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REVIEW ARTICLE

Bibliometric Analysis of Clinical Health and Medical Care Research: The Case of Sudan from 1991 to 2021

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Keywords

Bibliometric Analysis,

Clinical Medicine,

Health Care,

Research,

Sudan

ABSTRACT

Background: The World Health Organization (WHO) identifies good health as a crucial human resource for daily life, survival, security, and prosperity. Developing nations face numerous challenges that hinder the advancement of good health and well-being. As one of the largest countries in Sub-Saharan Africa, Sudan is positioned to advance "Good Health and Well-being." Therefore, stakeholders are examining the current status and future outlook of clinical health and medical care (CHMC) research in Sudan. This paper used a bibliometric analysis (BA) of CHMC research in Sudan to understand the current challenges, research landscape, and scientific developments.

Methodology: The PRISMA technique was used to identify, screen, and analyze 560 documents on CHMC research from 1991 to 2021 using Scopus data. BA was adopted to perform co-authorship, co-occurrence, and citation analyses using VOSViewer.

Results: Results revealed that 85.5% of the documents are research articles, although reviews, notes, and letters account for 10.2%. The most prolific authors are Peter Moszynski (United Kingdom), Ishag Adam (Saudi-Arabia), and Hashim Ghalib (United States). Khartoum University (Sudan) is the most prolific organization/affiliation. Funding analysis revealed that CHMC research is mainly financed externally by charitable and development organizations. The most active researchers in CHMC research are in Sudan, although strong collaboration exists with others abroad due to financial support, research funding, and knowledge exchange.

Conclusion: The study suggests that CHMC research in Sudan can significantly contribute to achieving the SDGs, but further research should address major social challenges and foster targeted collaborations.

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INTRODUCTION

The maxim, "health is the foundation of wealth," cannot be overemphasized. It states that the foundation of any community, society, or country largely depends on the good health and well-being of its inhabitants.[1,2] Likewise, the World

Health Organisation (WHO) defines good health as "a resource for everyday life" that is not solely based on "the objective of living."[3] Therefore, the WHO's definition of good health is primarily considered a positive notion that highlights the capabilities of an individual, group, or community based on personal, social, and physical resources.[3] According to the charter, attaining good health is a fundamental right for all humans irrespective of age, race, religion, political belief, and social, environmental, or economic situation. In addition, according to the charter, good health is critical to attaining national security and global peace by extension.[3] However, the challenges of providing good health and the control of diseases in many parts of the world, particularly developing countries, are considered a source of danger.[3-5]

The United Nations (UN) proposed "Good Health and Well-being" as one of the Sustainable Development Goals (SDGs) in 2015.[6,7] In practice, SDG Number 3 aims to promote healthy lives and the well-being of the human races of the world to ensure sustainable development. This objective is particularly crucial at this time in the world due to the growing spate of pandemics such as COVID-19, Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS), and tuberculosis, as well as hepatitis, malaria, water-borne, infectious, and other preventable diseases. In addition, the goal aims to reduce the global rates of maternal mortality, preventable child deaths, substance abuse, and road accidents, among others.[8, 9] According to the UN, attaining the SDGs will help stimulate socio-economic growth and sustainable development in the world's poorest nations.[10] Hence, there have been significant efforts to meet the UN SDGs in Sub-Saharan African countries.

As one of the member nations of the UN with a large population size, effective interventions in Sudan can accelerate the attainment of the UN's Sustainable Development Goals (SDGs). However, the progress in the realization of the UN SDGs has been hampered by numerous challenges, including political instability, widespread corruption, civil strife, perennial conflicts, and other bureaucratic bottlenecks.[11-17] The combined effects of these challenges have aggravated the already stretched state of the nation's health services and medical sector. In addition, the country has experienced humanitarian, economic, and ecological challenges ranging from drought, desertification, and floods to economic stagnation, embargoes, and sanctions, among others.[18-21] Therefore, the nation's health sector has witnessed an enormous dip in funding, which has resulted in a high incidence of health-related challenges ranging from a high rate of fatal diseases, malnutrition, and child mortality, among others.[22-25]

In response to these growing challenges, numerous researchers in the country and abroad have sought to identify and examine the ills affecting the health sector in the country.[26, 27] The studies have also highlighted the various diseases and medical conditions that have affected the

country's clinical health and medical care (CHMC) over the years.[28,29] Other studies have reviewed the current status, existing challenges, and potential developments on CHMC in Sudan, along with recommendations for future progress.[30,31] However, there is currently no critical review or comprehensive study on the research landscape of CHMC research in Sudan. Previous publications on the subject area have been limited to a handful of reviews that highlight only the problems in the nation's health sector. However, there has been no literature study that critically analyses the research background and active stakeholders (e.g., academic researchers, funding organizations, or collaboration) on CHMC research in Sudan.[32-35]

Therefore, this paper seeks to present an overview of the current research landscape on clinical health and medical care (CHMC) research in the country through bibliometric analysis and literature review. In principle, bibliometric analysis is a mathematical and statistical procedure typically used to examine the research background, empirical studies, and innovative developments in any field of science.[36-40] The concept has been successfully employed in previous studies to examine and highlight the status, challenges, and potentials in the fields of management, entrepreneurship, urban planning, biofuels, food safety, safety culture, hospitality, health facilities, occupational safety, agricultural waste management, and carbon dioxide management.[41-51]

