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Research Collaboration Landscape of the University of Ibadan Biomedical Authors between 2006 and 2015

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Abstract

This analysis of co-authorship of biomedical researchers at the University of Ibadan (UI), Nigeria between 2006 and 2015 is based on bibliographic data from the PubMed®. It describes the types and the countries of collaboration, comparison of the visibility of the collaboration types and funding status. The results show that internal collaboration was high while international collaboration was low, and about 30% of the published papers were funded. The papers received an average of 2.58 citations per year while collaborative coefficient was 0.65. Furthermore, international collaboration and funded papers received more citations. While about two-thirds of the international collaborations were funded, just about 20% of the internal collaborations were funded. Comparison of the visibility of international with internal collaboration shows that international collaborations have impacted UI biomedical research more significantly than internal collaboration.

Keywords: Co-authorship analysis, Research collaboration, University of Ibadan, Bibliometrics, Biomedical research

Introduction

Using co-authorship as a basis for measuring research collaboration assumes that co-authored research originates from research collaboration, and research collaborations result in co-authored research (Laudel, 2002). Though this assumption is considered faulty (Bennett and Taylor, 2003; Glänzel and Schubert, 2004; Katz and Martin, 1997; Teixeira da Silva and Dobránszki, 2016) co-authorship remains the commonest method of measuring collaboration in science (Katz and Martin, 1997; Subramanyam, 1983; Tsai, Corley, and Bozeman, 2016). The co-author concept of collaboration has several advantages over other social science research methods for investigating collaboration. First, co-authorship research is verifiable and reproducible with available and cheap data. Second, standard metrics for measurement are simple and developed with several available types of software. Third, available datasets are large enough to cover large sample sizes and are, therefore, statistically significant. Fourth, co-authorship research is practical and objective with developed theories and methods as datasets are collected from academic artefacts (Katz and Martin, 1997). Research collaboration is considered important because evidence has shown that collaboration correlates with higher productivity, greater credibility, a higher number of citations and higher influence (Bozeman and Boardman, 2014; Katz and Martin, 1997; Luukkonen, Persson, and Siverten, 1992; Subramanyam, 1983). Also, collaboration correlates with quality as most novel research and innovations are products of interdisciplinary collaborations, and the most prolific researchers collaborate most often (Bozeman and Boardman, 2014; Katz and Martin, 1997; Lee and

Bozeman, 2005; Luukkonen, Persson, and Siverten, 1992).

Studies about collaboration using co-authorship are very important to science and professional communities as they investigate the development, maturity or "conceptual and professional evolution" of a scientific discipline, scientist or a group of scientists (Larivière, Sugimoto, and Cronin, 2012). Such studies also help to achieve assessments of individual, organisational, national or regional scientific outputs, impacts, growth, and diversification which explain biases and the strengths and weaknesses of their research activities. For example, the influence a discipline or a region has on another discipline can be explicated by co-authorship analysis of the scientific publications from the influenced discipline. (Ocholla and Roux, 2011; Pettigrew and McKechnie, 2001; McKechnie and Pettigrew, 2002; Kim and Jeong, 2006; Jeong and Kim, 2005). Studies about collaboration also explain authorial behaviour which could include inbreeding or intramural collaboration and international or extramural collaboration (Glänzel and Schubert, 2004),

The growing importance of collaboration in science has also received significant attention from policymakers because of its potential for capacity building. For example, some developing countries have employed the model of collaboration for capacity development, especially in Medicine, Science and Technology (Petroze et al., 2012; Lan, 2014; Chu, Jayaraman, Kyamanywa, and Ntakiyiruta, 2014; Kotecha, Walwyn, and Pinto, 2011). Developed countries such as Japan and the US and multinational organisations such as the European Union, World Bank and World Health Organisation also earmark huge sums for collaboration between research institutions from the developed and the developing countries such as Nigeria with the aim of capacity building (Wagner, Brahmakulam, Jackson, Wong, and Yoda, 2001; Cooke, Ariss, Smith, and Read, 2015).

Today, one of the challenges Nigerian universities face is the inbreeding culture of researchers. This phenomenon has discouraged research multidisciplinarity, researchers' mobility, and international collaboration. On the other hand, inbreeding has encouraged intra-disciplinary and intra-institutional research collaboration. Scholarship inbreeding occurs when generations of academics in a university have studied and gained all their academic experiences from the same university or a closely related university in the country with little or no exposure to international experiences. As Amini-Philips (2016) notes, Nigerian universities employ their best students as teachers as a reward for their academic brilliance. This is unlike universities from the Western countries where a certain percentage of their faculty is from foreign countries and other universities. For instance, Woolley (2017) observed that most of the Canadian universities' economics teachers are from the United States and other countries while most of the doctoral graduates from Canadian universities seek employment in continents of Asia and Australia. This observation has resulted in the effort of the Federal Government of Nigeria in alleviating this trend by providing funding for the training of university academics internationally to break the bonds of inbreeding and encourage international collaboration and exposure through the Tertiary Education Fund (TETfund) (Na'iya, 2013).

