

Original Article

Finding the new potential research on diabetic kidney disease and hemodialysis in healthcare insurance databases: A bibliometric analysis

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Abstract

To the best of our knowledge, bibliometric analysis has not been performed for studies related to diabetic kidney disease (DKD) and hemodialysis using healthcare big data. Herein, the aim of this bibliometric analysis was to identify emerging research trends in DKD and hemodialysis within healthcare insurance databases by exploring authors, co-author networks, and countries to discover new potential research areas. A bibliometric study was conducted, utilizing data obtained from the Scopus database. Keywords such as diabetic kidney disease, hemodialysis, insurance or big data, and prediction were employed. Inclusion criteria were original articles and review articles written in English published between 2010 and 2022. VOSviewer and the Bibliometrix package in R were used for comprehensive bibliometric analysis. VOSviewer facilitated keyword co-occurrence analysis to identify clusters and visualize relationships among keywords, emphasizing distinct research themes, keyword density, and network visualization. Meanwhile, Bibliometrix allowed exploration of key metrics such as prolific authors and institutions, publication trends, co-authorship networks, citations, document types, emerging trends through keyword analysis, and network visualizations, including co-authorship and keyword co-occurrence. Results from both tools were integrated for a thorough analysis. The present study yielded 2,199 articles, which was reduced to 1,828 after removing duplicates and applying inclusion criteria. This bibliometric analysis found that machine learning and artificial intelligence are emerging yet remain relatively under-researched in the context of hemodialysis and DKD. The prominence of topics such as diabetic nephropathy, non-insulin treatments, and lifestyle modifications highlighted ongoing research priorities in DKD and hemodialysis. Taiwan's dominance in publications suggested robust research activity in this field, while international collaboration underscored global interest and the potential for diverse research perspectives. The need for similar research development in Indonesia, leveraging big data and machine learning, indicates opportunities for advancing the understanding and management of DKD and hemodialysis within the region.

Keywords: Diabetic kidney disease, bibliometric, hemodialysis, health insurance, machine learning

Introduction

Diabetic kidney disease (DKD), also known as diabetic nephropathy, is a crucial convergence of diabetes mellitus and end-stage renal disease (ESRD) [1]. The global rise in diabetes necessitates



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comprehensive management strategies, as DKD affects 20–40% of diabetic patients and is the leading cause of end-stage renal disease that often requires life-sustaining therapies such as hemodialysis [2,3]. Given the critical importance of access and coverage, understanding DKD and hemodialysis research within healthcare insurance databases is crucial for evidence-based policy-making and optimized healthcare delivery [4].

DKD disproportionately affects minorities and those with low socioeconomic and educational status [5]. Effective DKD management is hindered by insufficient knowledge among patients and providers, delayed nephrologist referrals, low healthcare literacy, and inadequate access to treatment and insurance [6]. Research on DKD and its consequences, particularly in the context of hemodialysis, is crucial due to its significant impact on patient health and healthcare system sustainability, as DKD poses both clinical and economic challenges [7].

Essential for ESRD patients, hemodialysis raises resource utilization concerns [8]. In 2008, in the United States of America (USA), Medicare and Medicaid covered \$26.8 billion in annual medical costs for dialysis patients, accounting for 5.9% of total population costs, with a 13.2% annual increase rate [9]. Hence, integrating research on DKD, hemodialysis, and healthcare insurance databases is therefore imperative [10]. Furthermore, regions with smaller populations can obscure factors contributing to increased DKD incidence, potentially due to reduced access to healthcare, lower service utilization, or a shortage of qualified personnel [11].

Healthcare insurance databases are crucial for assessing intervention effectiveness, care quality, and decision-making, providing unique insights into real-world clinical practices, outcomes, and health economics, especially in the context of DKD and hemodialysis [12,13]. The Truven Health MarketScan Research Databases study renal disease and health outcomes in large populations [14]. The Medicare End Stage Renal Disease Program provides tailored national health insurance for ESRD patients [15]. The Korean National Health Insurance Database investigates vascular access outcomes in hemodialysis, offering insights into treatment effectiveness [16-17]. Together, these resources advance research, policy, and healthcare for chronic kidney disease, enhancing patient outcomes [13-16].

