Research article

Fifty Years on: An Informetric Study of Kenya's Health Problems, 1966–2015

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ABSTRACT

The study was aimed at identifying and mapping Kenya's health problems between 1966 and 2015, using informetric techniques. A total of 11,028 journal articles were extracted from the MEDLINE database and analysed using various computer-aided software. Results indicate that the most problematic health issue as covered in the biomedical and health literature in Kenya is HIV/AIDS, followed by malaria and tuberculosis; the most researched and therefore affected age group is young adults aged between 19 and 44 years; most research target problems associated with the female population. There were strong correlations between the government of Kenya's efforts in improving health and the volume of research; and there were weak and insignificant correlations between the burden of disease and the volume of research. The findings give credence to the effect that informetrics can be used to assess health problems in a given country.

Keywords: *Informetrics, Health problems, Medical research, Health research Kenya, Research evaluation*

INTRODUCTION

Evidence shows that there have been attempts to improve the health sector and by extension the health of Kenyans in the spirit of the United Nations' mission to realise "health for all" (Roth & Fee, 2010). The number of medical institutions (e.g. hospitals, health centres and dispensaries) has grown from just 769 in 1966 (Republic of Kenya, Ministry of Economic Planning and Development, 1967) to 9,959 in 2014 (Republic of Kenya, Ministry of Finance and Planning, 2015). The decline in the total number of doctors practicing medicine in the country, which was experienced before and immediately after the country's independence, was reversed in 1966 (Republic of Kenya, Ministry of Finance and Planning, 1967). The Government of Kenya (GoK) has also directed a substantive amount of money towards creating an "enabling environment for the provision of sustainable quality health care that is acceptable, affordable and accessible to all Kenyans" (Republic of Kenya, Ministry of Finance and Planning, 2001:41). These efforts, among others, have seen the average life expectancy of the Kenyan populace increase from just 49 years in the 1960s to 54 years in the 1970s and then to 59 years in the 1980s (Republic of Kenya, Ministry of Finance and Planning, 2003). The life expectancy for both

sexes in Kenya had risen to 61 years by 1990, only for it to fall slightly to 60 years by 2009 (World Health Organization, 2012). This period recorded the highest life expectancy at birth, namely 77 years, in three countries, namely Andorra, Australia and Canada. The 2015 global health observatory (GHO) data shows that 71 years was the average life expectancy at birth of the global population in 2013, while Kenyans' life expectancy stood at 61 years (WHO, 2015).

Despite the remarkable efforts and achievements on the part of the government, specifically the Ministry of Health, and international partners such as the World Health Organization (WHO), health problems in Kenya have continued to persist. For instance, Phillips-Howard *et al.* (2014) reported that deaths ascribed to non-communicable diseases among rural Kenyan adults have continued to increase proportionately. Kenya's statistical profile (WHO, 2015b) lists the top ten causes of deaths in the country as HIV/AIDS, which killed a total of 54,500 people in 2012 alone, followed by lower respiratory infections (45,400 deaths), diarrheal diseases (23,400 deaths), protein-energy malnutrition (15,300 deaths), birth asphyxia and birth trauma (14,900 deaths), stroke (14,600 deaths), preterm birth complications (13,500 deaths), malaria (12,000 deaths), tuberculosis (9 400 deaths) and ischaemic heart disease (9,200 deaths). The adult mortality

rate stands at 250 per 1 000 people among females, while males record a mortality rate of 299 persons per 1 000 people. Furthermore, the WHO (2015b) notes that the number of deaths has continued to rise while the burden of disease related to maternal, neonatal and nutritional factors, as well as HIV/AIDS, tuberculosis (TB) and malaria, was the highest in 2012. Whereas the number of deaths has continued to grow and/or remained constant, life expectancy has improved slightly from 60 years in 2014 to 61 years in 2015.