Studies on research collaboration globally have shown that the proportion of African research products is negligible compared to other continents (Confraria and Godinho, 2015; Luukkonen et al., 1992). Similarly, Wagner and Leydesdorff (2005) noted that apart from South Africa which is an emerging regional research hub, other African countries are negligible nodes on the global research network. This is consistent with the results of Glänzel (2001) wherein African countries play fringe roles in the global knowledge production industry. One of the features of African knowledge production is that collaboration among African countries is minimal (Onyancha and Maluleka, 2011). Also, medicine and the natural sciences dominate the list of the most emphasised African research focus (Pouris and Ho, 2014). Egyptian, South African, Ethiopian, Nigerian and Ugandan institutions dominate the list of the most prolific institutions in Africa (Pouris and Ho, 2014). For decades, South Africa, Nigeria, Kenya, Tanzania and Ethiopia, arranged in descending order are the countries that published the highest number of articles in sub-Saharan Africa (Confraria and Godinho, 2015; Onyancha and Maluleka, 2011).

Literature has shown that Nigeria is one of the top three African knowledge producers. Pouris and Ho, (2014) also showed that Nigeria is the only country among the African countries whose

collaboration rate is lower than 50% and one of the two African countries that produced articles with more than 28% single authors. Nigeria is one of the four sub-Saharan African countries that Onyancha and Maluleka (2011) identified as having relatively low international collaboration growth.

With the University of Ibadan (UI) as the focal point, this study looks at the pattern of biomedical research co-authorship with the aim of providing some knowledge about internal and external collaboration in Nigeria. This research investigates the type of collaboration that produces the highest citation numbers per year. It also investigates if funded research is cited more. The University of Ibadan in Nigeria was considered for this study first, because of its importance as the oldest university in Nigeria, and considering that it houses the largest medical school in the country. Secondly, for decades, UI has consistently produced the highest number of publications in Nigeria.

Methodology

Data was collected from the PubMed®® database (http://www.ncbi.nlm.nih.gov), an open access bibliographic database of biomedical literature. Using its advanced search functionality, the "Affiliation" option was specified as "University of Ibadan" while "Date – Publication" was specified as "2006" to "2015" for each year respectively during the ten-year period. The search returned a total of 2198 bibliographic records. The data collected was cleaned by removing articles that were published earlier or later than 2006 or 2014.

Data collected about the articles included the number of authors, institutions and countries, names of researchers, institutions and countries, and the funding status of the articles. The number of citations per article from date of publication to 2016 was obtained from Google Scholar (scholar. google. com). The number of citations received for every article was divided by the publication age by year to normalise the effect of the year of publication. The authors' main affiliation was identified as the institution of affiliation. The first institution listed as the authors' address with more than one affiliation was regarded as the authors' main affiliation. Articles in which UI is not the main affiliation of any of the authors were removed.

One of the limitations of the study is the absence of data about some authors' affiliation and funding information. PubMed® did not fully include authors' affiliation other than first author's affiliation in its index until 2014. PubMed®, (2017) wrote in its manual that:

> *"Affiliation [AD]*
> *Affiliation may be included for authors, corporate authors and investigators, e.g., cleveland [ad] AND clinic [ad], if submitted by the publisher. Multiple affiliations were added to citations starting from 2014, previously only the first author's affiliation was included."*

Information about authors' affiliation and funding status of articles were manually traced when they were not provided by PubMed®. Affiliation histories of researchers with missing affiliation were manually traced on PubMed® and Google. Also, information about the funding status of articles which were not provided on PubMed® was manually traced from sources such as the full text of the article or other bibliographic databases. Articles with untraceable information about affiliation and/or funding status were removed from the sample; this is the second stage of cleaning the data. Though the data was collected carefully and consistently, tracing authors' affiliation and funding information manually did not provide the same level of accuracy as collecting the data directly from the database. One of the major challenges faced while tracing author's affiliation manually was reconciling some authors' affiliations. For instance, more than one author may bear the same name and initials and vice versa. After cleaning the data, 1915 articles remained and were used for the analysis.

Three types of collaboration were analysed: intra-institutional, national, and international. Intra-institutional collaboration occurs when all the collaborating authors are from UI alone. National collaboration occurs when all the collaborating authors of an article are from UI and other Nigerian institutions alone, and none of the authors is affiliated with an institution outside of Nigeria. International collaboration occurs when the collaborating authors of an article are from UI and institutions within and outside of Nigeria. International collaboration can be with African or non-African countries.

With the number of authors, the mean number of author per paper and collaborative coefficient (CC) was calculated. Using the formula by Ajiferuke, Burell, and Tague, (1988) CC was calculated as:

$$CC = 1 - \frac{\sum_{j=1}^{k}(1/j)f_j}{N} \quad \text{equation 1}$$

Where fj = the number of j-authored research papers published in a discipline over a period;

k = greatest number of authors per paper;

N = the total number of research papers published over a period.

Results

The results of this study are presented in six sub-sections. The first subsection presents the results of the patterns of collaboration. In this subsection, the results on the level of multi-authorship, percentage of funded publications, number of citations received by articles and the CC are also presented. The second subsection presents results on the types of collaboration which could be intra-institutional, national, or international. A further analysis which is presented in the third subsection shows the results of the countries which collaborating authors are from African and non-African countries. The fourth subsection presents results on statistical tests to investigate the type of collaboration that received the highest amount of citations. Similarly, the fifth subsection presents the result of a statistical test to investigate if funded research is cited more. The result of cross-tabulation of type of collaboration and funding is presented in the last subsection.