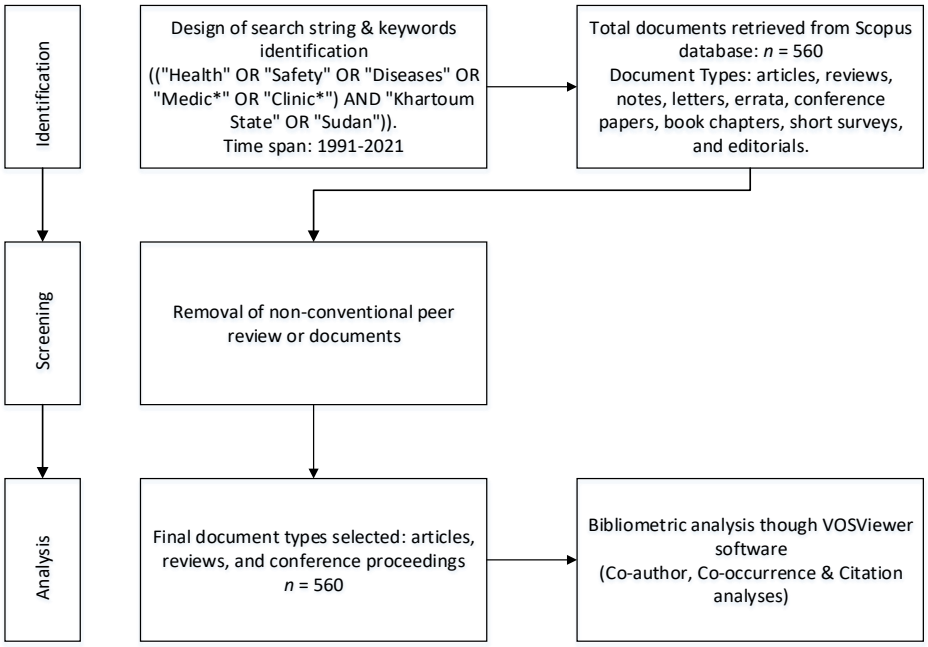

Figure 1: Schematic of PRISMA methodology used for CHMC research in Sudan

MATERIALS AND METHODS

This paper examined the bibliometric analysis of the current research landscape and literature review on clinical health and medical care (CHMC) research in Sudan from 1991 to 2021 based on data retrieved from the Scopus database. The search for published documents on the subject area was carried out on 06 November 2021 using the designed search string TITLE ((“Health” OR “Safety” OR “Diseases” OR “Medic*” OR “Clinic*”) AND “Khartoum State” OR “Sudan”)). The search returned 560 documents comprising articles, reviews, notes, letters, errata, conference papers, book chapters, short surveys, and editorials. Thereafter, the preferred reporting items for systematic reviews and meta-analyses (PRISMA) approach were selected to identify, select, and examine the retrieved documents from Scopus, [52-54], as shown in Figure 1.

Lastly, the publications data recovered as comma-separated value (CSV) files were inputted into the VOSViewer software to conduct a bibliometric analysis of the subject area of CHMC research in Sudan. The data from the CSV file was subsequently analyzed and processed to obtain data on the co-authorship (relationships for authors, organizations, and countries), keyword co-occurrence, and citation trends in the literature.

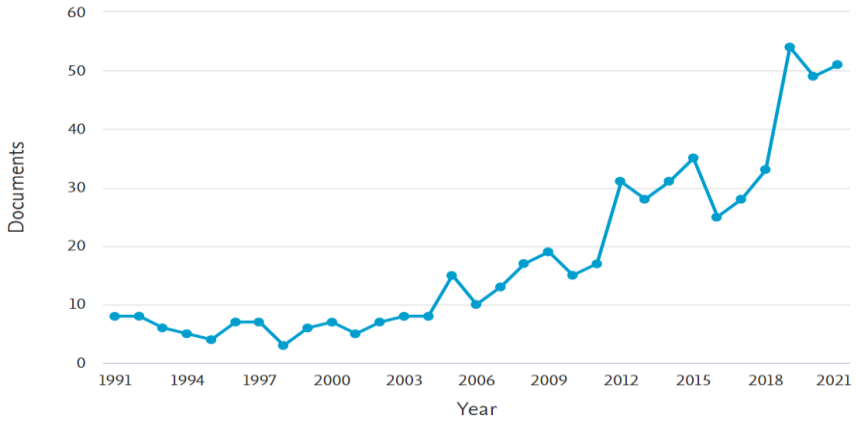

Figure 2: Publication trends on CHMC research in Sudan (1991-2021)

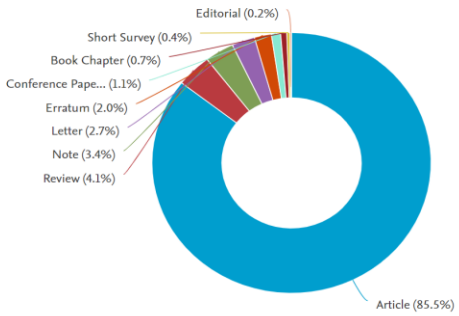

Figure 3: Distribution of published documents on CHMC research in Sudan

RESULTS

Publication trends

The publication trends of the subject area of clinical health and medical care (CHMC) research in Sudan based on the recovered data from Scopus were examined in this paper. Figure 2 presents the publication trends on the subject area over the period examined in the study. The findings showed that the published documents on CHMC research in Sudan increased from 8 to 51 from 1991 to 2021. However, the highest number of publications (54) was observed in 2019, whereas the lowest number (3) was in 1998. Overall, the results showed that the average annual number of publications on CHMC research during the period examined was 18.06. Further analysis showed that the documents recovered from CHMC research in Sudan are primarily published in open-access (gold, green, hybrid, and bronze) journals.

