

# Towards global partnerships in research in Sub-Saharan Africa: an informetric study of the national, regional and international country collaboration in HIV/AIDS literature in eastern and southern Africa

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*Research collaboration in Sub-Saharan Africa is increasingly being conducted internationally, perhaps due to the emphasis laid on international partnerships by international organisations such as the United Nations. Using informetric techniques, this paper explores the nature, extent and trends of HIV/AIDS research collaboration and also identifies countries that collaborate with Eastern and Southern African countries in HIV/AIDS research. The study reveals that interest in singly conducted HIV/AIDS research has been overtaken by collaborative research which registered more papers than the former in most countries. Although internal collaboration is largely visible, the trend shows an increased activity at the international level. This pattern can persist only if properly stipulated guidelines and policies on international research collaboration are strengthened or, where they do not exist, put in place to prevent fall-outs which have been recognised as factors influencing shifts in partnerships between countries. Cultivating trust and honesty among researchers is also recommended as one way of ensuring long-term collaborations and hence positioning Africa in the global collaboration map.*

**Keywords:** Country collaboration, HIV/AIDS, Informetrics, Sub-Saharan Africa

## I Introduction

The eighth United Nations millennium development goal (MDG) seeks to foster global partnerships between developed and least developed nations, with special reference to quota-free access for the latter's exports, debt cancellations, addressing special development needs, creating work, providing access to essential drugs, and sharing information, communications and other technologies (Economic Commission for Africa, 2005a). Although not clearly stipulated in this MDG, research is one of the areas through which global partnership can be fostered. By way of research collaboration, researchers from different countries (both developed and developing countries) come together for different purposes, among which are sharing of information, knowledge and technological transfer as well as finding solutions to specific problems, including epidemics in the developing countries. One of these epidemics includes human diseases, e.g. malaria, HIV/AIDS, tuberculosis, Ebola, typhoid, etc. It is worth noting that these diseases are a subject of the sixth UN MDG (Economic Commission for Africa, 2005b). De Cock, Gnamore, Kadio & Gayle (1994) observe that HIV/AIDS research has resulted in an increased collaboration between key researchers and research groups in Africa. Indeed, since the diagnosis of the pandemic in the early 1980s, Eastern and Southern Africa (henceforth referred to as E&S Africa), in particular, has witnessed a tremendous growth in research networks involving mostly foreign and domestic researchers. HIV/AIDS research has brought on board a variety of researchers, perhaps due to its developmental impact on the social, economic and political sectors (Onyancha & Ocholla, 2007).

## 2 Related studies

The result of the collaborative initiatives in HIV/AIDS research on E&S Africa has been the publication of high-profile AIDS papers. Sadly, though, informetric studies on the considerable literature produced in and about E&S Africa are rare. Thus far, very few studies have been conducted to specifically analyse the patterns, trends and types of collaboration in AIDS research in the region. Nevertheless, several informetric studies have been conducted to broadly analyse the patterns and trends of AIDS research, particularly in both developed and developing countries (e.g. Macias-Chapula, 2000; Macias-Chapula & Mijangos-Nolasco, 2002; Onyancha & Ocholla, 2004; Macias-Chapula, Mendoza-Guerrero, Rodea-Castro, Gutierrez-Carrasco & Juarez-Sanchez, 2006; Onyancha & Ocholla, 2006). Some of these studies have identified patterns of collaboration in AIDS research through the use of co-authorship. In a bibliometric study conducted by Macias-Chapula (2000:57) intent on "providing an insight into the construction and administration of AIDS knowledge" in Haiti, 75% of the total 363 Haitian HIV/AIDS records were published in collaboration between two or more authors. Using co-authorship to determine the pattern of collaboration, Macias-Chapula & Mijangos-Nolasco (2002) also noted a high pattern of collaboration through multiple-authorship (i.e. 91.54% of the publications were co-authored) in a study on AIDS

literature in Central Africa. Studies have also shown that the key players in HIV/AIDS research collaboration in South Africa are the local universities in the country (Dube & Ocholla, 2004). In a study conducted to review the management and diffusion strategies of HIV/AIDS information in South Africa, Dube & Ocholla (2004) noted a high pattern of research collaboration (73%) among local academic institutions. The authors observed that 33% of the local institutions of higher learning “collaborate with international institutions, and about 78% with provincial and national government departments in conducting research on HIV/AIDS and related areas” (Dube & Ocholla, 2004:167). Generally, the reviewed studies (except for Dube & Ocholla [2004] which partially identifies domestic collaboration) fell short of identifying the types of collaboration being applied, such as inter-individual, inter-national, inter-institutional, etc. Hence, it has been recommended that further research be conducted “in order to identify the types of these collaborations” (Macias-Chapula & Mijangos-Nolasco, 2002). Macias-Chapula & Mijangos-Nolasco (2002) specifically recommend that a study be conducted in order to identify the inter-institutional/national, inter-national and North-South types of collaboration. From the foregoing, little is therefore known regarding the collaborative networks between the institutions, countries and regions as well as within these entities in the African continent.

### 3 Purpose of the study

The purpose of this study is to examine the nature, trend and type of collaboration in HIV/AIDS research in E&S Africa by identifying individuals, institutions, and countries collaborating in HIV/AIDS research in the region. At this stage, the study reports only internal, sub-regional, regional/African and foreign/international **country** collaborations. This paper uses informetric approaches to examine

1. the extent of collaboration in each country by calculating;
  - Mean number of authors per co-authored paper
  - Degree of collaboration
  - Collaboration Coefficient
2. collaborating countries by analysing
  - Papers co-authored within the same country in the two regions of study – internal/domestic/local
  - Papers co-authored between researchers from countries in E&S Africa but not within the same country – sub-regional collaboration
  - Papers co-authored between E&S African countries and those from the rest of Africa – regional/African collaboration
  - Papers co-authored between E&S African countries and countries outside Africa – foreign or international collaboration

The study on individual and institutional collaborations is ongoing and will be reported in another article.

### 4 Methods and materials

According to Katz & Martin (1997), one of the paradoxes of measuring research collaboration is making a conceptual distinction between different types of collaboration. Smith & Katz (2000) classify the levels at which research collaboration can take place into six categories, namely, individuals, groups, departments, institutions, sectors and countries, hence Katz & Martin’s (1997) identification of three types of collaboration, i.e. inter-individual, inter-institutional, and inter-national. In addition to these three types of collaboration, Smith & Katz (2000) label collaboration between different sectors as inter-sectoral collaboration. Macias-Chapula & Mijangos-Nolasco (2002) also mention three such collaborations, i.e. inter-institutional, inter-national and North-South types of collaboration. Kreiner & Schultz (1993) and Smith & Katz (2000) categorise collaboration into informal and formal collaboration, the former being the most common in research cycles. It is widely acknowledged that countries *per se* do not collaborate but it is the individuals who collaborate in research. Nevertheless, it is generally agreed that policies and agreements about research collaboration are formulated or entered into by individuals on behalf of institutions and/or countries which they represent, hence country and institutional collaboration. No wonder therefore that accountability for donor research funds geared towards research collaboration is, to a large extent, the responsibility of either institutions or countries, which in turn require that researchers account for the funds they receive to conduct research.