Medical and health research is perhaps one of the biggest beneficiaries of bibliometric or informetric investigations in the world. It is well acknowledged that health problems can be identified using such methodological strategies as surveys, observations, epidemiological strategies and clinical trials, among others (WHO 2001). According to the WHO (2001), both descriptive and analytical strategies can be applied to conduct health research in a country. Descriptive studies would include case series; community diagnoses or needs assessment; the epidemiological description of a disease occurrence; descriptive cross-sectional studies or community (population) surveys; and ecological descriptive studies. Analytical strategies in epidemiology are largely observational in nature and "establishing a relationship (association) between a "risk factor (etiological agent) and an outcome (disease) is the primary goal" (WHO 2001:18). The strategies that fall into this category include case-control studies, prospective cohort studies, historical (retrospective) cohort studies and prognostic cohort studies. Once research has been completed, the findings are often disseminated and/or published in various formats such as journal articles, books and book chapters, and conference proceedings. It is upon the publication or dissemination of the research findings that bibliometrics can be applied to measure statistically the volume and impact of research in a field or discipline. The bibliometric assessment of research is based on two fundamental assumptions, namely: (a) scholars who have something important to say do publish their findings; and (b) scholars refer in their own work to earlier works of other scholars to acknowledge intellectual debt and to witness the use of information (Franceschet, 2009:6). A researcher or any other individual or institution driving a bibliometric research project often determines the variables of measurement in the bibliometric study. The variables would include a simple counting of the publications published in a given field, discipline or topic over a period of time; the subject terms used to index the literature; authors who have published the literature; authors' countries and institutions of affiliation; funding institutions; the number of citations; and so on. These variables often reflect the status, pattern and trends of research output and impact per individual, institution or country in a given topic, field or discipline.

Whereas the worldwide volume of research publications on the bibliometrics of biomedical research is high, there is no evidence of such studies in Kenya. In a world that is increasingly becoming selective and seeks to highlight significant or promising areas of research and to manage better investments in science (Thomson Reuters, 2008), Kenya, and indeed the rest of Africa where bibliometric studies are rare or non-existent, may find it challenging to make informed decisions. It is well acknowledged that bibliometric studies

assist in decision-making processes on many fronts, such as funding research, collection development in libraries, research collaboration, awarding researchers and prioritizing research areas, among others (Onyancha, 2008; OECD, 1997; Thomson Reuters, 2008; Wilsdon et al, 2015). For instance, in their study of the content of HIV/AIDS research in eastern and southern Africa, Onyancha and Ocholla (2009a) cite several authors who have made strong arguments for the bibliometric analysis of biomedicine, and more particularly of the subject foci of the research being conducted. Bibliometric analyses of diseases, for instance, may lead to the development of appropriate strategies for patients (Cohen, 2000), while knowledge of the shifts of research is essential when designing intervention programmes. Furthermore, Cohen (2000) observes that emerging areas may reflect new health problem areas, which may require paradigm shifts in dealing with them. Through bibliometric studies of biomedical research, stakeholders (e.g. funders, governments, institutions and even researchers) can "track the introduction of new terms that reflect innovations and discoveries in the knowledge field" (Cohen, 2000), where the knowledge field could be health problem areas such as human diseases. Finally, a study of the changing patterns in biomedical research in a given geographic region or country, provides a glimpse of the areas that may require stakeholders' (i.e. government, donors, health practitioners, etc) attention, especially if the less researched areas constitute the major health problems in a country.

In this study, we examined the publication trends and patterns of medical and health research in Kenya with a view to determining whether or not research prioritises the medical problem areas in the country. Specifically, the objectives of the study were

- to determine the volume and trend of medical and health research in Kenya from 1966 to 2015
- to analyse medical and health research according to gender and age groups so as to determine the most affected groups of people in Kenya
- to assess the frequency of occurrence of the most common medical subject headings over time so as to identify the shifts of research interests in the most common health problems in Kenya
- to ascertain the trend of research on selected diseases in Kenya as identified by the World Health Organization
- to determine the influence of the government's efforts and burden of disease on the volume of biomedical and health research.

MATERIALS AND METHODS

The study adopted an informetric approach to investigate Kenya's health problems from 1966 to 2015. Informetrics is a quantitative research method that largely employs mathematical and statistical techniques to assess patterns that show up in publications and also in any human activity, as long as that activity deals with information (Diodato, 1994:ix).

The MEDLINE database, hosted by EBSCO was used as the source of data to conduct the study. The MEDLINE is a bibliographic electronic database dedicated to indexing publications on a variety of health topics. The database

contains more than 22 million references to journal articles in life sciences with a focus on biomedicine. The database, which is owned by the United States National Library of Medicine (NLM), contains citations from more than 5,600 journals from all over the world.

The search for documents published between 1966 and 2015 was conducted using an advanced search strategy. The country name was used in the search query, *MH "Kenya"*, where MH stands for Medical Heading, in the subject field of a record. Specifically, the exact match of the subject term was sought for while executing the search. The search was also limited to articles published in academic journals and classified under the group *Humans*. Data were extracted from the database in February 2016.

Once extracted from the database, the data were saved and cleaned using Microsoft Excel. Bibexcel was then used to analyse the data to obtain frequencies of occurrence per year of publication, gender, age group and medical subject headings. A Pearson linear correlation test was conducted to determine the relationship between the efforts made by the government in improving health in the country and research endeavours and the burden of disease and research output in health in the country.

