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Research growth and citation impact of Tanzanian scholars: A 24 year's scientometric study

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A scientometric analysis was conducted to map the research growth and citation impact of Tanzania scholars over a period of 24 years starting from 1991 to 2015. We analyzed data for research publications of all Tanzania scholars obtained from the SCOPUS database. The study analyzed the year-wise distribution of publications, subject-wise distribution of publications, the authorship pattern, degree of collaboration, and the citation impact. A total of 12,379 articles were published from 34 academic and research institutions. The top three universities with high cumulative number of publications were Muhimbili University of Health and Allied Sciences, University of Dar es salaam and Sokoine University of Agriculture. The top subject was medicine. The maximum number of citations received in a single publication was 1914. Publications metrics scores varied a lot based on indices chosen to rank the Tanzanian scholars. The study findings call for a need for scholars to collaborate with external partners within and outside the country, and publish in journals with a higher impact.

Key words: Scientometrics, research growth, research performance, research publications, citation impact, Tanzania.

INTRODUCTION

Science, technology, and innovation are widely acknowledged as important components in achieving sustainable economic development goals (Guindon et al., 2010; Lavis et al., 2010; Toivanen and Ponomariov, 2011; Inglesi-Lotz and Pouris, 2013; Confraria and Godinho, 2015).

Parallel to this movement, the United Nations Sustainable Development Goals emphasized the critical

role of improving science, technology, and research cooperation as a specific goal, and as a means of implementing a number of thematic goals (United Nations, 2015). Universities and research institutions play a significant role in building a strong public sector of research and development of a country or region, and their capacity is critical for national system of innovation (Kotecha et al., 2011). However, there

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have been insufficient efforts to improve science, technology and innovation activities in Africa, despite the movement from agriculture-dominated economies to a research and knowledge-based future (Schemm, 2013).

In 1999, Tanzania developed the Development Vision 2025 which aims at propelling Tanzania from a least developed country to a middle income country with a high level of human development and whose economy is diversified and semi-industrialized. This implies that there is a need to prioritize science, technology and innovation to raise productivity, value addition and value chain in agriculture and to promote linkages with other sectors (The United Republic of Tanzania, 2010; The Citizen Magazine, 2016).

Most universities and research institutions in sub-Saharan Africa have a weak research infrastructure, capacity, and funding which affects their contribution to the world's knowledge production and development through research activities (Abrahams et al., 2009; Kotecha et al., 2011; Toivanen and Ponomariov, 2011; Pouris, 2015). Lack of access to international and local research outputs, and poor visibility of Africa's research outputs contribute to low research productivity (Abrahams et al., 2009; Nature, 2015).

Most of the African scholars disseminate their research findings in journals that are not indexed by international databases (Nature, 2015). Africa faces many challenges of which investments in science, technology and research could assist to improve their economic base. Understanding the nature and dynamics of research performance of a specific country is important for building and integrating the national innovation system (Toivanen and Ponomariov, 2011).

The African scientific outputs have been growing at a rapid rate than the world average, although the share of the Africa's scientific output at the global level has remained low (Schemm, 2013; Confraria and Godinho, 2015). For instance, Schemm (2013) reported that the share of Africa's research outputs to the world increased from 1.2% in 1996 to around 2.3% in 2012.

Further, the African science is dominated by a few countries. For instance, South Africa accounted for 64% of the region's 2014 World Future Council (WFC), followed by Egypt, Kenya, Algeria and Tunisia (Nature, 2015). Another research also reported almost similar findings that the leading countries in terms of research outputs were South Africa, Egypt, Tunisia and Nigeria (Confraria and Godinho, 2015). It is therefore important to have a complete picture of research productivity and level of collaboration of a certain region or country in order to determine gaps critical for socio-economic development.

Further, evidence shows that the research output in Tanzania is considerably less than other countries in the African region (Abrahams et al., 2009; Boshoff, 2010; Pouris, 2010; Confraria and Godinho, 2015; Onyanha, 2016). For instance, Abrahams et al. (2009), reported that Tanzania total publications according to Information

Sciences Institute (ISI) were 4,815 out of the 95,711 papers in 14 countries in the Southern African Development Community (SADC) during the period of 1990 to 2007.

In another study, Pouris (2010) reported that South Africa published almost 14 times more publications than the second country in the list-Tanzania, with a total of 4184 publications from 1994 to 2008. A recent study reported that Tanzania total publications were 2,354, which was twelve times less publications produced by South African scholars during the period 2007 to 2011 (Pouris and Ho, 2014). It is therefore important to assess whether the rapid developments of technology, open access movement and related initiatives such as research for life programmes (Schemm, 2013) have contributed to the growth of Tanzania's research outputs.

