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EXPERT CONSENSUS DOCUMENT

Building Sustainable Local Capacity for Global Health Research in West Africa

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Abstract

BACKGROUND Global health research in resource-limited countries has been largely sponsored and led by foreign institutions. Thus, these countries' training capacity and productivity in global health research is limited. Local participation at all levels of global health knowledge generation promotes equitable access to evidence-based solutions. Additionally, leadership inclusive of competent local professionals promotes best outcomes for local contextualization and implementation of successful global health solutions. Among the sub-Saharan African regions, West Africa in particular lags in research infrastructure, productivity, and impact in global health research.

OBJECTIVE In this paper, experts discuss strategies for scaling up West Africa's participation in global health evidence generation using examples from Ghana and Nigeria.

METHODS We conducted an online and professional network search to identify grants awarded for global health research and research education in Ghana and Nigeria. Principal investigators, global health educators, and representatives of funding institutions were invited to add their knowledge and expertise with regard to strengthening research capacity in West Africa.

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FINDINGS While there has been some progress in obtaining foreign funding, foreign institutions still dominate local research. Local research funding opportunities in the 2 countries were found to be insufficient, disjointed, poorly sustained, and inadequately publicized, indicating weak infrastructure. As a result, research training programs produce graduates who ultimately fail to launch independent investigator careers because of lack of mentoring and poor infrastructural support.

CONCLUSIONS Research funding and training opportunities in Ghana and Nigeria remain inadequate.

RECOMMENDATIONS We recommend systems-level changes in mentoring, collaboration, and funding to drive the global health research agenda in these countries. Additionally, research training programs should be evaluated not only by numbers of individuals graduated but also by numbers of independent investigators and grants funded. Through equitable collaborations, infrastructure, and mentoring, West Africa can match the rest of Africa in impactful global health research.

KEY WORDS western Africa, capacity-building, financial support, global health, research

INTRODUCTION

Global health has only recently evolved into a discrete entity, chiefly out of the disciplines of tropical medicine and hygiene, public health, and international health. Global health has been defined as "an area for study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide."[1] Beaglehole and Bonita[2] characterize Global health disciplines as being *collaborative*, *cross-national*, *research-oriented*, *action-based*, *promoting or improving health*, and encompassing *health for all*.

Although the highest burden of communicable and preventable diseases exists in low- and middle-income countries (LMICs),[3] the greatest numbers of the most well-capacitated global health institutions are located in high-income countries.[2,4,5] Consequently, the bulk of global health funding and initiatives for programs and research in LMICs originate from foreign institutions in high-income countries, further supporting the so-called 10/90 gap.[6]

Sustainable progress to global disease responses cannot be made if the most affected countries are unable to make robust contributions. Recent characterizations of global health make mention of formal research as an integral part of learning and practice[1,2] because it is from quality research that evidence is generated to inform effective health interventions and impactful policy changes. LMICs can increase participation and contribution to the global health response through leadership in research and evidence generation. The continued disparity in funding and disease burden between high- and LMICs calls for more deliberate approaches to building LMIC capacity to successfully compete for research funding from both local and foreign sources.

Globally, some of the highest disease-burdened populations are found in sub-Saharan Africa[3]; consequently, a large proportion of global health research is conducted in this region. Within sub-Saharan Africa, however, West Africa lags in global health research-related funding, even though it is the second most populous African region[7] and has major human disease burdens comparable to other African regions.[8] The United States (US) National Institutes of Health (NIH) is the largest funder of health research and research training worldwide.[9] A review of NIH research project awards in sub-Saharan Africa in 2005 reveals a total of 10 awards to East African institutions, 12 to southern African institutions, and only 7 awards to West African institutions; there were no awards to Central African institutions.[10]