Figure 3 shows the distribution of published documents on CHMC research in Scopus. The most preferred document type for researchers in the field is articles, which account for 85.5% (479) of all published materials, whereas reviews account for 4% (23) of documents.

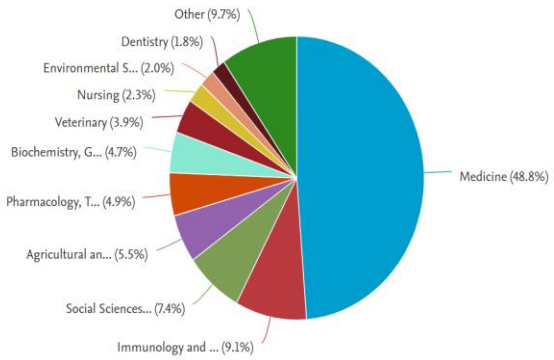

Figure 4: Subject themes for publications on CHMC research in Sudan (1991-2021)

Further analysis showed that the publications on the CHMC research in Sudan are categorized into various themes ranging from Agricultural and Biological Sciences to Environmental Science and Health Professions to Veterinary medicine. The field of medicine accounts for the highest number (398 or 48.8%) of publications on CHMC. The top five subject themes (and publication counts in brackets) on CHMC research are Medicine (398), Immunology and Microbiology (74), Social Sciences (60), Agricultural and Biological Sciences (45), along with Pharmacology, Toxicology, and Pharmaceutics (40).

Top authors, organizations, and country trends

Analysing the top authors, organizations, and country trends is critical to understanding the research landscape of clinical health and medical care (CHMC) research in Sudan. Figure 5 shows the top 10 authors on CHMC research in Sudan based on the published documents on the subject

area from 1991 to 2021 in the Scopus database. The top 10 researchers on CHMC research in Sudan published 6 - 8 documents (or 6.6 on average out of the top 10) each between 1991 and 2021. The most prolific author is *Peter Moszynski*, based in the United Kingdom. Others include *Ishag I. Adam*, affiliated with Al Qassim University (Saudi Arabia), *Hashim W. Ghalib* of the Infectious Disease Research Institute (United States), *Richard L.L. Lako* of the Ministry of Health (Sudan), and *Elfatih M. Malik* of the Khartoum University (Sudan). . . Figure 6 shows the affiliations of the top authors on CHMC in Sudan from 1991 to 2021.

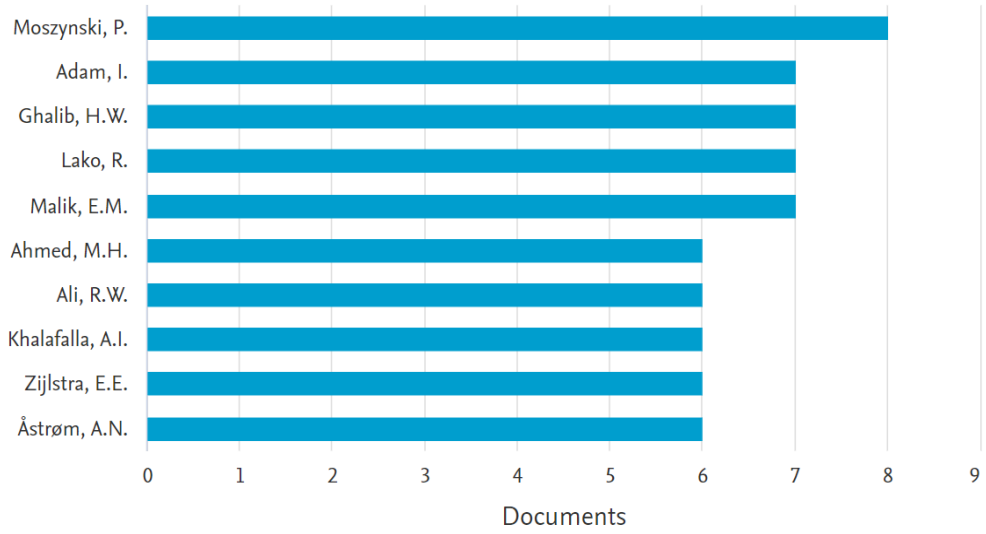

Figure 5: Top 10 authors in CHMC research in Sudan (1991-2021)

