pagepress

Review

A bibliometric analysis of medical informatics and telemedicine in sub-Saharan Africa and BRICS nations

Roy Tapera,[1,2] Yashik Singh[2]

[1]Department of Environmental Health, School of Public Health, University of Botswana, Gaborone, Botswana
[2]University of KwaZulu-Natal, Durban, South Africa

Abstract

The advances in eHealth have dramatically changed the face of healthcare delivery around the world, with Sub-Saharan Africa being no exception. It is essential to identify the prominent, emerging researchers, successful areas of research within the field of health informatics (HI) and telemedicine (TM) to be duplicated where there is a need. This study gives a bibliometric overview of original research articles on medical informatics and telemedicine indexed in Scopus, PubMed, and Science Direct over the last 20 years in sub-Saharan Africa. Keywords related to health informatics and telemedicine were used to retrieve relevant literature. We specifically analyzed the evolution, standard metrics, domains of medical informatics (MI) and TM in sub-Saharan Africa (SSA) and Brazil, Russia, India, China, and South Africa (BRIC) nations. Our results identified mhealth as the main field of research in telemedicine that has seen significant growth in both BRIC and SSA nations and is poised to be the focus of research activity in the near future. Research production in mhealth and telemedicine showed a considerable increase from 1999–2018. The production was dominated by articles from South Africa in Africa and China from the BRIC nations. Most prolific authors have resources and are leaders of health informatics projects. The production came from 26 sub-Saharan African countries, denoting this field's devotion in different areas around sub-Sahara. Research in mhealth needs to be encouraged, mostly in the fight against infectious and non-infectious diseases in sub-Saharan Africa, where technology can improve health services and decrease disease burden.

Introduction

Health informatics is an interdisciplinary field that studies and pursues the effective uses of biomedical data, information, and knowledge for the scientific inquest, problem-solving, and decision making, motivated by efforts to improve human health.[1] Health informatics tools include computers and clinical guidelines, formal medical terminologies, information, and communication systems. eHealth is the use of information and communication technologies (ICT) for health, while telemedicine is a subset of telehealth, which falls under the broader term of eHealth: involves the provision of health care services, where distance is a critical factor or just healing at a distance.[2]

Over the last decade or so, research in medical informatics and telemedicine has been growing rapidly, as evidenced by a large number of publications.[3] With the advent of social media technology, the use of social media technology has also fuelled the growth of research in telemedicine; for example, in developing countries, WhatsApp is used for administrative and clinical practice.[4] Bibliometric analysis can provide useful insights into a body of literature, and several such studies have been conducted in the domain of telemedicine.[5,6] It is essential to know how the research field has evolved, the total number of publications in sub-Saharan Africa and per country, whom the publishers are collaborating with internationally, and the most prolific, high impact researchers, impact of the research or identify impactful publications within a specific research field. This information is crucial because it can be used to evaluate scientific developments and can provide useful insights into a body of literature.[5,6] The information can also be used to assess journal impact factors.[7] The Journal Impact Factor assesses the quality of research being done in the ehealth field. By knowing how many times the journal has been cited one can assess the impact the journal has made through the contribution of science. Importantly, through bibliometric analysis one can determine the number of self-citations and if there are a specific group of researchers affiliated with the author citing the papers.

Medical informatics and is receiving significant research attention. For the past decade or so, medical informatics research has been increasing rapidly, partly driven by advances in information technologies and partly by an urgent need to improve quality of care and patient safety.[8,9] Despite this fact, no author has ever investigated medical informatics' bibliometric performance in sub-Saharan Africa over a long period. Scott and Mars[5] published

Significance for public health

Literature shows that medical informatics and telemedicine may expand access to services, create cost savings, and increase the ability to access health care services timely. The last decade of research in health informatics and telemedicine has been growing at a very rapid rate. Conducting a bibliometric analysis of medical informatics and telemedicine in sub-Saharan Africa will illustrate a historical perspective on the progress of scientific research on medical informatics and telemedicine. It is essential to know the total number of publications in sub-Saharan Africa and per country, whom the publishers are collaborating with internationally, and who are the most prolific and high impact researchers. This information is vital because it can be used for the evaluation of scientific developments. The information can also be used to assess journal impact factors. However, efforts to systematically map the entirety of the research field in medical informatics and telemedicine in sub-Saharan Africa are lacking.

a paper only on telehealth in the developing world: current status and prospects, and there were no comparisons with the publications from BRICS nations. BRICS is an association of major emerging economies or newly industrialized countries, which were large, fast-growing economies that exercised significant influence in their regions.[10] BRICS nations have created alliances in many respects, including research. Understanding how much they have published will allow us to understand gaps associated with each country and thus will show where possible collaborations between BRICS countries can happen. Other authors only focused on the growth of telemedicine literature from 1993 to 2012.

With this study, the main goal is to elucidate which prior publications have been the most impactful in telemedicine and medical informatics in Sub-Saharan Africa by analyzing different metrics so that other researchers can then use these results to conduct further studies. A secondary goal is to determine or establish domains or aspects of medical informatics and telemedicine research that require further attention from investigators and regulatory bodies. This would serve to encourage future research in these areas of need, which would benefit this field of research as a whole.