RESULTS

Trend and volume of biomedical and health research in Kenya, 1966–2015: Figure 1 illustrates the growth of the medical and health literature in Kenya between 1966 and 2015. The number of publications on biomedical research in Kenya has increased at an exponential rate ($R2 = 0.97$) rather than lineally ($R2 = 0.78$) over the study period, albeit slowly just after the country gained its independence from British rule. The publications increased lineally, in number, from 1966 to around 2000, when the growth rate became rapid. Thereafter the pattern changed and followed an exponential trend after 1996. The pattern of growth follows the trends of government efforts in improving health conditions in the country (e.g. growth of facilities, together with increasing the number of medical practitioners).

Biomedical and health research according to age groups, 1966-2015: The trend of publication of medical and health research by age group in table 1 demonstrates patterns similar to the general growth in publications in the country – the volume of research increased slowly immediately after independence and accelerated after 1996. The most researched age group was adults between the ages of 19 and 44 years

followed by adolescents aged between 13 and 18 years old, children aged between 6 and 12 years, and middle-aged persons (i.e. 45 to 64 years old). The least researched groups were infants younger than one month and persons older than 65 years.
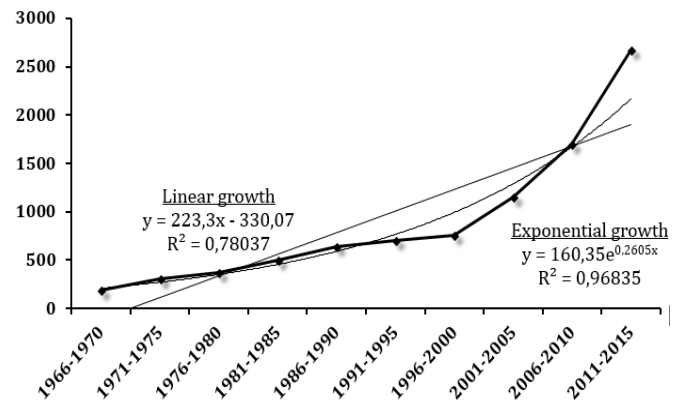

Fig 1:
Trend and volume of biomedical and health publications on Kenya, 1966–2015

Biomedical and health research according to gender, 1966-2015: Table 2 provides the patterns of biomedical and health research according to gender. The research that focused on males resulted in 4 620 articles, while there was a total of 5 365 articles published on females. Both sexes received almost equal attention from researchers in the early years after Kenya had gained its independence, that is, from 1966 to 1980, after which the gap between the number of articles focusing on males and females increased over time until the difference was 215 articles in the period 2006 to 2010. However, this gap was almost closed in the period 2011 to 2015, as the number of research articles targeting males and females stood at 1 264 and 1 271, respectively, thereby creating a gap of only seven articles.

Co-occurrence and overlap of subject terms in biomedical and health research, 1966-2015: The co-occurrence matrix of the number of subject terms in table 3 shows several instances where subject terms overlapped across a number of publication years. For instance, there were 333 terms that were common in the periods 1966 to 1970 and 1971 to 1975. Of particular interest, too, is the number of subject terms that appeared in both the periods 1966 to 1970 and 2011 to 2015.

Table 1: Number of health publications by age group in Kenya

	1966 –1970	1971 –1975	1976 –1980	1981 –1985	1986 –1990	1991 –1995	1996 –2000	2001 –2005	2006 –2010	2011 –2015	TOTAL
Infant, new-born: birth – 1 month	12	20	42	54	60	79	62	136	162	207	834
Infant: 1–23 months	23	52	82	81	108	145	142	226	301	459	1 619
Child, preschool: 2–5 years	33	69	99	111	127	173	172	247	366	483	1 880
Child: 6–12 years	59	100	136	162	172	218	222	319	404	553	2 345
Adolescent: 13–18 years	50	85	118	178	197	251	235	321	509	847	2 791
Adult: 19–44 years	76	112	151	206	249	326	315	438	726	1 244	3 843
Middle Aged: 45–64 years	42	61	85	110	145	170	163	235	373	686	2 070
Aged: 65+ years	20	35	47	45	65	79	90	113	162	253	909

Table 2: Number of health publications by gender in Kenya, 1966–2015

	1966–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015	Total
Male (a)	105	193	209	296	315	384	391	549	914	1264	4620
Female (b)	107	193	236	335	374	476	501	743	1129	1271	5365
a (NOT b)	20	38	36	45	51	47	47	65	99	124	572
b (NOT a)	22	38	63	84	110	139	157	255	314	486	1668
(a OR b)	127	231	272	460	425	523	548	808	1228	1936	6558
NOT (a OR b)	175	321	314	329	417	472	501	679	878	924	5010