The level of collaborative research activities in Africa is substantially higher as compared to the rest of the world, although the intra-Africa collaboration is still low (Onyanha and Maluleka, 2011; Confraria and Godinho, 2015; Nature, 2015).

According to the 2014 Nature Index, 70% of Africa's research output was generated through international collaborative research (Nature, 2015). Pouris and Ho (2014) also found that the international collaborative articles grew by 66 to almost twice the growth of the single-country articles in Africa.

However, other scholars found that the research collaborations within African countries are still low, when compared with extra-Africa collaborations (Onyanha and Maluleka, 2011; Confraria and Godinho, 2015; Nature, 2015). Further, the research collaboration of the top publishing African countries is dominated by a few external partners, mainly the US, UK and France (Confraria and Godinho, 2015). It is therefore imperative to assess the status of collaborative research activities in Tanzania, and how they influence the research productivity in the country.

Scientometrics is the statistical analysis of research patterns (Ramkumar et al., 2016). Scientometric is important for measuring research productivity and quality, specializations, collaborative networks, patterns of scientific communications (Perron et al., 2016). It allows a wide range of metrics to be conducted, including comparisons of different disciplines, institutions, countries, changes over time (Pouris, 2012).

Scientometric can inform decisions related to policy, resource apportionment, and understanding the socio-economic impact of research (Perron et al., 2016). It is an important approach for analyzing the research productivity and citation impact of researchers' work in their discipline, institutions or region. The number of publications produced by an individual is often regarded as a key research productivity indicator and the impact of such publications is based on the frequency of their citations. A number of research performance indicators such as h-index, g-index, Hc-index and HI-norm that

simultaneously consider quantitative and qualitative aspects of publications have been developed in recent years (Van Leeuwen et al., 2003).

H-index is a single-number metric that represents the impact of an author's publications. It is a combined measure of both the researcher's publications productivity and their visibility in terms of citation counts. According to Hirsch, a scholar has an index h if h of his/her total publications (N_p) have at least h citations each and the remaining ($N_p - h$) publications have less than h citations each (Hirsch, 2005). The Egghe's g -index improves the h -index by giving more weight to highly cited publications. A researcher has index g if g of his or her most cited publications collectively have at least g^2 citations (Egghe, 2006). The contemporary h -index (Hc-index) gives more weight to recent publications (Sidiropoulos et al., 2007); thus take into consideration the age of publications. The HI-norm index normalizes the number of citations for each publication through dividing the number of citations by the number of authors for that publication. This gives a better approximation of the individual author's impact in multi-authored publications (Braun et al., 2006).

When searching the literature on research productivity and impact in Tanzania, we found few African studies that included Tanzania in their analysis (Abrahams et al., 2009; Boshoff, 2010; Pouris, 2010; Pouris and Ho, 2014; Confraria and Godinho, 2015; Onyanha, 2016). Other Tanzanian's studies either focused on the research productivity and impact of a specific institution or discipline, or profession (Lwoga and Sife, 2013, 2014; Sife et al., 2013, 2014; Sife and Bernard, 2016). Thus, there is still no comprehensive study to examine the patterns and impact of research performance among the Tanzanian scholars.

This study reports findings of a scientometric study of research growth and impact in Tanzania scholars from 1991 to 2015. The aim of the paper is to provide empirical findings to inform multi-sectoral policies, programmes, capacity, and financing issues related to improving research performance across the country. The study seeks to answer the following research questions:

1. What is the growth of the Tanzanians' scholarly literature?
2. What is the year-wise and subject-wise distribution of publications?
3. What is the authorship pattern among Tanzania scholars?
4. What is the pattern of collaboration in knowledge production in Tanzania?
5. What is the citation impact of Tanzania scholars?

METHODOLOGY

We used the scientometric approach to assess the extent and impact of research growth among Tanzanian's scholars.

This scientometric analysis was conducted on data extracted from SCOPUS (Elsevier, 2016) on the 2nd June 2016.

The study data was extracted from the SCOPUS database, because it indexes quality research outputs and it provides adequate coverage of African research (Onyanha and Ocholla, 2009; Fari and Ocholla, 2016). We acquired the list of the Tanzanian universities from the Tanzania Commission for Universities (TCU) website, while the list of the research institutions was obtained from the Tanzania Commission for Science and Technology (COSTECH) website.

The study used the "institutional affiliation" search term to extract and download data from SCOPUS. The study created the search query with the specific names of the different search phrases (that is, AFFIL ("name of the university") AND (LIMIT-TO (AFFILCOUNTRY, "Tanzania"))).