Recent bibliometric studies have examined diabetes therapeutic potential in functional foods [18], concurrent chronic kidney disease (CKD) with progressive kidney function loss and frailty [13-19], DKD [15], and renal failure in general [20]. To the best of our knowledge, bibliometric analysis has not been performed for studies related to DKD and hemodialysis using healthcare big data. Bibliometric analysis is beneficial for identifying research evolution, publication distribution, author collaboration, and research influence in domains, revealing gaps and areas for further investigation [21]. Herein, the aim of this bibliometric analysis was to identify the emerging research trends in DKD and hemodialysis within healthcare insurance databases by exploring authors, co-author networks, and countries to discover new potential research areas. By examining existing literature, identifying themes, study designs, and trends, the aim was to inform healthcare policy and clinical practice, illuminate the research landscape, and guide evidence-based interventions to enhance care quality for affected patients.

Methods

Study design and search strategy

A bibliometric study was conducted, utilizing data obtained from the Scopus database. The search covered studies between 2010 and 2022, employing keywords such as diabetic kidney disease, hemodialysis, insurance or big data, and prediction. Boolean operators 'AND/OR' were utilized. The search strategy employed was as follows: (ALL ("diabetic kidney disease" OR "diabetic nephropathy" OR "diabetic renal disease" OR "diabetic renal failure" OR "diabetic renal insufficiency" OR hemodialysis) AND ALL (insurance OR bigdata OR "big data" AND ALL (prediction OR estimation)) AND PUBYEAR > 2009 AND PUBYEAR < 2023 AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re"))). Inclusion criteria were original and review articles written in English published between 2010 and 2022. Initial data cleaning was conducted to remove duplicate entries and missing important information to ensure data accuracy and consistency. All key information from each publication

was identified and collected, including title, authors, year of publication, source, keywords, abstract, and citations.

Data analysis and visualization

VOSviewer (Centre for Science and Technology Studies, Leiden University, The Netherlands) was employed for keyword co-occurrence analysis to identify clusters of related keywords and to visualize their relationships, highlighting: (1) distinct research themes; (2) keyword density in clusters to show the concentration of related terms; and (3) network visualization showing keyword co-occurrence with the nodes represented keywords and the edges depicted co-occurrence relationships. Bibliometrix package in R (K-Synth Srl, Academic Spin-Off of the University of Naples Federico II, Italy) was employed for comprehensive bibliometric analysis, allowing to explore key metrics: (1) identifying prolific authors and institutions; (2) analyzing publication trends; (3) visualizing co-authorship networks; (4) assessing citations and impact; (5) categorizing document types; (6) identifying emerging trends through keyword frequency analysis; and (7) visualizing networks such as co-authorship and keyword co-occurrence. Results from both VOSviewer and Bibliometrix packages were integrated to offer a thorough analysis.

Results

Characteristic of studies

The searches retrieved a total of 2,199 articles. After excluding other document types, the study yielded 1,895 articles consisting of only original articles and review articles. Additionally, non-English language papers were excluded, resulting in 1,846 articles. After removing duplicates and documents with missing information, the total was reduced to 1,828 articles.

Research on DKD and hemodialysis using health insurance databases has shown significant annual growth averaging 25.75% over recent decades. This increase underscores the importance of addressing complexities in diabetes-related kidney complications and renal replacement therapies. Each article in the dataset averages 68.25 citations, indicating significant publication impact and scholarly attention. The average document age is 4.16 years, highlighting recent research focus on current developments. The annual publication count in the bibliometric analysis of DKD, hemodialysis, and big data/health insurance databases, illustrating a growing trend of documents on DKD and hemodialysis within healthcare insurance databases over time, is displayed in **Figure 1**.