Table 3: Co-occurrence matrix of subject terms, 1966-2015

	1966–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015
1966–1970		333	281	266	288	315	292	318	307	346
1971–1975			490	477	510	516	519	536	521	616
1976–1980				554	625	640	592	597	572	670
1981–1985					840	853	751	716	730	829
1986–1990						1 213	1 102	1 050	1 014	1 174
1991–1995							1 526	1 458	1 417	1 641
1996–2000								1 714	1 691	1 943
2001–2005									2 285	2 547
2006–2010										3045
2011–2015										
TOTAL	916	1 557	1 537	2 022	2 738	3 773	4 144	5 335	5 901	9 445

A total of 346 subject terms that appeared in Kenya's biomedical and health literature at independence appeared in the literature published from 2011 to 2015. Therefore, about one-third (33%) of the subject terms that existed immediately after Kenya's independence have persisted to date. Equally important to note is the high number of subject terms that have co-occurred in two different time periods in recent times, e.g. 1991 to 1995 and 1996 to 2000 (1 526 articles); 1996 to 2000 and 2001 to 2005 (1 714 articles); 2001 to 2005 and 2006 to 2010 (2 285 articles); and 2006 to 2010 and 2011 to 2015 (3 045 articles). The bottom row in table 3 provides the number of subject terms that were used to describe biomedical health research in Kenya in each time period. An analysis of the disease-associated subject terms that appeared in 1966-1970 as well as 2011-2015 include *insect vectors, esophageal neoplasms/epidemiology, neoplasms /epidemiology, leishmaniasis, visceral/epidemiology, tsetse flies, sex factors, paleontology, tuberculosis/epidemiology, burkitt lymphoma/ immunology, zoonoses, ascariasis/epidemiology, trypanosomiasis, african/prevention & control, tuberculosis, pulmonary/epidemiology, blood pressure, burkitt lymphoma/epidemiology, isoniazid/pharmacology, and ancylostomiasis/epidemiology,* just to name a few.

Intensity of subject indexing of biomedical and health research in Kenya, 1966-2015

As a way of assessing whether or not the pattern in Table 3 was influenced by the indexing policies of database publishers, the number of terms per article was computed and presented in figure 2. The illustration shows that the number of subject terms per article has remained almost constant throughout the study period, although the general trend line reveals that the number of terms per article has continued to

decrease over time. From 4.92 in the period 1966 to 1970 it increased to 5.47 in the period 1996 to 2000, when it reached a peak, but then it decreased to the lowest integer (3.49) in the period 2011 to 2015
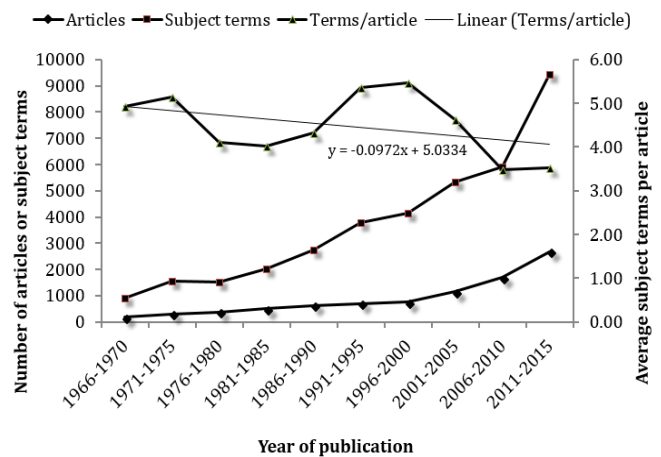

Figure 2:
Number of subject terms used to describe medical and health research in Kenya, 1966–2015

Most common subject terms in Kenya's medical and health research, 1966–2015

A sample of three five-year time periods, namely 1966 to 1970, 1991 to 1995 and 2011 to 2015, have been selected for purposes of assessing the most common research topics in Kenya's biomedical and health research.

Some terms that reveal the type of diseases that were the focus of research include *Esophageal neoplasms* (cancer) and *Neoplasms*, which occurred six times each; *Leishmaniasis*;

Nasopharyngeal neoplasms; *Tuberculosis*; *Burkitt lymphoma*; *Zoonoses*; *Ascariasis*; *Trypanosomiasis, African*; and *Tuberculosis, pulmonary*.

In terms of the terms related to diseases that appeared in the period 1991 to 1995, the term *viral diseases* was ranked ninth followed by *HIV infections* with 34 articles, *HIV infections/epidemiology* (23), and *HIV-1* (21). It should be noted that the term *Prevalence* is closely related to HIV infections, which had become largely visible in 1991-1995.