Ten years later, in 2015, there were 33 NIH grants awarded in East Africa, 73 in southern Africa, only 10 in West Africa, and none in Central Africa.[10] The situation is similar with respect to research publications. A 2011 *Nature* review of publication output from sub-Saharan Africa showed Nigeria, the most populous country in Africa, second only to South Africa in number of publications.[11] However, Nigeria dropped into the lower half of the list when publications were indexed against gross domestic product, with eastern and southern African countries (Uganda, Tanzania, Kenya, Ethiopia, and South Africa) leading in this category.[11] Furthermore, West African countries, such as Ghana and Nigeria, featured among those

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with the lowest researchers-per-million inhabitants figures.[11]

Clearly, West Africa needs to develop structures and strategies to train and retain more local researchers and attract more funding for research as other regions appear to have done. A more recent bibliometric evaluation shows an improvement in absolute number of publications, with South Africa and Nigeria still ranking highest in absolute number of publications and Ghana, Cameroon, and Senegal making the top 10.[12] However, the investigators cited that available and growing evidence did not appear to lead to an impact on the health of populations in many African countries, indicating a lack of strong country-level plans to translate research evidence into practice and policy, and nonalignment of research topics to health needs and priorities of local populations.[12]

A new era of local initiatives to develop capacity and funding for global health research is evolving in sub-Saharan Africa. Part of the success is, and will be, due to collaborations among researchers in Africa and with high-income countries.[2,4,11] Nevertheless, robust collaborations and bids for funding will have to be built upon, enabling in-country structures as well as local research capacity in the form of competent scientists.

In this consensus paper, researchers and other global health professionals with extensive experience in West Africa describe strategies to increase the participation of countries in this region in global health research training, capacity building, productivity, and impact. Examples from 2 West African countries, Ghana and Nigeria, are highlighted to illustrate the successes and challenges in obtaining funding and training local researchers in global health. Finally, we provide guidance to facilitate the agenda for sustainable, local ownership and capacity for global health research in West Africa.

METHODS

Contributing Global Health Professionals. Experts contributing to this paper were from 3 target groups who had experience in 1 or both of the profiled countries: academics who have served as principal investigators (PIs) on research grants, global health educators, and representatives of funding institutions. We searched online grants databases, such as for the NIH[10] and Wellcome Trust,[13] and within professional networks to identify potential contributors with relevant expertise from each of the 3 groups. Ultimately, 10 PIs, 3 global health educators, and 2 funding institution representatives contributed to this expert consensus article (Table 1).

RESULTS AND DISCUSSION

International Sources of Global Health Research Funding in Ghana and Nigeria. Worldwide, the 6 major sources of health research funding are the US NIH, the European Commission, the United Kingdom's (UK) Medical Research Council, the Institut National de la Santé et de la Recherche Médicale of France, the US Department of Defense, and the UK-based Wellcome Trust.[9] There is a dearth of published data ranking major sources of research funding in Ghana and Nigeria. Other than the US NIH, which has a searchable webpage,[10] we were unable to obtain detailed, comprehensive information on research awards for grants in Ghana and Nigeria sourced from international funders.

Table 2 presents NIH grants awarded for projects in Ghana and Nigeria spanning at least 10 years, from 2005 to 2016. A total of 30 research grants were identified (20 R01 awards, 8 R21 awards, and 2 R03 awards). The majority of primary recipient institutions were foreign (non-Nigerian, non-Ghanaian) universities; only 7 direct awards were made to local institutions (3 each to the University of Ghana and the Noguchi Memorial Institute for Medical Research, Ghana, and 1 to the University of Ibadan, Nigeria).

Local Research Funding Sources in Ghana. In Ghana, local sources of research funding and related information are scarce. Faculty at public tertiary institutions receive a total annual allocation of 6,000 cedis (~US $1,500) as a "book and research" allowance from the government of Ghana. The purpose of this funding is to assist faculty members to conduct small studies and to collect preliminary data to support applications for larger grants.[14] However, "book and research" fund release has often suffered inconsistencies and delays,[15,16] leading to circumstances where faculty have to privately finance their own research or remain stagnant in their research career development. This in turn affects their ability to competently mentor and support students; where the faculty mentor is underfunded and underdeveloped, the mentoring available to students will invariably be of low quality.