For the purposes of conducting this study on the country collaborative patterns in HIV/AIDS research on E&S Africa, the co-authorship of HIV/AIDS papers was used as an indicator of research collaboration. Although Katz & Martin (1997) note that co-authorship is merely a partial indicator of collaboration, they nevertheless point out four key advantages of using the technique to measure collaboration, namely, its verifiability, stability over time, data availability and ease of measurement. They observe the following:

First, it is invariant and verifiable; given access to the same data set, other investigators should be able to reproduce the results. Secondly, it is a relatively inexpensive and practical method for quantifying collaboration.

Furthermore, the size of sample that it is possible to analyse using this technique can be very large and the

results should therefore be statistically more significant than those from case studies. Finally, some would argue that bibliometric studies are unintrusive and indeed non-reactive – that is, the measurement does not affect the collaboration process. This may be true in terms of an immediate effect but others have suggested that the results from a bibliometric investigation may influence collaboration practices over the longer term (Katz & Martin, 1997: Multiple Authorship and Collaboration section, para 6).

Co-authorship has been used in several informetric studies to analyse research collaboration. For example, the approach has been used to study collaboration patterns in Indonesian nutrition research papers (Hartinah, Davis, Hydari & Kent, 2001:227), Estonian international co-operation in science in the 1990s (Lewison & Must, 2001), science in Africa (Narvaez-Berthelemot, Russell, Arvanitis, Waast & Gaillard, 2001:470), collaboration, growth, and development of Iranian Scientific publications from 1985 to 1999 (Osareh & Wilson, 2001), growth and collaboration trends in nuclear science research literature in India from 1980 to 1994 (Ravi, 2001) and to analyse the nature of research collaboration in biomedical sciences in 24 Latin American and Caribbean countries (Fernandez, Sancho, Morillo, Filippo & Gomez, 2003:66). Research collaboration patterns have also been measured using co-authorship by Rao & Raghavan (2003), Wagner & Leydesdorff (2003), Yoshikane & Kageura (2003), Persson, Glazel & Danell (2003), and Wang, Wu, Pan & Ma (2003). Co-authorship remains the most preferred indicator used to describe collaboration and co-operation in all areas of research (Gauthier, 1998).

As mentioned, only collaboration amongst countries was analysed. Data was extracted from Thompson Scientific's Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) by combining 26 HIV/AIDS-specific keywords or descriptors and 22 geographic names (representing names of countries and geographic regions in E&S Africa). Name and descriptor variations, too, were used to search for relevant documents. The number of authors per publication was used to determine the nature of authorship, i.e. single or multiple. An analysis of the author's country of origin, information that was obtained from the author's address field, provided the basis for determining the nature of collaboration between the countries and other geographical regions. We followed the same procedures used by Onyanha & Ocholla (2007) to determine co-authorship frequencies among the participating countries. Essentially, a country was counted only once irrespective of the number of times it appeared in a record. In order to determine the number of collaborating authors for each publication, the authors of each paper were counted and the figures recorded, accordingly, onto electronic spreadsheets prepared with the help of Microsoft Excel ©2003. The nature of collaboration was determined by classifying the papers into either single or multiple authored papers, and according to the number of authors per paper, i.e. one-author, two-author, three-author, etc.

UCINET for Windows version 6.170 ©2007 and its technologies and tools was used to conduct further analyses of the data. The Microsoft Excel data were exported to UCINET using the *Export to UCINET Network Format (DL)* option, where DL was used to identify the file as a **data language** file. We thereafter inputted the generated dataset consisting raw paper co-author counts into the categorical core/periphery model in order to identify which countries belong in the core and which belong to the periphery. The categorical core/periphery analysis uses a genetic algorithm to fit a core/periphery model to the data which can be either positive (indicating that larger values imply stronger relationships) or negative (indicating that larger values in the data imply a more distant relationship). Since the data was positive, the larger co-authorship frequencies indicated stronger relationships among co-authoring countries. However, we noted that the core/periphery model does not work very well with raw co-author counts. For instance, while generating the core/periphery matrix for the international raw co-author data, the USA emerged as the only country in the core partition, yet judging from the data, there were other countries that formed the core collaborators with E&S African countries. We therefore chose to normalise the data using the *Transform/Normalize* option wherein we selected the *matrix* as the dimension to standardise (in which case we wanted the normalisation to be applied to the entire matrix) and *Euclidean* as the standardising criterion (in which case we wanted the generated Euclidean figure to equal to 1 by row, column, matrix or row and column).

## 5 Results and discussion

This section presents and discusses the findings in order to assess and identify the nature, trends and patterns of collaboration in HIV/AIDS research in E&S Africa by examining the extent of research collaboration as well as identifying the regional and international country collaborations.

### 5.1 Extent of collaboration

Rao & Raghavan (2003) identify three different measures commonly used to study collaboration, namely:

- The Collaborative Index – Mean number of authors per paper
- The degree of collaboration – Proportion of single- and multiple-author papers)
- The Collaborative Coefficient – The ratio of the total number of collaborative papers to the total number of papers

published in a domain during a fixed period of time.

This study employed all three measures to compare and study the extent of HIV/AIDS research collaboration in E&S African countries. An analysis of the number of multiple authors for a single paper showed that co-authorship ranged between two and 202 authors. Thus, the highest number of authors who participated in writing a single paper on HIV/AIDS was 202. Table I shows the growth and distribution of single- and multiple-author papers from 1980 to 2005. This analysis was meant to evaluate the trend of single and multiple-author papers in order to examine and compare the trend of research collaboration, as opposed to research that is conducted individually. It can be seen that both single- and multiple-author papers grew over time for each country.

**Table I** Growth and distribution of single and multiple-authored papers from 1980-2005

Country	1980-1982		1983-1985		1986-1988		1989-1991		1992-1994		1995-1997		1998-2000		2001-2003		2004-2005		TOTAL		Unknown author(s)	GRAND TOTAL
	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m				
South Africa	0	0	2	8	6	18	13	57	31	97	39	171	93	412	154	624	102	483	440	1870	3	2313
Uganda	0	0	0	0	1	6	3	44	15	109	12	132	41	191	36	280	27	227	135	989	0	1124
Kenya	0	0	0	1	1	16	10	55	9	105	19	147	35	178	16	215	14	155	104	872	0	976
Tanzania	0	0	0	0	0	8	2	30	3	77	11	128	27	156	28	203	13	139	84	741	0	825
Zambia	0	0	0	0	1	8	4	31	9	63	14	84	18	85	12	124	7	74	65	469	0	534
Malawi	0	0	0	0	0	1	2	10	3	25	7	65	15	91	18	145	12	111	57	448	0	505
Zimbabwe	0	0	0	0	0	5	2	29	3	51	6	65	14	85	14	124	15	89	54	448	0	502
Ethiopia	0	0	0	0	0	3	2	12	4	27	7	30	4	55	7	88	2	40	26	255	0	281
Botswana	0	0	0	0	0	0	0	1	0	3	2	0	7	16	20	38	11	35	40	93	0	133
Mozambique	0	0	0	0	0	0	0	2	1	5	0	9	1	9	2	14	5	8	9	47	0	56
Sudan	0	0	0	0	0	1	0	4	0	3	0	6	5	10	3	13	2	5	10	42	0	52
Swaziland	0	0	0	0	0	0	0	1	2	2	1	1	1	4	2	8	2	11	8	27	0	35
Namibia	0	0	0	0	0	1	0	1	0	3	2	4	1	6	3	5	0	2	6	22	0	28
Djibouti	0	0	0	0	0	0	1	6	0	4	0	4	1	4	0	2	0	2	2	22	1	25
Lesotho	0	0	0	0	0	0	0	0	0	0	0	2	1	3	3	4	0	4	4	13	0	17
Somalia	0	0	0	0	0	1	0	4	0	2	0	2	1	1	0	1	0	1	1	12	0	13
Angola	0	0	0	0	0	2	0	1	0	0	0	2	1	1	0	1	0	2	1	9	0	10
Eritrea	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	1	3	0	4
TOTAL*	0	0	2	9	9	70	39	288	80	576	120	852	267	1310	318	1889	212	1388	1047	6382	4	7433