Table 4: Most common subject terms in the biomedical and health literature in Kenya, 1966–1970

No.	Subject Term	Papers
1	Pregnancy	14
2	Age factors	11
3	Ethnic groups	8
4	Insect vectors	7
5	Disease reservoirs	6
6	Antibodies/analysis	6
7	Esophageal neoplasms/epidemiology	6
8	Drug resistance, microbial	6
9	Neoplasms/epidemiology	6
10	Leishmaniasis, visceral/epidemiology	6
11	Insect control	5
12	Tsetse flies	5
13	Nasopharyngeal neoplasms/etiology	5
14	Hospitals	5
15	Sex factors	5
16	Skin tests	5
17	Tuberculin test	5
18	Paleontology	5
19	Tuberculosis/epidemiology	4
20	Burkitt lymphoma/immunology	4
21	Disease vectors	4
22	Tropical medicine	4
23	Zoonoses	4
24	Sputum/microbiology	4
25	Ascariasis/epidemiology	4
26	Virus cultivation	4
27	Trypanosomiasis, African/prevention & control	4
28	Neutralization tests	4
29	Tuberculosis, pulmonary/epidemiology	4
30	Nutritional physiological phenomena	4

The main focus of medical and health researchers in the period 2011 to 2015 was on prevalence, which occurred in 307out of a total of 2 675 articles. The term prevalence, therefore, appeared in 11.48% of the total number of articles published from 2011 to 2015. Risk factors, Pregnancy, HIV infections/epidemiology, Health knowledge, attitudes and practice, HIV infections/drug therapy and HIV infections/prevention and control were given equally substantive attention.

Table 6 reveals a number of diseases that appeared among the top 30 most common subject terms in the medical and health literature published between 2011 and 2015. HIV infections and Malaria are the only diseases that appeared in the list as key subject terms. Investigations into HIV infections revolved around epidemiology, drug therapy, Prevention & control, Transmission, Psychology, Virology, Diagnosis,

Complications, and Immunology. On the part of malaria, the focus centered on Epidemiology and Prevention and control.

Table 5: Most common subject terms in the biomedical and health literature in Kenya, 1991–1995

No.	Subject Term	Papers
1	Prevalence	109
2	Risk factors	98
3	Diseases	97
4	Age factors	91
5	Demographic factors	77
6	Incidence	60
7	Health	58
8	Pregnancy	56
9	Viral diseases	47
10	Infections	40
11	HIV infections	34
12	Health knowledge, attitudes, practice	33
13	Age distribution	32
14	Delivery of health care	32
15	Physiology	31
16	Population surveillance	30
17	Hospitals, public	28
18	Rural health	26
19	Morbidity	26
20	Mortality	25
21	Treatment	24
22	Sex factors	24
23	Sex behaviour	24
24	HIV infections/epidemiology	23
25	Family planning	23
26	Sexual behaviour	23
27	Prostitution	21
28	HIV-1	21
29	Fertility	21
30	Reproductive tract infections	20

Trend of publication of biomedical literature in selected diseases, 1966–2015: The Regional Office for Africa of the World Health Organization identified 12 diseases, which were then regarded as the main health problems in Kenya in 2004 (Charles University in Prague, 2014). These so-called Kenyan health problems yielded mixed patterns of publication in the literature between 1966 and 2015, as shown in table 7.

During the early years of independence, the research in Kenya focused on Tuberculosis, Trypanosomiasis and Leishmaniasis, which respectively recorded 35 (18.82%), 21 (11.29%) and 15 (8.06%) posts in the literature.

The following period, namely 1971 to 1975, saw the dominance of *Trypanosomiasis* and a strong new focus on *malaria*. *Schistosomiasis*, too, became strongly visible in the literature, having occurred 25 times – one position behind *Trypanosomiasis*. It was not until the period 1981 to 1985 that *malaria* became the main research focus. The topic maintained that position for only that period (1981-1985) before it was overtaken by HIV/AIDS, which emerged in the period 1981 to 1985 with five (0.99%) articles but topped the list of prioritised health problems in the period 1986 to 1990 with 119 (18.77%) articles. HIV/AIDS maintained its first position onwards.