Thereafter, in order to identify a wide range of research institutions, we used truncated search queries with terms that are broadly used to name research-based institutes in the country, such as science-, technology-, research, center, etc., (that is, AFFIL("sci*") AND (LIMIT-TO(AFFILCOUNTRY, "Tanzania")). The study used both specific and truncated queries, which were restricted to the year between 1991 and 2015. Domestically and internationally co-authored papers were identified for co-authorship analysis through descriptive bibliometrics. We calculated Tanzania scholars' publications, citation counts, number of authors per publication, average citations per paper, average citations per year, h -index, g -index, Hc-index and the HI-norm index.

From the list of aggregated authors and affiliations, we identified the authors' affiliations and countries from the fields of affiliation and corresponding address. The names of affiliations and countries that were not well formatted were reconstructed from the author's address. We manually reprocessed the author's affiliation to reflect the historical changes of names for those institutions that had changed their names. Python version 2.7 scripts (<https://www.python.org/>) were used for cleaning data and splitting the authors' names, and the data was stored in a MySQL® version 5.5 (<https://www.mysql.com/>) database. The data cleaning was finalized using Microsoft Excel® version 2010 (<https://products.office.com/en-us/excel>).

A total of 16,662 articles were retrieved when we conducted a search by using country affiliation "Tanzania" as the search term. In order to confirm that these articles were published by the Tanzanian scholars, we conducted a search by using the institutional affiliations of authors. We also excluded articles that were not published by authors in Tanzania, which had been accidentally included in the original set. Finally, we retrieved a total of 12,379 articles that were published by Tanzanian scholars, and they were finally used for analysis.

RESULTS

The study findings indicate that the research publications increased exponentially to a total of 12,379, and the highest number of publication (1307) was recorded in 2015 (Figure 1).

There was more than 12.5 fold increase in number of articles per year from 105 in the year 1991 to 1,327 articles in the year 2015, which is a 92% increase in publications. A rapid growth in annual publication turnover was witnessed after 2000, for example the number of articles doubled in 4 years from 235 in 2000 to 456 publications in 2005. The results further indicate that most researchers published journal research articles (83.9%) (Table 1), which were followed by reviews and

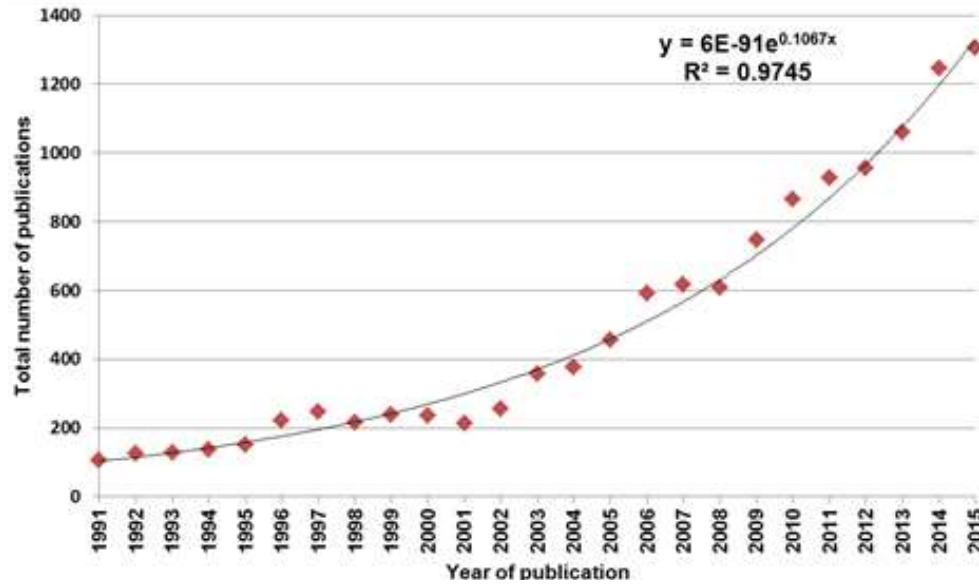


Figure 1. Annual increase of research articles in Tanzania from 1991 to 2015.

Table 1. Publication types published by Tanzanian scholars.

Publication type	Number (%)
Articles	10392 (83.9)
Reviews	587 (4.7)
Conference papers	579 (4.7)
Book chapters	393 (3.2)
Letters	169 (1.4)
Others	224 (1.8)
Books	35 (0.3)
Total	12379 (100)

Other = editorials, erratum and notes.

conference presentations, each contributed 4.7%.

The study results further show that Muhimbili University of Health and Allied Science (MUHAS) was the leading Institution with a cumulative total of 2009 articles during the 24 years, accounting for 16.2% of all publications in the study period (Table 2). Other institutions with high number of publications were University of Dar es Salaam, Sokoine University of Agriculture and National Institute for Medical Research. None of the institution maintained the same rank over the study period (Figure 2). In 2015, Sokoine University of Agriculture (SUA) was the leading institution with 183 articles compared to University of Dar es Salaam (UDSM) and MUHAS, which had 178 and 168 publications, respectively.