Key: S = Single-authored papers; M = Multiple-authored papers;

TOTAL\* - The totals include duplicate articles (articles belonging to two or more countries were counted as whole articles in each country)

For most countries, especially the 8 top ranking countries (i.e. South Africa, Uganda, Kenya, Tanzania, Zambia, Malawi, Zimbabwe and Ethiopia), the exponential growth of multiple-author HIV/AIDS papers is more clear. For instance, South Africa's multiple-author papers grew from 8 in 1983-1985 to 18 in 1986-1988 and thereafter to 57 in 1989-1991, while 1992-1994 recorded 97 papers. The trend continued with 1995-1997 contributing 171 papers, which grew to 412 and 624 papers in 1998-2000 and 2001-2003, respectively. The number of papers then dropped to 483 in 2004-2005. This trend is common in all the E&S African countries. The total single- and multiple-author papers per year are presented in Fig. 1. The Figure shows that although multiple-author papers were many and appeared to rapidly grow from one year-period to the next, they occasionally grew at a lesser rate than single-authored papers.

When analysing the rate at which the literature grew for both categories (i.e. single- and multiple-author papers), Fig. 1 shows that single-author papers increased by 350% (7 papers), from 2 papers between 1983-1985 to 9 papers in 1986-1988, while co-authored papers grew by an even larger percentage (677.8%) - from just 9 papers to 70 papers over the same time period. Paper-wise growth and corresponding percentage increments of single-author papers were as follows: 1986-1988/1989-1991 (30, 333.3%); 1989-1991/1992-1994 (41, 105.1%); 1992-1994/1995-1997 (40, 50.0%); 1995-1997/1998-2000 (147, 122.5%); 1998-2000/2001-2003 (51, 19.1%) while multiple-author papers grew as follows: 1986-1988/1989-1991 (218, 311.4%); 1989-1991/1992-1994 (288, 100.0%); 1992-1994/1995-1997 (276, 47.9%); 1995-1997/1998-2000 (458, 53.8%); 1998-2000/2001-2003 (579, 44.2%). Papers in both categories illustrated a downward trend between 2001-2003 and 2004-2005, with single-author papers dropping by 106 papers (33.3%) and multiple-author papers decreasing by 501 papers (27.5%).

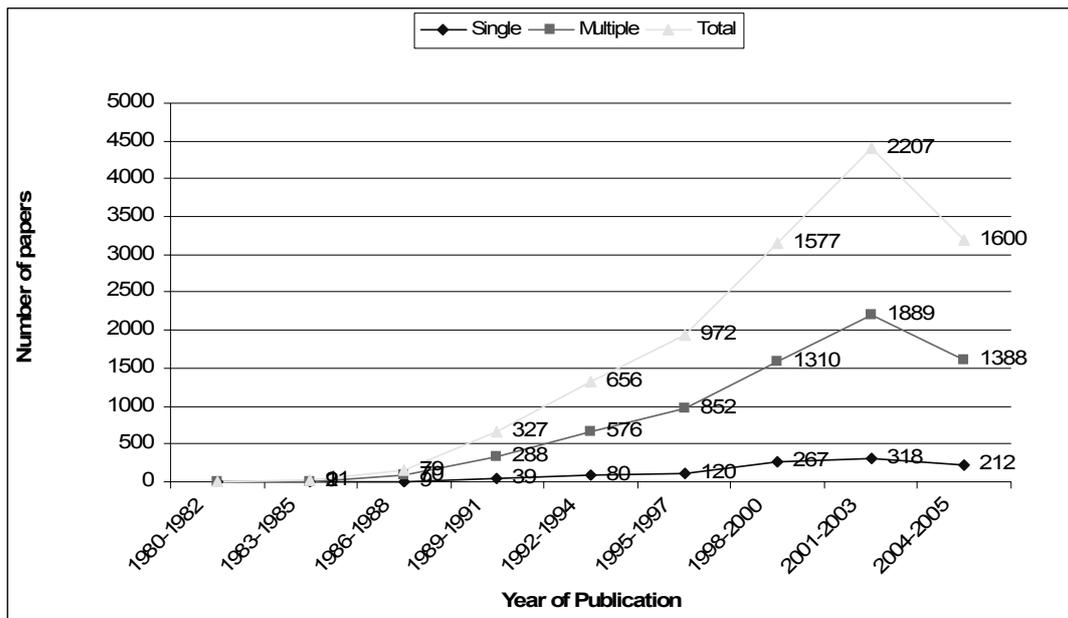


Fig. 1: Trend of single- and multiple-authored papers

Table 2 compares countries according to the total number of papers, number of papers with known authors, number of authors, mean number of authors per paper, degree of collaboration and collaborative coefficient. Papers with known authors refer to papers which had the personal names of authors. Those papers whose authors were unclear or not given were excluded from the analysis presented in column 2.

Overall, the results show that South Africa was ranked first in terms of the total number of papers (i.e. 2313 papers), out of which 2310 were authored by 9330 persons, thus producing an average number of 4.03 authors per paper. Second was Uganda, which yielded 1124 papers, all of which provided the personal names of authors who numbered 7374 in total. Kenya was third, while Tanzania, Zambia, Malawi, Zimbabwe, Ethiopia, Botswana and Sudan occupied positions three to ten, respectively.

As regards the degree of collaboration (comparing the percentage contributions of single-author papers and multiple-author papers), it can be seen that collaborative papers accounted for 85.9 % of the papers whose authors were given. In this respect, Somalia emerged as the country with the highest pattern of collaboration, with 92.3% of the country's papers resulting from joint authorship. This was followed by Djibouti, which recorded a co-authorship percentage of 91.7%, Ethiopia (90.8%), Angola (90.0%), Tanzania (89.8%), Kenya (89.3%), Zimbabwe (89.2%), Malawi (88.7%), Uganda (88.0%) and Zambia, which came tenth in the list of the top 10 countries with 87.8% collaborative papers.