Within the last 5 years, most local universities have established their own research funding schemes, from which faculty members competitively source seed grants for research or for career development training. These awards range from 8,000 to

Table 1. Profile of Contributing Authors and their Global Health Research and Education Support

	Name	Main Research/Teaching Topic Areas	Grants Leveraged for Local Research Capacity-Building in Ghana and Nigeria, to Date
1	Yaw A. Afrane	- Malaria Entomology - Insecticide Resistance	- NIH R01AI123074
2	Muktar H. Aliyu	- Implementation Science - Prevention of Mother-Child HIV transmission - Maternal and Child Health	- NIH R01HD075075 - NIH R01NS094041 - NIH R21NS080639
3	Gladys Amponsah	- Medical Education - Pain Management	- None
4	Gordon Awandare	- Malaria: Biology, pathogenesis, vaccine development - Infectious Diseases - Human Genetics	- NIH R01AI102848 - Royal Society/Leverhulme Africa - World Bank African Centres of Excellence - Wellcome Trust DELTAS Africa
5	Llewellyn J. Cornelius	- Stigma and Discrimination in Health - Healthcare Accessibility - Interpersonal Violence - Behavioral Health - Behavioral aspects of HIV prevention and treatment	- University of Maryland Baltimore Center for Global Education Initiatives Award - University of Maryland Baltimore Competitive Innovative Research Award
6	Echezona Ezeanolue	- Implementation Science - Community-Based Participatory Research - Maternal and Child Health	- NIH R01HD075050 - NIH R21TW0102521 - NIH R01HD087994 - NIH R01HD089871
7	Anita Ghansah	- Malaria genetics and drug resistance	- NIH R01AI099527
8	Awewura Kwara	- TB and HIV coinfection management - Pharmacokinetics and pharmaco-genetics of HIV therapy	- NIH R01HD071779 - NIH D43TW010055
9	Gabou Mendy	- HIV Clinical and Community Care and Treatment - Global Health program management and education - Health Information Systems, eHealth and mHealth in public health programs	- None
10	Folasade Ogunsola	- Clinical Microbiology - Antibiotic resistance - Infection Prevention and Control - HIV	- NIH D43TW010134
11	Chima Onoka	- Utilization of services for diseases and conditions of public health importance - Health Systems Financing - Retention in care	- NIH R01HD087994
12	Elijah Paintsil	- Pediatric HIV outcomes in resource-limited countries - Antiretroviral Therapy and Mitochondrial Toxicity	- NIH R01HD074252
13	Nadia Sam-Agudu	- Access to, and delivery of services for child and adolescent HIV prevention, care and treatment - Implementation Science - Maternal and Child Health	- WHO RPC 531 INSPIRE MoMent Nigeria - University of Maryland Baltimore Center for Global Education Initiatives Award - NIH R01HD089871
14	George Siberry	- PMTCT - Pediatric/adolescent HIV Treatment - Complications of Pediatric & adolescent HIV infection	- United States Office of the Global AIDS Coordinator
15	Rachel Sturke	- Implementation Science	- Fogarty International Center, National Institutes of Health

AIDS, Acquired Immune Deficiency Syndrome; DELTAS, Developing Excellence in Leadership, Training and Science; HIV, Human Immunodeficiency Virus; INSPIRE, Integrating and Scaling Up PMTCT Through Implementation Research; NIH, United States' National Institutes of Health; PMTCT, prevention of mother-to-child transmission of HIV; TB, tuberculosis; WHO, World Health Organization.