The subject-wise breakup of all publications published in the years 1991 to 2015 indicates that nearly half of the publications (55.5%, n=6868) belonged to the medicine subject category, which was followed by agricultural and

biological sciences (42.5%, n=5260) and immunology and microbiology (22.5%, n=2781) (Table 3).

The distribution of articles in journals showed that most Tanzanian researchers published in journals in the field of medical sciences, which was followed by agricultural journals. Table 4 indicates that most researchers had published in the Plos One Journal (n=328), which was followed by Malaria Journal and Tanzania Journal of Health Research.

However, most articles that had received high number of citations were published in the Lancet journal (n=10.354), which was followed by Malaria journal and New England Journal of Medicine with 6.013 and 5.506 citations, respectively. The journals showed variations in ranking based on number of articles, citation, and average number of citations per publication in that journal as shown in Table 4.

The top six most cited publications with more than 500

Table 2. Overall Institution publications rank in the study period 1991 to 2015.

Name of institution	Number of publications (%)
Muhimbili University of Health and Allied Sciences	2009 (16.2)
University of Dar es Salaam	1880 (15.2)
Sokoine University of Agriculture	1571 (12.7)
National Institute for Medical Research	1004 (8.1)
Kilimanjaro Christian Medical Centre	703 (5.7)
Ifakara Health Institute	664 (5.4)
Catholic University of Health and Allied Sciences	332 (2.7)
Ministry of Health and Social Welfare	226 (1.8)
Muhimbili National Hospital	184 (1.5)
Tanzania Wildlife Research Institute	142 (1.1)
University of Dodoma	104 (0.8)
Tanzania Fisheries Research Institute	98 (0.8)
Ardhi University	82 (0.7)
Nelson Mandela African Institute of Science and Technology	80 (0.6)
International Institute of Tropical Agriculture	69 (0.6)
African Medical and Research Foundation	68 (0.5)
Veterinary Investigation Centre	67 (0.5)
Haydom Lutheran Hospital	61 (0.5)
Wildlife Conservation Society	60 (0.5)
Kongwa Trachoma Project	58 (0.5)
Tanzania Food and Nutrition Centre	58 (0.5)
Open University of Tanzania	53 (0.4)
Tropical Pesticides Research Institute	50 (0.4)
Africa Rice Center	46 (0.4)
Tanzania Forestry Research Institute	44 (0.4)
Tanzania National Parks	44 (0.4)
Kilimanjaro Clinical Research Institute	39 (0.3)
Mzumbe University	37 (0.3)
Hubert Kairuki Memorial University	34 (0.3)
Dar es Salaam Institute of Technology	33 (0.3)
Helminth Control Laboratory Unguja	33 (0.3)
Ocean Road Cancer Institute	31 (0.3)
Other institutions	2415 (19.5)
Total	12379 (100)

citations had a total of 2.8% (n=5285) citation out of 186,777 citations from all Tanzanian publications in the study period (Table 5). The top 20 prolific authors in Tanzania had published 2,207 (17.8%) of all publications and included many publications from the field of health sciences (Table 6).

With respect to the number of publications, J. Fawzi was the most prolific author (200 publications), who was followed by M. Schellenberg (163 publications) and R. Tanner (162 publications). When ranked based on the citation counts, M. Schellenberg ranked the first (7258 citations), who was followed by R. Tanner (7002 citations) and H. Hayes (5138 citations). With respect to the number of cites given to each individual's publications, P. Mayaud ranked the first with 115.6 cites per paper though

with average rank of 59. M. Schellenberg and R. Tanner had the highest h-index of 46, meaning that their 46 publications had been cited 46 or more times each, and the rest of the publications had fewer than 46 citations.

When more weight is given to the authors' highly cited publications, M. Schellenberg again ranked the first (g-index 81), who was followed by R. Tanner (g-index 80) and H. Hayes (g-index 70 each). By giving more weight to newly published works, R. Tanner topped the list (Hc-index 28), who was followed by M. Schellenberg (Hc-index 27), J. Fawzi (Hc-index 25) and S. Mshinda (Hc index 24). With regard to the HI norm-index which evaluates the effects of co-authorship, M. Schellenberg and R. Tanner occupied the first position with HI-norm index of 14, who was followed by J. Fawzi and S.