Methods

A desktop review was conducted using bibliometric techniques. A search strategy was created and applied to all publications indexed from 1999 to 2018, from Sub-Saharan Africa and BRICS countries. Publications were retrieved using Scopus, Science Direct, and PubMed. PubMed was chosen as the search engine because it is the largest database of peer-reviewed literature, and it includes original articles, reviews, conferences, letters, editorials, articles in press.[11,12] Elsevier runs Scopus, which is one of the largest electronic databases available for literature retrieval. It is friendly to use and provides functions like "limit" and

Table 1. The spread of publications in sub-Saharan African and BRIC countries in the field of medical informatics and telemedicine 1999–2018.

Rank	Country	The absolute number of papers published periodically for Sub-Saharan African countries					
		1999- 2003	2004-2008	2009-2013	2014-2018	Total (n=324)	%
1	South Africa	5	28	45	35	113	34.9
2	Kenya	2	15	20	5	42	13
3	Malawi	0	7	12	7	26	8
4	Nigeria	0	7	14	3	24	7.4
5	Rwanda	0	5	10	2	17	5.3
6	Tanzania	0	3	9	2	14	4.3
7	Uganda	0	5	7	2	14	4.3
8	Zambia	0	3	7	4	14	4.3
9	Ghana	0	2	7	5	14	4.3
10	Botswana	0	1	6	3	10	3.2
11	Mozambique	0	1	2	2	5	1.6
12	Cameroon	0	2	3	0	5	1.6
13	Ethiopia	0	0	4	0	4	1.2
14	Mali	0	2	2	0	4	1.2
15	Cote d'Ivoire	0	2	1	0	3	0.9
16	Zimbabwe	0	2	0	1	3	0.9
17	Benin	0	2	0	0	2	0.6
18	Namibia	0	0	2	0	2	0.6
19	Sudan	0	0	1	0	1	0.3
20	Senegal	0	0	1	0	1	0.3
21	Lesotho	0	0	0	1	1	0.3
22	Mauritius	0	1	0	0	1	0.3
23	Gambia	0	0	0	1	1	0.3
24	Congo	0	0	0	1	1	0.3
25	Burundi	0	0	1	0	1	0.3
26	Burkina Faso	0	0	1	0	1	0.3
Total		7	88	155	74	324	100
The absolute number of papers periodically for BRIC Countries (n=1153)							
1	China	35	48	245	227	555	48
2	India	17	33	81	122	253	22
3	Brazil	15	27	65	128	235	20.4
4	Russia	12	16	37	45	110	9.6
Total		79	124	428	522	1153	100

"exclude" that facilitates data refining and analysis.[13]

Furthermore, Scopus can provide researchers with country profile, institution profile, citation analysis, author profile, and source journals for any specific field data. PubMed is accessed free of charge. PubMed's keyword search offers prime update frequency and includes new online articles; PubMed remains an optimal tool in biomedical electronic research.[14]

The keywords searched for in publication title, abstract, and keywords were the following:

Medical informatics terms:
"Medical Informatics" or *"Medical Information Systems"* or *"MI"* or *"M.I.S."* or *"Biomedical Informatics"* or *"Health Informatics"* or *"Clinical Informatics"* or *"HIS"* or *"Hospital Information System"* or *"E.H.R."* or *"Electronic Health Records"* or *"E.M.R."* or *"Electronic Medical Records."*

Telemedicine terms:
"Telemedicine" or *"Telehealth"* or *"telecare"* or *"telehomecare"* or *"E-health"* or *"ehealth"* or *"m-Health"* or *"mhealth"* or *"electronic health"* or *"mobile health"* or *("cellular phone"* and *"medicine").*

Exclusion criteria

Papers that were not related to the field, published before 1999 and which are not from the BRIC nations and SSA. and not written in English were excluded. Since South Africa appears in both BRICS and SSA. countries, the term BRIC will be used without South Africa. South Africa will only be counted under the SSA countries.

Table 2. Active authors and publication period in medical informatics and telemedicine from Sub-Saharan Africa and BRIC nations.

Rank	Name	Period and publications in sub-Saharan Africa 1999-2003	2004-2008	2009-2013	2014-2018	Frequency
1	Mars M	2	8	16	16	42
2	Tierney WM	4	9	6	1	20
3	Douglas GP	1	6	7	5	19
	Kimaiyo S	1	7	6	0	14
	Nyandiko WM	1	7	4	2	14
	Pottas D	1	3	9	1	14
	Gadabu OJ	1	3	5	5	14
4	Sidle JE	1	5	2	1	11
	Clarke DL	0	6	2	3	11
6	Aldous C	0	0	4	6	10
7	Boulle A	0	6	2	1	9
	Bruce JL	0	5	2	1	9
9	Feeney ME	0	1	4	2	7
10	Wolfe BA	0	4	0	2	6
	Period and publications in BRIC nations					
1	Duan H	2	3	13	5	23
2	Kopanitsa G	3	2	8	4	17
3	Li JS	2	2	10	2	16
3	Yang J.J	2	2	8	1	14
4	Araki K	1	2	3	2	8
5	Li X	1	4	2	1	7
	Mohan V	1	2	3	1	7

Table 3. Top ten active institutions or organizations publishing in medical informatics and telemedicine.

Country	Frequency	Proportion%	Institution/Organization
China	50	15.8	Zhejiang University
Indiana	42	13.3	Indiana University School of Medicine-Indianapolis
Brazil	32	10.1	Universidade de Sao Paulo – USP
Kenya	31	9.8	Moi University
Brazil	28	8.9	Universidade Federal de Sao Paulo
China	24	7.6	Ministry of Education in China
China	24	7.6	Shanghai Jiaotong University
South Africa	23	7.3	University of KwaZulu-Natal
China	22	7.0	Peking University
China	20	6.3	China Academy of Chinese Medical Sciences
Kenya	20	6.3	Regenstrief Institute Inc
Total	316	100	

Table 4. The domains of medical informatics and telemedicine between BRIC and SSA countries over the past 20 years.

