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Review

Trends in diabetes research outputs in South Africa over 30 years from 2010 to 2019: A bibliometric analysis



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ABSTRACT

Diabetes mellitus (DM) is one of the leading causes of mortality in South Africa, which is impelled by people's consumption of unhealthy diets and lifestyles, negligence about an individual's health status, and increased urbanization. DM can be linked to several human diseases and thus, making it an important public health issue in the South African health sector. Therefore, it is necessary to assess the level of research that has been conducted in the country on diabetes, in a quest for solutions against the deadly disease. Hence, the present study aimed to map diabetes-related research in South Africa from 2010 to 2019. Data on the subject was retrieved from the Web of Science Core Collection (WoSCC) and bibliometric package in Rstudio statistical software was used to analyze the data while VOSviewer was explored for data visualization networks. Our analysis revealed that the annual growth rate of publication trends was 23.2%. The authors per document were 23.3 with a collaboration index of 23.4. From the 416 articles analyzed, Islam MS (n = 34) was the most prolific author and the top active institution was University of KwaZulu-Natal (n = 165) and the top journal was Diabetes Research and Clinical Practice (n = 20). Findings from this study reveal that the quantity of research on diabetes has significantly increased over the decade, and the outcomes of this scientific progress can guide future research and substantially provide the basic needs for improving management procedures for diabetes in the country.

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Contents

1. Introduction	2915
2. Materials and methods	2915
2.1. Extraction of data	2915
2.2. Data analysis	2916
3. Results and discussion	2916
3.1. Main information	2916
3.2. Annual scientific production	2917
3.3. Relevant authors	2917
3.4. Relevant institutions	2918
3.5. Relevant journals	2918
3.6. Authors and institution collaboration networks	2919
3.7. Countries collaborating with South African on diabetes research from 2010 –2019	2920

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3.8. Bibliographic coupling analysis 2920
 3.9. Co-citation network analyses 2922
 3.10. Co-occurrence keywords network 2922
 3.11. Limitations..... 2923
 4. Conclusions..... 2923
 Declaration of Competing Interest 2923
 Acknowledgements 2923
 References 2923

1. Introduction

Diabetes mellitus (DM) is a metabolic disorder sequel from the inability of either insulin to perform its normal function, secretion, or both concurrently (Skylar et al., 2017). It is usually characterized by high blood glucose levels and it is one of the principal causes of morbidity and mortality globally (Aynalem and Zeleke, 2018; Coetzee et al., 2019). DM has drastically affected health budgets and health systems worldwide (Pheiffer et al., 2018). In 2019, the International Diabetes Federation reported a DM prevalence of 12.8% in South African adults (20–79 years), but cautioned that this may be an underestimate, as DM in Africa remains largely undiagnosed (3/5 persons with DM; 60%) (IDF, 2019). The prevalence of DM in South Africa is high, and the country’s healthcare system is not only burdened by the increasing prevalence of DM but also by other diseases’ problems such as human immunodeficiency virus and tuberculosis (Idemyor, 2010; Coetzee et al., 2020).

South Africa is a diverse country in terms of race, socioeconomic status, and other societal and structural determinants of health (Atun et al., 2017). An increase in socioeconomic and demographic changes in the country as well as ageing people are factors influencing the prevalence of diabetes mellitus and other related-disease conditions (Kapoor et al., 2015). In addition, urbanization and access to starchy food, inactive lifestyles have a substantial effect on diabetes statistics in the country (Hu and Malik, 2010; IDF, 2017). The reports of Joubert et al. (2000) and Pheiffer et al. (2018) highlighted some possible factors such as excess body weight and obesity which could also increase the prevalence of diabetes in the country. Diabetes mostly affects the working-aged individuals within the age of 40 and 60 years (Peer et al., 2014); and this consequently reduces the productivity of a country with a negative impact on the national economy (Pheiffer et al., 2018). At present, South Africa is facing many crises from maternal and child mortality, non-communicable disease, accident-related injuries, and infectious diseases. As a result, the annual budget allocated to the health sector is usually overwhelmed by several diseases, thereby affecting the percentage of the budget dedicated to the management of diabetic patients in the country (Mayosi et al., 2009; Sheik et al., 2016). Thus, urgent action is required to end escalating diabetes endemic in South Africa (Pheiffer et al., 2018). However, studies on quantitative analysis on diabetes research in South Africa are lacking and this topic needs more attention.

The bibliometric analysis can be used to evaluate the productivity trends of a research topic over the year and it could also be used to compare the research outputs of scholars, most active institutions, countries and journals in a particular field of interest (Jia et al., 2014; Kamdem et al., 2017; Lyu et al., 2017). It uses the literature system and literature metrology characteristics as research objects and analyzes the publications quantitatively and qualitatively (Ekinci et al., 2015). Over the years, bibliometric analysis has gained popularity in the scientific community with the aim to summarize research trends in a particular research niche (Baladi and Umedani, 2017; Krauskopf, 2018). It has been increasingly popular because of its application in different fields (Geaney

et al., 2015; Lei et al., 2019; León-Silva et al., 2020; Mao et al., 2020; Okaiyeto et al., 2020; Orimoloye and Ololade, 2020; Rumin et al., 2019). Despite, the increase in the involvement of researchers on diabetes research in South Africa, there is no bibliometric report on the subject that quantitatively analyses the research productivity in order to determine how scholars are getting closer in finding a permanent solution to the disease dilemma facing the populace in South Africa. Therefore, to the best of our knowledge, this is this first study on the scientific mapping of diabetes research in South Africa from 2010 to 2019. The specific objectives were to determine the annual scientific outputs on diabetes research, investigate the most prolific authors, active institutions, and journals, determine the authors’ and institutions’ collaboration networks, investigate other countries collaborating with South African on diabetes research, analyze the bibliographic coupling existing between authors, institutions, and journals, investigate the authors, references, and sources of co-citation networks, and evaluate the co-occurrence keywords used on the subject.

2. Materials and methods

2.1. Extraction of data

Several electronic databases can be explored as a source of information for bibliometric analyses of research outputs in a particular field (Sharma et al., 2018). As acknowledged in the report of

Table 1
Main information of diabetes-related research in South Africa from 2010 to 2019.

