of GDM and gut microbiota.

The examination of the quantity of publications and citations indicates that this topic of study was identified fifteen years ago, and since 2017, it has been receiving increased attention. We discovered that in the upcoming years, it will become more significant. Additionally, it has a high significance, which suggests that nations and areas with strong publication opportunity share research. The top 10 nations are divided among three Asian countries, three North and South American countries, three European countries, and the remaining two European countries. China tops the list of the ten most successful institutions, with six, followed by Australia in second place with three institutions. It is clear that, the dominance of Chinese research in this field may be attributed to increased funding opportunities, advanced research infrastructure, and government policies prioritizing scientific innovation in public health domains.

Chinese and Malaysian writers share the top spot with 89 citations between the most cited authors based on the high impact and high citation connection, and Italian authors coming in second. China is generally seen as a pioneer in the research on the gut microbiota in GDM.

Ultimately, although the first studies on this topic was mostly keyword-focused on "probiotics" and "obesity" until 2020, it began to focus genetic research on "16rRNA sequencing" between 2020 and 2023. By of 2023, the GDM gut microbiota has grown more cognizant of pathophysiological and metabolic issues by exploring hormone metabolism, its association with metabolic biomarkers, and markers for habit change.

Furthermore, we expect more thorough and excellent works with various approaches to studying the gut microbiota to be published in this subject in the upcoming years.

Conclusion

The creation of a bibliometric study can contribute to this situation, because this sort of research allows finding and evaluating the current literature in an academic field, measuring its influence, accessibility, trends, and cooperation in the scientific community. More high-quality research on GDM and gut microbiota requires improved collaboration across nations with diverse economies.

Strengths and Limitations

We believe that our work represents the first bibliometric analysis of the knowledge domain and recent research trends on gut microbiota and GDM. We also partially recognized potential research trends, hotspots, and borders in this field of study. As with all academic studies, this study also has a limitation. Foremost, we included only SCI-E, ESCI, and SSCI

from the WoS database in our investigation, which may have resulted in the exclusion of additional high-quality literature in databases in this field. To address this limitation, future studies should consider integrating alternative databases and exploring grey literature to encompass a broader spectrum of research. Differentiating the keywords to be used in subsequent projects, databases, reviewing the diversity and different data types of the index will contribute to its comprehensive expansion and generalization.

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