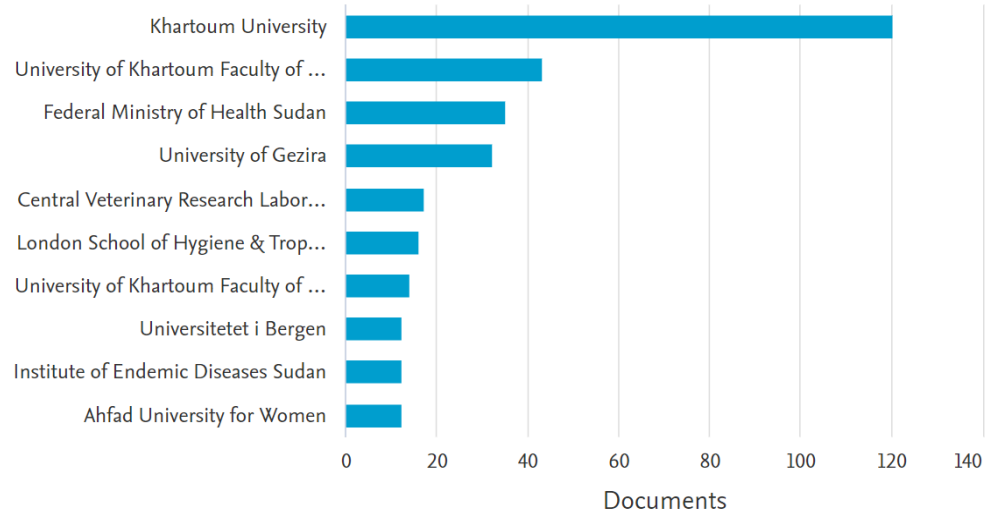

Figure 6: Top 10 affiliations for research on CHMC in Sudan (1991-2021)

The top affiliations for publications on the subject area are Khartoum University (Sudan) and the Federal Ministry of Health (Sudan), with 163 and 35 published documents, respectively. Following these are the University of Gezira (Sudan) and the Central Veterinary Research Laboratory (Sudan), with 32 and 17 published documents, respectively. Other notable affiliations with publications on CHMC include the London School of Hygiene & Tropical Medicine (16, United Kingdom), University of Bergen (12, Norway), Institute of Endemic Diseases (12, Sudan) and Ahfad University for Women (12, Sudan). The findings reveal that CHMC research is a widely researched area by academic and research institutions in Sudan. Figure 7 presents the top funders of CHMC research in Sudan from 1991 to 2021. As observed, the major funders for research on the subject area are located outside Sudan, particularly in Norway, the United Kingdom, Switzerland, and the United States. The findings indicate these organizations have funded between 3 and 7 publications over the period examined in the paper. Figure 8 presents an overview of the top 10 countries with published documents on CHMC research in Sudan from 1991 to 2021.

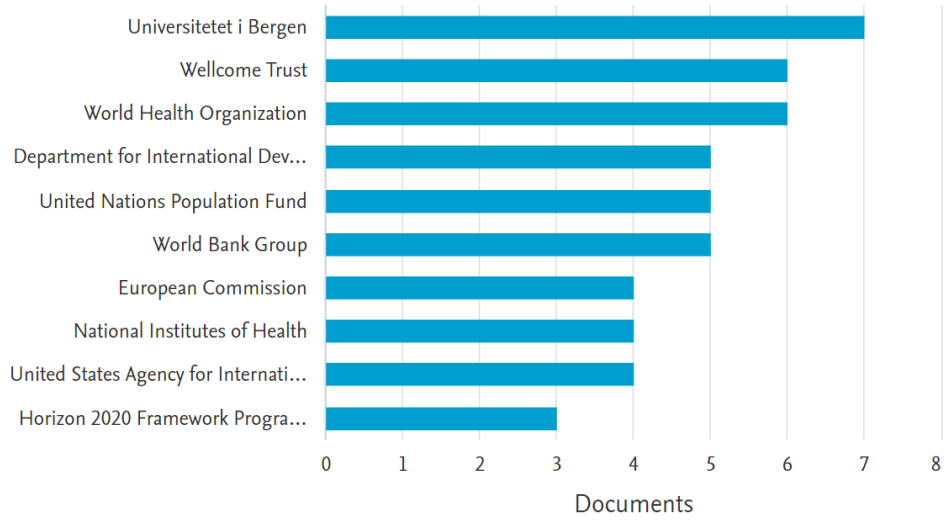

Figure 7: Top 10 agencies and organizations funding CHMC research in Sudan

As observed in Figure 8, Sudan (with 350 documents) has the highest publications on the subject, as earlier revealed in Figure 6, due to the active research activities of the nation's government agencies as well as research and academic institutions such as the University of Khartoum, Federal Ministry of Health, and the University of Gezirat. However, the findings also reveal that the UK, the US, Saudi Arabia, and the Netherlands are also active in CHMC research.

Bibliometric analysis (BA)

BA was used to evaluate the research landscape and scientific developments in CHMC research in Sudan. [36-40] According to the study by Durieux

and Gevenois, the bibliometric analysis could also be used to critically assess the research impact and scientific relevance of any given subject area. [55] In this paper, the approach has been adopted to critically examine and highlight the impact of research on clinical health and medical care (CHMC) research in Sudan. Based on the data recovered between 1991 and 2021 from the Scopus™ database, the authors have carried out co-author, keyword co-occurrence, and citation analysis of publications on CHMC research in Sudan.