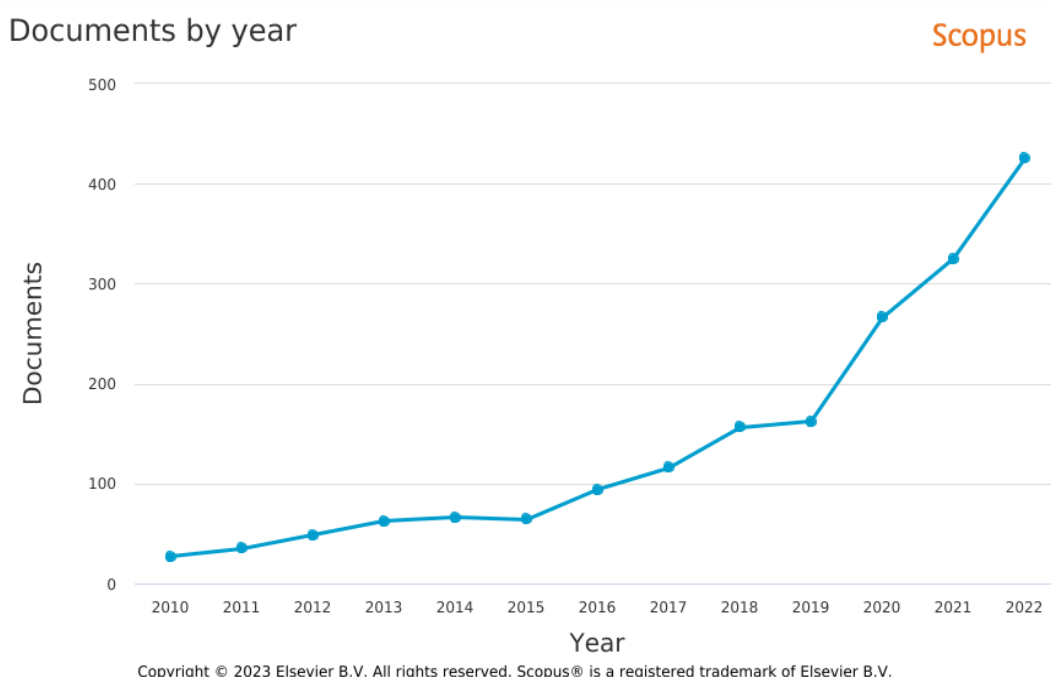


Figure 1. Document growth number in bibliometric analysis of diabetic kidney disease (DKD) and hemodialysis concerning healthcare insurance databases over the years.

Emerging research themes and innovative approaches

Metformin, malnutrition, and convolutional neural networks are the top three trending topics in 2022 (**Table 1** and **Figure 2**). From 2020 to 2022, machine learning and artificial intelligence remain prominent and are expected to grow further. Despite extensive research on diabetes mellitus, it remains a significant topic due to its relevance to human development and lifestyle. Therefore, CKD could potentially resurface as a linked issue with diabetes mellitus, similar to the ongoing developments in kidney failure (320 articles) and chronic conditions (412 articles) over the past twelve years. The present bibliometric analysis identified emerging research themes in DKD and hemodialysis, featuring innovative methods and study designs. These include machine learning and artificial intelligence, lifestyle and social modifications, body mass index (BMI) control, smoking, health behavior, cost-benefit analysis, and malnutrition. Taiwan emerged prominently with 335 articles in this domain.

The topic density and recency over four years are depicted in **Figure 3**. Topics existing since 2017 were marked in dark blue, with newer topics fading from dark blue to yellow circles indicating recency. The circle size denotes topic frequency; smaller circles indicate lower density. Machine learning, learning systems, and hemodialysis are newer low-density topics (small, yellow circles) introduced in 2020. Topics such as diabetic nephropathy and non-insulin diabetes appeared in 2019 (light green circle). The figure highlights Taiwan as the sole country researching DKD and hemodialysis (dark blue circles), suggesting opportunities for similar research in Indonesia.