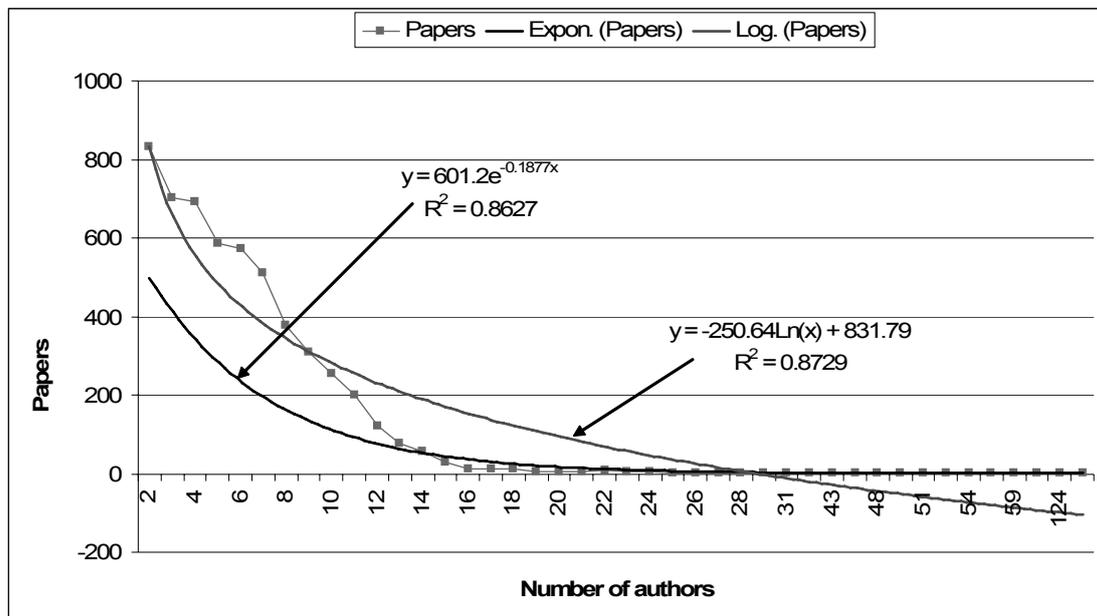
The ratio of the co-authored papers to the total number of papers (otherwise known as the collaborative coefficient – CC) was highest in Somalia, which recorded 0.92. Other countries with high CCs were, in descending order, Ethiopia (0.91), Angola (0.90), Tanzania (0.90), Kenya (0.89), Malawi (0.90), Zimbabwe (0.89), Uganda (0.88), Zambia (0.88), Djibouti (0.88), Mozambique (0.84), South Africa (0.81), and Sudan (0.81). The rest of the countries had a CC that was less than 0.80. Unlike the findings of the analysis of the degree of collaboration, where the minimum ratio of co-authored papers stood at 0.75, the CC fell below that figure in the case of Botswana.

Another approach for measuring the extent of collaboration is to consider the number of papers that have been written by a certain number of authors [i.e. two, three, four, five, etc.] (Rao & Raghavan, 2003:234). As has been mentioned, the number of authors that were engaged in writing HIV/AIDS in E&S Africa ranged between 2 and 202. The findings are presented in Fig 2 which generally shows that two-author papers were the majority (832), followed by three-author papers which totaled 804, and three-author papers which numbered 703. There were 693 four-author papers, 586 five-author papers, 573 six-author papers, and 510 seven-author papers, etc. It was noted that the total number of papers fell as the number of authors per paper grew, which implies a reverse relationship between the number of papers and the number of authors participating in the writing of each paper.

**Table 2:** Distribution of papers by the average number of authors per paper, degree of collaboration and collaboration coefficient, 1980-2005

Country	Total Number of papers	No. of papers with known authors	Number of authors	Authors per paper	Degree of collaboration				Collaborative Coefficient
					s	%	m	%	
South Africa	2313	2310	9330	4.03	440	19.05	1870	80.95	0.81
Uganda	1124	1124	7374	6.56	135	12.01	989	87.99	0.88
Kenya	976	976	6125	6.28	104	10.66	872	89.34	0.89
Tanzania	825	825	4805	5.82	84	10.18	741	89.82	0.90
Zambia	534	534	2974	5.57	65	12.17	469	87.83	0.88
Malawi	505	505	3058	6.06	57	11.29	448	88.71	0.89
Zimbabwe	502	502	2390	4.76	54	10.76	448	89.24	0.89
Ethiopia	281	281	1601	5.70	26	9.25	255	90.75	0.91
Botswana	133	133	446	3.35	40	30.08	93	69.92	0.70
Mozambique	56	56	292	5.21	9	16.07	47	83.93	0.84
Sudan	52	52	202	3.88	10	19.23	42	80.77	0.81
Swaziland	35	35	153	4.37	8	22.86	27	77.14	0.77
Namibia	28	28	143	5.11	6	21.43	22	78.57	0.79
Djibouti	25	24	162	6.48	2	8.33	22	91.67	0.88
Lesotho	17	17	94	5.53	4	23.53	13	76.47	0.76
Somalia	13	13	71	5.46	1	7.69	12	92.31	0.92
Angola	10	10	64	6.40	1	10.00	9	90.00	0.90
Eritrea	4	4	17	4.25	1	25.00	3	75.00	0.75
TOTAL*	7433	7429	39301	5.29	1047	14.09	6382	85.91	0.86

Total\* = Duplicate entries are included in the analysis (i.e. same papers that appear under two or more countries are included in the Total figures)



**Fig 2:** Distribution of multiple-authored papers by the number of authors per paper  
Key: Expon. (Papers) – Exponential trendline; Log. (Papers) – Logarithmic trendline



Kenya (14), Zambia (14), Uganda (9), Tanzania (7), Swaziland (6), Botswana (6), Lesotho (5), Ethiopia (2), Mozambique (2) and Namibia (2). As concerns the normalized co-authorships, it was found that South Africa registered the highest strength of collaboration with Zimbabwe (0.316), Zambia (0.237), Kenya (0.221) and Malawi (0.174). Kenya's normalised co-author counts were highest with Tanzania, Uganda and Zambia, each measuring 0.174. An equally higher count was registered between Tanzania and Uganda (i.e. 0.158).