Table 6: Most common subject terms in the biomedical and health literature in Kenya, 2011–2015

No.	Subject Term	Papers
1	Prevalence	307
2	Risk factors	264
3	Pregnancy	261
4	HIV infections/epidemiology	220
5	Health knowledge, attitudes, practice	214
6	HIV infections/drug therapy	196
7	HIV infections/prevention and control	195
8	Incidence	124
9	Anti-HIV agents/therapeutic use	107
10	HIV infections/transmission	101
11	HIV infections/psychology	98
12	Sex factors	88
13	HIV infections/virology	86
14	Poverty areas	84
15	Urban population	83
16	HIV infections/diagnosis	81
17	HIV infections/complications	78
18	Family characteristics	74
19	Cd4 lymphocyte count	73
20	Malaria/epidemiology	70
21	Health services accessibility	70
22	HIV	69
23	HIV infections/immunology	66
24	Longitudinal studies	66
25	Genotype	66
26	Malaria/prevention & control	66
27	Sexual behaviour	58
28	Sexual partners	57
29	Patient acceptance of health care	54
30	Poverty	54

Correlations between government commitments or efforts, burden of disease and research: Government efforts in terms of financial commitments to the health sector were assessed against the number of publications in medical and health research to gauge whether or not there are significant relationships between (a) expenditure and volume of research; (b) volume of research and the number of medical personnel; and (c) volume of research and the number of medical institutions. The correlational test was also conducted to determine the relationship between the volume of medical and health research and the burden of disease over time.

Table 8 provides a correlation coefficient matrix for government expenditure, number of medical institutions, papers and number of medical personnel. All the variables in table 8 exhibit strong positive linear relationship with one another. The highest correlation coefficient was recorded between medical personnel and institutions ($r = 0.99141$, $p<0.05$). Equally strong was the relationship between papers (research) and medical personnel –the correlation coefficient stood at $r = 0.92011$, $p < 0.05$. The relationships between expenditure, on the one hand, and medical personnel and institutions, on the other hand, were equally strong, with correlation coefficients of over 0.8 at $p < 0.05$.

Table 9 demonstrates weak negative linear relationships between the various variables, namely the number of papers (papers) and the burden of disease (average death rate). Although most of the variables recorded some correlations, it was noted that most relationships among the various variables were not significant at $p < 0.05$. For example, there was no significant relationship between (a) papers and deaths [Males]; (b) papers and deaths [Females]; and (c) papers and total deaths. However, the relationships between (a) deaths [Males] and deaths [Females]; (b) deaths [Males] and total deaths; and (c) deaths [Females] and total deaths, were all significant at $p < 0.05$.

DISCUSSION

This paper sought to use informetrics to determine Kenya's health problems, and to examine the relationship between the government efforts and burden of disease, and the research volume. The trend of medical and health research in Kenya has continued to exhibit an upward movement since the country attained her independence in 1963. Specifically, the volume of research grew slowly and linearly immediately after independence but gained momentum from 1996 onwards, to increase exponentially. The slow start may be attributed to several factors, including the small number of medical researchers and teaching staff in the country at the time (Republic of Kenya, Ministry of Finance and Planning, 1967:114).

Table 7: Trend of publication of biomedical literature on selected health problems, 1966–2015

	1966–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015	TOTAL
HIV/AIDS	0	0	0	5	119	320	393	661	1 123	1 901	4 522
Malaria	2	23	13	58	89	184	305	550	593	603	2420
Schistosomiasis	6	25	44	70	58	74	95	80	90	177	719
Tuberculosis	35	20	27	18	21	58	54	47	82	121	483
Leishmaniasis	15	15	11	61	45	113	23	10	28	17	338
Trypanosomiasis	21	47	9	13	44	14	22	49	7	39	265
Cholera	0	9	5	0	2	4	15	10	10	38	93
Lymphatic Filariasis	10	21	4	6	0	0	1	1	0	2	45
Leprosy	4	5	6	7	5	5	1	2	0	0	35
Typhoid Fever	0	0	0	1	0	9	4	5	2	2	23
Onchocerciasis	4	4	0	0	1	1	0	0	0	0	10
Amoebiasis	0	1	0	5	0	0	1	0	0	0	7
TOTAL articles*	**186**	**303**	**375**	**503**	**634**	**703**	**758**	**1 151**	**1 693**	**2 675**	**8 981**

*The total number of papers refers to the number of papers published in each year period, including on other subject areas that are not reflected in table 8.

Table 8: Correlation coefficient matrix for government efforts and research, 1978–2014

Variable	R	No. of valid cases	t	p-value	R St dev
Personnel vs Institutions	0.99141	37	44.85353	0.00000	0.00049
Personnel vs Papers	0.92011	37	13.89874	0.00000	0.00438
Personnel vs Expenditure-B	0.90969	37	12.95949	0.00000	0.00493
Institutions vs Expenditure-B	0.90398	37	12.50799	0.00000	0.00522
Institutions vs Papers	0.89736	37	12.02999	0.00000	0.00556
Personnel vs Expenditure-A	0.89625	37	11.95431	0.00000	0.00562
Institutions vs Expenditure-A	0.88112	37	11.0232	0.00000	0.00639
Expenditure-B vs Expenditure-A	0.87123	37	10.50029	0.00000	0.00688
Expenditure-A vs Papers	0.82468	37	8.62593	0.00000	0.00914
Expenditure-B vs Paper	0.77231	37	7.19249	0.00000	0.01153