Description	Results
“MAIN INFORMATION ABOUT DATA”	
“Timespan”	2010:2019
“Sources (Journals, Books, etc)”	184
“Documents”	416
“Average years from publication”	4.13
“Average citations per documents”	34.75
“Average citations per year per doc”	6.387
“References”	13,543
“DOCUMENT TYPES”	
“Article”	416
“DOCUMENT CONTENTS”	
“Keywords Plus (ID)”	1278
“Author’s Keywords (DE)”	853
“AUTHORS”	
“Authors”	9674
“Author Appearances”	17,516
“Authors of single-authored documents”	2
“Authors of multi-authored documents”	9672
“AUTHORS COLLABORATION”	
“Single-authored documents”	3
“Documents per Author”	0.043
“Authors per Document”	23.3
“Co-Authors per Documents”	42.1
“Collaboration Index”	23.4

Zyoud et al. (2017) “WoS has been identified as one of the most reliable and comprehensive databases for bibliometric studies and it hosts a wide range of quality and high-impact scientific studies (12 million articles in over 12,000 journals)”. Hence, the WoSCC was used to retrieve data for bibliometric analysis on diabetes research in South Africa from 2010 to 2019. We tried several keywords in our search strategy and we did that to extract all information related to the subject study without leaving out any significant article in the literature. We explored the following keywords for our search “diabetes” OR “diabetes mellitus” OR “antidiabetic” OR “anti-diabetic”) AND (“South Africa”). We used the title search to eliminate unwanted documents that could give false-positive results as highlighted by the report of Sharma et al. (2018). A total of 847 documents were obtained but we limited our search to those indexed in Science Citation Index Expanded (n = 579) and we further excluded other documents that do not align to our priority. SCI-Expanded is the most appropriate database used to obtain scientific information among the Web of Science Citations indexes (Ho, 2019). Furthermore, we excluded other articles that were written in French (n = 4) and restricted our search to those written in English (n = 575). In terms of the document type, our focus was to search for only research articles on diabetes research in South Africa aimed at determining the contributions of researchers in the field. We further excluded other documents and devoted to only research articles (n = 419). Subsequently, we validated the data manually to remove unnecessary articles or redundancy in our results (Orimoloye and Ololade, 2020). Of which, three (3) articles that did not relate with our focus were further excluded and 416 articles were eligible for the bibliometric analysis in the present study. These articles were exported from WoS and saved with Bibtext file format in a notepad for analysis.

2.2. Data analysis

Rstudio (v.3.4.1) was used for data analysis (Ekundayo and Okoh, 2018). The retrieved data was imported into “bibliometrix

(biblioshiny)” in Rstudio and the data were analyzed accordingly (Aria and Cuccurullo, 2017). Analyzed data extracted from the software were based on the objectives of the study which include the annual scientific production, most prolific authors, active institutions, and journals on diabetes research in South Africa from 2010 to 2019. Subsequently, VOSviewer software (v.1.6.14) was used to determine the authors’ and institutions’ collaboration networks, investigate other countries collaborating with South African researchers on diabetes research within the stipulated period, analyze the bibliographic coupling existing between authors, institutions, and journals, investigate the authors, references, and sources co-citation networks and evaluate the co-occurrence keywords on the subject.

3. Results and discussion

3.1. Main information

In the present study, we mapped the productivity trends on diabetes-related research in South Africa from 2010 to 2019. Based on our literature search from the WoS, we retrieved 416 research articles written in English from SCI-Expanded (Table 1). One of the reasons we chose WoS is that it is the most used database for bibliometric analysis (Castor et al., 2020; Huang et al., 2019). Hence, we observed that these 416 articles were published in 184 sources by 9674 authors. Authors of single-authored documents were only 2, and authors of multi-authored documents were 9672. Overall, the 416 articles comprise 13,543 references and the average years from the publication were 4.13 whereas average citations/year/doc and average citations/year/doc were 34.75 and 6.387. The total keyword plus and the author’s keyword identified from these articles were 1278 and 853, respectively. Single-authored documents were 3 and 0.043 for documents/author. The authors/documents were 23.3, co-authors/documents were 42.1, and the collaboration index was 23.4. The collaboration index observed in this study is higher than those reported by researchers

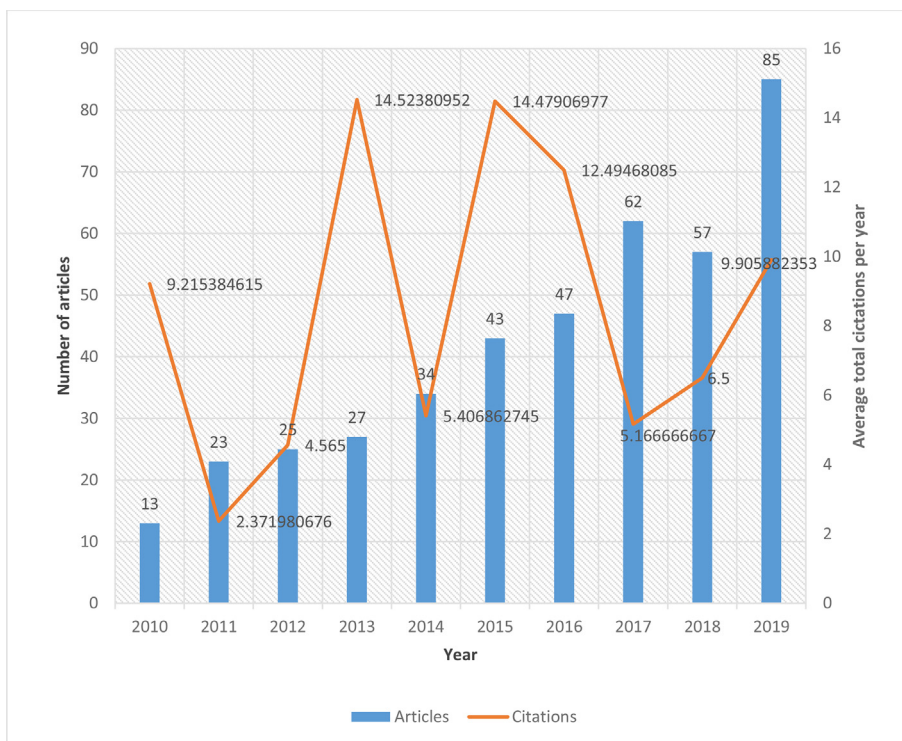


Fig. 1. Annual scientific production on diabetes-related research in South Africa from 2010 to 2019. The annual growth rate was 23.2%.

in other studies (Ekundayo and Okoh, 2018; Olisah et al., 2019). The high collaboration index observed from this analysis shows that 413 (99.3%) of the 416 articles retrieved on the subject were co-authored with multiple researchers and this could have accounted for the high research outputs in the field from this region.