Patterns of Collaboration

Total of 1915 publications were analysed and were written by 1848 unique authors from UI in collaboration with 2163 unique authors from 651 different institutions located in 74 countries. With reference to Table 2, the number of publications increased each year from 2006 to 2015; the number of publications doubled in 2013 and tripled in 2015 in comparison with 2006. According to Table 2, the mean number of authors is 4.25 (min=1, max=370, SD=8.81) for the ten-year period. The least mean number of authors was 2.38 and was recorded in 2009, while the highest was 6.01 and was recorded in 2015. Most (55.82%) of the articles were written by authors from UI only. The average number of authors ranged from 3.26 to 3.85 between 2006 and 2013, but increased to 5.02 and 6.21 in 2014 and 2015 respectively. The average number of authors for articles written by UI authors was 3.10. The average number of authors per article for national and international collaboration was 3.80 and 7.24 respectively. Table 1 further explains the distribution of articles by authors. It shows that few articles were written by one author, where 91.72% of the articles were written by more than one author. Concerning levels of multi-authorship or collaboration, three-author papers accounted for the largest proportion with about a quarter (25.10%) of the articles, followed by two-author and four-author papers which accounted for 22.69% and 17.10% respectively. Until 2009, two-author papers accounted for the highest proportion and this changed in the year 2010 to three author papers.

The analysis also shows that 30.09% of all the articles were funded. Less than 30% of articles published between 2006 and 2013 were funded, until 2014 when more than 35% of articles published were funded. The CC for the ten-year period is 0.65, while the least CC occurred in 2013 with CC of 0.61. The highest occurred in 2008 with CC of 0.77. The mean citation per year was 2.58 (min=0, max=45.44, SD=3.49). The papers received the highest (3.46) mean citation per year in 2007, while the papers received the lowest (1.89) mean number of citations per year in 2013.

Table 1: Number of Authors Per Year

Year	Number of Authors											
	1 (%)	2 (%)	3(%)	4 (%)	5 (%)	6 (%)	7 (%)	8 (%)	9 (%)	10(%)	>10 (%)	Total (%)
2006	7.41	23.15	25.93	16.67	10.19	4.63	1.85	2.78	2.78	3.70	0.93	5.64
2007	10.91	20.91	24.55	16.36	8.18	9.09	2.73	3.64	2.73	0.00	0.91	5.74
2008	12.68	23.24	24.65	12.68	9.86	7.75	2.82	1.41	1.41	0.70	2.82	7.42
2009	12.67	25.33	25.33	15.33	9.33	6.00	3.33	0.67	1.33	0.67	0.00	7.83
2010	8.70	19.25	30.43	21.12	8.70	4.35	3.73	2.48	0.62	0.00	0.62	8.41
2011	7.19	25.75	27.54	13.77	9.58	9.58	2.99	1.80	0.60	0.60	0.60	8.72
2012	7.54	24.62	29.15	17.59	11.06	5.53	0.50	1.01	1.01	0.00	2.01	10.39
2013	3.54	28.32	28.76	23.89	7.52	2.21	0.88	3.10	0.44	0.00	1.33	11.80
2014	1.26	19.50	24.53	17.30	9.75	5.97	4.40	3.77	1.89	3.77	7.86	16.61
2015	5.39	16.47	23.05	14.67	11.68	9.58	5.69	2.10	2.10	1.80	7.49	17.44
Total	6.68	22.09	26.16	17.08	9.77	6.53	3.19	2.35	1.46	1.31	0.00	100.00

The average number of institutions per article for national and international collaboration was 2.45 and 4.16 respectively. According to Table 2, the highest number of institutions that participated in collaboration was 231. The mean number of institutions per article over the ten-year period is 1.95 (min=1, max=231, SD=5.54), the least mean was recorded in 2007, and the highest in 2015. 48.94% of the institutions were from Nigeria, while 51.06% were from other countries. Researchers from 152 different institutions in Nigeria participated at least once 566 times. Researchers from 80 different institutions in Africa participated at least once in 200 times; 428 different institutions from non-African countries participated at least once 826 times. Table 2 shows a list of institutions in Nigeria, Africa and non-African countries that collaborated with UI researchers, which gives greater depth to the analysis of institutions. Most (52.17%) of the articles were written by UI researchers alone, followed by 25.11% and 7.65% by researchers from two and three institutions respectively.

Table 3 shows that the UI researchers collaborated more with researchers that are affiliated with universities and other educational institutions. Among the top ten local and international collaborating researchers' institutions of affiliations, only two non-academic institutions were listed. The UI researchers collaborated with researchers that are affiliated with 147 institutions in Nigeria; more than half (77) are non-academic institutions (37 hospital, 22 research organisations, 14 government ministries and agencies and four other non-governmental organisations). However, only 26.87% of all the national collaboration articles were written with researchers that are affiliated with non-academic institutions. Similarly, 46.75% and 24.82% of African and other international collaborating authors' institutions of affiliation are non-academic, but they participated in only 20.88% and 23.34% of the collaborations respectively.

Institutions in Nigeria that collaborated most with UI biomedical researchers are Obafemi Awolowo University first, followed by Ladoke Akintola University and the University of Lagos. Institutions in Africa that collaborated most with UI biomedical researchers are the University of the Witwatersrand, South Africa first, followed by the University of Ghana and Makerere University. Institutions from non-African countries that collaborated most with UI biomedical researchers are World Health Organisation, Harvard University, and Johns Hopkins University.