Table 1. Trending terms in the bibliometric analysis of diabetic kidney disease (DKD) and hemodialysis using healthcare insurance databases over time

Terms	n	Year (Q1)	Year (Medium)	Year (Q3)
Metformin	33	2018	2022	2022
Malnutrition	30	2016	2022	2022
Convolutional neural network	23	2020	2022	2022
Machine learning	316	2020	2021	2022
Artificial intelligence	147	2020	2021	2022
Body mass	136	2018	2021	2022
Human	1,534	2017	2020	2021
Diabetes mellitus	580	2017	2020	2022
Controlled study	516	2017	2020	2021
Female	1,480	2016	2019	2021
Male	1,479	2016	2019	2021
Humans	1,166	2016	2019	2021
Aged	1,255	2016	2018	2020
Chronic	412	2015	2018	2021
Risk assessment	367	2016	2018	2021
Priority journal	410	2015	2017	2019
Taiwan	335	2015	2017	2020
Kidney failure	320	2014	2017	2020
Kaplan-Meier estimate	37	2013	2016	2017
Cost-benefit analysis	33	2014	2016	2020
Lifestyle modification	31	2012	2016	2020
Health behavior	21	2012	2015	2020
Smoking cessation	20	2012	2015	2016
Chronic kidney disease	82	2012	2014	2016
Biological markers	13	2012	2013	2014
Marriage	12	2012	2013	2020
Angioplasty	11	2011	2013	2018
Heart atrium fibrillation	16	2011	2012	2014
Hyperuricemia	10	2011	2012	2020
Questionnaires	9	2012	2012	2013
Sexual dysfunction	8	2011	2011	2018
Finland	7	2010	2011	2017
Abdominal aorta aneurysm	6	2011	2011	2011

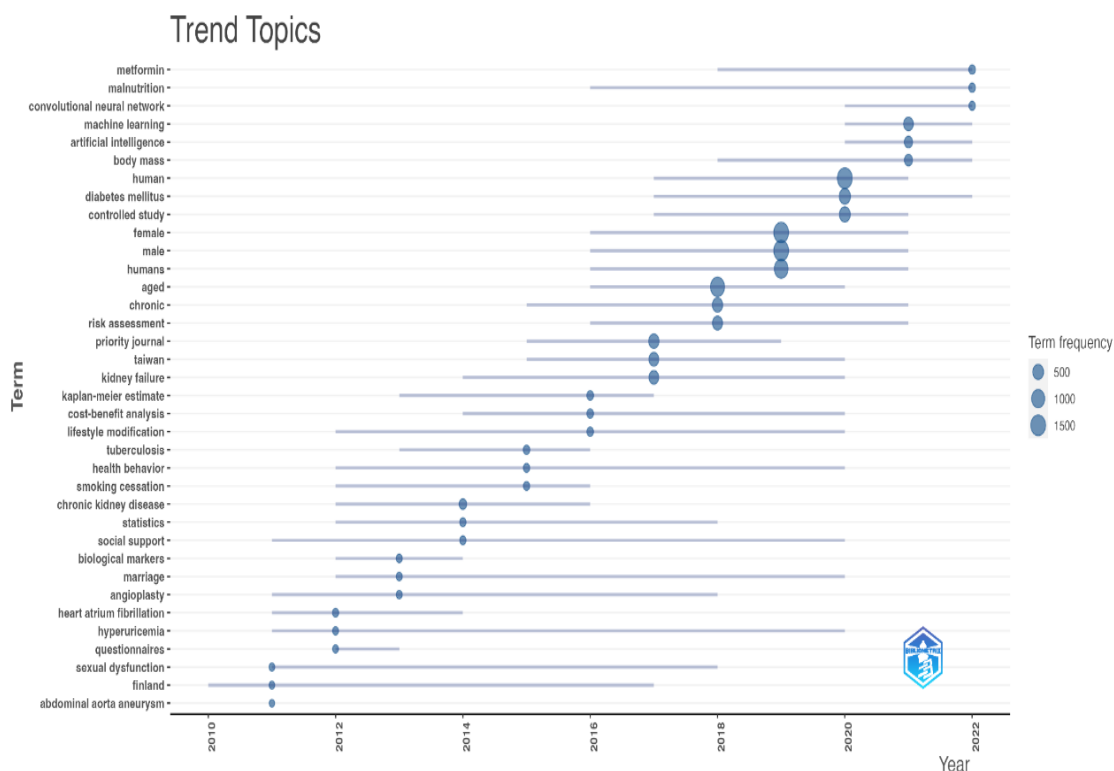


Figure 2. Trending terms in the bibliometric analysis of diabetic kidney disease (DKD) and hemodialysis using healthcare insurance databases over time.