3.2. Annual scientific production

As highlighted by Mao et al. (2019), “variations in the number of academic papers on a certain research field is a significant indicator for the development trend”. A plot of the number of publications over time and conducting multivariate statistical analysis contributes to understanding the research level and future trend. Concerning productivity trends on diabetes-related research, we observed a tremendous increase in research outputs from 2010 to 2019 on the subject. About 122 (29.3%) of the 416 research articles were published between 2010 and 2014 whereas 294 (70.7%) were produced from 2015 to 2019 (Fig. 1). The maximum research outputs was observed in 2019 with 85 articles accounting to 20.4% of the total productivity. From our analysis of the retrieved articles, we observed the annual growth rate to be 23.2%. This implies that diabetes research received a positive research trend over the year and scholars from this region have been actively involved in the field. Besides, they published their works in good journals that are indexed in WoS. Although, the statistics might not represent the whole research articles published on the subject by the researchers in this field, however, it is of great importance to note that some research scholars do not care about the quality of the journals in which they published their works. They do not always bother to check the databases whether the journals they selected to publish their works are indexed. This is because some researchers only want to send papers to journals where they will get published fast and not considering the visibility of their papers to other researchers. The likely reason why the total number of articles was fairly low could be the misleading errors in the accredited journals lists released by Department of Higher Education and Training (DHET) annually that contain some predatory journals. DHET gives subsidies annually to the institutions within the country based on their research outputs. One of the major problems that the researchers in South Africa experience about the accredited journal lists is that they might publish in a particular journal this year and the following year such journal might be found to be a predatory journal and this would lead to its removal from the list. Besides,

some researchers do not even check if such journals are indexed in WoS, Scopus, PubMed, or other good databases before publishing in them. Overall, it is of paramount importance to note that our findings were only based on the information retrieved from WoS and other databases were not considered in the present study. In the same vein, total average citation per year was analyzed concomitantly with research outputs and we noticed a fluctuation in the citations pattern over the years and the highest citations were received in 2013 and 2015 while the lowest citation was recorded in 2011. Citation of a research article can be influenced by several factors and among which, the year of publication and visibility of the publication to other researchers in the field are essential factors. It is expected that old published papers have more citations than recent ones (Aksnes et al., 2019). Most times, citations of a paper do not determine the quality of the paper. Papers published in open access are more accessible to other scholars and they are more cited than those published in not open access. Citations are assumed to reflect the impact of the research or its quality. However, the big question is “what is the justification for these assumptions and how do citations relate to research quality?” Research quality is a multidimensional concept where plausibility/soundness, originality, scientific value, and societal value are perceived as key characteristics (Aksnes et al., 2019). However, “quality” and “impact” of a paper are debated topics globally in the field of scientometric (Leydesdorff et al., 2016).

3.3. Relevant authors

To determine the most productive authors on diabetes research in South Africa between 2010 and 2019, the information retrieved from WoS on the subject revealed that 9674 authored the 416 articles used for the analysis and authors per document was 23.3; and this shows the level of collaboration that exists among these researchers in the field. Therefore, it is worth noticing to identify the most prolific author among these researchers. The top 7 authors on the list are Islam MS (n = 34, h-index 12 and 419 total citations), Kengne AP (n = 32, h-index 14 and 686 total citations), Rheeder P (n = 17, h-index 7 and 367 total citations), Sobngwi E (n = 17, h-index 11 and 473 total citations), Erukainure OL (n = 15, h-index 6 and 100 total citations), Koorbanally NA (n = 15, h-index 7 and 117 total citation) and Zinman B (n = 15, h-index 10 and 4694 total citations) (Table 2). The h-index, as an indicator for assessing the quality of scientific output (Huang et al., 2019), is used to calculate both the productivity and citation

Table 2
Top 20 authors on diabetes-related research in South Africa from 2010 to 2019.

Author	h_index	g_index	m_index	TC	NP	PY_start	Authors	Articles	Authors-Frac	Articles Fractionalized	
Islam MS	12	19	1,2	419	34	2011	Islam MS	34	Islam MS	1.26e+01	1.26e+01
Kengne AP	14	26	1,556	686	32	2012	Kengne AP	32	Kengne AP	5.80e+00	5.80e+00
Rheeder P	7	17	1,167	367	17	2015	Rheeder P	17	Rheeder P	4.87e+00	4.87e+00
Sobngwi E	11	16	1,222	473	16	2012	Sobngwi E	16	Koorbanally NA	4.02e+00	4.02e+00
Erukainure OL	6	9	1,5	100	15	2017	Erukainure OL	15	Adam S	3.17e+00	3.17e+00
Koorbanally NA	7	10	1	117	15	2014	Koorbanally NA	15	Erukainure OL	3.12e+00	3.12e+00
Zinman B	10	11	1,667	4694	11	2015	Zinman B	15	Ibrahim MA	2.87e+00	2.87e+00
Garcia	8	8	1,333	4164	8	2015	Garcia	14	Matsha TE	2.81e+00	2.81e+00
Karlsson T	8	8	1,333	4409	8	2015	Karlsson T	14	Pretorius E	2.80e+00	2.80e+00
Matsha TE	7	14	0,7	253	14	2011	Matsha TE	14	Longo-mbenza B	2.77e+00	2.77e+00
Distiller L	11	13	1,375	6626	13	2013	Distiller L	13	Erasmus RT	2.35e+00	2.35e+00
Van	11	13	1,1	6256	13	2011	Van	13	Norris SA	2.28e+00	2.28e+00
Andersen J	10	10	1,667	4670	10	2015	Andersen J	12	Mohammed A	2.17e+00	2.17e+00
Chen J	10	12	1,25	6619	12	2013	Chen J	12	Afolayan AJ	2.17e+00	2.17e+00
Levitt NS	7	12	0,636	838	12	2010	Levitt NS	12	Oguntibeju OO	2.17e+00	2.17e+00
Lu Y	12	12	2	4788	12	2015	Lu Y	12	Sobngwi E	2.16e+00	2.16e+00
Amod A	9	10	0,818	4212	10	2010	Amod A	11	Levitt NS	2.08e+00	2.08e+00
Anderson M	11	11	1,833	4899	11	2015	Anderson M	11	Ashafa AOT	1.83e+00	1.83e+00
Hissa M	11	11	1,833	4899	11	2015	Hissa M	11	Mbanya JC	1.76e+00	1.76e+00
Jain M	11	11	1,833	4702	11	2015	Jain M	11	Dias S	1.67e+00	1.67e+00

Table 3

Top 10 most relevant institution on diabetes research in South Africa from 2010 to 2019.

Affiliations	Articles
“University of Kwazulu-Natal”	165
“University of Cape Town”	137
“University of Pretoria”	99
“University of Witwatersrand”	85
“Stellenbosch University”	61
“South African Medical Research Council”	59
“Cape Peninsula University Technology”	56
“Northwest University”	34
“Walter Sisulu University”	32
“University of Fort Hare”	26

impact per author or group of authors belonging to an institute or country (Jones et al., 2011). h-index value is based on a list of publications ranked in descending order by the times cited count, calculated by the principle that h articles are cited at least h times (Hirsch, 2005). As reported by Miao et al. (2018), “h-index is an accurate reflection of the academic contribution and achievement and is applied in many bibliometric analyses” however, h-index is not suitable for comparing interdisciplinary fields (Guilak and Jacobs, 2011).