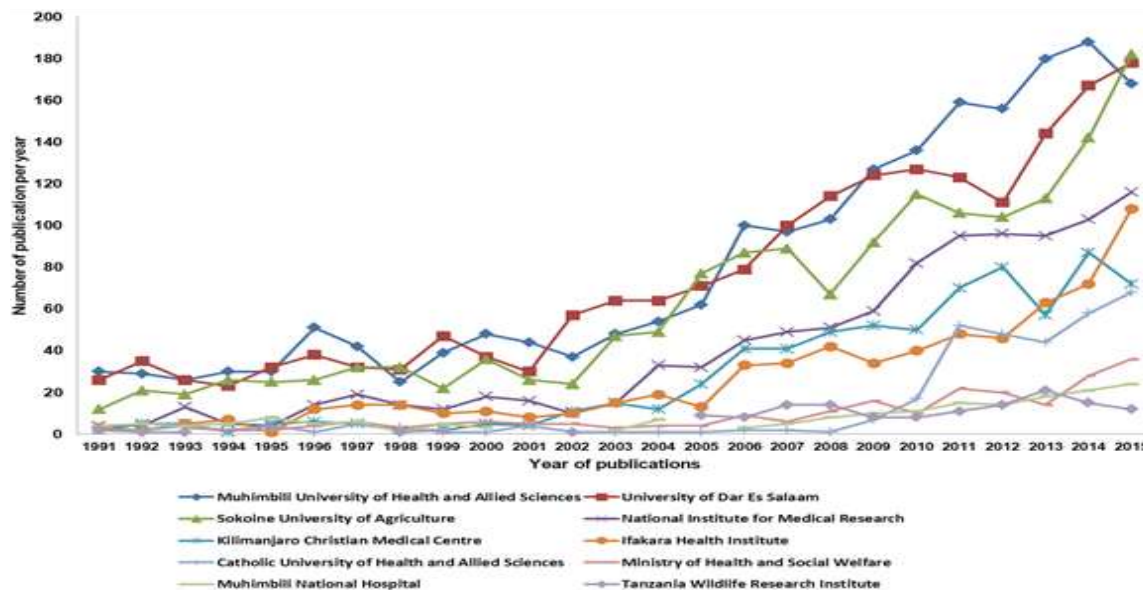


Figure 2. Annual progress of top 10 performing institutions in Tanzania.

Table 3. Subject classification of publications for all the 12,379 Tanzania publications from 1991 to 2015 (Some articles have more than one subject area).

Subject area of publications	Number of publications
Medicine	6868 (55.5)
Agricultural and Biological Sciences	5260 (42.5)
Immunology and Microbiology	2781 (22.5)
Environmental Science	2309 (18.7)
Biochemistry, Genetics and Molecular Biology	1853 (15)
Social Sciences	1800 (14.5)
Earth and Planetary Sciences	1017 (8.2)
Veterinary	865 (7)
Engineering	572 (4.6)
Pharmacology, Toxicology and Pharmaceutics	532 (4.3)
Chemistry	419 (3.4)
Economics, Econometrics and Finance	355 (2.9)
Computer Science	274 (2.2)
Business, Management and Accounting	258 (2.1)
Energy	247 (2)
Arts and Humanities	232 (1.9)
Nursing	228 (1.8)
Psychology	190 (1.5)
Multidisciplinary	183 (1.5)
Chemical Engineering	177 (1.4)
Physics and Astronomy	176 (1.4)
Mathematics	175 (1.4)
Health Professions	168 (1.4)
Materials Science	167 (1.3)
Neuroscience	148 (1.2)
Dentistry	116 (0.9)
Decision Sciences	58 (0.5)
Undefined	17 (0.1)

Table 1. Journal ranking with respect to three measures; total citations, total number of publications and average citation per publication, ranking is shown in brackets. Journals are listed in the order of average rank of the three measures.

Average rank	Journal	Total citations (Rank)	Total publications (Rank)	Average citation (Rank)
1	Lancet	10354 (1)	108 (10)	95.9 (12)
2	New England Journal of Medicine	5506 (3)	26 (66)	211.8 (3)
3	Nature	3600 (8)	21 (78)	171.4 (4)
4	Science	2662 (11)	25 (71)	106.5 (9)
5	AIDS	3668 (7)	92 (15)	39.9 (76)
6	Journal of Infectious Diseases	2713 (10)	82 (16)	33.1 (110)
7	American Journal of Tropical Medicine and Hygiene	3924 (6)	136 (7)	28.9 (145)
8	Transactions of the Royal Society of Tropical Medicine and Hygiene	3431 (9)	125 (9)	27.4 (162)
9	Tropical Medicine and International Health	4885 (4)	213 (4)	22.9 (219)
10	Malaria Journal	6013 (2)	287 (2)	21 (248)
11	PLoS ONE	3942 (5)	328 (1)	12 (452)
12	BMC Public Health	1414 (24)	128 (8)	11 (491)
13	East African Medical Journal	1521 (20)	188 (5)	8.1 (629)
14	Nature Genetics	835 (40)	3 (692)	278.3 (2)
15	Journal of Personality and Social Psychology	280 (102)	2 (916)	140 (6)
16	Livestock Research for Rural Development	437 (66)	154 (6)	2.8 (992)
17	Journal of Cross-Cultural Psychology	267 (108)	2 (968)	133.5 (7)
18	Tanzania journal of health research	474 (61)	247 (3)	1.9 (1101)
19	Journal of Experimental Medicine	285 (99)	2 (1086)	142.5 (5)
20	Nature Medicine	332 (83)	1 (2176)	332 (1)
21	Nature Reviews Microbiology	127 (211)	1 (2174)	127 (8)
22	Metallurgical and Materials Transactions A: Physical Metallurgy and Materials Science	105 (255)	1 (2222)	105 (10)