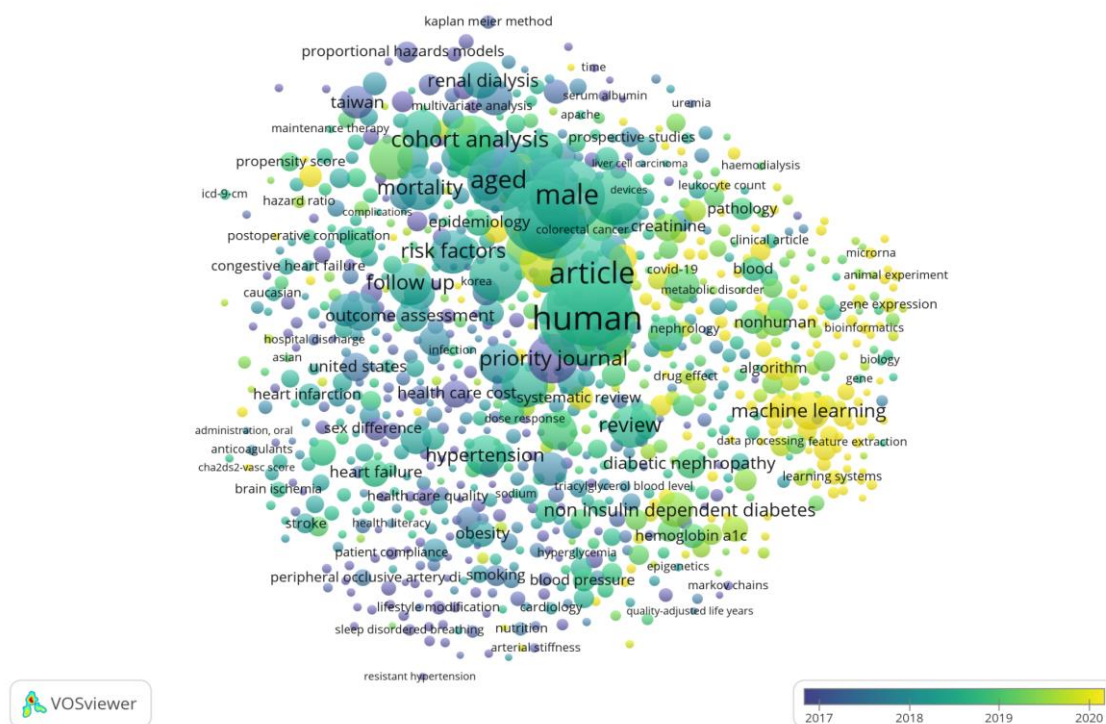


Figure 3. Recency and density of document topics in the bibliometric analysis of diabetic kidney disease (DKD) and hemodialysis using healthcare insurance database, 2017–2022.

Author, institution, and country contribution

The leading authors in DKD and hemodialysis research include Zhang, Y. with 32 publications, Wang, Y. with 22 publications, and Kim, J. with 20 publications (Table 2). The top research

institutions contributing to DKD and hemodialysis are Taipei Medical University (153 publications), China Medical University (94 publications), and Chang Gung University (90 publications), ranking prominently among Taiwanese universities (**Table 3**). In terms of regions with relevant publications, China leads with 2,785 publications, followed by the USA (2,271 publications) and Korea (707 publications) (**Table 4**).

Table 2. Top 15 authors who published articles on diabetic kidney disease (DKD) and hemodialysis using healthcare insurance databases over the years

Author	Frequency
Zhang, Y.	32
Wang, Y.	22
Kim, J.	20
Kim, Y.S.	18
Chen, L.	17
Hwang, S.J.	16
Yang, C.W.	16
Kim, H.	15
Li, J.	15
Wang, X.	15
Chen, J.	14
Kang, S.W.	14
Lee, C.C.	14
Li, Y.	14
Wang, L.	14

Table 3. Top 15 institutions that published articles on diabetic kidney disease (DKD) and hemodialysis using healthcare insurance databases over the years