Similarly, citations of the publications of the researchers were also assessed in this study. According to the report of Su et al. (2018), “citations of researchers can be considered as an indicator of impact, although in a real sense, the number of publications did not represent highly cited articles since there were several factors that influence citation of an article”. Citations are an imperfect means of measuring an author’s impact on the field (Stern and Arndt, 1999). In the present study, we found that the top authors were not with the highest citations. For example, from our analysis, despite the fact that Islam MS had the highest articles on the subject, however, in terms of citations, out of the top 20 researchers listed in Table 2, the top 3 researchers with the highest citations

are Distiller L (6626 citations) and Chen J (6619 citations) and Van (6256). It has been acknowledged in the literature that publication year influences citation of a paper, however, in this case, despite the fact that publication year of Islam MS was 2011, it is surprising that both Distiller L and Chen J whose publications started 2013 attained higher citations than Islam L.

3.4. Relevant institutions

The publications associated with the top institutions in the country on the subject were investigated and the results are represented in Table 3. The University of KwaZulu-Natal has the highest publication with 165 articles, followed by University of Cape Town (n = 137), University of Pretoria (n = 99), University of Witwatersrand (n = 85), Stellenbosch University (n = 61), South African Medical Research Council (n = 59), Cape Peninsula University of Technology (n = 56), Northwest University (n = 34), Walter Sisulu University (n = 32) and University of Fort Hare (n = 26). Amazingly, a research institute (South African Medical Research Council) was about the top 6 on the list. It is important to note that the number of articles represented in Table 3 are the total number of articles with institutions affiliation. Due to the high collaboration index observed in this study, we noticed that a paper can have several affiliations on it. Several studies from other researchers have assessed the most relevant institution on a particular subject using bibliometric analysis (Arshad et al., 2020; León-Silva et al., 2020; Mo et al., 2018; Qi et al. 2019).

3.5. Relevant journals

As highlighted by the reports of Leydesdorff and Rafols (2009), “journals and subject category are basic units in bibliometric analysis, which can explain the distributions of the research scope in a certain topic”. In the present study, the publications on diabetes research in South Africa from 2010 to 2019 was distributed in 53 WoS subject categories (Table not shown). The five (5) top subject

Table 4

Top 20 relevant journals in diabetes-related research in South Africa between 2010 and 2019.

Relevant journals	Most cited journals	Most impactful journals							
Journals	Articles	Journals	Citations	Journals	h-index	g-index	TC	NP	PY Start
Diabetes Research and clinical practice	20	Diabetes Care	966	Diabetes Research and Clinical Practice	10	20	542	20	2011
South African Medical Journal	19	Lancet	396	South African Medical Journal	5	12	155	19	2010
Plos one	16	New Engl J Med	349	Plos One	10	15	251	16	2011
Journal of Ethnopharmacology	13	J Ethnopharmacol	316	Journal of Ethnopharmacology	9	13	185	13	2011
Diabetes Obesity \& Metabolism	11	Diabetes	299	Diabetes Obesity \& Metabolism	9	11	346	11	2011
Diabetic Medicine	10	Plos one	281	Diabetic Medicine	6	10	110	10	2010
Lancet diabetes \& Endocrinology	9	Diabetes Res Clin Pr	250	Lancet Diabetes \& Endocrinology	8	9	552	9	2014
Biomedicine \& Pharmacotherapy	8	Diabetologia	248	Biomedicine \& Pharmacotherapy	5	8	83	8	2017
Diabetes Care	8	Diabetic Med	244	Diabetes Care	8	8	396	8	2010
Bmc Public Health	7	Circulation	180	Bmc Public Health	4	7	84	7	2011
Primary Care Diabetes	7	Jama J Am Med Assoc	161	Primary Care Diabetes	4	7	65	7	2012
Acta Poloniae Pharmaceutica	6	J Agr Food Chem	114	Acta Poloniae Pharmaceutica	4	6	37	6	2015
Cardiovascular Diabetology	6	No Title	104	Cardiovascular Diabetology	5	6	192	6	2013
Cardiovascular Journal of Africa	6	Captured		Cardiovascular Journal of Africa	4	6	67	6	2010
International Journal of Diabetes in Developing Countries	6	J Clin Endocr Metab	103	International Journal of Diabetes in Developing Countries	2	3	9	6	2014
New England Journal of Medicine	6	Lancet Diabetes Endo	98	New England Journal of Medicine	6	6	6590	6	2010
Pediatric Diabetes	6	Samj S Afr Med J	95	Pediatric Diabetes	5	6	306	6	2013
African Health Sciences	5	Diabetes Obes Metab	94	African Health Sciences	3	4	23	5	2012
Bmj Open	5	Food Chem	92	BMJ Open	4	5	37	5	2015
Lancet	5	J Biol Chem	86	Lancet	5	5	872	5	2010
		Bmj Brit Med J	82						

categories are Endocrinology Metabolism (n = 134 records, 32.212%), Medicine General Internal (n = 59 records, 14.183%), Pharmacology Pharmacy (n = 58 records, 13.942%), Cardiac Cardiovascular Systems (n = 30 records, 7.212%) and Chemistry Medicinal (n = 26 records, 6.250%).

With respect to the most active journals on the subject, twenty (20) articles were published in Diabetes Research and Clinical Practice (IF – 3.239), followed by South African Medical Journal (n = 19, IF – 1.500), Plos one (n = 16, 2.776), Journal of Ethnopharmacology (n = 13, IF – 3.414), Diabetes Obesity & Metabolism (n = 11, IF – 6.133), Diabetic Medicine (n = 10, IF – 3.107), Lancet Diabetes & Endocrinology (n = 9, IF – 24.540), Biomedicine & Pharmacotherapy (n = 8, IF – 3.743), Diabetes Care (n = 8, IF – 15.27) and BMC Public Health (n = 7, IF – 2.567) (Table 4). The respective impact factors of the journal were obtained on the journals’ websites. According to the report of Meyerholz and Flaherty (2017), an impact factor is a commonly used metric for evaluating scientific journals and this serves as an indicator of a journal’s scientific influence. It can be calculated by dividing the total number of articles published in a particular journal in the previous two years divided by the total citations received by the journal during the years”. From the journal analysis, we observed that the researchers published their articles in quality journals with good impact factors and it is worth noticing that most of the journals in which the researchers published these articles are related to diabetes and public health except for Journal of Ethnopharmacology, which is an interdisciplinary journal.

In addition, citations from each journal were also evaluated and the top 5 journals with highest citations were Diabetes Care (n = 966 citations) followed by Lancet (n = 396), New England Journal of Medicine (n = 349), Journal of Ethnopharmacology (n = 316), Diabetes (n = 299). Similarly, the h-index of the journals within the study years (2010–2019) was also assessed and we found Diabetes Research and Clinical Practice with the highest h-index of 10, publication year start of 2011 (Table 4).