Country	Domains and activities	Common domains
South Africa	Uses mHealth (Mxit) application as a clinical decision support system for HIV/AIDS content delivery (Mxit).[15]	Mhealth application for a clinical decision support system.
Kenya	Uses mhealth (Epi Surveyor) for remote monitoring by health workers to collect and exchange health information. It is used in Kenya, Uganda, and Zambia to track immunization and monitor stocks of vital products and drugs.[16] Uses mhealth (mPedigree) application for clinical decision support systems. It offers free text messaging-based platform to stop the sales of counterfeit drugs in developing countries. Patients in Nigeria, Ghana, and Kenya can verify the authenticity of their medication free of charge.	
Ghana	Uses mhealth (mPedigree) application for a clinical decision support system. It offers free text messaging-based platform to stop the sales of counterfeit drugs in developing countries. Patients in Nigeria, Ghana, and Kenya can verify the authenticity of their medication free of charge.	
Nigeria	Uses mobile phones as a tool for improving cancer care in Nigeria. The tool is used for patient follow-up and psychosocial support.[17] Uses mhealth (mPedigree) application for a clinical decision support system. It offers free text messaging-based platform to stop the sales of counterfeit drugs in developing countries. Patients in Nigeria, Ghana, and Kenya can verify the authenticity of their medication free of charge.	
Tanzania	mhealth (eIMCI) clinical decision support provides a full assessment of children of ages between 2-59 months and suggests medication.[16]	
Malawi	Uses text message reminders sent to patients for improved appointment adherence in Malawi.[18] Uses a mhealth (Mawana) application for education and awareness to provide early-stage antenatal care for mothers and deliveries, HIV tests through SMS.	mhealth messages for adherence, an appointment with patients and handling patients data
Brazil	Developed a mhealth application used for short message service text messages sent as appointment reminders to patients' cell phones at outpatient clinics in São Paulo, Brazil.[19]	
Uganda	Uganda uses mhealth (Epi-handy) is a mobile phone-based tool for collecting and handling patients' records. It has been proven effective in Uganda to reduce the error in data collection.[16] People in Uganda use mhealth (AED Satellite) remote monitoring for disease surveillance and health information collection.	
Zambia	There is a telemedicine project for sharing scientific literature about cholera epidemic infections with health workers and the communities.[20] mhealth (Mawana) for education and awareness to provide early-stage antenatal care for mothers and deliveries, HIV tests through SMS.	Mhealth for education, awareness and provision of pregnancy-related
	Uses a mhealth (Epi Surveyor) application for remote monitoring by health workers to collect and exchange health information. It is used in Kenya, Uganda, and Zambia to track immunization and monitor stocks of vital products and drugs.	information for pregnant women
Russia	Developed a mhealth (Text4baby) for education and awareness, provides health and pregnancy-related personalized information to women following their delivery date.[21]	
South Africa	The University of Kwazulu Natali developed and uses a video conference-based, postgraduate tele-education service.[22] In South Africa, some studies have led to a videoconference based services, with the development of clinical, operational, and technical guidelines and an administrative model for telepsychiatry	Video conferencing for teaching health professionals.
Rwanda	National Information and Communication Infrastructure in Rwanda initiated a project that involves three hospitals with video conferencing facilities to enhance a participatory approach in teaching, continuous medical education to medical students, and health workers.[23]	
China	Developed and uses an application targeting people who are not health care professionals focused on providing telemedicine and appointment-making services. The application is focused primarily on diabetes, hypertension, and hepatitis management.[24]	Mhealth application for prevention of diseases non-communicable and communicable diseases
Botswana	Uses a mHealth application for T.B. contact tracing.[25] Uses of an application called txt2MEDLINE, which is a short messaging service (SMS) query of PubMed/MEDLINE, and SMS-optimized clinical guidelines for medical students in Botswana.[26]	
India	Developed and is using a mHealth application for prevention of cardiovascular diseases in Kerala.[27] Uses mobile health education intervention (Peek) application on spectacle wear among children in India.[28]	
Botswana	Uses a mobile telemedicine system for specialist consultation and care for patients with complicated oral lesions.[29]	Telemedicine consultation
India	Uses telemedicine projects such as Apollo, Otri, and Asia Heart Foundation. They Focus on major needs of cardiology, emergency, radiology, ophthalmology, and nephrology departments. Signals, diagnostic images, and videos are transferred among workstations based on Intel computers among health care professionals.[20]	
China	Government-sponsored major telemedicine consultation program established by West China Hospital of Sichuan University (hub), covering 249 spoke hospitals in 112 cities throughout western China and 40 medical expertise areas.[30] The other telemedicine consultation centre is in the northwest of China, Gansu Province.	
Brazil	There is a Telehealth Network, connecting university hospitals with the state's remote municipal health departments. The network support professionals in providing Tele assistance and perform	
	tele-electrocardiography and teleconsultations.[31] There is also a telemedicine network for remote pediatric cardiology services in Paraiba north-east Brazil.[32]	
Ghana	Hospitals in London, UK, and Geneva, Switzerland offer education on malaria to local physicians in Ghana through telemedicine.[20]	

Documents screening

Screening of articles at all stages was done by the two authors. One thousand nine hundred and forty (1940) records were identified using earlier stated medical informatics and telemedicine search key terms. Five hundred and thirty documents (530) were retrieved from Scopus, 230 from Science Direct, and 1180 from PubMed databases. Data from the documents from each database were exported into excel spreadsheets. Three hundred and seven (307) duplicates were removed, which appeared in the three databases to remain with 1633 documents. Further screening for the reasons shown in the PRISMA diagram (Figure 1) was done until a total of 324 publications for SSA countries, and 1153 for BRIC countries were final selected for analysis.