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Table 2. NIH Research Grants Awarded for Projects Implemented in Ghana and Nigeria, 2005 to 2016

	Principal Investigator(s) (PIs)	PI's Institution (Institution awarded the grant)	Grant Type*	Title of Study	Duration of Award	Country of implementation
1	Appawu, Maxwell	University of Ghana, Ghana	R03	Effect of bednets on Ghanaian malaria vectors	2005-2006	Ghana
2	Merritt, Richard W	Michigan State University	R01	Ecological Relationships of Mycobacterium infection	2005-2010	Ghana
3	Happi, Christian T	University of Ibadan, Nigeria	R03	Molecular Determinants of *P. falciparum* Resistance to ACTs in Nigeria.	2007-2010	Nigeria
4	Charurat, Manhattan E	University of Maryland, Baltimore	R01	Acute HIV Infection and Pregnancy	2009-2013	Nigeria
5	Cohen, Alexander; Gureje, Oyewusi	London School of Hygiene and Tropical Medicine, UK	R21	Scaling up services for people with psychosis in Nigeria: a pilot study	2011-2013	Nigeria
6	Wonodi, Ikwunga	University of Maryland, Baltimore	R21	A Genetic Study of Schizophrenia Endophenotypes in Sub-Saharan Africans	2011-2013	Nigeria
7	Slusher, Tina	Minneapolis Medical Research Association	R21	Determining Prevalence of Acute Bilirubin Encephalopathy in Developing Countries	2012-2013	Nigeria
8	Aliyu, Muktar H.	Vanderbilt University	R01	Optimizing PMTCT services in rural North-Central Nigeria	2012-2013	Nigeria
9	Ezeanolue, Echezona	University of Nevada, Las Vegas	R01	Comparative Effectiveness Of Congregation and Clinic-Based Approaches to PMTCT	2012-2013	Nigeria
10	Debaun, Michael; Aliyu, Muktar H; Jordan, Lori	Vanderbilt University	R21	Primary Prevention of Strokes in Nigerian Children with Sickle Cell Disease	2012-2014	Nigeria
11	Afrane, Yaw Asare	University of Ghana, Ghana	R01	Impact of Insecticide Resistance on the Behavior and Fitness of Malaria Vectors	2012-2014	Ghana
12	Blattner, William; Charurat, Manhattan E	University of Maryland, Baltimore	R01	Network-Based Recruitment of MSM into HCT, Care, Treatment and Prevention Services at Trusted Community-based Venues (TRUST)	2012-2016	Nigeria
13	Obaro, Stephen	University of Nebraska	R01	Global Genomic and Proteomic Profiling of African Children with Typhoid Fever	2012-2016	Nigeria
14	Wilson, Michael	Noguchi Memorial Institute for Medical Research, Ghana	R01	Epidemiology and Molecular Mechanisms of Anti-Helminthic Treatment Failure in Kintampo	2012-2017	Ghana
15	Kwara, Awewura	Miriam Hospital	R01	Pharmacokinetics of Anti-tuberculosis and Antiretroviral drugs in Children	2012-2017	Ghana
16	Paintsil, Elijah	Yale University	R01	A Bio-ecological Pediatric HIV Disclosure Intervention in Ghana "SANKOFA"	2012-2017	Ghana
17	Awandare, Gordon Akanzuwine	Noguchi Memorial Institute for Medical Research, Ghana	R01	Role of Complement Receptor 1 in Erythrocyte Invasion by *Plasmodium Falciparum*	2012-2017	Ghana
18	Pascual, Mercedes; Day, Karen; Koram, Kwadwo	University of Michigan	R01	Impact of Seasonality and Vector Control on Population Structure of *P. falciparum*	2013-2016	Ghana

(*continued on next page*)