Table 2. Highly cited articles.

Publication	Number of citations	Tanzania Institution
Haynes et al.(2009). A surgical safety checklist to reduce morbidity and mortality in a global population. New England Journal of Medicine	1914	St Francis Designated District Hospital
Grosskurth et al. (1995). Impact of improved treatment of sexually transmitted diseases on HIV infection in rural Tanzania: Randomized controlled trial. The Lancet	1061	African Medical and Research Foundation (AMREF)
Sankaran et al. (2005). Determinants of woody cover in African savannas. Nature	649	University of Dar Es Salaam
Tishkoff et al. (2007). Convergent adaptation of human lactase persistence in Africa and Europe. Nature Genetics	592	Muhimbili University of Health and Allied Sciences
Tishkoff et al. (2009). The genetic structure and history of Africans and African Americans. Science	562	Muhimbili University of Health and Allied Sciences
Olldashi et al. (2010). Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): A randomised, placebo-controlled trial. The Lancet	507	Muhimbili Orthopaedic Institute

Mshinda with indices of 13 and 12 respectively. Overall, M. Schellenberg ranked the first, who was followed by R.

Tanner, H. Hayes, S. Mshinda and J. Kapiga (Table 6). There was a high level of collaboration with three quarters

Table 6. Ranked list of prolific Tanzania scholars.

Author name	Number of publications	Number of citations	Cites per paper	H-index	G-index	HC-index	HI-Norm	Average position
Schellenberg M.	163 (2)	7258 (1)	44.5 (66)	46 (1)	81 (1)	27 (2)	14 (1)	1
Tanner R.	162 (3)	7002 (2)	43.2 (75)	46 (2)	80 (2)	28 (1)	14 (2)	2
Hayes H.	112 (7)	5138 (3)	45.9 (62)	40 (5)	70 (3)	20 (12)	10 (16)	3
Mshinda S.	117 (6)	4821 (6)	41.2 (86)	41 (4)	67 (5)	24 (4)	12 (5)	4
Kapiga J.	92 (13)	4507 (8)	49 (52)	29 (16)	67 (6)	23 (5)	10 (17)	5
Todd H.	101 (9)	4951 (5)	49 (51)	34 (9)	70 (4)	19 (15)	9 (26)	6
Grosskurth H.	63 (36)	4722 (7)	75 (12)	31 (13)	63 (8)	16 (35)	9 (32)	7
Reyburn C.	77 (19)	3286 (13)	42.7 (77)	30 (14)	57 (13)	23 (6)	11 (7)	8
Lengeler C.	62 (38)	2913 (18)	47 (60)	35 (7)	54 (15)	21 (10)	11 (10)	9
Drakeley G.I.	41 (76)	3293 (12)	80.3 (10)	28 (22)	41 (30)	21 (11)	11 (11)	10
Msamanga S.	103 (8)	3562 (11)	34.6 (118)	33 (10)	57 (12)	19 (14)	13 (4)	11
Abdulla G.	123 (5)	4094 (10)	33.3 (129)	35 (6)	62 (10)	22 (7)	10 (15)	12
Killeen WW.	75 (23)	2680 (20)	35.7 (114)	33 (11)	51 (17)	20 (13)	11 (8)	13
Fawzi J.	200 (1)	5130 (4)	25.7 (196)	41 (3)	64 (7)	25 (3)	13 (3)	14
Changalucha J.A.	155 (4)	4309 (9)	27.8 (164)	34 (8)	62 (9)	21 (9)	10 (14)	15
Crump Z.	74 (24)	3279 (14)	44.3 (69)	28 (20)	58 (11)	22 (8)	7 (79)	16
Premji F.	73 (25)	2504 (21)	34.3 (122)	31 (12)	49 (19)	18 (19)	10 (19)	17
Mosha M.	56 (43)	2844 (19)	50.8 (47)	25 (29)	54 (16)	16 (36)	8 (58)	18
Lemnge D.	87 (16)	3138 (15)	36.1 (111)	28 (18)	55 (14)	17 (25)	8 (52)	19
Mabey T.K.	40 (85)	2946 (17)	73.7 (13)	25 (30)	40 (36)	15 (51)	9 (39)	20

of publications (73%, n=9075) being co-authored with international scholars. The top collaborating countries were the United States (21.6%) and the United Kingdom (20.2%). The top African collaborator was Kenya, which contributed 7% of all collaborations with the Tanzanian researchers (Table 7). The results further indicate that ninety percent of publications were multi-authored and nearly half of research articles were authored by six or more authors (40.7%) (Table 8).