3.6. Authors and institution collaboration networks

Collaborative research networks can help other researchers expand their field of research or join groups conducting related studies (Wenwen et al., 2019). It reveal the status and levels of scientific collaboration in this field. As reported by Han et al. (2014) “analyzing their co-occurrence relationship can better reflect the truth of scientific research and academic communication, because the cooperation of authors, institutions and countries can measure the cooperation at different levels” In the present study, co-authorship of authors’ analysis was carried using a fractional counting method and the maximum number of authors per document was 25, with 5 as the minimum number of documents of an author and we kept the minimum number of citations of an author at 0. We observed 1549 authors, out of which 47 meet the chosen thresholds. We further decrease the minimum number of documents of an author to 3 and the number of authors that meet the thresholds increases to 143 and these results was visualized thereafter. We found the top 5 authors to be: Kengne AP (40 documents, 884 citations, and 40 links), Islam MS (36 documents, 437 citations, 28 links), Koorbannally NA (17 documents, 148 citations, and 17 links), Sobngwi E (16 documents, 682 citations, and 16 links), Erukainure OL (15 documents, 100 citations, and 15 links) (Fig. 2). From the analysis, 143 items in the network were not connected and the largest set of connected items comprises 85 items and we visualized them. The 143 items were grouped into 29 Clusters all together in VOSviewer. “Cluster 1 comprises 18 items”, “Cluster 2 (17 items)”, “Cluster 3 (11 items)”, “Cluster 4 (11 items)”, “Cluster 5 (9 items)”, “Cluster 6 (7 items)”, “Cluster 7 (6 items)”, “Cluster 8 (6 items)”, “Cluster 9 (6 items)”, “Cluster 10 (6 items)”, “Cluster 11 (6 items)”, “Cluster 12 (5 items)”, “Cluster 13 (5 items)”, “Cluster 14 (4 items)”, “Cluster 15 (4 items)”, “Cluster 16 (3 items)”, “Cluster 17 (3 items)”, “Cluster 18 (3 items)”, “Cluster 19 (2 items)”, “Cluster 20 (2 items)”, “Clusters 21–29 comprise 1 item each” as seen in Fig. 2. Each node in the map denotes a

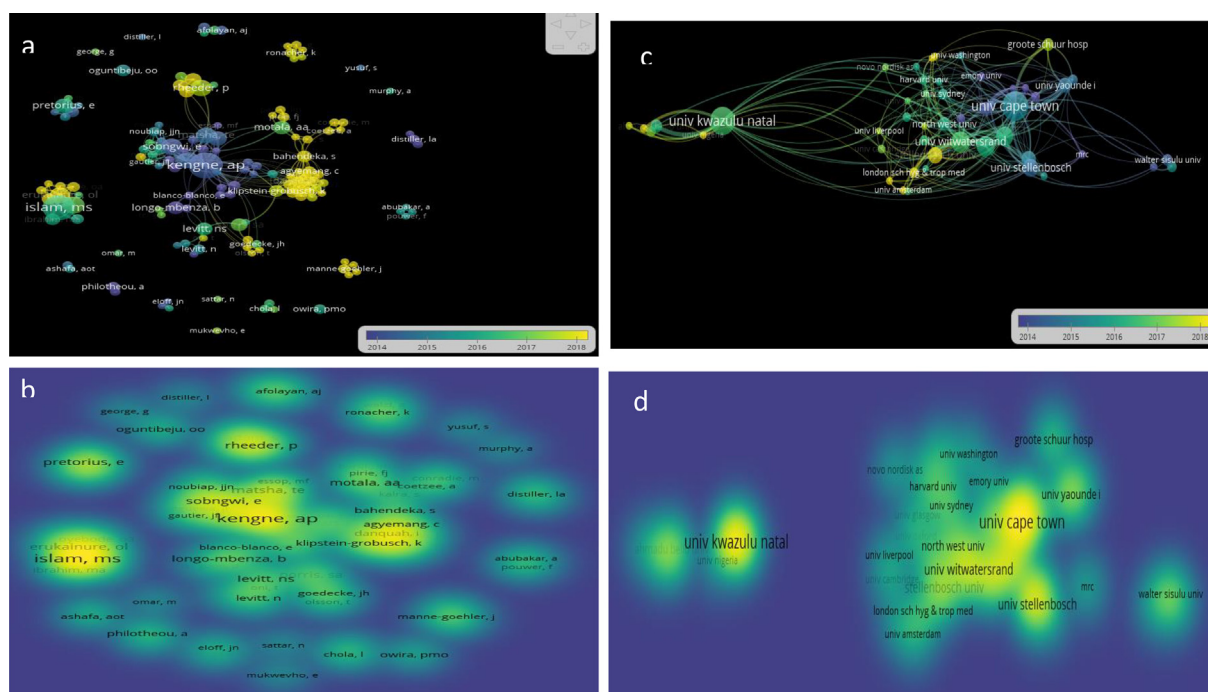


Fig. 2. Overlay visualization (a) and density visualization (b) of authors’ and Overlay visualization (c) and density visualization (d) institutions’ collaboration on diabetes-related research in South Africa.

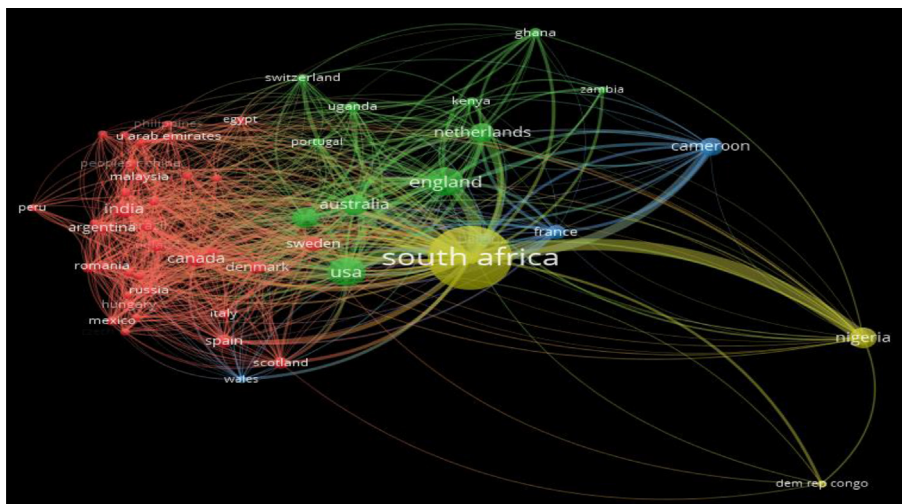


Fig. 3. South African researchers collaborating network with other researchers from different countries on diabetes-related research from 2010 to 2019.

term that occurred at least 3 times and the size of the node of each term is relative to the number of occurrences of that term. In addition, the colour of each cluster signifies that authors with close connections (Kamdem et al., 2019).