Table 2: Authors', Institutions', countries' and collaborative co-efficient statistics per year

	No. of Pub.	Number of authors						Number of institutions					Number of countries							
		Avg au	=1 (%)	=2 (%)	=3 (%)	=4 (%)	Hist au	Avg inst.	=1 (%)	=2 (%)	=3 (%)	Hist inst	Avg cty	=1 (%)	=2 (%)	=3 (%)	Hi cty	Av. Cit	Fund (%)	CC
2006	108	3.85	7.41	23.15	25.93	16.67	12	1.56	61.11	26.85	8.33	5	1.27	79.63	14.81	4.63	4	3.05	23.14	0.66
2007	110	3.72	10.91	20.91	24.55	16.36	13	1.38	70.91	22.73	3.64	4	1.09	91.82	7.27	0.91	16	3.55	21.05	0.61
2008	142	3.69	12.68	23.24	24.65	12.68	20	1.73	57.75	31.69	7.04	19	1.44	80.99	21.83	2.11	6	3.03	28.87	0.77
2009	150	3.31	12.67	25.33	25.33	15.33	10	1.49	66.67	24.67	5.33	10	1.27	80.67	16.67	0.67	7	2.51	25.33	0.57
2010	161	3.52	8.70	19.25	30.43	21.12	13	1.60	62.11	25.47	7.45	11	1.27	79.50	16.77	3.11	7	2.50	27.95	0.61
2011	167	3.55	7.19	25.75	27.54	13.77	11	1.49	68.86	18.56	7.78	4	1.25	80.24	15.57	3.59	4	2.32	28.74	0.62
2012	199	3.48	7.54	24.62	29.15	17.59	14	1.56	60.80	27.14	9.55	8	1.29	77.89	17.59	4.02	6	2.15	30.15	0.62
2013	226	3.51	3.54	28.32	28.76	23.89	24	1.46	71.68	22.57	2.65	13	1.17	88.94	9.29	0.44	9	1.90	23.45	0.64
2014	318	5.18	1.26	19.50	24.53	17.30	33	2.47	40.88	30.82	13.21	27	1.72	65.72	22.64	5.35	22	2.52	40.57	0.71
2015	334	6.05	5.39	16.47	23.05	14.67	370	3.05	46.41	25.75	12.87	231	1.72	68.86	17.96	5.99	27	3.98	35.62	0.69
All	1915	4.26	6.68	22.09	26.16	17.08		1.95	58.38[1]	25.65	7.79		1.41	77.28[2]	16.76	3.50		2.61	30.09	0.65

Avg au=Average number of authors per paper, Hist au= Highest number of authors, Avg inst=Average number of institutions per paper, Hist inst.= Highest number of institutions, Avg cty=Average number of countries per paper, Hi cty= Highest number of countries, Av Cit=Average Citation, Fund=Funded Research, CC=Collaboration Coefficient

Table 3: Top ten Institutions that collaborated with UI by Region

	Nigeria	%	Africa	%	Rest of the World	%
1	Obafemi Awolowo University	7.30	University of the Witwatersrand, South Africa	9.34	World Health Organisation (Italy, Switzerland, Cambodia)	4.84
2	Ladoke Akintola University of Technology	7.12	University of Ghana, Ghana	7.69	Harvard University, USA	3.63
3	University of Lagos	6.41	Makerere University, Uganda	7.14	Johns Hopkins University, USA	2.06
4	Olabisi Onabanjo University	4.45	Stelenbosch University, South Africa; University of Cape Town, South Africa	6.04	London School of Hygiene, UK; University of Maryland USA	1.69
5	FMC (Owo, Abeokuta and Katsina)	3.91	University of Pretoria, South Africa	4.40	North-western University, USA	1.57
6	University of Port Harcourt	3.20	Kwame Nkrumah University of Science and Technology, Ghana	3.30	Indiana University, USA	1.45

[1] All articles written in one institution (UI) including articles written by single authors

[2] All articles written in one country (Nigeria), including articles written by single authors

7	Federal University of Agriculture, Abeokuta; University of Ilorin	2.67	North West University, South Africa; University of Fort Hare, South Africa	2.75	University of Chicago, USA	1.21
8	Lagos State University	2.49	Nelson Mandela Metropolitan University, South Africa	2.20	University of São Paulo, Brazil; Loyola University USA; University of Illinois, USA	1.09
9	Babcock University	2.31	University of Nairobi, Kenya	2.20	Shanghai Institute of Planned Parenthood Research, China; King's College, UK; National Institutes of Health, Bethesda USA	0.97
10	Ahmadu Bello University, Nnamdi Azikiwe University, University of Maiduguri	2.14	Cuttington University, Liberia; Kinshasa School of Public Health; University of Malawi, Malawi; University of Zimbabwe, Zimbabwe	1.65	Liverpool School of Tropical Medicine, UK; Veterinary Laboratories Agency, UK; Karachi University, Pakistan	8.47

Types of Collaboration

Of the 1915 articles that were analysed, 1787 (93.31%) were written by multi-authors. Most (55.09%) of the collaborations are intra-institutional, followed by international (24.21%), and national (20.14%). Figure 2 shows that there was more institutional collaboration than national and international collaborations between year 2006 and year 2013. In 2014 and 2015, international collaborations increased while the proportion of intra-institutional collaboration reduced.