Results

Evolution of ehealth research over the last 20 years between BRIC and SSA countries

A total of 324 publications for S.S.A. countries and 1153 for BRIC nations were located using the customized query in Scopus, Science Direct, and PubMed databases. The distribution of publications over time in the field is illustrated in Table 1. South Africa had the highest number of papers, 113 (34.9%), followed by Kenya, with 42 (13%) publications over 20 years. There were few publications from the 1999-2003 period. Most publications were recorded from 2004-2008 and 2009-2013 period, and a slump decline during the 2014-2018 period.

Amongst the BRIC nations, China had the highest number of publications, 555 (48 %), followed by India 253 (22 %), Brazil 235 (20.3 %), and then Russia, with 110 (9.6 %), as shown in Table 1. In Table 1, it is evident that there has been a sharp increase in publications from the 1999-2003 period to the 2014-2018 period. South Africa ranked first with an average number of citations of 26.7 per article, followed by Tanzania and Rwanda.

Based on the number of journal articles only the most prolific authors in telemedicine and medical informatics research in sub-Saharan Africa were M. Mars from the University of KwaZulu Natal South Africa with 42 articles, followed by W.M. Tierney from Indiana University (USA), who co-authored 20 articles, followed by G.P.W. Douglas with 19 articles. The most prolific authors in telemedicine and medical informatics research in BRIC countries were H. Duan from China with 23 articles, followed by G. Kopanitsa from Russia with 17 articles, and J.S. Li from China with 16 articles, respectively (Table 2).

The top institutions with researchers publishing on medical informatics and telemedicine are Zhejiang University with 50 publications from China, followed by Indiana University School of Medicine with 42 publications. On the third position is Universidade de Sao Paulo from Brazil with 32 publications. Moi University is in the fourth position making it number 1 in Africa with 31 publications. The University of Kwazulu Natal is in the 8th position and the second country in Africa with 23 publications (Table 3).

The journal mostly used by the authors in Africa and BRIC nations to publish research on telemedicine and medical informatics is the Studies in Health Technology and Informatics Journal, with 159 publications, followed by the Journal of Medical Systems with 54 and PloS One with 50 publication.

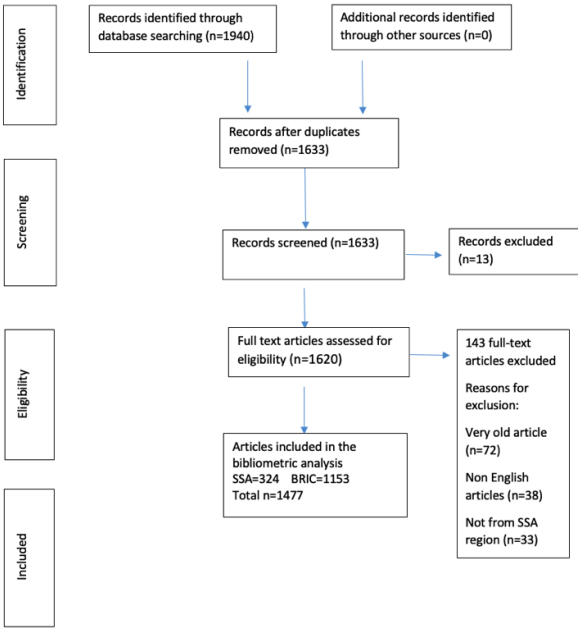

Figure 1. PRISMA Flow diagram used for screening and selection of medical informatics and telemedicine documents from SSA and BRIC nations (http://prisma-statement.org/PRISMA statement/flow diagram.

Domains that have dominated medical informatics and telemedicine in BRIC and SSA publications over the past 20 years

The primary domain that has dominated medical informatics and telemedicine in BRIC and SSA publications over the past 20 years is mhealth (Table 4). The mobile phone is facilitating telemedicine in most disciplines.

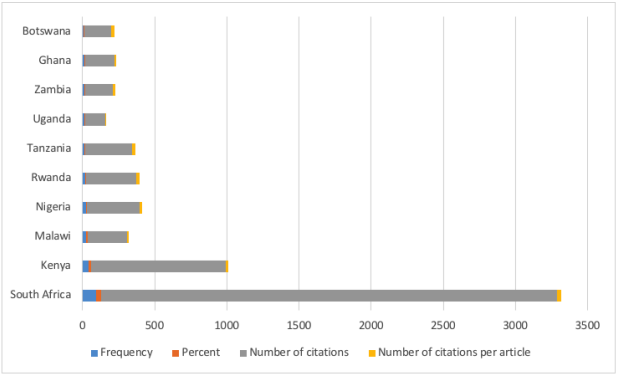

Figure 2. Top ten countries publishing in medical informatics and telemedicine research in Africa.

Table 5. Collaborations between the top authors in medical informatics and telemedicine in sub-Saharan African countries and BRIC nations.