Table 2. continued

	Principal Investigator(s) (PIs)	PI's Institution (Institution awarded the grant)	Grant Type*	Title of Study	Duration of Award	Country of implementation
19	Ghansah, Anita	Noguchi Memorial Institute for Medical Research, Ghana	R01	Impact of Distinct Eco-epidemiology on malaria drug resistance in Ghana	2013-2018	Ghana
20	Postels, Douglas	Michigan State University	R21	Viral Co-Infections in Cerebral Malaria: Preparing for Clinical Trials	2014-2017	Ghana
21	Charurat, Manhattan E	University of Maryland, Baltimore	R01	Microbiome Affects Risk of Growth in HIV-exposed but Uninfected Infants in Nigeria (MARGIN)	2014-2019	Nigeria
22	Ghiran, Ionita Calin	Beth Israel Deaconess Medical Center	R21	Malaria screening in Resource-poor Settings Using a Simple, Power-free, Cellphone-friendly Device	2015-2016	Nigeria
23	Ovbiagele, Bruce	Medical University of South Carolina	R21	Phone-based Intervention Under Nurse Guidance after Stroke	2015-2017	Ghana
24	Ezeanolue, Echezona	University of Nevada, Las Vegas	R21	Point of Delivery Prenatal Test Results Through mHealth to Improve Outcome	2015-2017	Nigeria
25	Debaun, Michael; Aliyu, Muktar; Galadanci, Najibah; Jordan, Lori	Vanderbilt University, USA	R01	Primary prevention of stroke in children with SCD in Sub-Saharan Africa II	2015-2020	Ghana, Nigeria
26	Afrane, Yaw Asare	University of Ghana Medical School, Ghana	R01	Impact of Insecticide Resistance on the Behavior and Fitness of Malaria Vectors	2016-2021	Ghana
27	Ezeanolue, Echezona; Onoka, Chima	University of Nevada, Las Vegas	R01	Intervention for Sustained Testing and Retention (ISTAR) among HIV-infected patients	2016-2021	Nigeria
28	Ezeanolue, Echezona; Sam-Agudu, Nadia	University of Nevada, Las Vegas	R01	Adolescent Coordinated Transition (ACT) to Improve Health Outcomes among Nigerian HIV-positive Youth	2016-2021	Nigeria
29	Charurat, Manhattan E	University of Maryland, Baltimore	R01	Building TRUST	2016-2021	Nigeria
30	Tepper, V; Charurat, Manhattan E; Ekong, Ernest E	University of Maryland, Baltimore	R01	The Adolescent to Adult Patient-Centered HIV Transition study (ADAPT)	2016-2021	Nigeria

HCT, HIV counseling and testing; MSM, men who have sex with men; PMTCT, prevention of mother-to-child transmission of HIV; SCD, Sickle Cell Disease; UK, United Kingdom.

* R01, Research Project Grant; R03, Small Research Grant; R21, Exploratory/Developmental Research Grant.

140,000 cedis (~US $2,000-$35,000; J.O. Gyapong, personal communication 2016). Some private tertiary institutions also provide seed grants for their faculty for research, and research organizations also have internal grants for master's and PhD students and junior faculty to be sourced competitively.

The purpose of these grants is to support up-and-coming scientists to undertake research for their degrees or help establish them as independent researchers. Unfortunately, the availability of these funds is neither consistent nor universal, and faculty and trainees who are not able to source these funds often have to use their own funds, source from private donations, and/or conduct poor-quality research due to limited funds.

Aside from academic institution–generated funds, some support is available to Ghanaian researchers from the government. The Ministry of Environment, Science, Technology, and Innovation has funds available for piloting innovative ideas, for implementation research, and for transfer of technology to communities and industry.[17] Additionally, the Health Research Unit of the Ghana Health Service and the Ministry of Health have funds available for operational and implementation research in health. Similar to these, the Ghana AIDS Commission intermittently has funds available to researchers for HIV-related research.

Private, for-profit organizations and industries in Ghana provide support for research, however, again,

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the consistency of these funds is not guaranteed and information not comprehensive and well cataloged.

Financial institutions have also participated in funding local research in Ghana, albeit again, not consistently. Proactive scientists with innovative research ideas are able to source funding from financial institutions. For example, the Ghana Commercial Bank, Ecobank Ghana Limited and CAL Merchant bank have funded several investigator-initiated research proposals from the University of Ghana Medical School (A.A. Adjei, personal communication 2016). Since 2006, the Ghana Reinsurance Company Limited has provided small grants up to 23,000 cedis (~US $5,750) to several local institutions to support health research conducted by postgraduate students.[18]

Overall, the local research in Ghana is underfunded compared to what is available in highly resourced countries. However, the next most important issue is that the few available funding streams appear largely disjointed and inconsistent, and information on these opportunities is neither readily available nor comprehensive. This creates a situation where access to the already limited funding is inadequate, and researchers are likely missing opportunities to write grants, win awards, and develop their skills.