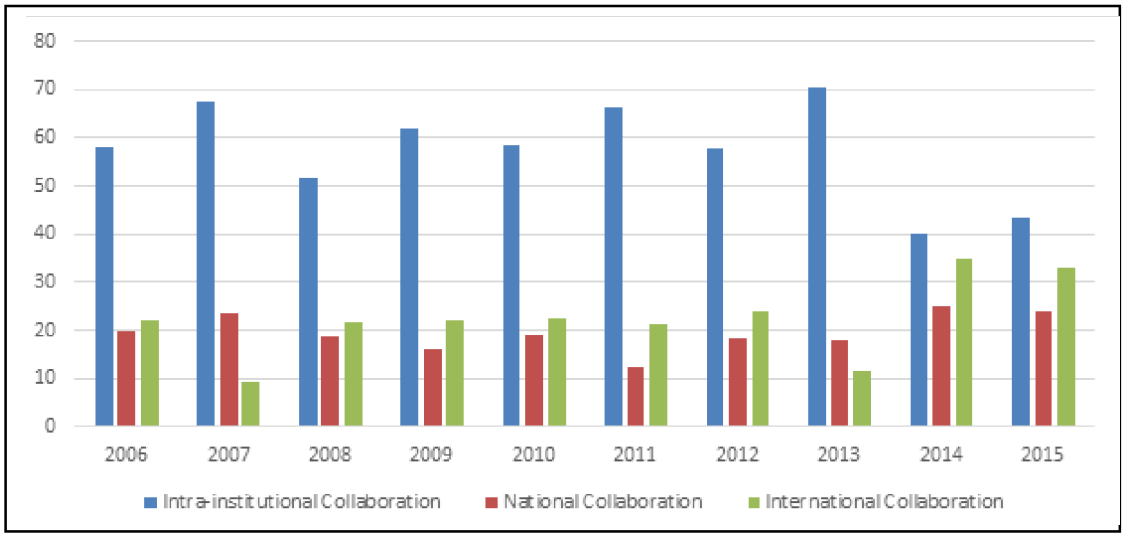

Figure 2: Types of Collaboration

Countries of Collaboration

Table 4 shows the distribution of African and non-African countries that collaborated with UI authors. Only 22 African and 52 non-African countries collaborated with the UI researchers. A total of six African and 25 non-African countries collaborated with the UI biomedical researchers at least five times. UI biomedical researchers collaborate mostly with researchers from non-African countries such as the US, followed by the United Kingdom, Switzerland, India and Germany. They also collaborate mostly with African countries such as South Africa, followed by Ghana, Uganda, Kenya and Cameroun.

The mean number of countries per article over the ten years is 1.48 (min=1, max=27, SD=1.38). The least mean number of countries per article which is 1.07 was recorded in 2007 while the highest mean, 1.72, was recorded in 2013. Most (69.60%) of the articles were written by authors from Nigeria only, while 16.45% and 3.42% were written by authors from two and three countries respectively.

Table 4: Ranking of Countries that Collaborate with UI Biomedical Researchers

Rank	Country	Participation (%)
1	USA	24.22
2	UK	11.42
3	**South Africa**	7.40
4	Switzerland	5.77
5	India	4.52
6	**Ghana**, Germany	3.14
7	Brazil	2.89
8	China	2.01
9	Italy, France, **Uganda**	1.88
10	Sweden, Australia	1.76
11	Spain	1.51
12	**Kenya**	1.38
13	Netherlands	1.25
14	Saudi Arabia, Japan, Pakistan, Canada	1.00
15	Cameroun, Finland, Israel, Norway	0.75
16	Lebanon, Mexico, Denmark, Belgium, **Tanzania**	0.63
17	Greece, Portugal, Colombia, Thailand, Luxembourg, Malaysia	0.50
18	Iraq, Bulgaria, UAE, **Malawi, DR Congo, Zimbabwe, Ethiopia**	0.38
19	**Egypt, Gambia, Senegal, Congo, Senegal, Congo, Liberia, Morocco**, Kuwait, Sri Lanka, Iceland, Iran, Cambodia, Myanmar, Austria, Peru, Poland, South Korea, New Zealand, Hong Kong, Romania, Bangladesh	0.25
20	**Mozambique, Rwanda, Guinea, Niger, Mali, Zambia**, Lao's People Republic, Ukraine, Jamaica, Argentina, Taiwan	0.13

Note: African countries in **bold** letters

Which type of collaboration produced the highest number of citations per year?

The Kruskal-Wallis test was conducted to investigate if there is a difference in the number of citation per year between international, national and intra-institutional collaborations. The result of the Kruskal-Wallis test is displayed on Tables 5a and 5b. The following hypotheses were stated while the null hypothesis was tested:

Null hypothesis: The means of the number of citations per year for international, national and intra-institutional collaboration are similar.

Alternative hypothesis: At least one pair of the means of the number of citations per year for international, national and intra-institutional collaborations is not similar.

The Kruskal-Wallis H test shows that there was a statistically significant difference in the number of citations per year between the three different types of collaborations, $\chi^2(2) = 76.105$, $p \approx 0.001$, with a mean rank score of 834.76 for intra-institutional collaborations, 828.63 for national collaboration, and 1077.69 for international collaboration. The null hypothesis was rejected, therefore at least a pair of the three types of collaborations is not similar.

Table 5: Kruskal-Wallis Mean Ranks H Test Statistic

	Collaboration Type	N and	Mean Rank		Citation per year
Citation per year	Intra-Institutional Collaboration	977	834.76	Kruskal-Wallis H	75.400
	National Collaboration	366	828.63	df	2
	International Collaboration	446	1077.69	Asymp. Sig.	.000
	Total	1787	a. Kruskal Wallis Test b. Grouping Variable: Collaboration Type		

To test for the pairs of variables that have significantly different means, three tests of the Mann-Whitney U statistical tests were conducted for international and intra-institutional, international and national and, national and intra-institutional collaborations. The following hypotheses were tested:

Null hypothesis 1: The means of the number of citations per year for intra-institutional and national collaboration are similar.