Key: Expenditure-A (recurrent expenditure); Expenditure-B (development expenditure)

Table 9: Correlation coefficient matrix for burden of disease and research, 2000–2015

Variable	R	No# of valid cases	t	P-value	R St Dev
Total deaths vs Deaths [Males]	0.99894	16	81.10683	0.00000	0.00015
Total deaths vs Deaths [Females]	0.99888	16	79.0855	0.00000	0.00016
Deaths (Females) vs Deaths [Males]	0.99564	16	39.95431	0.00000	0.00062
Deaths [Males] vs Papers	-0.42779	16	-1.77084	0.09835	0.05836
Total deaths vs Papers	-0.41342	16	-1.69887	0.11145	0.05922
Deaths [Females] vs Papers	-0.39778	16	-1.62222	0.12705	0.06013

The present study has demonstrated that research output has a strong correlation with the number of medical personnel, which implies that the smaller the number of medical personnel, the less the volume of research. Jacobs (2002) reports that research is also dependent on the number of institutions engaged in research and those funding research. The country has witnessed a continued growth in the number of medical institutions, culminating in five teaching and referral hospitals in the country by 2016; two of these are national teaching hospitals. These are the Jaramogi Oginga Odinga Teaching and Referral Hospital in Kisumu, Mathare National Teaching and Referral Hospital in Nairobi, Moi Teaching and Referral Hospital in Eldoret, Kenyatta University Teaching and Referral Hospital, and Kisii Teaching and Referral Hospital in Kisii. It has been pointed out that medical and health research is heavily concentrated in the teaching and referral hospitals (Rotich & Onyancha, 2016), which are associated or linked to some of the most prestigious universities in Kenya (i.e. University of Nairobi, Kenyatta University and Moi University). Closely linked to the growth of medical institutions is the proliferation of medical schools at universities in Kenya. In 2016, the Kenya Medical Practitioners and Dentists Board (KMPDB) had registered nine medical schools and two dental schools. In addition to these, the Board had registered 29 medical schools and seven dental schools from the East African Community (EAC) (Republic of Kenya, Ministry of Health, 2016). These efforts, among others, might have resulted in the exponential growth of publications that was witnessed after 1996.

The distribution of publications according to age groups shows that most research targeted persons between the ages of 19 and 44. This age group comprises approximately 50% of the country's total population and has consistently recorded high death rates since 2000 (WHO 2015b). Most deaths in Kenya are associated with communicable diseases as opposed to non-communicable diseases and injuries (World Health Organization 2015c). Kilonzo (2016), citing a report of the National Aids Control Council, identifies HIV/AIDS as the leading cause of deaths and disability among young persons aged between 10 and 24. It is no wonder therefore that HIV/AIDS tops the list of most researched diseases (see table 7), as it is the most problematic health issue in the country. It was further demonstrated that subject terms such as prevalence and risk factors, which can be closely associated with HIV/AIDS, were the most common in the medical and health research that was published from 2011 to 2015. The Institute for Health Metrics and Evaluation in Kenya (IHME) (2017) identifies unsafe sex as the main risk factor that leads to death and disability in Kenya.

In terms of the trend and pattern of research focusing on gender, it was noted that research consistently focused more on women than on men. However, the gap narrowed between 2011 and 2015. It is true that the population in Kenya is distributed almost evenly according to gender, with the number of females being slightly more than males, but there were no data to support the notion that there is a significant correlation between the female population and research volume. The trend concerning gender in research publications seems to follow the trends of life expectancy in females, which has equally remained higher than that of males since the 1990s (Institute for Health Metrics and Evaluation in Kenya (IHME) 2017). It has also been noted that the infant mortality rate among females is lower than among males (IHME 2017). Although any of the most common subject terms in tables 4, 5 and 6 can be associated with both females and males, it is illustrative that the term pregnancy, which is specifically associated with the female population, consistently featured among the top ten subject terms. The subject term was ranked first in table 4, eighth in table 5 and third in table 6. It can be concluded therefore that the most problematic health issues for women in Kenya are issues related to pregnancy. Ferguson (1986:17) notes that "women, in particular, are subject to a high degree of stress… [there is] higher-than-average economic dependence on women… water collection patterns show that 70% of all trips are made by women over 15 years over a median distance of 3.5 km and that 87% of women

collecting water carry loads without any mechanical assistance compared with 42% of men". It can safely be said that the intensity of research on the female population in Kenya might be a testimony of the GoK's efforts to improve women's health. The special emphasis placed on women's health is also reflected in the 2014 Demographic and Health Survey, which, among others, investigated such women-specific issues as marriage and sexual activity, fertility, fertility experiences, family planning, infant and child mortality, maternal health, nutrition of children and women, women's empowerment, demographic and health outcomes, domestic violence, adult and maternal mortality, and female genital cutting (Kenya National Bureau of Statistics [KNBS], 2014). Several researchers also conducted research on two of the main women-specific health issues, namely maternal health and reproductive health (Kagia, 2013).