Co-authorship analysis

The level of co-authorship on any subject of bibliometric analysis is critical to examining the research landscape among researchers, organizations, and countries. In this study, the co-authorship analysis was evaluated using the VOSViewer software. Figure 9 shows the network visualization map for the most active researchers in the area of CHMC Research in Sudan. The analysis of authors was examined based on a minimum of 3 documents, resulting in the selection of 2082 authors, of which 99 were selected for computation. Therefore, the data in Figure 9 is based on 49 connected authors, which produced a total of 8 clusters differentiated by the colours. The co-authorship analysis among the authors produced 8 clusters denoted by the various colours in Figure 9.

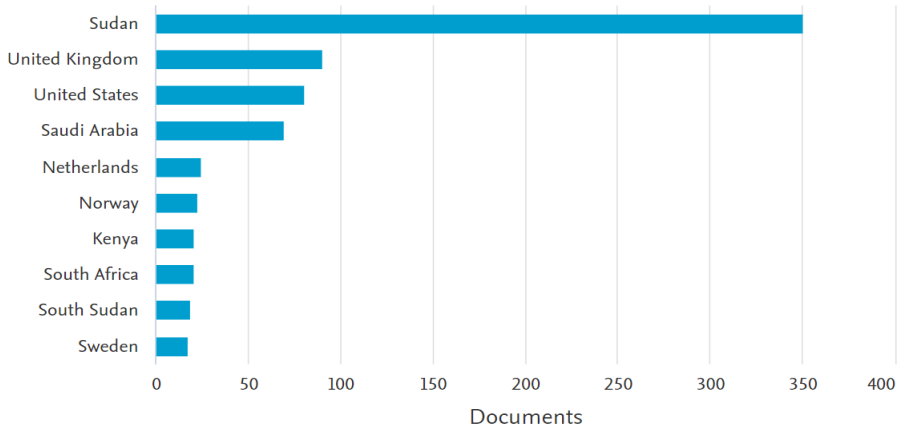

Figure 8: Top 10 countries with published documents on CHMC research in Sudan

As observed, the red cluster (comprising authors such as Ali A.A. Abdallah T.M., among others) exhibited the highest number of nodes and links (5) to other clusters in the figure. The findings indicate that the authors in the red cluster are the most active in terms of collaboration, particularly with highly prolific authors such as Ghalib HW, Lako R, Malik EM, Ahmed MH, and Adam I from the other clusters. However, the findings also showed that 4 clusters (brown, purple, blue, and green) are linked to only one other cluster each, indicating limited collaboration. Overall, the findings showed that research collaboration between researchers in the subject area is weak (1 link), medium (≤ 2), and strong (> 2).

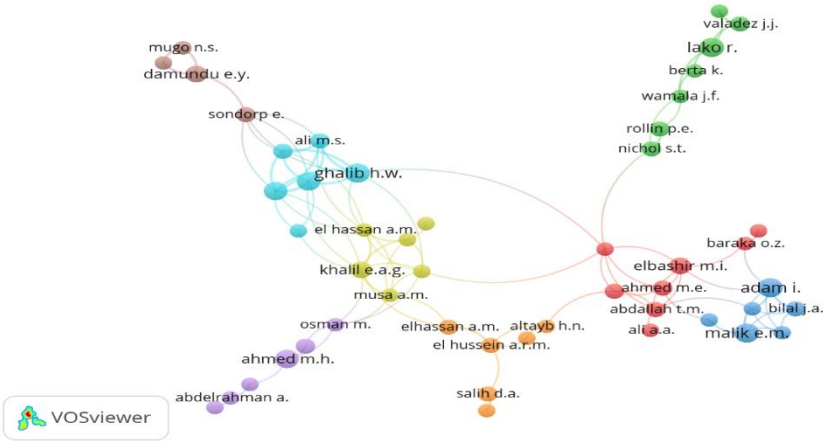

Figure 9: Network visualization map for authors working on CHMC Research in Sudan

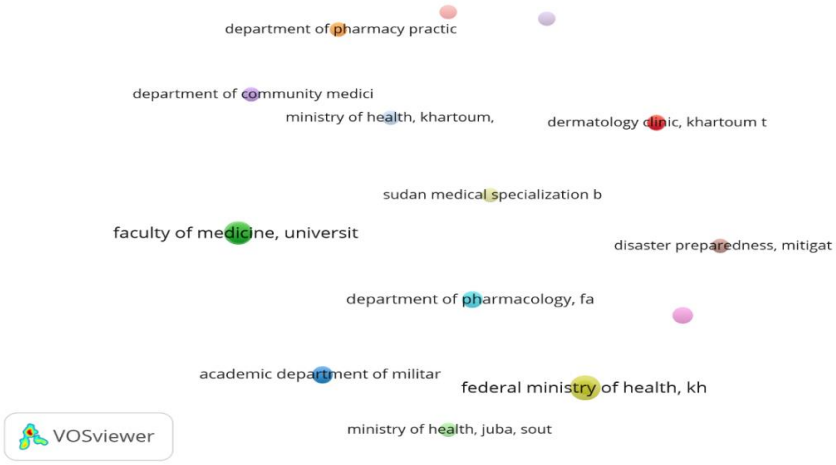

Figure 10: Network visualization of organizational collaboration(s) on CHMC research in Sudan

Conversely, the analysis of collaboration links between organizations was found to be very weak, as depicted in Figure 10. The study was based on the computation of a minimum of 3 documents for each organization, which resulted in 83 organizations and 41 meeting the search criteria. Despite the total of 9 clusters obtained, there was no apparent link between any of the organizations working in the subject area.