Null hypothesis 2: The means of the number of citations per year for intra-institutional and international collaboration are similar.

Null hypothesis 3: The means of the number of citations per year for national and international institutional collaboration are similar.

The result of Mann-Whitney U mean rank is presented on Table 6 while the result of Mann-Whitney U statistic test result is presented on Table 6. Mann-Whitney test showed that there was a statistically insignificant difference in the means of the number of citations per year between intra-institutional and national collaboration $Z = -0.254$, $p = 0.846$ with a mean rank score of 687.11for intra-institutional collaboration and 673.14 for national collaboration. Hypothesis one was not rejected, and the result means that national and intra-institutional collaborations were cited equally. Mann-Whitney test also shows that there was a statistically significant difference in the means of the number of citation per year between intra-institutional and international collaboration $Z = -8.297$, $p \approx 0.001$ with a mean rank score of 650.62 for intra-institutional collaboration and 845.17 for international collaboration. Hypothesis two was rejected, and the result means that international collaboration is cited more than intra-institutional collaboration. Mann-Whitney U test showed that there was a statistically significant difference in the means of the number of citations per year between national and international collaboration $Z = -6.735$, $p \approx 0.0001$ with a mean rank of 344.52 for national and 455.52 for international collaboration. Null hypothesis three was rejected, and the result means that international collaboration is cited more than national collaboration.

Table 6: Mann-Whitney U Mean Ranks

	Collaboration Type	N	Mean Rank	Sum of Ranks
Citation per year	Intra-Institutional Collaboration	977	673.14	657658.50
	National Collaboration	365	667.11	243494.50
	Total	1342		
	Intra-Institutional Collaboration	977	650.62	635651.00
	International Collaboration	445	845.17	376102.00
	Total	1422		
	National Collaboration	365	344.52	125750.50
	International Collaboration	445	455.52	202704.50
	Total	810		

Table 7: Mann-Whitney U Test Statistics Result

Test Statistics	Intra-Institutional and National Collaboration	Intra-Institutional and International Collaboration	National and International Collaboration
	Citation per year	Citation per year	Citation per year
Mann-Whitney U	176699.500	157898.000	59256.500
Wilcoxon W	243494.500	635651.000	126417.500
Z	-0.254	-8.297	-6.735
Asymp. Sig. (2-tailed)	0.799	0.000	0.000
a. Grouping Variable: Collaboration Type			

Are funded research Articles cited more?

Mann-Whitney U test was conducted to investigate if there is a difference in the means number of citations per year of funded papers and papers that were not funded.

Null hypothesis 4: The means of the number of citations per year for papers that were funded and papers that were not funded are the same.

Table 8 shows that the difference in means of the number of citations per year for funded papers and papers that were not funded is significant (Z = -9.451, *p*H”0.0001), therefore null hypothesis four was rejected. The table also shows that funded papers (1138.16) have higher mean rank than papers that were not funded (879.15). This means that funded papers were cited more.

Table 8: Mann- Whitney Mean Ranks and Test Statistic

	Funding Status	N	Mean Rank	Sum of Ranks		Citation per year
Citation per year	Not Funded	1332	879.15	1171022.00	Mann-Whitney U	283244.000
	Funded	583	1138.16	663548.00	Wilcoxon W	1171022.000
	Total	1915			Z	-9.451
					Asymp. Sig. (2 tailed)	.000
					a. Grouping Variable: Funding Status	

Funding and Type of Collaboration

Table 9 shows that only about 20% of national and intra-institutional collaborations were funded while about two-thirds of the international collaborations were funded.

Table 9: Collaboration Type and Funding

		Collaboration Type				
		No Collaboration	Intra-Institutional Collaboration	National Collaboration	International Collaboration	Total
Funding	Not					
Status	Funded	82.81%	78.81%	83.56%	33.93%	69.56%
	Funded	17.19%	21.19%	16.44%	66.07%	30.44%
	Total	6.68%	51.02%	19.06%	23.24%	100%

Summary of Findings and Discussion

This research is a descriptive analysis of biomedical research collaboration in UI between a ten-year period of 2006 and 2015. All the 1915 papers that were analysed for this study were written by 1848 unique authors from UI in collaboration with 2163 unique authors from 660 different institutions located in 74 countries apart from Nigeria. For 1871 authors to have written 1957 papers in ten years suggests that productivity of the authors is low. Most (77.28%) of the papers were written by researchers from Nigeria only. International collaboration of about 23% suggests that the international collaboration is low among biomedical researchers in Nigeria. This is in tandem with the results of Pouris and Ho (2014) which showed that 29% of papers written by researchers that are affiliated with Nigeria are co-authored with researchers from other countries. Researchers from 74 (22 African, 52 non-African) countries collaborated with UI biomedical researchers; this shows a good spread of global collaboration. UI biomedical researchers collaborate mostly with researchers from countries such as the US, followed by the United Kingdom, South Africa, Switzerland, India, Ghana and Germany. Unlike South Africa that publishes the highest number of academic paper in Africa and equally strongly collaborates with Nigeria, noteworthy is the low collaboration with Egypt, even though it publishes the second highest number of papers in Africa. The US and the United Kingdom combined contributed about 35% of the international collaboration.