DISCUSSION

The use of scientometrics can help countries to make informed political decisions with regards to achieving sustainable development goals. The scientific research and scientific publication are requirements for the creation of the necessary long-term potential for sustainable economic development (Confraria and Godinho, 2015).

The study reveals an exponential growth of articles spanning over 24 years; between the year 1991 and 2015. The propensity to publish in the Tanzania has grown at a high speed since 2004-2008, suggesting that a possible take-off of Tanzania science similar to trend observed in other countries in sub-Saharan Africa (Pouris and Ho, 2014; Confraria and Godinho, 2015; Breugelmans et al., 2015).

This period was marked by the establishment of new

private and public universities which might have contributed to the growth of research publications in Tanzania. Similarly, the increase in number of publications from 2004 was observed by other countries in Africa and this may be due to presence of international collaborations such as the presence of medical and Tropical research centers focusing in poverty diseases in East Africa (Breugelmans et al., 2015).

Notable productivity of African science, as measured by publications to gross domestic product, has risen in recent years to a level above the world average (Confraria and Godinho, 2015). However, it is argued that looking at the equivalent ratio after it has been normalized by population; there is still a huge gap to overcome (Confraria and Godinho, 2015). It is therefore important to analyze the growth rate with respect to the country population and the number of researchers in a given institution.

The research on medical sciences appears to be the leading research field in Tanzania. Other important subjects were agriculture and biological sciences, and immunology and microbiology. This is in concordance with other studies which indicate that Africa's research outputs are greatly represented in the fields of health sciences which is similar to the coverage of world's publications (Abrahams et al., 2009; Confraria and Godinho, 2015).

The high contribution of research publications in health-related sciences, such as medicine and immunology and

Table 7. Top collaborating countries in published literature during 1991 to 2015.

Country	Number of articles	% of all articles
United States	2673	21.6
United Kingdom	2496	20.2
Kenya	870	7.0
The Netherlands	752	6.1
Switzerland	741	6.0
South Africa	724	5.8
Sweden	715	5.8
Germany	661	5.3
Denmark	627	5.1
Norway	576	4.7
Uganda	559	4.5
Belgium	472	3.8
Canada	364	2.9
Japan	326	2.6
Australia	314	2.5
France	305	2.5
Italy	294	2.4
Nigeria	236	1.9
Ghana	219	1.8
Zambia	211	1.7
Spain	205	1.7
India	200	1.6
Malawi	193	1.6
Ethiopia	182	1.5
Zimbabwe	169	1.4
Austria	155	1.3
Thailand	144	1.2
China	139	1.1
Finland	134	1.1
Mozambique	130	1.1
Brazil	127	1.0
South Korea	125	1.0

Table 8. Authorship patterns of Tanzania scholars between the years 1991 to 2015.

Category of authorship	Number of publications (%)
Single author	1206 (9.7)
Two authors	1504 (12.1)
Three authors	1713 (13.8)
Four authors	1607 (13)
Five authors	1308 (10.6)
Six/More authors	5041 (40.7)
Total	12379 (100)

microbiology, may stem from research work on tropical diseases and specific health problems, and the visible presence of international cooperation between Tanzanian

researchers and those overseas (Gondwe, 2010; Confraria and Godinho, 2015).

The prosperity of health related research may also be

due to increase of funding in these areas by organizations such as Swedish International Development Cooperation Agency (SIDA), the European and Developing Countries Clinical Trials Partnership (EDCTP), Wellcome-Trust, and National Institute for Health (NIH) among others (Breugelmans et al., 2015).

The ranking of agricultural sciences seems reasonable, given the needs of the Tanzania to depend on agriculture. Similar trend and the significance of agriculture applies to other studies in Africa (Abrahams et al., 2009; Confraria and Godinho, 2015). Therefore, scientific specialization, in Tanzania is not quite different from the overall Africa's specialization in areas of medical research and Agriculture. However, compared to the world patterns, agricultural sciences are relatively more important in Africa (Confraria and Godinho, 2015).