Figure 11 presents the network visualization of collaborations between Sudan and other nations on CHMC research. Sudan has the largest node, with its size and thickness of the link showing a high number of documents, authors, citations, and organizations focused on this subject area. Also, the strongest links exist between Sudan and Saudi Arabia, the United Kingdom, and the United States, as observed in Figure 8 indicating that a triangular research collaboration exists between Sudan and the top three nations.

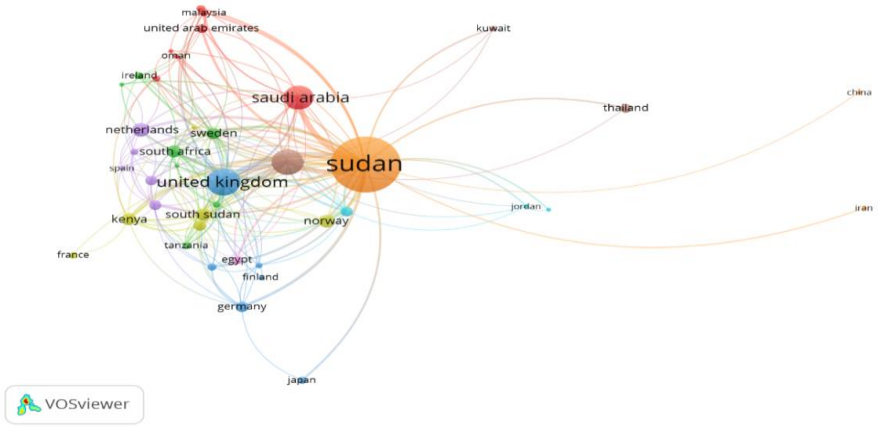

Figure 11: Network visualization of inter-country collaboration on CHMC research in Sudan

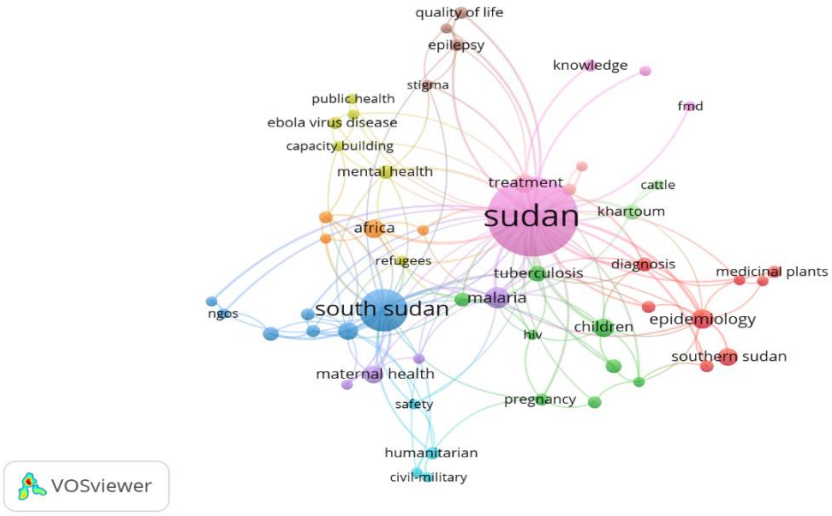

Figure 12: Network visualization of co-occurrent keywords on CHMC Research in Sudan

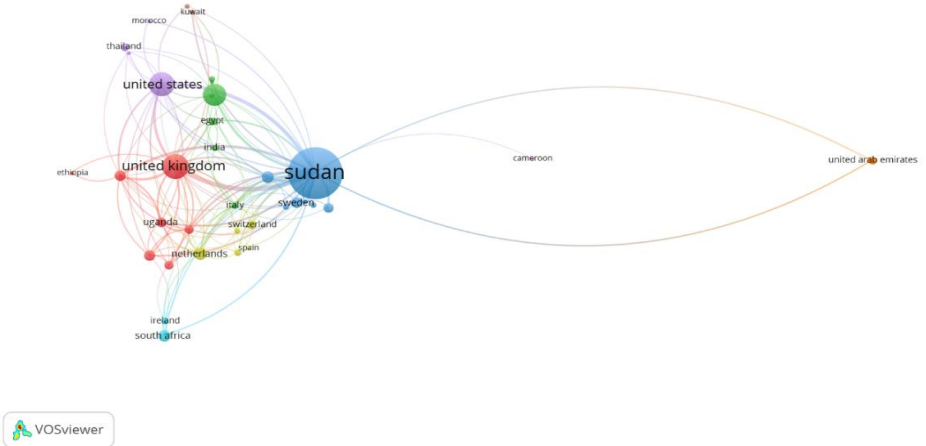

Figure 13: Network visualization for country-based citations on CHMC research in Sudan

Co-occurrence analysis

The keywords related to the subject area were also analysed in this study. This analysis was carried out based on a minimum of 3 keywords, which resulted in 1296 documents, of which 59 fulfilled the required criteria. Based on the findings, the VOSViewer generated the network visualization of co-occurrent keywords on CHMC Research in Sudan, as depicted in Figure 12. The network visualization map generated 11 clusters as differentiated by the various coloured links and nodes. The most important keyword on the subject area, as indicated on the node size, is "Sudan," which is to be expected due to the developed search string for the study. The keyword "Sudan" is the most significant node of the purple cluster, along with other smaller keyword nodes.