The number of publications increased each year from 2006 to 2015; the number of publications

doubled in 2013 and tripled in 2015 in comparison to 2006. 93.52% of the articles were written by more than one author. Mean number of authors per paper was 4.24 (min=1, max=370, SD=8.81), with three author papers the highest, followed by two author papers and four author papers. 1.94 institutions per paper (min=1, max=231, SD=5.54), with majority (52.17%) written in one institution (UI) only, followed by two and three institutions respectively. The average number of institutions per article for national and international collaboration was 2.45 and 4.16 respectively. UI researchers collaborated more with researchers who are affiliated with universities and other educational institutions.

The major trend was that collaboration landscape was largely unchanged between 2006 and 2013. There were significant changes in all the parameters considered for analysing collaboration and productivity in 2014 and 2015. First, productivity increased by more than 40% between 2013 and 2014. Second, the average number of authors between 2006 and 2013 which ranged between 3.28 and 3.85 increased to 5.16 and 6.01 in 2014 and 2015 respectively; same trend was recorded for average number of institutions and countries and the collaborative co-efficient. Third, the ratio of intra-institutional-international collaboration changed. Before 2014, proportion of intra-institutional collaboration was always the largest. This changed as the proportion of international collaboration increased in 2014 and 2015. The only phenomenon that remained unchanged was the proportion of national collaboration which was the least and single-authorship which was minimal throughout the period of investigation. The trend observed could be due to the index errors from the data source (see Paragraph three under method section for details) and partly possible positive fallout of the six- month strike action of academic staff in Nigerian universities that preceded 2014.

A total of 30.09% of all the articles were funded. Less than 30% of articles published between 2006 and 2013 were funded; but the proportion of funded publications increased in 2014 and 2015 as more than 35% of articles published were funded. A further probe into the type of collaborations that were mostly funded shows that about two-thirds of international collaborations were funded while only about 20% of the national and the intra-institutional collaborations were funded. It is therefore assumed that funding is one of the motivations for international collaboration; however, this research did not take into consideration the source of the funding. Collaborative co-efficient for the ten-year period was 0.65 while the mean citation per year was 2.58. International collaboration and funded papers received the highest number of citations than national and intra-institutional collaborations and papers that were not funded. This corroborates earlier research works that have shown that collaboration correlates with higher productivity, greater credibility, a higher number of citations and higher influence (Bozeman and Boardman, 2014; Katz and Martin, 1997; Luukkonen, Persson, and Siverten, 1992; Subramanyam, 1983). However, this research provides evidence that international collaboration provides higher visibility to biomedical research from a developing country academic institution. Lastly, about two-thirds of the funded papers were funded, while only about 20% of the national and intra-institutional collaborations were funded.

Conclusion

Higher research impact and funding from international collaborations as evident in this research is an incentive to reduce the still strong academic inbreeding in Nigerian universities. On the other hand, high level of collaboration as observed in this study is a positive development. Suggestions for future research include investigating the effect of gender difference on collaboration between biomedical researchers in Nigeria. Also, there is a need to investigate the motivation for collaboration among researchers in Nigeria. Lastly, there is a need to find out if the type of journals in which the authors' papers are published influences the visibility of their publications.

There are limitations to the assumption of "co-authorship as collaboration", as the research method used in this study because not all co-authored research emanated from research collaboration. This is proven with the practices of gift/honorary/ unjustified and guest authorship where individuals are listed as authors without making real contributions to a research article (Bennett and Taylor, 2003; Teixeira da Silva and Dobránszki, 2016). There are also limitations to the assumption that research collaborations result in publications as there are other products of collaboration other than publications such

as course syllabus, grant proposal, etc. Also, there are some forms of research collaboration that cannot be quantified, such as casual interactions between researchers during which breakthrough ideas about a research work are mentioned (Katz and Martin, 1997). Furthermore, not all contributors to a research work are adequately acknowledged in form of authorship or sub-authorship (Glänzel and Schubert, 2004). Lastly, there are research (mal)practices of ghost authorship where major contributor(s) to or creators of research articles are not acknowledged appropriately (Bennett and Taylor, 2003; Teixeira da Silva and Dobránszki, 2016).

References

Ajiferuke, I., Burell, Q. and Tague, J. (1988). Collaborative coefficient: A single measure of the degree of collaboration in research. *Scientometrics*, 14(5–6), 421–433.

Amini-Philips C. and Harrison E.F. (2016) Inbreeding in Nigerian universities: Merits and challenges. *International Journal of Capacity Building in Education and Management*, Vol. 2, No 4, 65-74.

Bennett, D. M. and Taylor, D. M. (2003). Unethical practices in authorship of scientific papers. *Emergency Medicine Australasia*, *15*(3), 263–270.

Bozeman, B. and Boardman, C. (2014). Assessing Research Collaboration Studies: A framework for analysis. In: Bozeman, B. and Boardman, C. (2014) *Research Collaboration and Team Science*. Cham: Springer International Publishing. [online]. https://doi.org/10.1007/978-3-319-06468-0. [Accessed 18 January 2018].

Chu, K. M., Jayaraman, S., Kyamanywa, P. and Ntakiyiruta, G. (2014). Building research capacity in Africa: Equity and global health collaborations. *PLoS Medicine*, 11(3). [online]. https://doi.org/10.1371/journal.pmed.1001612 [Accessed 31 December 2018]

Confraria, H. and Godinho, M. M. (2015). The impact of African science: A bibliometric analysis. *Scientometrics*, 102(2), 1241–1268.

Cooke, J., Ariss, S., Smith, C., and Read, J. (2015). On-going collaborative priority-setting for research activity: A method of capacity building to reduce the research-practice translational gap. *Health Research Policy and Systems*, 13(25). [online]. https://doi.org/10.1186/s12961-015-0014-y [Accessed 22 January 2018].