Active authors and co-authors in medical informatics and telemedicine from sub-Saharan Africa					
Institute of affiliation	Country	First Author	Collaborating authors	Countries of affiliation	Topic/Domain
University of Kwazulu Natal	South Africa	Mars M	Rachael Odhiambo	Kenya	Telemedicine
			Laticha Walters	South Africa	Tele rehabilitation
			Richard Scott		Tele-psychiatry
			Sean Broomhea		Tele-audiology
			Tom Jones		Paediatric surgery
			Christopher J Seebregts		Tele-dermatology
			Christopher Morris		mhealth
			Daan Den Hollander		ehealth and ICT.
			Anthony Maeder		Tele-education
			Michael Alfred Gregory		Medical informatics
			Louisse C. Affleck-Hall		e-health
			Yashik Singh		Health care delivery
			Caron Lee Jack		Medical information system
			Jennifer Anne Chips		Medical records review
			Savira Ramlall		
			De Wet Swanepoel		
			Leonard Mauco	Botswana	
			Kagiso Ndlovu		
			Vincent Kiburu	Uganda	
			Bolajoko Olusanya	Nigeria	
			Shashi B. Gogia	India	
			Patricia A Abbot	USA	
			William Hersh		
			John Holmes		
			Paula Otero	Argentina	
			Henning Muller	Switzerland	
			Marilynne Hebert	Canada	
University of Texas	USA	Tierney WM	Einterz RM	USA	Medical informatics
			Hannan TJ		Electronic medical records
			Mamlin JJ		Tele-health
			Rotich JK	Kenya	Medical documentation
			Kimaiyo S		Medical records system
			Sidle JE		Public health informatics
			Siika AM		Patients monitoring and treatment
			Simuyu CJ		Medical computing
			Nyandiko WM		
			Odero WW		
			Diero L		
			Kigotho EM		
University of Pittsburg	Pennsylvania	Douglas GP	Gabadu OJ	USA	Electronic medical records
			Asamani JA	Ghana	Patients management Information system
			Ogoe HA		Mobile health
			Soyapi Mumba	Malawi	ehealth
			Mtonga TM		Medical computing
			Bwanalai M		Medical informatics
			Chiumia		
			Boyce R		
			Fisher AM		
			Connor SE		
			Hochheiser H		
			Smith A		
			Oliver J		
			Camacho J		
			Wools-Kaloustain K		
Moi University	Kenya	Kimaiyo S	Simuyu CJ	Kenya	electronic health records
			Siddle JE		electronic medical records
			Rotich JK		Medical informatics
			Kigotho EM		mhealth
			Siika A		
			Hannan TJ	USA	
			Mamlin BW		
			Tierney WM		
			Wools-Kaloustian K		

Table 5. Collaborations between the top authors in medical informatics and telemedicine in sub-Saharan African countries and BRIC nations.

Active authors and co-authors in medical informatics and telemedicine from sub-Saharan Africa					
Institute of affiliation	Country	First Author	Collaborating authors	Countries of affiliation	Topic/Domain
Moi University	Kenya	Nyandiko WM	Tierney WM	USA	electronic medical records
			Hannan TJ		Health care records
			Mamlin BW		Medical records
			Were MC		Mhealth
			Hannan JJ	Australia	Health informatics
			Siika A	Kenya	
			Musinguzi N	Tanzania	
			Mokowon B	Uganda	
University of Capetown	South Africa	Pottas D	Mxoli A	South Africa	Information security
			Gerber M		mhealth
			Phipps-Mostert N		Electronic health records
			Box D		Tele-health
			Van Greunen D		ehealth
			Herselman		Health care
			De la Harpe R		Information and communication technology
			Goverder S		Medical records
			Lotriet H		
			Tuyikize T		
			Wills J	USA	
Moi University	Kenya	Sidle JE	Hannan J	South Africa	Electronic medical records
			Rotich JK	USA	Medical records systems
			Esamai F	Kenya	ehealth
			Nyandiko WM		Mobile health
			Kimaiyo S		Health technology and informatics
			Interz RM		
			Wools-Kaloustain K	England	
University of Kwazulu Natal	South Africa	Aldoucs C	Skinner DL	South Africa	Primary health care
			Bruce JL		Electronic medical records
			Clarke DL		Medical informatics
			Laing GL		Medical records
			Kong YV		Patients Care
			Handes J		
University of Michigan	USA	Gadabu O.	Mumba S	Malawi	ehealth data
			Manjomo R		Health technology
			Munthali CV		Telemedicine
			Feldacker FC	USA	Medical informatics
			Smith AB		Electronic medical records reviews
			Berger D		
			Douglas GP		
University of Capetown		South Africa	Boulle A	Rangaka M	South Africa Primary health care
			Wilkinson RJ		Infectious diseases
			Clearly SM		mhealth
			Dubula V		Electronic health system
			Myer L		Health technology
			Custom Van G		Patients care
			Hogg R	USA	
University of Stellenbosch		South Africa	Bruce JL	Aldous C	South Africa Electronic medical records
			Clarke D		Clinical informatics
			Sartorius		Medical informatics
			Laing G		Health technology
University of Kwazulu-Natal		South Africa	Clarke D	Bruce JL	South Africa Medical records
			Skinner D		Electronic health
			Kong VY		mhealth
			Handley JJ		Patient care
			Aldous C		
			Laing GL		
			Mulwafu W		
			Carlson LC		
			Derbew M		
			Lin JA		
			Walker J	U.S.A.	
			Wolf JL		

Table 5. Collaborations between the top authors in medical informatics and telemedicine in sub-Saharan African countries and BRIC nations.