The co-occurrence matrix of subject terms in table 3 is a manifestation of the persistence of a number of health issues in Kenya since 1966. It is worth noting, however, that some of the subject terms do not necessarily reflect the health problem areas; as tables 4, 5 and 6 reveal, the majority of the subject terms refer to health problem areas. The subject terms further show that there have been new areas of medical and health research in Kenya. Equally important to note is that almost one-third of the medical and health issues that were the subject of investigation in 1966 were also researched between 2011 and 2015, implying that the medical and health problems that existed at independence have persisted to date. Several authors (e.g. Mohajan, 2014) applaud the Government of Kenya for her efforts towards improving the health status of her citizens, but at the same time the authors indicate that the health sector in the country must still go far to reach its Millennium Development Goals (Republic of Kenya, Ministry of Devolution and Planning, 2013).

The trend analysis of the number of subject terms used to index medical and health research in Kenya, as illustrated in figure 2, demonstrates an upward and linear growth pattern. However, the average number of subject terms per article has continued to decline since the period 1996 to 2000. It follows therefore that the huge difference of co-occurrence of words in any given two periods cannot be attributed to the increased number of terms used to index literature as observed by Bierbaum and Brooks (1995). The authors imply that indexing intensity might be attributed to changes in literature (such as the greater complexity of individual articles) or to a greater depth and thoroughness (Bierbaum & Brooks 1995:533). This study reveals that authors are supplying fewer keywords per paper. This practice may be attributed to journal editorial policies requiring authors to limit the number of keywords to a bare minimum. It is also likely that authors are satisfied that the few keywords used to explain the content of the medical and health literature are sufficient.

The dynamism with which the subject terms have shifted in their ranking since independence is traced from 1966 to 2015 and provided in tables 4, 5 and 6. Whereas there were no dominant topics that were the most researched immediately after independence, HIV/AIDS, sex factors, malaria and maternal/reproductive health have taken centre stage in medical and health research in Kenya. Table 7 also demonstrates that HIV/AIDS, which emerged in the period

1981 to 1985, malaria, schistosomiasis, and tuberculosis have emerged as the major health problem areas. The Institute for Health Metrics and Evaluation (IHME) (2017) reports that HIV/AIDS was the main killer disease in Kenya in 2015, followed by diarrheal diseases, lower respiratory infection, neonatal encephalopathy, neonatal preterm birth, congenital defects, malaria, meningitis, neonatal sepsis and protein-energy malnutrition. It is worth mentioning that the ranking of these diseases in 2005 exhibited slightly different patterns. For instance, whereas malaria was ranked in position four in 2005, it was in the eighth position in 2015, implying that other health problems have emerged, within a period of ten years, as the main threats to human life in Kenya. These diseases that have overtaken malaria include neonatal encephalopathy, neonatal preterm birth and congenital defects; they are all associated with maternal and child health. This pattern may explain the research emphasis placed on females and not on males.

Finally, the study found a moderate to strong significant correlation between some of the GoK's efforts and the volume of research. One such finding was the relationship between the number of medical personnel and the research volume. This relationship is very interesting as it leads one to wonder whether or not all medical personnel (practitioners) are actively engaged in medical and health research in the country. Whereas it is true that some practitioners double up as teaching staff in some universities in Kenya where the teaching and referral hospitals are linked to the said universities, it is also true that most medical personnel comprise registered nurses, enrolled nurses, clinical officers and pharmaceutical technologists who may not be competent enough to conduct and publish research (Rotich & Onyancha, 2016). It was also revealed that the number of medical institutions has a significant relationship with the volume of research. Equally significant were the relationships between the government expenditures and the volume of research. However, we noted weak links between the burden of disease (only death rates were used as an indicator) and the volume of research. Nevertheless, the reverse relationship noted in the analysis implies that the burden of disease decreases as the volume of research increases, leading to a conclusion that research may be influencing policy, even though the GoK states in its 2014 health policy document that there is poor linkage between research and policy (Republic of Kenya, Ministry of Health, 2014). Further research is therefore recommended to ascertain the impact of research on policy in the health sector in Kenya. This can be achieved through the altmetrics analysis of discussions on health research in policy documents or through such research designs as surveys.

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