On the other hand, the second largest node was observed for the keyword "South Sudan," which forms the blue cluster. Other clusters in the map contain other vital keywords such as tuberculosis, epidemiology, maternal health, Africa, epilepsy, and quality of life.

Citations Analysis

The citation analysis was also conducted to examine the extent to which current research works on CHMC research are receiving attention in the scientific world. Hence, the citations at the country level for the subject area were examined based on a minimum of 3 citations per country. The results produced 83 countries, of which 41 fulfilled the criteria and generated 9 clusters, as depicted in Figure 13. Based on the network visualization map, it can be seen that studies by researchers in Sudan garnered the highest share of citations on CHMC research. Closely behind the host country are Saudi Arabia, the United Kingdom, and the United States of America, which also garnered high citations over the period under investigation. Likewise, the strongest links are between Sudan, the UK, and Saudi Arabia.

The summary of the most cited publications on CHMC research in Sudan is presented in Table 1. As observed, the most cited documents were mainly published between 1992 and 2012, with citations ranging from 74 to 172 or an average of 106. The most cited publication is by Zijlstra [56] (cited 172 times) on Endemic *kala-azar,* otherwise known as *Visceral leishmaniasis* (VL) in the eastern region of Sudan. The longitudinal study examined the occurrence of clinical and subclinical infection of the highly fatal form of VL in the area of the country. Similarly, Zijlstra et al. [57] published another highly cited study (cited 77 times) on the VL outbreak in the year 2000.

Other notably cited documents are publications by Awad, Arnot, and Musa, which have garnered 171, 122, and 102 citations, respectively.[58-60] Further analysis showed that the Royal Society of Tropical Medicine and Hygiene Transactions account for 2 out of the 10 most-cited journals in the subject area. In general, the studies examine various diseases such as VL, Ebola, and Malaria, as well as behavioural problems and the use of medicinal remedies to treat multiple illnesses in the country.

Table 1: Top 10 most cited documents on CHMC Research in Sudan

Authors	Title	Source Title	Citations
Zijlstra [56]	Endemic kala-azar in Eastern Sudan: A longitudinal study on the incidence of clinical and subclinical infection and post kala-Azar dermal leishmaniasis	American Journal of Tropical Medicine and Hygiene	172
Awad[58]	Self-medication with antibiotics and antimalarials in the community of Khartoum State, Sudan	Journal of Pharmacy and Pharmaceutical Sciences	171
Arnot[59]	Unstable malaria in Sudan: The influence of the dry season clone multiplicity of Plasmodium falciparum infections in individuals exposed to variable levels of disease transmission	Transactions of the Royal Society of Tropical Medicine and Hygiene	122
Musa [60]	Ethnobotanical study of medicinal plants in the Blue Nile State, South-eastern Sudan	Journal of Medicinal Plants Research	102
Roberts [61]	Post-conflict mental health needs: A cross-sectional survey of trauma, depression and associated factors in Juba, Southern Sudan	BMC Psychiatry	93
Geltman [62]	The "Lost Boys of Sudan": Functional and behavioural health of unaccompanied refugee minors resettled in the United States	Archives of Pediatrics and Adolescent Medicine	86
El Hassan [63]	Post kala-azar dermal leishmaniasis in Sudan: Clinical features, pathology, and treatment	Transactions of the Royal Society of Tropical Medicine and Hygiene	83
Tumwine [64]	Clinical and epidemiologic characteristics of nodding syndrome in mundri county, southern Sudan	African Health Sciences	80
Zijlstra [57]	Post kala-azar dermal leishmaniasis in Sudan: Clinical presentation and differential diagnosis	British Journal of Dermatology	77
MacNeil [65]	Reemerging Sudan Ebola virus disease in Uganda, 2011	Emerging Infectious Diseases	74

DISCUSSION

Research on CHMC in Sudan has increased significantly over the last 30 years. This growth underscores the relevance of CHMC research in Sudan. It should be noted that the overall trend in scholarly research on CHMC research is related to health communication management, cancer research, and COVID-19 management.[66-68] However, it needs to be investigated whether this growing trend can support best practices for medical care. Future studies might, therefore, examine the effects of the growing trends in CHMC research on medical care in Sudan. The increase in CHMC research in Sudan as observed in Figure 2 may be ascribed to several factors. Firstly, the global attention given to AIDS, pioneered by WHO in 1987, might have directed several resources to CHMC research in Sudan and other African nations in the 1990s. [66] Another plausible reason for this growth may be due to the country's national policy and research priority area. In addition, the availability of internal and external research funding or financial support for the subject area in the country may have stirred the growth of CHMC research in Sudan. Consequently, global organizations like the World Bank and International Monetary Fund began to provide financial support through local NGOs, Universities, and international NGOs in the 1980s, which may have significantly changed how CHMC researchers conduct research in African nations such as Sudan. [67] Again, the high