Active authors and co-authors in medical informatics and telemedicine from sub-Saharan Africa					
Institute of affiliation	Country	First Author	Collaborating authors	Countries of affiliation	Topic/Domain
UCSF	USA	Feeney, M.E	Mars M Clarke D Laing G Bruce J Basset I Cloete C Hanmer L	South Africa	Malaria ehealth Transactional medication Health technology
Indiana University	USA	Wolfe, B.A	Mamlin BW Biondich PG Frazer H Smith AB	USA	Medical records systems ehealth Medical informatics Electronic medical records
Active authors in medical informatics and from BRIC nations					
Country of affiliation		**First Author**	**Names of collaborating authors**	**Countries of affiliation**	**Topic/Domain**
Nanyang Technological University	Singapore	Duan, H	Lu X Rao K Xu Y Chen S Gao Z Guo Y Li YP Liu B Liu D Liu L Pan F Wang X Wang Y Yang P Yang X Yuwen S Zhang H Zhang R	China USA Hong Kong Canada Japan United Kingdom Australia Germany Netherlands	Health technology Telemedicine ehealth Medical Information system Medical computing Electronic medical records Health informatics
Politehniceskij	Russian Federation		Kopanitsa G Veseli H Chang CH Demski H Hildebrand C Lee TH Shieh M Shifrin M Tsvetkova Z Yampulsky V Stausberg J	Tsvetkvu Z Germany USA Taiwan UK Croatia Estonia France Greece Netherlands Sweden	Russia Medical data visualisation Medical informatics electronic health records Clinical decision support system Tele-dermatology Medical records
Anhui University	China	Li JS	Araki K Guo J He M Li H Nakashima Y Niu T Sato J Suzuki M Suzuki T Takada A Yoshihara H Cao F Chang Z	China Hong Kong Singapore	Electronic medical performance Electronic medical records Electrocatalysts Electronic health records Medical information systems Medical informatics Information systems

Table 5. Collaborations between the top authors in medical informatics and telemedicine in sub-Saharan African countries and BRIC nations.

Active authors and co-authors in medical informatics and telemedicine from sub-Saharan Africa					
Institute of affiliation	Country	First Author	Collaborating authors	Countries of affiliation	Topic/Domain
University of Massachusetts	U.S.A.		Yang JJ Araki K Cao F Gajic O Huang Z Liu H Lu X Yu Y Guan Y Lei J Li G Liu B Liu D Ni Y Poon CCY Suzuki M	Li X Japan Hong Kong Australia	China Medical computing Electronic medical records Classification of medical records Medical information system
Division of Infectious, Diseases Center for Inflammation and Tolerance, Cincinnati Children's	USA	Araki K	Guan Y Lei J Cai F Cao Z Chen CM Dong W Fu X He B Huang Z Ji L Li CT Liu J Lu M Ma J	China USA Taiwan Canada Australia Austria Netherlands Singapore	Electronic medical information system Medical computing Health informatics/medical informatics eHealth technology
University of Washington	USA		Li X Cao F Gajic O Huang Z Liu H Lu X Culver DS Dai D Dai F Gao J Gao W	Araki K Singapore Japan Hong Kong	China Electronic medical records Electronic medical transitions Medical records eHealth Medical informatics
Vasavi Hospital and Research Center	India	Mohan V	Aggarwal R Agrawal A Anand K Bardia A Chockalingam A Dadich JP Deepa VP Gupta PC Jabbour S Jain NC Kapoor SK Kulanthaivel G Kulshreshtha M	India Brazil Argentina	CT scans applications Electronic medical records Access to medication Medical informatics Advanced health technology

Collaboration with other authors

Table 5 shows that most of the collaborations between authors writing on HI and TM in SSA are from the USA. Authors from Kenya, Moi University, collaborated among themselves and also with researchers from the USA. There were few collaborations between the BRIC nations and SSA countries. There were also a few collaborations among BRIC nations.

The most prolific author from KwaZulu Natal University, Mars, co-authored papers with both South African and international authors. His co-authors span from South Africa, Kenya, Uganda, Botswana, Nigeria, and the United States of America, Switzerland, and Canada. From the BRIC nations, Mars co-authored with Gogia from India and Tierney from the USA. Mars also collaborated with authors from the USA and Kenya. Douglas, from the USA, collaborated with authors from the USA, Ghana, and Malawi. Most of the authors who wrote about sub-Saharan Africa collaborated with USA authors. Out of the 14 top authors from SSA listed in Table 5, only two authors from South Africa did not collaborate or co-authored with international researchers. The other 12 authors collaborated with at least one author from the USA.

The top authors who wrote about the BRIC nations Duan, from China, collaborated with co-authors from China, USA, Canada, Japan, UK, Australia, Germany, and the Netherlands. The second prolific author from the BRIC nations, G. Kopanitsa from Russia, collaborated with researchers from Russia, European countries, and the USA; V. Mohan from India, is the only author who collaborated with researchers from other BRIC nations Brazil.

No first authors from BRIC nations collaborated with researchers from sub-Saharan. It was only Maurice Mars from South Africa who collaborated with researchers from India. The top sub-Saharan authors interacted amongst themselves compared to their BRIC nation's counterparts. All three authors from Kenya, Moi University, collaborated with each other. They also co-authored with Tierney from the USA. Feeney from the USA co-authored an article with Mars from South Africa. No interaction was observed among the BRIC nations' authors. Collaborations among African authors themselves were few, but most sub-Saharan authors were partnering with USA authors.