Institution	Frequency
Taipei Medical University	153
China Medical University	94
Chang Gung University	90
National Yang-Ming University	85
China Medical University Hospital	81
University Of Michigan	81
Kaohsiung Medical University	72
Taipei Veterans General Hospital	62
National Taiwan University Hospital	60
Chang Gung Memorial Hospital	54
National Taiwan University	54
National Cheng Kung University	53
University Of Washington	50
Harvard Medical School	49
University Of California	49

Table 4. Top 10 countries that published articles on diabetic kidney disease (DKD) and hemodialysis using healthcare insurance databases over the years

Country	Frequency
China	2,785
United States of America	2,271
Korea	707
Japan	601
United Kingdom	355
Canada	272
Germany	263
Australia	262
Italy	176
India	154

Co-authorship and collaboration network

The research collaboration network within the domains of DKD and hemodialysis typically comprises three primary clusters. The green network represents Taiwan, encompassing institutions such as China Medical University, Taipei Medical University, and National Yang-Ming Chiao Tung University, renowned for their prolific research output and extensive

collaborative networks (**Figure 4**). In contrast, the red network signifies collaborations in the USA involving prestigious institutions such as Harvard Medical School, the University of Michigan, and the University of California, characterized by moderate research frequency. Meanwhile, the blue network denotes collaborations in Korea, including Seoul National University Hospital, Yonsei University College of Medicine, and Catholic University of Korea, which are noted for their comparatively lower research frequency. International collaborations spanning these countries are also observed. Insights into authors' national affiliations, highlighting contributions from Taiwan, the USA, Korea, and diverse nations worldwide, are provided in **Figure 5**. Notably, authors from Indonesia collaborate with researchers from countries such as the USA, Singapore, Korea, and Slovenia, albeit with limited involvement.

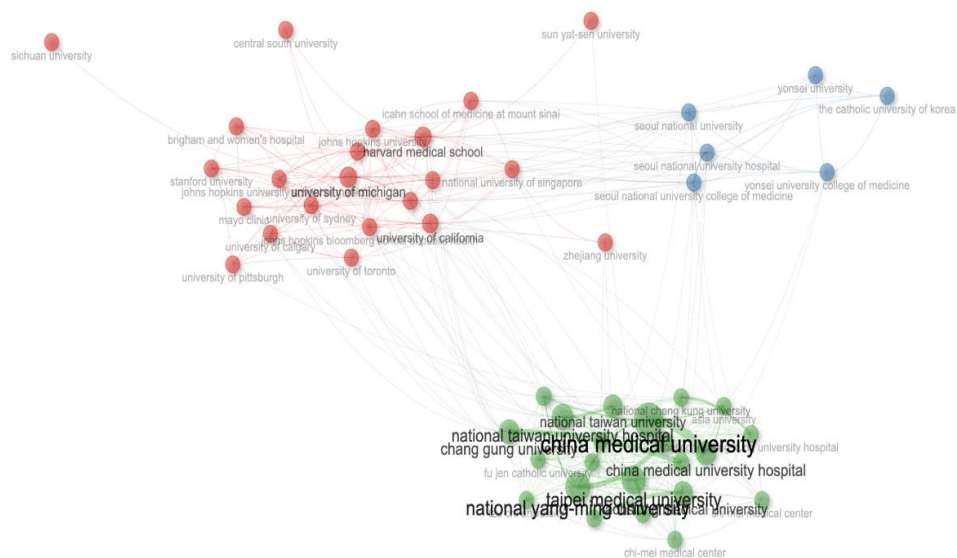


Figure 4. Collaboration among authors' affiliations that published articles on DKD and hemodialysis using healthcare insurance databases over the years.