preference for these areas of study may be due to various socio-economic, techno-environmental, and geopolitical factors. As with many developing nations, Sudan faces numerous challenges. In particular, Sudan faces health, sanitation, famine, desertification, and internal conflicts. Therefore, government policies and significant human and economic resources promote socio-economic growth, infrastructural development, and a sustainable environment. To attain this level of national upliftment, human capital and research funding (internal and external) are annually allocated to address the outlined challenges. As observed in Figure 3, the preference for articles and reviews observed for CHMC research can be ascribed to the academic prestige attached to these published documents in the academic world. However, such preferences may also be due to the incentive policies of many academic institutions, which afford greater monetary rewards to peer-reviewed articles and reviews over other forms of publications such as (books, book chapters, letters, and notes) in the literature as reported in Xu. [69] Similar reports have highlighted the existence of the practice in many other countries, such as the United States, Germany, Denmark, South Africa, and Malaysia, among others. [70] For scholars, publishing in peer-reviewed, high-impact journals typically results in significant financial incentives, academic prestige, and national accolades. Therefore, scholars should choose reputable journals in their specific fields and publish their work in those journals.

As can be gleaned from Figure 7, the result from funding analyses shows a clear indication that CHMC research in Sudan is influenced by external funders from Norway, UK, Switzerland and the US. This finding indicates that Sudan-based institutions are underrepresented in top funders due to inadequate reporting, organizational inefficiency, or personal funding for research. However, empirical data is required to ascertain or confirm this assertion concretely.

The results from Figure 8 show that Sudan-based researchers have the highest number of publications on CHMC research although the results from co-author analysis in Figures 9 and 10 revealed a weak or limited collaboration among authors and organizations from Sudan to the extent expected. This finding is consistent with studies that accounted for low collaboration among authors from one nation. [71] One plausible reason for this finding may be that single-author publications receive more credits for promotions and rewards when compared to collaborative work.[72] However, there have been collaborations between researchers from Sudan and their peers in the UK, the US, and Saudi Arabia as depicted in Figure 11. This observation could be due to the availability of research support in the form of funding, equipment, or exchange of knowledge between Sudan and these nations over the years. The interest in CHMC research in Sudan could be ascribed to the global pandemics and cardiovascular and chronic lung diseases, which have spurred active research collaborations between Sudanese academics and Western and

African nations. Findings from Figure 12 show the network visualization of co-occurrence keywords of the author on CHMC in Sudan. These keywords provide an understanding of the various diseases, illnesses, and research thrusts, and the target patients in CHMC research in Sudan. For example, the red cluster, which highlights the keywords medicinal plants, diagnosis, epidemiology, and South Sudan, highlights the current emphasis on using alternative medicines to understand, prevent, and treat various illnesses in the country. Furthermore, the keywords of the purple cluster indicate that challenges such as maternal health and malaria remain significant health challenges in Sudan, as is evident in the number of studies in the country. The green cluster shows that HIV and Tuberculosis are considerable health challenges in Khartoum (the capital of Sudan), along with health issues related to women and children. Overall, the keyword co-occurrence analysis reveals that researchers on CHMC in Sudan are actively researching socially impactful topics that benefit the larger society. There is also a clear indication that research funding, particularly from external sources (evident in the keywords NGOs, humanitarian, and capacity building), is playing a crucial role in addressing the health, clinical, and medical problems in the country.

Based on findings from citation analysis in Figure 13, network visualization revealed that researchers from Sudan, Saudi Arabia, the UK and the US had the largest number of citations with Sudan having the highest which is to be expected as the target country. This observation from the citation analysis could also be due to strong research ties between home-based and foreign Sudanese researchers based in Saudi Arabia, the UK and the US. Various studies in the literature confirm that the two nations host numerous Sudanese nationals working in research and academia.[73,74] This observation may also account for the high publications, research funding, and citations, as shown in Figure 13.

CONCLUSION

The paper examined the research landscape on clinical health and medical care (CHMC) research in Sudan based on 560 publications indexed in Scopus over the last three decades. The analysis of the publication trends showed that there has been a steady increase in the number of documents published from 1991 to 2021, indicating growing scientific interest in CHMC research. The findings from the study will offer researchers crucial insights into relevant articles which could serve as a springboard for CHMC research in Sudan. Based on the findings, we suggest that CHMC research in Sudan could be improved by aligning future research with national health priorities and focusing on local research infrastructure. It is important to note that the study's focus on English language publications and Scopus-indexed journals may limit the overall analysis of CHMC research landscape in Sudan. Thus, broadening the language, search criteria, and scientific database could improve the analysis of CHMC research

landscape. Overall, the study offered a comprehensive overview of CHMC research in Sudan and provided insights for future researchers, organizations, and policymakers in decision-making and funding pursuits.

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Author's contribution: Conceptualization Omer F, Otitolaiye VO, Methodology, Omer F, Otitolaiye VO, Results and Analysis Omer F, Otitolaiye VO, Review and Editing Otitolaiye VO, Original draft preparation Omer F, Visualization Otitolaiye VO.

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