Accordingly, a number of health institutions including medical universities and research institutions appear to rank high in the list of contributors of Tanzanian science in our analysis. The most prolific institution in the 24 years period was Muhimbili University of Health and Allied Sciences (MUHAS), which produced a volume of 16.2% (n=2009) of all publications. The top 3 institutions alternated the first to third rank. In 2015, the leading institution was SUA followed by UDSM and MUHAS. These results coincide with web ranking of Tanzania University in 2016 (Ranking web of Universities United Republic of Tanzania, 2016).

The authorship pattern is dominated by multiple authors (90.3%), indicating a high degree of collaboration among Tanzanian scholars. Furthermore, collaboration between Tanzania and international researchers is quite high at 73%. In other studies, it was noted that collaborative patterns among African scholars are substantially higher than in the rest of the world (Pouris and Ho, 2014; Nature, 2015). Tanzania Scientists that collaborate with peers in Europe and US are likely to receive more scholarly impact as reflected in their citation impact (Confraria and Godinho, 2015; Breugelmans et al., 2015). Papers that had more citation impact were those papers that were coauthored in collaboration with international researchers.

The top 20 scholars comprise mostly researchers in the field of health. The list includes both Tanzanian native scholars and foreign scholars working in Tanzania. The productivity and impact of the top 20 scholars varied in various metrics since no single scholar maintained the same rank in all metrics. For instance, some of the top scholars in terms of publications had fewer citations compared to some scholars with fewer publications.

Hence, these findings support the argument that research performance is a complex multifaceted endeavor that cannot be assessed using a single indicator (Smith and Katz, 2000). This confirms the fact that citation counts depend on several factors other than the number of publications.

Moreover, the ranking of researchers in this study was

based on publications and citations that were available online covering the mentioned period. This means that some senior researchers could rank differently if their productivity and impacts were measured based on their career life and if offline publications and citations were retrieved.

The top six most cited publications had received more than 500 citations each. All these top six papers had multiple authors. These findings suggest that citation counts rely on several factors including the number of authors, accessibility of journals where articles are published, the age of the publication, the quality of the publication, the size of the scientific community, the topic which one publishes (Bornmann and Daniel, 2008) and the visibility of collaborating authors.

Moreover, the top ranking journals with high number of citations were the high impact journals such as *Lancet* and *New England Journal of Medicine*. *Malaria journal*, an open access journal ranked second in both number of articles and citations rank. Medical researchers in this area should consider the online and open access journals to boost their impact and visibility. One local journal, the *Tanzanian Journal of Health Research* was ranked third in the number of articles, however the journal was ranked poorly in the average number of citations with each articles receiving less than 2 citations. This underscores the need for Tanzania authors to publish in the highly visible e-journals and open access journals in order to improve their visibility and citation impact.

Conclusion

The amount of research publications from Tanzania increased exponentially from 1991 to 2015. Collaborative research with external partners had a higher impact, and it was more cited than non-collaborative research. This, work emphasizes the importance of research collaboration among African countries and others, on common issues related to economic growth and sustainable development.

Limitations

The study had several limitations. We used Elsevier's Scopus (Elsevier, 2016) database to analyze research impact of Tanzanian scholars over other online databases alternatives such as Thomson's Reuters Web of Science (WOS) database.

Scopus covers about 20,000 journals compared to 13,000 journals which are hosted by WOS (Mongeon and Paul-Hus, 2016). Moreover, the database is updated on daily basis rather than weekly. This gives opportunity to get a wider coverage of publications. The coverage of data in WOS with English-language journals is very comprehensive. One limitation of the WOS is that

coverage of non-English-language journals is less extensive, although this has recently increased with the inclusion of French and Portuguese journals. In a study of pharmacy and pharmacology journals, Gorraiz and Schloegl (2008) found that Scopus reported a higher citation rate for health relevant articles as compared to WOS possibly because Scopus indexes more biomedical journals than WOS.

Gorraiz and Schloegl (2008) further revealed that both WOS and Scopus databases differ in the number of articles within a tolerable margin of deviation for most journals when pharmacy and pharmacology journals research were analyzed from both databases. In addition, Scopus database is periodically updated with previous articles. Therefore, results from Scopus need to be interpreted with caution when one compares these data with other databases. Another potential limitation of our analysis is the method used to assign papers to organization. Authors often report their affiliations in different ways for different publications. Even though, we used an algorithm to unify these affiliations, some authors who published in foreign countries may have been excluded in the analysis. Moreover, scientists from foreign countries working in Tanzania were also counted as Tanzanian scholars.

The findings imply that researchers should continue to collaborate with external partners within and outside the country to increase the impact of their scientific works. Moreover, these findings can be used by the Tanzanian government to prioritize research funding for research institutions and increase budget to support research activities to more than the current 1% of the Gross Domestic Product (GDP). This initiative will enable researchers, policy-makers and service providers to collaborate in efforts to bridge the gaps between research, policy and practice for the country to progress from a low- to a middle-income country.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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