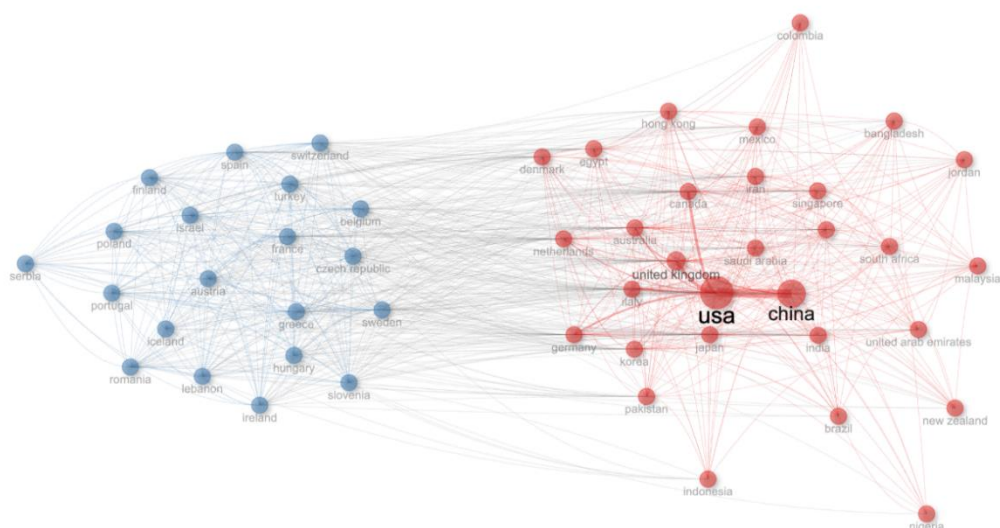


Figure 5. Collaboration among authors' countries that published articles on DKD and hemodialysis using healthcare insurance databases over the years.

Discussion

The present study revealed a significant increase in research on DKD and hemodialysis domains using insurance/healthcare databases or big data from 2010 to 2022. This growth reflected the

increasing recognition of healthcare challenges associated with these conditions. It underscored the growing relevance of healthcare policy, burden, and sustainability considerations, as evidenced by emerging research on malnutrition, body mass, social support, lifestyle modification, and cost-benefit analysis. DKD can lead to reduced calorie and protein intake, exacerbating hypoalbuminemia [10]. Addressing inflammation and managing malnutrition and proteinuria can mitigate the progression to ESRD [11]. Intensive diet and lifestyle therapies such as weight loss, increased physical activity, smoking cessation, Mediterranean diet, and sodium restriction are routinely prescribed for individuals with DKD [22].

Emerging research themes identified in the present study include machine learning and artificial intelligence, notably applied in personalized approaches to DKD treatment, considering factors such as age, gender, and body mass [23-24]. Various machine learning models, such as the random forest algorithm, have shown superior performance, offering high accuracy compared to logistic regression [25].

The present bibliometric analysis on DKD highlighted predominant research originating from the USA and Europe, excluding big data variables and predictions [15,19]. However, there is an increasing trend in research emerging from Asian countries such as China, Korea, Japan, and Taiwan, which are noted for their robust healthcare systems and high rates of universal health coverage within Asia [26,27]. The limited representation of Indonesian authors within the Americas-Asia cluster suggests that considerable potential remains untapped for studying hemodialysis and DKD using the health insurance database.

Health insurance databases can be used to analyze DKD that occurs within a certain period, contributing to predicting future disease events and encouraging the formulation of data-based policies [28]. Korea's National Health Insurance (NHI) system analyzes treatment and expenditure data for hemodialysis vascular [29]. In the USA, health insurance claims to identify peritoneal dialysis patients [30]. These databases enable large-scale investigations into renal disease and health outcomes without experiments [13]. Public health insurance covers the health and financial impacts of type 2 diabetes mellitus, offering early detection through constant monitoring and treatment, thereby preventing costly complications such as cardiovascular disease and nephropathy [31].

The limitation of the present study is that it was conducted to find novelty or potential research opportunities, so it did not review the content or details of the collected database in depth. Suggestions for future research include conducting studies on DKD and hemodialysis using national health insurance big data.

Conclusion

Machine learning and artificial intelligence are emerging yet remain relatively under-researched in the context of hemodialysis and DKD. The prominence of topics such as diabetic nephropathy, non-insulin treatments, and lifestyle modifications highlights ongoing research priorities in DKD and hemodialysis. Taiwan's dominance in publications suggested robust research activity in this field, while international collaboration underscored global interest and the potential for diverse research perspectives. The need for similar research development in Indonesia, leveraging big data and machine learning, indicates opportunities for advancing the understanding and management of DKD and hemodialysis within the region.

Ethics approval

Not required.

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available as part of the article.

How to cite

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