Discussion

This study is a bibliometric analysis of medical informatics and telemedicine literature published from 1999 to 2018 *via* Scopus, PubMed, and Science Direct database. The findings indicate a significant rise in telemedicine and health informatics literature in the last 20 years.

In SSA countries, there were few publications from the 1999-2003 period. This could be because the field was still in its infancy stages. After the 1999-2003 period, there was an exponential growth in publications, which could be attributed to technological developments in the ICT industry and healthcare improvements. There was a noticeable fall in the number of publications starting in the year 2014-2018, and the reason for this decline is unclear. This suggests a common factor, such as a sudden, temporary reduction in the number of papers being published, or a sudden decrease in the number of journals being indexed by the databases.

The most prolific authors in telemedicine and medical informatics research in both SSA and BRIC nations success could be attributed to a variety of reasons; for example, Mars from the University of KwaZulu Natal is the head of a department that provides postgraduate education (Masters and PhD) in both medical informatics and telemedicine in Africa and beyond. He is more likely to have resources at his disposal to conduct a wide range of studies in the two fields. Mars is an editor of the Journal of the International Society for Telemedicine and eHealth (JISfTeH) and serves on several eHealth journals' editorial boards. He has many publications in (JISfTeH). Tierney led the implementation and study of electronic medical records and health information technologies during his stay of more than three decades at Indiana University and the Regenstrief Institute. He was responsible for grants and contracts totalling more than $32 million USD.[33] Tierney led a team of Americans and Kenyans that implemented the first and most successful outpatient electronic medical record system in sub-Saharan Africa. His profile shows that he had resources to conduct research and publish papers. He was also an editor of the Journal of General Internal Medicine and co-editor-in-chief of Medical Care in which he published several papers. Although Douglas is from the USA, he works and publishes with researchers from Malawi. He publishes in a wide variety of Journals. Duan from China holds several influential posts in China. For example, he is the Chinese Ambassador of openEHR International Standards Organization, Member of Digital Medicine Branch of the Chinese Medical Association, and Deputy Director of China Digital Medical and Medical Informatization Committee, among other posts.[34] The five Journals mostly used by the authors in Africa and BRIC nations to publish research on Telemedicine and Health Informatics are all peer-reviewed with impact factors. Three of the Journals are specialist journals in the field of medical informatics and telemedicine.

Researchers from BRIC nations dwelled much on mhealth applications for non-communicable diseases prevention and telemedicine consultation. Similarly, SSA nations also dwelled on mhealth applications for infectious diseases prevention, clinical decision support system, medication adherence and appointment scheduling. Researchers from sub-Saharan African countries focused on a variety of various domains, which included Health Informatics, telemedicine, and m-Health: is being used for education and awareness, clinical decision support, and remote monitoring. Telemedicine practices saves time, reduce travel expenses, reduce medical costs.[35]

PubMed was the search engine with the highest number of papers; such a trend could be because PubMed is a recognized primary tool for scholars in the medical field. It remains the optimal tool in biomedical electronic research.[14] Most of the articles were appearing in at least two of the three search engines used.

This study's limitation is on the use of only three databases, which makes the findings not necessarily an accurate representation of all the literature on medical informatics and telemedicine. The study also looked only at the literature that was written in English. Yet, there could be more literate on medical informatics and telemedicine in some other languages other than English.

Conclusion

Both BRIC and S.S.A nations are using mhealth application for various purpose ranging from health education, disease prevention, appointments and drug adherence. However, few S.S.A are doing Telemedicine consultations as compared to BRIC nations. The most prolific authors have influential positions at their organizations and are more likely to be well resourced. This calls for further funding to be allocated to medical informatics and telemedicine research so that early carrier researchers find it easy to do research.

Correspondence: Roy Tapera, Department of Environmental Health, School of Public Health, University of Botswana, Private Bag 82293, Molapo Crossing, Gaborone, Botswana.
Tel. +267.76533462. E-mail: taperar@ub.ac.bw

Key words: Bibliometric analysis; sub-Saharan Africa; medical informatics; telemedicine.

Contributions: The two authors contributed to writing this article. Both authors discussed the data and insights of the paper. They all edited the manuscript and approved the final version.

Conflict of interest: No potential conflict of interest was reported by the authors.

Received for publication: 17 August 2020.
Accepted for publication: 6 March 2021.