Local Research Funding Sources in Nigeria. Research has always been a criterion for promotion in Nigerian universities. However, much like the situation in Ghana, research has not been adequately funded, and obtaining information on sources of local funding is difficult and slow.

Due to the lack of robust funding from the federal government, out-of-pocket funding still remains the main mode of research financing for many trainees and faculty in Nigerian universities.[19,20] Research funding was almost exclusively sourced from international sources until the federal government established the Tertiary Education Trust Fund (TETFund) in 1993. The TETFund is funded through a 2% tax on profits of all registered companies in Nigeria and is the largest local source of research funds in Nigeria, providing awards up to 50 million naira (~US $158,800) per successful application. The first set of grants was awarded in November 2013 to the tune of 2.6 billion naira (~US $8.25 million) to 13 researchers. Of these 6, 3 awards were human health related. In 2014, there was no allocation, and in 2015, there were 65 awards of which 8 were health related.[21]

In addition to research protocol awards, TETfund supports both federal and state universities for staff development. A portion of this fund is used for supporting research within the universities. The University of Nigeria Nsukka, for example, disbursed 31,820,000 naira (~US $101,000) from TETfund sources in 2015 for research; 11,070,000 naira (35%; ~US $35,000) was spent on health sciences but none on communicable diseases. Much like in Ghana, some Nigerian universities are able to provide research support from internally generated funds. For example, the University of Lagos has been providing internally generated research funds since the late 1990s, and faculty can access up to 3 million naira (~US $9,523) for research.

Pharmaceutical industries have supported research in the universities, but these have often been to facilitate market penetration of their drugs through clinical trials. Nigerian branches of large international pharmaceutical companies such as Glaxo Smith Kline,[22] Astra Zeneca,[23] and Pfizer,[24] have supported clinical trials and other research in Nigeria.

Aside from local branches of international pharmaceutical companies, local foundations have also supported research, but these opportunities have been few and often not sustained. One of the largest private sources of health-related funding is the TY Danjuma Foundation, established in 2009 with funding from a local philanthropist. To date, the Foundation has provided more than 2 billion naira (~US $6.4 million) to fund nearly 150 projects in community health and education programs.[25] Unfortunately, the TY Danjuma Foundation does not fund research projects, and therefore this resource cannot be tapped into for global health research at this time.

There is no doubt that over the past 10 years, local funding for research has improved in Ghana and in Nigeria, but available information is not well catalogued, and therefore it is difficult to fully understand the scope of funding. Furthermore, there has been poor response of researchers to calls for proposals, even for the limited local funding. Some of the reasons include:

- Poorly executed and limited dissemination of information on funding opportunities to the appropriate audience;
- Poor training and mentoring for research, and therefore low confidence in and poor preparation for timely response to the calls;
- There is often a high rejection rate of research proposals without adequate constructive feedback. This unfortunately feeds an often-held notion that local grant review processes are not objective and are skewed toward well-established or well-connected

academics. As a result, junior scientists and faculty feel discouraged in responding to calls for proposals.

Regardless, international grant awards are still the major drivers of research, including global health research, in the 2 countries.

Research Training and Capacity Development in Ghana and Nigeria. The 2 main problems plaguing research and development (R&D) in Africa are: (1) low numbers of researchers in R&D and (2) low percent of gross domestic product (GDP) spent on research, research training, and career development. Most African countries continue to spend <0.4% of their GDP for research and development,[11,26] despite a target for each nation to spend 1% of its GDP on R&D endorsed by members of the African Union in 2006.[27] This low level of public funding is reflected in the limited availability of local public funds in Ghana and Nigeria, as discussed in the previous section.

In 2010, the United Nations Educational, Scientific, and Cultural Organization Institute for Statistics estimated that most African countries had <100 researchers per 1 million people.[28] Not surprisingly, the rise in research publication output from Africa has been slow. In 1996 and 2009, sub-Saharan African researchers produced roughly 0.8% and 1% of the total papers in the Scopus database, respectively.[11] High-quality research, particularly locally driven research,[29] is needed to identify the health needs of a locality, inform strategies to improve health outcomes,[30] and increase the representation of African investigators in scientific publications.