In the same vein, VOSviewer software was used to analyze the institution collaboration network using a fractional method and chose 25 to be the maximum number of organizations per document and 3 as a minimum number of documents of an organization. Of 690 organizations selected from the thresholds, 107 meet the thresholds. The top 7 institutions were University of Cape Town “(87 documents, 1640 citations and 71 total link strength)”, University of KwaZulu-Natal “(79 documents, 1337 citations and 49 total link strength)”, South African Medical Research Council “(39 documents, 568 citations and 39 total link strength)”, University of Witwatersrand “(43 documents, 571 citations and 33 total link strength)”, University of Stellenbosch “(33 documents, 530 citations and 27 total link strength)”, University of Pretoria “(41 citations, 547 citations and 23 total link strength)” and Cape Peninsula University of Technology “(27 citations, 596 and 22 total link strength)”. In summary, it grouped 107 items into 10 Clusters and these items had 651 links with 396.50 total link strength. “Cluster 1 comprises 19 items”, “Cluster 2 (14 items)”, “Cluster 3 (13 items)”, “Cluster 4 (12 items)”, “Cluster 5 (11 items)”, “Cluster 6 (11 items)”, “Cluster 7 (10 items)”, “Cluster 8 (9 items)”, “Cluster 9 (4 items)”, “Cluster 10 (4 items)”. Each node represents a term and its diameter signifies occurrence and the multiple colours denote different clusters in which these items belong and the thickness of the link shows their strength. The bubble size refers to the total number of highly cited articles, while line thickness shows the strength of their collaboration network (Fig. 2).

3.7. Countries collaborating with South African on diabetes research from 2010 –2019

We conducted this analysis to identify those countries around the world collaborating with South Africa on diabetes research from 2010 to 2019, and VOSviewer software was used to visualize the mapped network. We explored a fractional counting method for the analysis and the maximum number of countries per document was 25 and we selected 5 to be the minimum number of documents of the country. Of the 103 countries, 53 meet the thresholds and we visualized the results with VOSviewer software. From the mapped network displaced in VOSviewer software, it grouped the 53 items to 4 Clusters with 84 links and 513.50 total link strength. “Cluster 1 comprises 35 items”, “Cluster 2 (11

items)”, “Cluster 3 (4 items)”, and “Cluster 4 (3 items)” (Fig. 3). Clusters are categorized by the rate of shared co-occurrence terms that represent each country. Terms with the same colour means, they are closely connected, and they are categorized into the same cluster. Our observation corroborates with the findings of other researchers in different fields (Deng et al., 2020; Moral-Munoz et al., 2019; Zhang et al., 2019). Usually, in countries’ collaboration network analysis, the more publications a country has produced, the larger the size of its circle will be; the larger the scale of the cooperation is, the thicker the connecting line will be (Deng et al., 2020). It is important to note that the geographical focus of our study was on South Africa and the size of its sphere does not mean that South Africa is the leading country in diabetes-related research globally. However, we intended to investigate the extent of the collaborating network that South African researchers in the field have with other researchers in different countries. Therefore, this analysis is only based on South African researchers collaborating networks with researchers from other countries. The line connecting two items in Fig. 3 is called “link strength” and this is a measure of the degree of collaboration between two terms. For example, the link strength between South Africa and Nigeria is 38.46, South Africa and the USA is 30.55, whereas, South Africa and England is 29.46, Cameroon and South Africa is 18.12. These are the top three (3) countries with the highest link strengths with South Africa and this directly related to the extent of their collaborating network as seen in Fig. 3. The significance of this analysis is high because country co-authorship maps would assist South African scholars to know the current collaborators on the subject and this could greatly help new researchers in the field to identify potential collaborators in their future studies when launching into new projects (Deng et al., 2020) (see Fig. 4).

3.8. Bibliographic coupling analysis

As highlighted by the report of Mao et al. (2020), “bibliographic coupling analysis aims to find the relatedness of items based on the number of references they share and generate the knowledge domain map of main research journals, institutions and countries”. In the present study, bibliographic coupling of authors was carried out with fractional counting method. We ignored documents with a large number of authors with maximum number of authors per documents of 25, and we chose 5 as the minimum number of documents of an author. From this analysis, out of 1549 authors, 47 meet the chosen thresholds and we analysed the results in VOS viewer which is software developed by van Eck commonly used

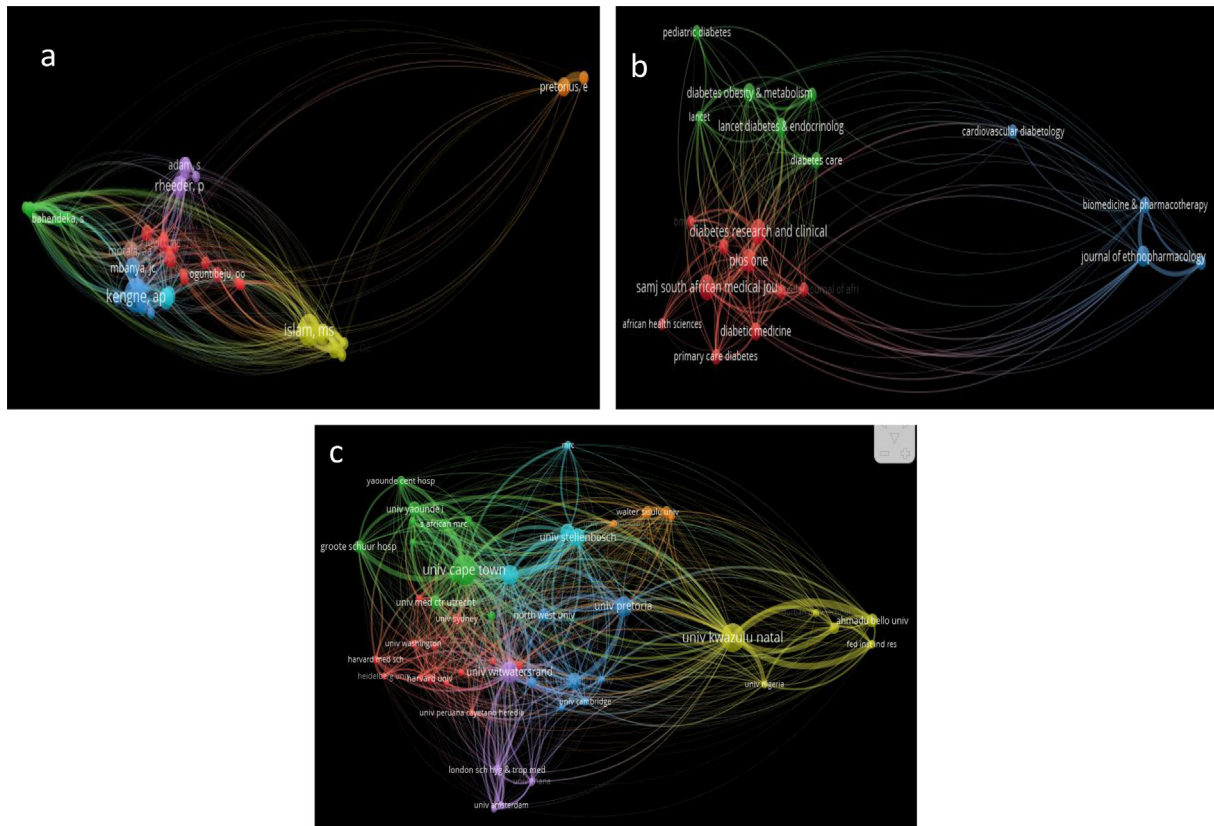


Fig. 4. Bibliographical coupling analysis Authors (a), sources (b) and institution (c).