Journal of Public Health Research 2021;10:1903
doi:10.4081/jphr.2021.1903

References

1. Kulikowski CA, Shortliffe EH, Currie LM, et al. AMIA Board white paper: Definition of biomedical informatics and specification of core competencies for graduate education in the discipline. J Am Med Informatics Assoc 2012;19:931–8.
2. Strehle EM, Shabde N. One hundred years of telemedicine: does this new technology have a place in paediatrics? Arch Dis Child 2006;91:956–9.
3. Liang HN. Overview of the health informatics research field: A bibliometric approach. IFIP Adv Inf Commun Technol 2010;335:37–48.
4. Mars M, Scott RE. WhatsApp in clinical practice: A literature review. Stud Health Technol Inform 2016;231:82–90.
5. Scott R, Mars M. Telehealth in the developing world: current status and future prospects. Smart Homecare Technol TeleHealth 2015;25.
6. Askari A, Khodaie M, Bahaadinbeigy K. The 60 most highly cited articles published in the Journal of Telemedicine and Telecare and Telemedicine Journal and E-health. J Telemed Telecare 2014;20:35–43.
7. Reuters T. Whitepaper using bibliometrics: Thomson Reuters. 2008.
8. Protti D. The synergism of health medical informatics revisited. Methods Inf Med 1995;34:441–5.
9. Deloitte [Internet]. Queensland Health - eHealth Strategy. 2006. Available from: https://www.health.qld.gov.au/__data/assets/pdf_file/0030/440958/ehealth-strategy.pdf
10. Vladzymyrskyy A, Jordanova M, Lievens F. A century of telemedicine. Basel: ISfTeH - International Society for Telemedicine & eHealth; 2017.
11. De Moya-Anegón F, Chinchilla-Rodríguez Z, Vargas-Quesada B, et al. Coverage analysis of Scopus: A journal metric approach. Scientometrics 2007;73:53–78.
12. Burnham JF. Scopus database: A review. Biomed Digit Libr 2006;3:1–8.
13. Sweileh WM, Al-Jabi SW, AbuTaha AS, et al. Bibliometric analysis of worldwide scientific literature in mobile - health: 2006-2016. BMC Med Inform Decis Mak 2017;17:1–12.
14. Falagas ME, Pitsouni EI, Matietzis GA, Pappas G. Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. FASEB J 2008;22:338–42.
15. de Tolly K, Alexander H, Town C. Innovative use of cellphone technology for HIV/AIDS behaviour change communication: 3 pilot projects project SMS ARV reminders. Cellphones 4HIV; 2009. Available from: https://www.w3.org/2008/10/MW4D_WS/papers/kdetolly.pdf
16. Akter S, Ray P. mHealth an ultimate platform to serve the unserved. Yearb Med Inform 2010;94–100.
17. Odigie VI, Yusufu LMD, Dawotola DA, et al. The mobile phone as a tool in improving cancer care in Nigeria. Psychooncology 2012;21:332–5.
18. Mahmud N, Rodriguez J, Nesbit J. A text message-based intervention to bridge the healthcare communication gap in the rural developing world - IOS Press. Technol Heal Care 2010;18:137–44.
19. da Costa TM, Salomão PL, Martha AS, et al. The impact of short message service text messages sent as appointment reminders to patients' cell phones at outpatient clinics in São Paulo, Brazil. Int J Med Inform 2010;79:65-70.
20. Combi C, Pozzani G, Pozzi G. Telemedicine for developing countries. A survey and some design issues. Appl Clin Inform 2016;7:1025–50.
21. Parker RM, Dmitrieva E, Frolov S, Gazmararian JA. Text4baby in the United States and Russia: An opportunity for understanding how mHealth affects maternal and child health. J Health Commun 2012;17:S30–6.
22. Mars M. Telemedicine in KwaZulu-Natal: From failure to cautious optimism. J Telemed Telecare 2007;13:S57–9.
23. Nchise A, Boateng R, Mbarika V, et al. The challenge of taking baby steps-Preliminary insights into telemedicine adoption in Rwanda. Health Pol Technol 2012;1:207–13.
24. Hsu J, Liu D, Yu YM, et al. The top Chinese mobile health apps: A systematic investigation. J Med Internet Res 2016;18:e222.
25. Ha YP, Tesfalul MA, Littman-Quinn R, et al. Evaluation of a mobile health approach to tuberculosis contact tracing in Botswana. J Health Commun 2016;21:1115–21.
26. Armstrong K, Liu F, Seymour A, et al. Evaluation of txt2MEDLINE and development of short messaging service-optimized, clinical practice guidelines in Botswana. Telemed e-Health 2012;18:14–7.
27. Feinberg L, Menon J, Smith R, et al. Potential for mobile health (mHealth) prevention of cardiovascular diseases in Kerala: A population-based survey. Indian Heart J 2017;69:182–99.
28. Morjaria P, Bastawrous A, Murthy GVS, et al.Effectiveness of a novel mobile health education intervention (Peek) on spectacle wear among children in India: Study protocol for a randomized controlled trial. Trials 2017;18:1–10.
29. Tesfalul M, Littman-Quinn R, Antwi C, et al. Evaluating the potential impact of a mobile telemedicine system on coordination of specialty care for patients with complicated oral lesions in Botswana. J Am Med Informatics Assoc 2016;23:e142–5.
30. Wang TT, Li JM, Zhu CR, et al. Assessment of utilization and cost-effectiveness of telemedicine program in western regions of China: A 12-year study of 249 hospitals across 112 cities. Telemed e-Health 2016;22:909–20.
31. Alkmim M, Figueira R, Marcolino M, et al. Improving patient

access to specialized health care: The Telehealth network of minas Gerais, Brazil. Bull World Health Organ 2012;90:373–8.
32. Mattos S da S, Hazin SMV, Regis CT, et al. A telemedicine network for remote paediatric cardiology services in north-east Brazil. Bull World Health Organ 2015;93:881–7.
33. University of Texas [Internet]. William Tierney Directory. 2020. Accessed: 2020 Jul 16. Available from: https://dellmed.utexas.edu/directory/william-tierney
34. Huilong D [Internet]. Zhejiang University Personal homepage. Personal Homepage. 2019. Accessed: 2020 Jul 16. Available from: https://person.zju.edu.cn/en/0091070
35. Howell JD, Krupinski EA, Harms KM. The empirical foundations of telemedicine interventions in primary care. Telemed J e-Health 2016;22:342–75.