**Table 4** Percentage distribution of internal co-authorships

	1980- 1982	1983- 1985	1986- 1988	1989- 1991	1992- 1994	1995- 1997	1998- 2000	2001- 2003	2004- 2005	TOTAL
Angola	0(0%)	0(0.00%)	1(50.00%)	0(0.00%)	0(0.00%)	1(50.00%)	0(0.00%)	0(0.00%)	0(0.00%)	2(22.22%)
Botswana	0(0%)	0(0.00%)	0(0.00%)	1(100.00%)	0(0.00%)	0(0.00%)	8(50.00%)	15(39.47%)	10(28.57%)	34(36.56%)
Djibouti	0(0%)	0(0.00%)	0(0.00%)	0(0.00%)	1(25.00%)	1(25.00%)	0(0.00%)	0(0.00%)	0(0.00%)	2(9.09%)
Eritrea	0(0%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)
Ethiopia	0(0%)	0(0.00%)	1(33.33%)	3(25.00%)	8(29.63%)	2(6.67%)	17(30.91%)	27(30.68%)	25(62.50%)	83(32.55%)
Kenya	0(0%)	0(0.00%)	9(56.25%)	19(34.55%)	32(30.48%)	41(27.89%)	57(32.02%)	74(34.42%)	56(36.13%)	288(33.03%)
Lesotho	0(0%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	1(50.00%)	0(0.00%)	0(0.00%)	0(0.00%)	1(7.69%)
Malawi	0(0%)	0(0.00%)	0(0.00%)	0(0.00%)	7(28.00%)	29(44.62%)	31(34.07%)	58(40.00%)	35(31.53%)	160(35.71%)
Mozam- bique	0(0%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	3(33.33%)	1(11.11%)	3(21.43%)	2(25.00%)	9(19.15%)
Namibia	0(0%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	6(100.00%)	0(0.00%)	0(0.00%)	6(27.27%)
Somalia	0(0%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	1(100.00%)	0(0.00%)	0(0.00%)	1(8.33%)
South Africa	0(0%)	6(75.00%)	5(27.78%)	28(49.12%)	42(43.30%)	56(32.75%)	209(50.73%)	275(44.07%)	192(39.75%)	813(43.48%)
Sudan	0(0%)	0(0.00%)	1(100.00%)	3(75.00%)	0(0.00%)	1(16.67%)	1(10.00%)	3(23.08%)	1(20.00%)	10(23.81%)
Swaziland	0(0%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	2(18.18%)	2(7.41%)
Tanzania	0(0%)	0(0.00%)	1(12.50%)	9(30.00%)	35(45.45%)	47(36.72%)	49(31.41%)	47(23.15%)	26(18.71%)	214(28.88%)
Uganda	0(0%)	0(0.00%)	1(16.67%)	14(31.82%)	15(13.76%)	36(27.27%)	46(24.08%)	61(21.79%)	55(24.23%)	228(23.05%)
Zambia	0(0%)	0(0.00%)	2(25.00%)	7(22.58%)	9(14.29%)	25(29.76%)	15(17.65%)	29(23.39%)	18(24.32%)	105(22.39%)
Zimba- bwe	0(0%)	0(0.00%)	0(0.00%)	9(31.03%)	12(23.53%)	15(23.08%)	28(32.94%)	41(33.06%)	21(23.60%)	126(28.13%)
Total	0(0%)	6(66.67%)	21(30.00%)	93(32.29%)	161(27.95%)	258(30.28%)	469(35.80%)	633(33.51%)	443(31.92%)	2084(32.65%)

Note: Percentages were derived from the total number of locally/domestically co-authored papers divided by the total number of multiple author papers, multiplied by 100.

### 5.2.3 Regional (or African) collaboration

The phrase 'regional collaboration' in this study refers to research collaboration between a country in the E&S Africa region and one from outside the region but within Africa. This type of collaboration can also be termed as African collaboration. Data was analysed in order to examine collaboration in HIV/AIDS research between countries in the E&S African region, and those countries from the rest of Africa, in order to compare collaboration within and outside E&S Africa.

**Table 5** Regional Countries collaborating with E&S African countries, with corresponding number of co-authored papers (in brackets)

E&S African country	Collaborating African country(ies) outside E&S Africa
Angola	-
Botswana	Cote D'Ivoire(1), Nigeria(1), Rwanda(1)
Djibouti	-
Eritrea	-
Ethiopia	Cameroon(1)
Kenya	Cameroon(9), Zaire(8), Benin(4), Burkina Faso(4), Cote D'Ivoire(3), Egypt(3), Ghana(3), Senegal(3), Gambia(2), Rwanda(2), Gabon(1)
Lesotho	Sierra Leone(1)
Malawi	Rwanda(1), Gambia(1)
Mozambique	Nigeria(1)
Namibia	-

Somalia	-
South Africa	Cote D'Ivoire(6), Gambia(4), Burkina Faso(3), Cameroon(3), Benin(1), Egypt(1), Gabon(1), Ghana(1), Nigeria(1), Rwanda(1), Sierra Leone(1), Tunisia(1)
Sudan	Egypt(6),
Swaziland	Sierra Leone(1)
Tanzania	Cameroon(3), Gambia(3), Burundi(2), Cote D'Ivoire(2), Guinea Bissau(1)
Uganda	Cameroon(4), Cote D'Ivoire(4), Rwanda(4), Egypt(3), Gambia(3), Zaire(1), Ghana(1), Nigeria(1),
Zambia	Cameroon(7), Benin(4), Rwanda(3), Senegal(2), Zaire(2), Burkina Faso(1), Congo(1), Mali(1), Niger(1), Nigeria(1), Chad(1), Togo(1), Egypt(1), Cote D'Ivoire(1)
Zimbabwe	Nigeria(3), Cote D'Ivoire(2), Rwanda(1), Zaire(1), Mali(1), Burkina Faso(1), Cameroon(1)

Results show that Angola (as was the case in sub-regional collaboration) did not have any collaborative links with any African country outside E&S Africa. Similarly, Djibouti, Eritrea, Namibia and Somalia recorded no records in regional co-authorships. Botswana co-authored most of her papers with Cote D'Ivoire (1), Nigeria (1) and Rwanda (1). Outside E&S Africa, the normalized counts revealed strong co-authorship of papers between Kenya and Cameroon (0.118), Kenya and Zaire (0.105), South Africa and Nigeria (0.144), and Zimbabwe and Zaire (0.131).

#### 5.2.4 International collaboration

International country collaboration is defined (in this particular study) as a partnership between an Eastern and/or Southern African country and a country from outside Africa. International co-authorship between E&S African countries and countries outside Africa (herein sometimes referred to as foreign countries) is taking center stage in HIV/AIDS research in the region. All the countries in the region had collaborative links with at least one foreign country. Table 6 provides a summary of the number of collaborating countries (i.e. domestic, regional and international) as well as the top ranked foreign countries that collaborated with E&S African countries. South Africa collaborated with the highest number of foreign countries (51), followed by Uganda (38), Kenya (37), Tanzania (32), Zambia (28), Zimbabwe (27), Ethiopia (24) and Malawi (22). The rest of the countries' collaborative partners numbered less than 20 each.

The Table shows that Angola largely co-authored her HIV/AIDS papers with Sweden (2) and Portugal (1) while Botswana collaborated with the USA (54), Canada (7) and England (5). Djibouti had collaborative links only with the USA (1). Eritrea largely co-operates with Sweden (3), while Ethiopia partners with the Netherlands (58), Sweden (45) and France (14). The countries of Canada (156), England (129), Belgium (65), Switzerland (40), Netherlands (38) and Thailand (15), are among the list of collaborators working with Kenya. Among major foreign countries collaborating with Lesotho is the USA (4), which also leads the pack of countries co-authoring HIV/AIDS papers in Malawi with 138 papers, followed by England (122), the Netherlands (20), Australia (12) and Switzerland (12), among others. The leading foreign countries in Mozambique's co-authorships are Sweden (7), Norway (6), USA (6), England (3) and Spain (3). Namibia exhibited her strongest co-authorship links with the USA (4), Germany (3) and England (2) while Somalia's strongest co-authorship partner was the USA (3). South Africa also exhibited its strongest links with the USA (352), followed by England (231), France (45), Switzerland (43) and Canada (38), among others. Sudan's and Swaziland's major collaborator was the USA, which contributed 6 and 8 papers with each of the two countries, respectively. Again, the USA (154) was the leading collaborator with Tanzania followed by England (93), Sweden (66) and Netherlands (40). Uganda's major contributing partners were the USA (284), England (124), Switzerland (37) and Italy (28), etc. Zambia co-authored 114 papers with England, 109 with the USA and 15 with Switzerland, to name a few. Lastly, Zimbabwe participated in authoring 87 papers in conjunction with the USA, 50 with England and 16 with Switzerland. An analysis of the normalized counts revealed that the strongest that the strongest international collaboration was between South Africa and the USA (0.297) followed by that of Uganda and the USA (0.240), Kenya and the USA (0.237), South Africa and England (0.196), Kenya and Canada (0.134), Tanzania and the USA (0.130), Malawi and the USA (0.117), Uganda and England (0.113), Kenya and England (0.107) and Malawi and England (0.105).