African researchers cannot appreciably contribute to global health evidence generation without producing impactful research; however, the quality of research is inextricably linked to the capacity of the researchers. In the last 2 decades, in part due to persistent and devastating epidemics, we have seen an unprecedented commitment of the international community to develop research capacity in sub-Saharan Africa.[31–35] Many overseas governmental and nongovernmental agencies are partnering with African countries to develop their research capacities.[9,36] Examples of these agencies include the US NIH, the Wellcome Trust, the World Health Organization (WHO) Special Programme for Research and Training in Tropical Diseases (TDR), the Multilateral Initiative on Malaria (MIM), the Global Forum for Health Research, the European and Developing Countries Clinical Trials Partnership (EDCTP), the Netherlands-African Partnership for Capacity Development and Clinical Interventions of Poverty-Related Diseases (NACCAP), and the Bill and Melinda Gates Foundation. The main vision of these agencies is to create equitable and sustainable south-south and north-south partnerships and networks between institutions, although their missions differ.

The Wellcome Trust traditionally funds master's and PhD programs in several health disciplines as part of institutional or research grants.[13] The WHO TDR supports individual career development and institutional research capacity strengthening. Although TDR provides hands-on skills throughout the research continuum, most of their training grants also emphasize traditional master's and PhD training programs. The MIM aims to strengthen and sustain, through collaborative research and training, the capacity of malaria-endemic countries in Africa to conduct research that will lead to control and eradication of malaria.[37] The EDCTP provides grants that focus on clinical trials as the core while providing opportunities for networking and strengthening research capacity in HIV/AIDS, malaria, and tuberculosis.[38–41] The NACCAP builds research capacity between several sub-Saharan African academic institutions with support from Dutch partners.[42]

Most researchers in Africa obtain their PhDs from outside institutions, and scholarship and postdoctoral training is usually not part of the package. These academics go back to their home countries immediately after their PhDs without learning how to navigate research independence and project management and governance. In 2011, the Bill and Melinda Gates Foundation funded the first-ever postdoctoral training program in Ghana at the Noguchi Memorial Institute for Medical Research, University of Ghana.[43] The main objective of the program is to build a critical mass of young African scientists and equip them to compete effectively for international funding for research in their countries.

The Wellcome Trust has also augmented this initiative through its Developing Excellence in Leadership, Training and Science (DELTAS) Africa program, which in 2015 awarded a grant to the West African Centre for Cell Biology of Infectious Pathogens at the University of Ghana.[44] This 5-year grant will support the training of PhD students and postdoctoral fellows at the University of Ghana and other partner institutions in West Africa. Due to the availability of robust data, the rest of this section focuses on NIH research capacity building in Ghana and Nigeria after having mentioned in brief, the other funding agencies.

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NIH-Funded Research Capacity Building in Ghana and Nigeria. The NIH currently provides support for research training and capacity building in Nigeria and Ghana through initiatives like the Fogarty Global Health Training Program for Fellows and Scholars (RFA-TW-11-001)[45] and Fogarty HIV Research Training Program for low- and middle-income institutions (PAR-13-126).[46] The purpose of these programs is to support research-training activities to strengthen the scientific capacity of institutions in LMICs to conduct global health or HIV-related research.

A search in the NIH's Reporter[10] using the terms "training grants" and "Nigeria" or "Ghana," as well as a similar search in the Fogarty International Center's grants database[47] yielded a list of 43 research education, training, and capacity-building grants implemented in the 2 countries (Table 3). The search was limited to grants awarded and/or implemented between 2005 and 2016. The training grants listed focused on building research capacity in Ghana, Nigeria, or several African countries for research in multiple human diseases and postdoctoral and junior faculty training in education and research.