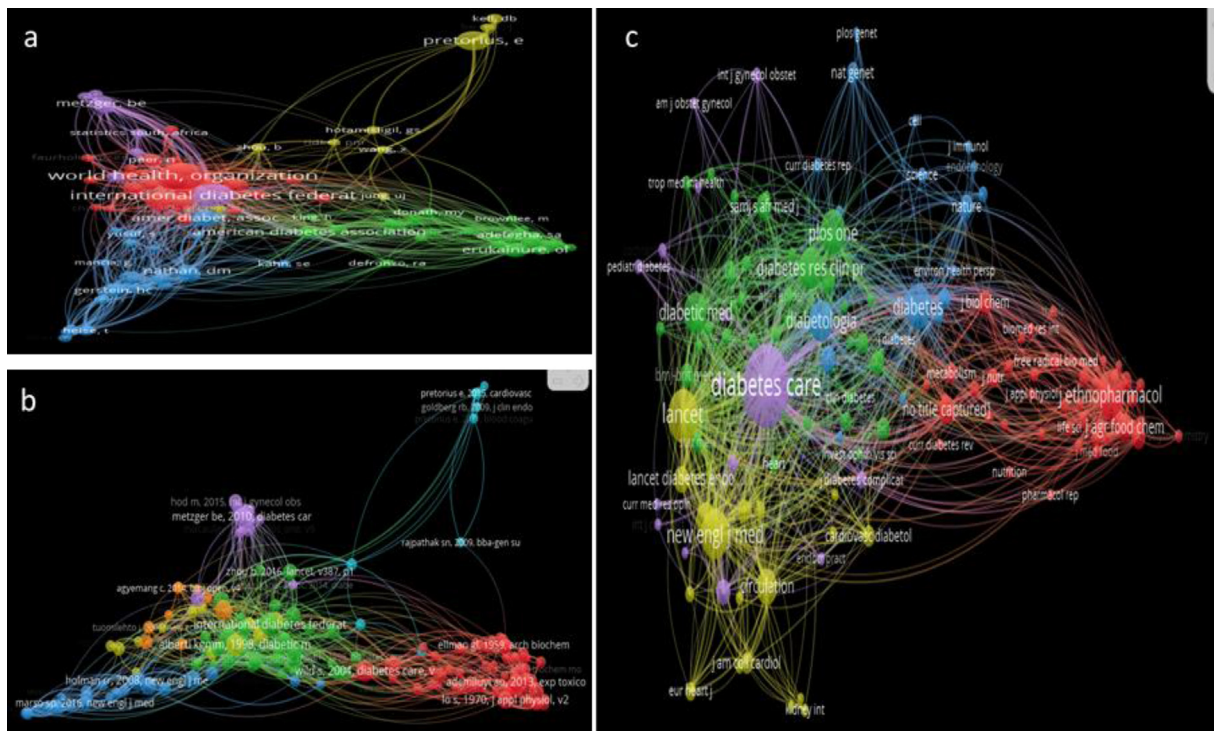


Fig. 5. Co-citation networks. Authors' co-citation networks (a), references co-citation network and sources co-citation network.

to visualize bibliometric networks (van Eck and Waltman, 2010; van Eck and Waltman, 2014). This software is freely available at www.vosviewer.com.

3.9. Co-citation network analyses

We carried co-citation analyses in this study as described by Mao et al. (2020) to assess the relatedness or connection between items, which are established based on the frequency at which they were being co-cited together in a published paper. By the virtue of co-citation analysis, the significant knowledge of a subject or topic in a particular field can be effortlessly known from the bulk of cited authors, sources and references, and this assists in the analysis of the most relevant papers on a particular subject. For authors co-citation analysis in the present study, published papers from the literature with the minimum number of citations of authors of 10 were used and we found 10,563 authors, of which, only 108 authors meet the chosen threshold to increase clarity (Geaney et al., 2015); and we analyzed the results with VOSviewer software as seen in Fig. 5a. From the analysis, the larger the dimension of the sphere, the greater the strength and we observed World Health Organisation to be the lead author on the subject with 129 citations and total link strength of 100.09 followed by the International Diabetes Federation with 99 citations and 85.95 total link strength. American Diabetes Association had 53 citations and 51.21 total link strength whereas, Kengne AP “(55 citations and 43.59 total link strength)” and Alberti KGMM “(42 citations and 40.15 total link strength)” were noted to be fourth and fifth authors in the row. Subsequently, the analysis through the VOS viewer revealed 108 items that were grouped into five clusters. “Cluster 1 comprises 34 items”, “Cluster 2 (34 items)”, “Cluster 3 (23 items)”, “Cluster 4 (9 items)”, and “Clusters 5 (8 items)” as seen in Fig. 5a. The links between spheres represent the collaborations where the greater width of the link (namely link strength) means the closer collaborations, which is also applied to other network analyses carried out in this study. Co-authorship links were also used to group the members into clusters of individuals who are relatively strongly connected with each other. In the visualization of the co-authorship network, the colour of a name indicates the cluster to which the member belongs (Palmlblad and Jan van Eck, 2018).

Likewise, co-citation of cited references was conducted, and we chose fractional counting as our preferred method and 5 as the minimum number of citations of a cited reference. We observed 13,515 cited references and of which, only 176 meet the chose threshold and these were further analyzed through VOS viewer and the top 5 were as follows: International Diabetes Federation 2015 “(25 citations, 24.00 total link strength)”, Alberti KGMM 1998 “(21 citations, 21.00 total link strength)”, Peer N 2012 “(18 citations, 18 total link strength)”, Wild S, 2004 “(21 citations, 17 total link strength)”, and Shaw JE, 2010 “(16 citations, 16 total link strength)”. The analysis from the VOS viewer revealed that these 176 items were categorized into 7 clusters. “Cluster 1 comprises 63 items”, “Cluster 2 (46 items)”, “Cluster 3 (24 items)”, “Cluster 4 (13 items)”, “Cluster 5 (12 items)”, “Cluster 6 (9 items)” and “Cluster 7 (9 items)” (Fig. 5b). Furthermore, we carried out co-citation of cited sources using fractional counting, the minimum number of citations of a source was 200 and we found 3751 sources, of which 137 meet the threshold selected. It is worthy to note that there are no specific criteria that guide the selection of thresholds to be used for this analysis, however; it is wise to choose a reasonable value that would be most suitable to view our results. As a result, therefore, the top 5 cited sources were as follow: Diabetes Care “(967 citations with 781.16 total link strength)”, Lancet “(396 citations with 351.73 total link strength)”, New England J Med “(349 citations with 304.34 total link strength)”, Diabetes “(299 citations with 275.39 total link strength)” and Plos one “(281 citations with 258.85 total link strength)”. The analysis of 137 items on VOS viewer revealed 5 groups and Cluster 1 consists of 46 items, Cluster 2 (39 items), Cluster 3 (19 items), Cluster 4 (18 items), and Cluster 5 (15 items) as shown in Fig. 5.