**Table 6:** Domestic, Regional and International co-authorships

	Number of collaborating countries				Top ranked international countries with corresponding co-authored papers
	D	R	I	TOTAL	
Angola	-	-	4	4	Sweden (2), Portugal (1), France( 1), Italy (1)
Botswana	9	3	15	27	USA (54), Canada (7), England (5), Israel (4), Thailand (3), Netherlands (2), Japan (2), Switzerland (2), India (2)
Djibouti	-	1	1	2	USA (1)
Eritrea	-	-	1	1	Sweden (3)
Ethiopia	5	1	24	30	Netherlands (58), Sweden (45), France (14), England (14), USA (13), Norway (11), Belgium (5), Israel (5)
Kenya	8	11	37	56	USA (280), Canada (156), England (129), Belgium (65), Switzerland (40), Netherlands (38), Thailand (15), Italy (14)
Lesotho	6	1	9	15	USA (4), Switzerland (1), Bolivia (1), China (1), South Korea (1), Nepal (1), Peru (1), Portugal (1), Spain (1)
Malawi	10	2	22	34	USA (138), England (122), Netherlands (20), Australia (12), Switzerland (12), Luxembourg (10), France (8)
Mozambique	3	1	16	20	Sweden (7), Norway (6), USA (6), England (3), Spain (3), France (2), Switzerland (2), Belgium (1), Netherlands (1)
Namibia	6	0	5	11	USA (4), Germany (3), England (2), Japan (1), Lithuania (1)
Somalia	-	1	3	4	USA (3), Italy (2), Netherlands (1)
South Africa	12	12	51	75	USA (352), England (231), France (45), Switzerland (43), Canada (38), Germany (37), Netherlands (35)
Sudan	1	1	9	11	USA (6), Netherlands (2), France (2), Norway (1), Germany (1), Switzerland (1), Sweden (1), India (1), England (1)
Swaziland	7	1	10	18	USA (8), Switzerland (1), China (1), South Korea (1), Bolivia (1), Nepal (1), Peru (1), Portugal (1), Spain (1)
Tanzania	8	5	32	45	USA (154), England (93), Sweden (66), Netherlands (40), Norway (28), Germany (26), Denmark (21), Belgium (15)
Uganda	7	8	38	53	USA (284), England (124), Switzerland (37), Italy (28), Germany (25), France (23), Netherlands (19), Scotland (18)
Zambia	5	14	28	47	England (114), USA (109), Switzerland (15), Sweden (9), Belgium (9), Japan (7), Austria (7), Scotland (6), Norway (6)
Zimbabwe	11	7	27	45	USA (87), England (50), Switzerland (16), France (12), Denmark (12), Canada (11), Sweden (9), Belgium(9)

Key:D – Domestic; R – Regional; I – International

## 6 Conclusions and recommendations

Generally, authorship of HIV/AIDS papers in and about E&S Africa is largely through multiple-authorship, or simply put, collaboration between two and/or more authors. This therefore implies that HIV/AIDS research in the region is conducted mainly through collaboration, although some of it is conducted individually. Despite the fact that single-author papers were visible and showed slight growth rates, Table 1 and Fig 1 indicate that they were fewer than the co-authored papers in each country throughout the period of study. The highest number of multiple authors was 202, a figure that could be said to be extra-ordinary. Assuming that all the authors indeed participated in the authorship of the said paper, the implication is that all the authors were involved in conducting a particular HIV/AIDS research project in or about E&S Africa. It would be interesting to investigate the management and organization of the study's research team and facilities, particularly if the project was a success, as this may provide some useful lessons in managing a large research team as this.

Table 2 confirms the dominance of co-author papers when we considered the average number of authors per paper, degree of collaboration and the collaborative coefficient. Whereas the average number of authors per paper was above two, implying a high pattern of collaboration, the multiple-author papers comprised 85.91% of the total number of papers (above 70% in each country), while the ratio of the collaborative papers to the total number of papers was 0.86 (cc was above 0.70 in each country). Although the co-author papers were the majority, the visibility of single-author papers is in total disregard of Price's prediction in 1963 that single-author papers would disappear by 1980. Then, Price (as cited in Steynberg & Rossouw, 1995:469) predicted that "if it [the rate of increase of co-authored papers] continues at the present

rate, by 1980 the single-author paper will be extinct". It was not immediately clear in this study why single-author papers are not only visible, but also increasing, albeit slowly, but it can be attributed to the type of research that is conducted in the region. As it were, basic research (which is commonly conducted in universities) may require little or no collaboration. On the other hand, applied/active research may require the participation of multiple researchers. Secondly, research on social or epidemiological aspects of HIV/AIDS can be equally conducted by a single individual as opposed to microbiological and virological issues of HIV infections. Whether this pattern of research will persist for long, especially in the present world where collaboration is increasingly being pegged on securing funds for research is anyone's guess. As Onyancha & Ocholla (2007:239) observe, "current trends indicate that securing research grants is to a large extent pegged on whether the intended research would be conducted through collaboration". Seemingly, therefore, few or no individualistic research will receive funding from donors, implying that we are likely to witness more co-authored papers while single-author papers will continue to decline in number. The trendlines in Fig 1 further cements this argument. The Fig shows that multiple-author papers have increased steadily since 1981. In fact, their increment can be said to be exponential. Several sociological studies of science that have been conducted to examine the nature of authorship as a means of studying research collaboration have registered similar findings, i.e. a continued increase in co-author papers (e.g. Basu & Aggarwal, 2001). The interest that has been placed on collaborative research, as opposed to individualistic research, stems from the benefits associated with collaboration, e.g. enabling researchers to share knowledge, skills, and techniques; making it possible to transfer tacit knowledge; providing intellectual companionship; plugging a researcher into a wider network of contacts in the scientific community; and enhancing the potential visibility and citedness of a work (Katz & Martin in Onyancha & Ocholla, 2007:239). Seemingly, countries in E&S Africa have noted these benefits and are consequently encouraging researchers to embrace collaborative research. There were, however, several instances where countries with more papers had low percentage distributions of the total number of multiple-author papers. This scenario may be attributed to the high pattern of single-authorships in countries such as South Africa. South African research environment, wherein researchers earn more subsidies from singly published SAPSE (South African Post-Secondary Education) – accredited journal article, may be encouraging more single- than multiple-author papers. Another factor that may be encouraging single-authorship of papers is where institutions use adjusted counting of co-authored papers to measure an author's research output for purposes of academic promotions and tenure. In that respect, academics would prefer to publish singly as opposed to collaborative publication of papers.

As regards sub-regional collaboration (collaboration between countries in Eastern and those of Southern Africa), a country's geographical location (e.g. proximity to another), seemingly plays a big role in influencing collaboration between countries in the two regions. For instance, with the exception of 14 papers which were co-authored between Kenya and South Africa, Kenya's major collaborating domestic partners were Tanzania (12) and Uganda (11). Both countries are located in Eastern Africa. South Africa also largely collaborates with Zimbabwe (20), Zambia (14) and Malawi (11). All three countries are part of the SADC region. Zambia, aside from her high collaboration with South Africa, collaborates largely with Kenya (11) and Zimbabwe (9). Similarly, Malawi's major collaborators include South Africa (12), Zimbabwe (6) and Zambia (4). It is difficult to predict the future trends of partnership between the countries in the two regions. On the one hand, the aforementioned pattern is likely to continue, especially in the case of Eastern Africa with the revival of the East African Community. On the other, Southern Africa (specifically, post-apartheid South Africa) is increasingly attracting the interest of researchers (and students) from other African countries, thus creating an environment for research collaborative activities between researchers in the region and those from outside the region. This may change collaborative patterns, especially in South Africa.