Glänzel, W. (2001). National characteristics in international scientific co-authorship relations. *Scientometrics*, 51(1), 69–115.

Glänzel, W. and Schubert, A. (2004). Chapter 11: Analysing Scientific Networks through co-authorship. In: H. F. Moed, W. Glänzel, and U. Schmoch (Eds.), *Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S and T Systems*. Dordrecht: Kluwer Academic Publishing. pp. 257–276.

Jeong, D. and Kim, S. J. (2005). Knowledge structure of library and information science in South Korea. *Library and Information Science Research*, 27(1), 51–72.

Katz, S. and Martin, B. (1997). What is research collaboration. *Research Policy*, 26, 1–18.

Kim, S. J. and Jeong, D. Y. (2006). An analysis of the development and use of theory in library and information science research articles. *Library and Information Science Research*, 28(4), 548–562.

Kotecha, P., Walwyn, D., and Pinto, C. (2011). Deepening Research Capacity and Collaboration across Universities in SADC: A Southern African Universities Regional Research and Development Fund. *Southern African Regional Universities Association (SARU)*. [Online]. http://www.sarua.org/files/publications/RDFund/SARU_RD%20Fund_May%202011%20Ver%201.pdf [Accessed 23 January 2018].

Lan, G. (2014). Building research capacity in Sub-Saharan Africa through inter-regional collaboration. *Research Trends*, (Featured Issue 39). [Online] http://www.researchtrends.com/issue-39-december-2014/building-research-capacity-in-sub-saharan-africa/ [Accessed 31 December 2017].

Larivière, V., Sugimoto, C. R., and Cronin, B. (2012). A bibliometric chronicling of library and information science's first hundred years. *Journal of the American Society for Information Science and Technology*, 63(5), 997–1016.

Laudel, G. (2002). What do we measure by co-authorships? *Research Evaluation*, 11(1), 3–15.

Lee, S., and Bozeman, B. (2005). The impact of research collaboration on scientific productivity. *Social Studies of Science*, 35(5), 673–702.

Luukkonen, T., Persson, O., and Siverten, G. (1992). Understanding patterns of international scientific collaboration. *Science, Technology and Human Values*, 17(1), 101–126.

McKechnie, L. E and Pettigrew, K. E. (2002). Surveying the use of theory in library and information science research: A disciplinary perspective. *Library Trends*, 50(3), 406–417.

Na'iya, A. (2013). Transforming the Education Sector: The role of the tertiary education trust fund (TETFund). Federal Ministry of Information, Nigeria. [Online] fmi.gov.ng/wp-content/uploads/2013/.../TETFund-Presentation-final.pdf [Accessed 31 January 2017]

Ocholla, D. and Roux, J. (2011). Conceptions and misconceptions of theoretical frameworks in Library and Information Science Research. In: *6th Biennial Prolissa Conference, Pretoria* (pp. 9–11).

Okiki, O. C. (2013). Research productivity of teaching faculty members in Nigerian federal universities: An investigative study. *Chinese Librarianship: An International Electronic Journal*, 36, 99–118.

Onyancha, O. B., and Maluleka, J. R. (2011). Knowledge production through collaborative research in Sub-Saharan Africa: How much do countries contribute to each other's knowledge output and citation impact? *Scientometrics*, 87(2), 315–336.

Petroze, R. T., Mody, G., Ntaganda, E., Calland, F., Riviello, R., Rwamasirabo, E., and Kayibanda, E. (2012). Collaboration in surgical capacity development: A report of the inaugural meeting of the strengthening Rwanda surgery initiative. *World Journal of Surgery*, 37(7), 1500–1505.

Pettigrew, K. E. and McKechnie, L. E. (2001). The use of theory in information science research. *Journal of the American Society for Information Science and Technology*, *52*(1), 62–73.

Pouris, A., and Ho, Y.-S. (2014). Research emphasis and collaboration in Africa. *Scientometrics*, 98(3), 2169–2184.

PubMed®. (2017). *PubMed® Help*. National Center for Biotechnology Information (US), Pike, U. S. National Library of Medicine 8600 Rockville, USA, [Online] https://www.ncbi.nlm.nih.gov/books/NBK3827/ [Accessed July 21 2017]

Subramanyam, K. (1983). Bibliometric studies of research collaboration: A review. *Journal of Information Science*, 6(1), 33–38.

Teixeira da Silva, J. A. and Dobránszki, J. (2016). Multiple authorship in scientific manuscripts: Ethical challenges, ghost and guest/gift authorship, and the cultural/disciplinary perspective. *Science and Engineering Ethics*, 22(5), 1457–1472.

Tsai, C. C., Corley, E. A., and Bozeman, B. (2016). Collaboration experiences across scientific disciplines and cohorts. *Scientometrics*, 108(2), 505–529.

Wagner, C. S. and Leydesdorff, L. (2005). Mapping the network of global science: Comparing international co-authorships from 1990 to 2000. *International Journal of Technology and Globalisation*, 1(2), 185–208.

Wagner, C. S., Brahmakulam, I., Jackson, B., Wong, A., and Yoda, T. (2001). Science and Technology Collaboration: Building Capability in Developing Countries. [Online]. http://oai.dtic.mil/oai/oai?verb=getRecordandmetadata Prefix=htmlandidentifier=ADA391917 [Accessed 31 January 2017.

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