3.10. Co-occurrence keywords network

In this section, we carried out analysis to visualize the network of co-occurrence of keywords frequently used in the 416 retrieved research articles from SCI-Expanded on diabetes related research in South Africa from 2010 to 2019 and the results are represented in Fig. 6. In the visualization of the keywords co-occurrence network, the size of a keywords reflects the number of publications in which the term occurs, and the distance between two keywords

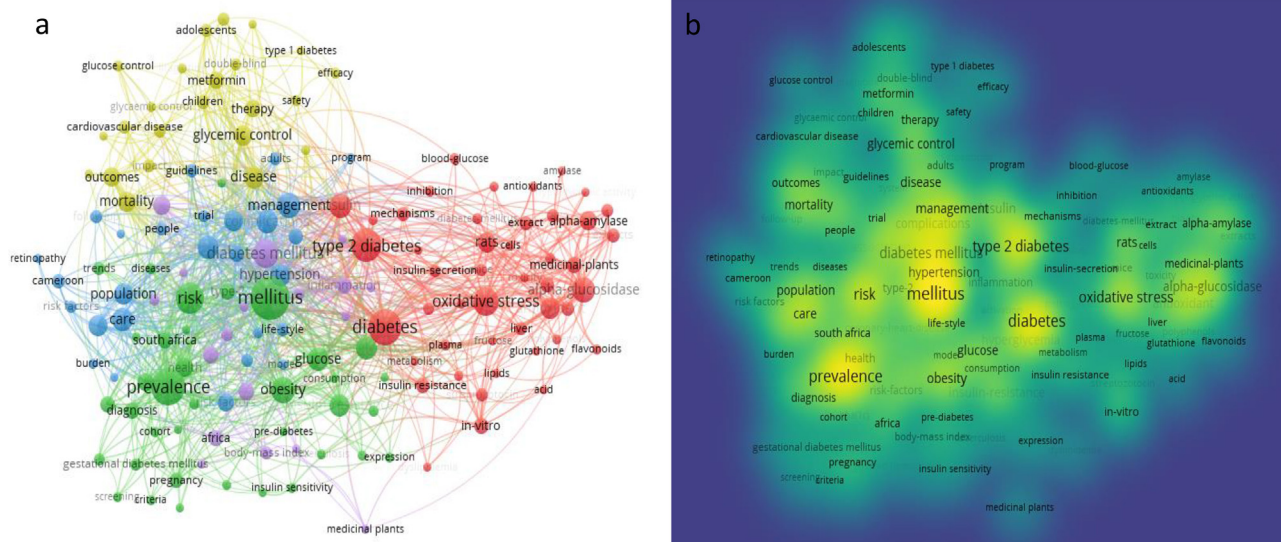


Fig. 6. Co-occurrence keywords network on diabetes-related research in South Africa between 2010 and 2019.

provides an approximate indication of the relatedness of the terms (Palmbad and Jan van Eck, 2018). In this analysis, author co-occurrence was assessed based on fractional counting and minimum number of occurrences of a key was 5. We observed 1906 keywords and out of these, 151 keywords meet the chosen threshold and these results were visualized in VOS viewer. The top 10 keywords were as follows: Mellitus “(98 occurrences with 96 link)”, prevalence “(74 occurrences with 72 links)”, diabetes “(69 occurrences with 67 links)”, type 2 diabetes “(60 occurrences with 59 links)”, risk “(54 occurrences with 53 links)”, diabetes mellitus “(42 occurrences with 42 links)”, oxidative stress “(43 occurrences with 42 links)”, obesity “(38 occurrences with 37 links)”, management “(35 occurrences with 35 links)” and alpha-glucosidase “(34 occurrences with 34 links)”. These keywords identified in this study indicate research hotspot on the subject over the last 10 years among the researchers in South Africa and several scholars have used keywords to identify research trends in a particular field (Cancino et al., 2017; Li and Zhao, 2015; Kamdem et al., 2019; Muhuri et al., 2018). In the visualization, the 151 items were grouped into 5 Clusters and “Cluster 1 comprises of 46 items”, “Cluster 2 (37 items)”, “Cluster 3 (27 items)”, “Cluster 4 (23 items)” and “Cluster 5 (18 items)” as observed in Fig. 6. The closeness or relatedness of keywords was determined based on their number of co-occurrences. It is noteworthy that the larger the number of articles in which two keywords both appear together, the stronger the relation between the keywords and the smaller, on average, the distance between the keywords in the visualization. Colours represent clusters of terms that are relatively strongly related to each other as seen in Fig. 6.

3.11. Limitations

The present study presents a national mapping of diabetes research in South Africa from 2010 to 2019; however, the analysis might not provide the holistic research articles published on the subject because we only focused on published articles indexed in Web of Science without considering articles indexed in other scientific databases such as Scopus and PubMed. Moreover, due to the global recognition of English, we did not include those articles written in other languages such as French in the data retrieved from SCI-Expanded and this could result into incomplete coverage of published research articles on the subject. Likewise, despite the rigorous search to arrive at the eligible articles used for the analysis in the present study, it is possible that we did not exhaust all the potential keywords associated with diabetes research in South Africa within the stipulated period, and such constraint might create a bias in the analysis. Also, some scholars may have collaborated with several researchers from different institutions, and this consequently influence the number of articles associated with each affiliation in the study. Finally, the present study did not critically analyze the content of each paper to know the scientific quality or soundness, as the study only mapped the research trends on the subject; hence, we are very careful about drawing a strong assumption or definitive conclusion on the published papers that were analyzed.

4. Conclusions

This study provides deep insight into diabetes research in South Africa from 2010 to 2019. About 416 articles were retrieved from SCI-Expanded and the articles were written by 9674 authors, the authors/documents were observed to be 23.3, co-authors/documents were 42.1, and the collaboration index was 23.4. The eminent collaboration network among the researchers signifies national involvement of different institutions, which could yield

significant outputs that may assist the government in eradicating the disease. Also, we believe that this study would assist new researchers in discovering collaborators in future studies. With an increase in research funding, support from the government or private sections, we believe that the researchers in the field would be able to conduct more research on the subject and this would reduce the mortality statistics associated with diabetes in the country.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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