A comparison between internally and externally (or internationally) co-authored papers reveals that collaboration between E&S African countries and the rest of Africa was minimal, although registering some visibility. Kenya, South Africa, Tanzania, Uganda, Zambia and Zimbabwe recorded a relatively high number of African countries with which each co-authored papers. These countries, all of which are located in central and western Africa, include Cote D'Ivoire, the Democratic Republic of Congo (Zaire), Benin, Nigeria, Gambia, Sierra Leone, Rwanda, Burkina Faso, and Ghana, with Cameroon maintaining a strong presence in all six countries with high patterns of collaboration. There was less activity in the co-authorship of HIV/AIDS papers between E&S African countries and northern African countries, which are largely Arabic speaking. Exceptions were as follows: Kenya and Egypt (3 papers); South Africa and Egypt (1 paper); South Africa and Tunisia (1 paper); Sudan and Egypt (6 papers); and Uganda and Egypt (3 papers). It should be noted that Sudan is largely Arabic and English is a minority language. Evidently, therefore, E&S African countries largely collaborate with Central or Western African countries. This could be attributed to language and racial factors, although this claim may not be substantiated in this study.

Internal co-authorship (collaboration within the same country) was highest in South Africa (813 or 43.48%), followed by, in descending order of the percentage of the total number of papers in each country, Botswana (34 or 36.56%),

Malawi (160 or 35.71%), Kenya (288 or 33.03%), and Ethiopia (83 or 32.55%). Notably, countries that were highly ranked in terms of their overall performance in research collaboration switched positions with those lesser ranked when it came to internal collaboration. For example, it was observed that Somalia was the highest ranked in terms of the collaboration coefficient (see Table 2), followed by Djibouti, Ethiopia, Angola, Tanzania, Kenya, Zimbabwe, Uganda, Zambia, and Malawi, while South Africa took position 11. The latter analysis (i.e. internal collaboration) reveals a heavy reliance of some countries such as South Africa, Malawi, and Ethiopia on publishing their research publications through internal partnerships. Kenya's minimal performance, when compared to Malawi in terms of internal collaboration, can be attributed to the latter's heavy reliance on international collaboration as illustrated in Table 6, which indicates that the country had the second highest number of foreign countries with which she collaborated. An analysis of the trend of internal collaboration between 1980 and 2005 shows a mixed pattern of growth. The last row in Table 4 reveals a remarkable increment of the number of internally co-authored papers from 0 papers in 1980-1982, to 443 in 2004-2005. These papers accounted for between 27.95% and 35.80% of the total multiple-author papers throughout the period of study, except for the 1983-1985 year period whose 6 papers accounted for 66.67%. Some countries recorded slightly higher percentages, the highest being 75.0% in the case of South Africa in 1983-1985, followed by Ethiopia which yielded 25 (62.5%) in 2004-2005. Overall, each country seems to be encouraging HIV/AIDS research collaboration among researchers resident in each respective country.

Although internal collaboration is dominant in each country, international collaboration seems to be increasingly taking center stage in HIV/AIDS research in E&S Africa. Table 6 illustrates that all the countries, except Namibia, had more foreign/international than domestic/regional country collaborators. Previous studies (e.g. Narvaez-Berthelemot, Russell, Arvanitis, Waast, & Gaillard, 2001) have shown that countries in the African continent publish most of their publications through international collaboration. In this study, a high pattern of collaboration was witnessed between E&S African countries and several industrialized nations, with the USA, England and the Netherlands being the major collaborators. Narvaez-Berthelemot, Russell, Arvanitis, Waast, & Gaillard (2001:474) attribute this pattern to the dependence of developing countries on industrialized countries for the publication of their papers. The authors opine that "*the less productive the developing country, the greater the dependence on international co-authorship for mainstream publication*". In addition, they observe that international collaboration is influenced by the countries' historical ties, especially as regards colonial legacies. Commenting on their findings, the authors argue that "*the colonial legacies of many of the African countries*" was one of the factors that influenced scientific ties with industrialized countries such as France and the United Kingdom. Similar patterns were found in the present study, especially in the 1980s and 1990s.

The main sub-regional collaborators are Botswana, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe while Sudan was the only country in the periphery, meaning less/fewer and/or weaker collaborative links with the rest of the E&S African countries. Regionally, Benin, Botswana, Burkina Faso, Cameroon, Cote D'Ivoire, Kenya, Malawi, Nigeria, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zaire, Zambia, and Zimbabwe formed the core of collaborators while at the periphery were 24 countries (i.e. Burundi, Central African Republic, Chad, Congo, Djibouti, Egypt, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Lesotho, Mali, Mozambique, Namibia, Niger, Senegal, Senegambia, Sierra Leone, Somalia, Sudan, Togo, and Tunisia). Of the total 78 foreign countries which collaborate with E&S African countries, only 18 featured in the cluster of core collaborators (i.e. Argentina, Australia, Spain, The Netherlands, Belgium, England, Brazil, Scotland, Canada, Thailand, India, the USA, Denmark, France, Germany, Italy, Switzerland, and Sweden).

Although not within the scope of this study, it should be pointed out that HIV/AIDS research collaboration between foreign and local researchers focuses on a variety of sub-fields (Cohen, 2000). These focus areas differ from one E&S African country to another, perhaps reflecting the priority areas of HIV/AIDS research in each country. For instance, Kenya's international collaboration focuses on Sexually Transmitted Diseases (STDs), Mother-to-child-transmission (MTCT), sex workers, vaccines, immunology, epidemiology, microbicides, and transmission while research collaboration in South Africa focuses on vaccines, STDs, migrants, sex workers, epidemiology, NIH's vaccine trials network (VTN), virology, tuberculosis (TB), MTCT, microbicides, immunity, and pediatrics. Other sub-fields of international HIV/AIDS research collaboration in E&S Africa include natural history, discordant couples, acute infection, vitamin A, human herpesvirus-8, Kaposi's sarcoma, anti-retroviral resistance, pathogenesis, viral sub-types, etc.

In conclusion, there are strong indications that international collaboration in Africa, as a whole and Sub-Saharan Africa, in particular is growing from strength to strength. This relationship is likely to foster growth in the affected regions as well as solve myriad problems that undermine socio-economic development in the continent. However, properly stipulated guidelines and policies on international research collaboration should be strengthened or, where they do not exist, be put in place to prevent fall-outs which Onyancha & Ocholla (2007) ascribe to shifts in partnerships between countries. Trust and honesty among the researchers should also be cultivated to ensure long term collaborations.

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## References

- Cohen, J. 2000. Balancing the collaboration equation. *Science*, 288(5474): 2155-2158.
- De Cock, K.M., Ekpin, E., Gnaore, E., Kadio, A. & Gayle, H.D. 1994. The public health implications of AIDS research in Africa. *Journal of American Medical Association*, 272(6): 481-486.
- Diodato, V. 1994. *Dictionary of bibliometrics*. New York: Haworth.
- Dube, L. & Ocholla, D.N. 2004. A review of management and diffusion strategies of HIV/AIDS information in institutions of higher education in South Africa. In T. J. D. Bothma & A. Kaniki. *Prolissa 2004: proceedings of the 3<sup>rd</sup> biennial DISSAnet conference*, Pretoria, October, 28-29. Pretoria: Infuse, p. 149-171.
- Economic Commission for Africa. 2005a. Goal 8 – developing a global partnership for development. [Online]. <http://www.uneca.org/mdgs/goal8.asp> (Accessed 22 September 2007).
- Economic Commission for Africa. 2005b. Goal 6 – Combating HIV/AIDS, malaria and other diseases. [Online]. <http://www.uneca.org/goal6.asp> (Accessed 22 September 2007).
- Fernandez, M. T., Sancho, R., Morillo, F., De Filippo, D. & Gomez, I. 2003. Comparative analysis of ISI (SCI & SSCI) and MEDLINE databases in the biomedical sciences: case study of 24 Latin American and Caribbean countries. In: J. Guohua, R. Rousseau & W. Yishan. *Proceedings of the 9<sup>th</sup> International Conference on Scientometrics and Informetrics – ISSI*, 55-67.
- Gauthier, E. 1998. Bibliometric analysis of scientific and technological research: a user's guide to the methodology. [Online]. <http://www.statcan.ca/english/research/88F0006XIE/88F0006XIB1998008.pdf> (Accessed 4 November 2004).
- Katz, J.S. & Martin, B.R. 1997. What is research collaboration? *Research Policy*, 26(1): 1-18
- Hartinah, S., Davis, M., Hydari, A. & Kent, P. 2001. Indonesian nutrition research papers 1979-98: a bibliometric analysis. In: M. Davis & C. S. Wilson (eds.). *Proceedings of the 8th International Conference on Scientometrics and Informetrics*, Sydney, July, 16-20, 1: 225-177.
- Kreiner, K. & Schultz, M. 1993. Informal collaboration in R&D: the formation of networks in organizations. [Online]. *Organization Studies*. [Online]. [http://www.findarticles.com/p/articles/mi\\_m4339/is\\_n2\\_v14/ai\\_14443077](http://www.findarticles.com/p/articles/mi_m4339/is_n2_v14/ai_14443077) (Accessed 4 November 2004).
- Lewis, G. & Must, U. 2001. Estonian international cooperation in science in the 1990s: new politics, new methods. In: M. Davis & C. S. Wilson (eds.). *Proceedings of the 8th International Conference on Scientometrics and Informetrics*, Sydney, July, 16-20, 2: 385-395.
- Macias-Chapula, C.A. 2000. AIDS in Haiti: a bibliometric analysis. *Medical Library Association. Bulletin*, 88(1): 56-61
- Macias-Chapula, C.A. & Mijangos-Nolasco, A. 2002. Bibliometric analysis of AIDS literature in Central Africa. *Scientometrics*, 54(2): 309-317.
- Macías Chapula, C.A., Mendoza-Guerrero, J.A., Rodeo-Castro, I.P., Gutierrez-Carrasco, A. & Juarez-Sanchez, E. 2006. Collaboration on HIV/AIDS research in Latin America and the Caribbean: comparison of regional and international databases. In: *Proceedings The International Workshop on Webometrics, Informetrics and Scientometrics, Nancy (France). E-Prints in Library and Information Science*. [Online]. <http://eprints.rclis.org/archive/00006039/> (Accessed 10 August 2006).
- Narvaez-Berthelemot, N., Russell, J.M., Arvanitis, R., Waast, R. & Gaillard, J. (2001). Science in Africa: An overview of mainstream scientific output. In: M. Davis & C. S. Wilson (eds.). *Proceedings of the 8th International Conference on Scientometrics and Informetrics*, Sydney, July, 16-20, (2): 469-476.
- Onyancha, O.B. & Ocholla, D.N. 2004. A comparative study of the literature on HIV/AIDS in Kenya and Uganda: a bibliometric study. *Library & Information Science Research*, 26:434-447
- Onyancha, O.B. & Ocholla, D.N. 2006. HIV/AIDS research and the youths: an informetric analysis of the literature. *South African Journal of Libraries & Information Science*, 72(2):85-97.
- Onyancha, O.B. & Ocholla, D.N. 2007. Country-wise collaborations in HIV/AIDS research in Kenya and South Africa, 1980-2005. *Libri*, 57:239-254.
- Osareh, F. & Wilson, C.S. 2001. Iranian scientific publications: collaboration, growth, and development from 1985-1999. In: M. Davis & C. S. Wilson (eds.). *Proceedings of the 8th International Conference on Scientometrics and Informetrics*, Sydney, July, 16-20, 2, 499-509.
- Persson, O. Glazel, W., & Danell, R. 2003. Inflationary bibliometric values: the role of scientific collaboration and the need for relative indicators in evaluative studies. In: J. Guohua, R. Rousseau & W. Yishan. *Proceedings of the 9<sup>th</sup> International Conference on Scientometrics and Informetrics – ISSI*, pp. 411-420.
- Rao, M.K. & Raghavan, K.S. 2003. Collaboration in knowledge production: a case study of superconductivity research in India. In: J. Guohua, R. Rousseau & W. Yishan. *Proceedings of the 9<sup>th</sup> International Conference on Scientometrics and Informetrics – ISSI*, pp. 230-240.
- Ravi, S. 2001. Growth and collaborative trends in nuclear science research literature: a case of India, 1980-1994. In: M. Davis & C. S. Wilson (eds.). *Proceedings of the 8th International Conference on Scientometrics and Informetrics*, Sydney, July, 16-20, (2): 573-585.

- Smith, D. & Katz, J.S. 2000. Collaborative approaches to research: HEFCE fundamental review of research policy and funding. [Online]. [www.nerf-uk.org/nerf/word/webcolabhefce.doc?version=1](http://www.nerf-uk.org/nerf/word/webcolabhefce.doc?version=1) (Accessed 4 November 2004).
- Steynberg, S. & Rossouw, S.F. 1995. Multiple authorship in biomedical papers: A South African case study. *Journal of the American Society for Information Science*, 46(6): 468-472.
- Wagner, C. S. & Leydesdorff, L. 2003. Mapping global science using international co-authorships: A comparison of 1990 and 2000. In: J. Guohua, R. Rousseau & W. Yishan. *Proceedings of the 9<sup>th</sup> International Conference on Scientometrics and Informetrics – ISSI*, pp. 330-340.
- Wang, Y., Yishan, W., Yuntao, P. & Zheng, M. 2003. Status of collaboration in science and technology in China as reflected in co-authorship. In: J. Guohua, R. Rousseau & W. Yishan. *Proceedings of the 9<sup>th</sup> International Conference on Scientometrics and Informetrics – ISSI*, pp. 421-429
- Yoshikane, F. & Kageura, K. 2003. Comparative analysis of co-authorship networks of different domains: the growth and change of networks. In: J. Guohua, R. Rousseau & W. Yishan. *Proceedings of the 9<sup>th</sup> International Conference on Scientometrics and Informetrics – ISSI*, pp. 362-367.