Other grants listed, such as K-series awards, provide support for research training and career development of junior- to mid-level faculty or independent investigators to conduct locally relevant health research in nutrition or chronic noncommunicable diseases. For D43 grant types, requirements stipulate that training programs propose a long-term master's or PhD degree training, medium-term research-driven training, and short-term in-country workshops designed to build skills to enhance research capacity. These grants provide critical support to local master's and PhD graduate students who otherwise would have to personally fund their thesis and dissertation research because of little to no institutional support.

Aside from D43-type grants, R25 education grants provide opportunities for pursuing interests in biomedical research and in enhancing capacity, and these are also listed in Table 3. A bioethics-focused R25 grant, funded since 2004, provides comprehensive bioethics training to researchers as well as members of ethics committees in Nigeria. In addition, 2 other R25s involve specialized training programs, one using information and communications technology resources to enhance cardiovascular training in Ghana, and the second provides training in experimental and translational hematology for graduate students, postdoctoral scientists, and junior faculty investigators from several institutions, including the Universities of Ghana and Ibadan. The local and US institution collaboration requirements for the NIH training grants establishes a potentially long-term and mutually productive partnership for faculty and trainees for all institutions and countries involved.

Evaluation of the Success of Training Grants and Programs in Ghana and Nigeria. Although literature abounds in initiatives to improve and sustain research capacity in African countries,[5,12,48–61] systematic evaluation of the impact of these initiatives is limited. Most programs report impact or achievement only by count: the numbers of researchers trained, the number of publications resulting from the training, and the numbers of independent funding obtained by the beneficiaries. The Fogarty International Center aims to go beyond these measures of outputs in their program evaluations through the use of a program logic model and often captures more nuanced stories of capacity built via case studies from grantees.

Mugabo et al[62] recently reported that only a few research training programs in Africa used a recognized, systems-approach framework (ie, assessing capacity at individual, organizational, and systems level) for evaluation. The evaluation of impact of research capacity building should depend on the areas of research competencies addressed. Therefore, a one-size-fits-all approach may not be applicable. However, adaptation of evaluation tools such as Cooke's framework[63] and the logical model could be used. Cooke's framework[63] has 2 dimensions: (1) 4 structural levels of development activity, including individual, team, organizational, and the network or supraorganizational support level and (2) 6 principles of capacity building—building skills and confidence, developing linkages and partnerships, ensuring the research is "close to practice," developing appropriate dissemination, investments in infrastructure, and building elements of sustainability and continuity. Cooke's framework[63] could be organized into a logical model proposed by Marjanovi et al[64] for comprehensive evaluation of the impact of the research capacity building programs as illustrated in Figure 1.

Adopting the Multiple-PI Approach in Research Capacity Building. The NIH describes its multiple-PI model as a mechanism for multidisciplinary and collaborative health research among equals, when that is the most appropriate way to answer a scientific question.[65] The NIH adopted the multiple-PI model in 2006 in a bid to stimulate interdisciplinary science for selected grant applications. This

Table 3. NIH-Funded Research Training, Education, and Capacity-Building Grants Implemented in Ghana and Nigeria, 2005 to 2016

	Principal Investigator(s)	Grant Type*	West African Partner(s)	US Partner(s)	Focus Area	Duration of Award
1	Essex, Myron Max	D43	Nigeria and Senegal	Harvard School of Public Health	HIV/AIDS training and research	1993-2013
2	Blattner, William	D43	Institute of Human Virology Nigeria, Nigeria	University of Maryland Baltimore	HIV/AIDS training and research	1998-2015
3	Adebamowo, Clement Adebayo	R25	University of Ibadan and collaborating institutions, Nigeria	University of Maryland Baltimore	Bioethics training	2004-2017
4	Mock, Charles N	D43	Kwame Nkrumah University of Science and Technology, Ghana	University of Washington	Injury-related health research	2005-2016
5	Adebamowo, Clement Adebayo	R25	University of Ibadan	Not applicable	Cancer in Africa	2006-2008
6	Murphy, Robert	D43	University of Ibadan & University of Jos, Nigeria; University of Bamako, Mali	Northwestern University	HIV and TB research training	2008-2013
7	Robins, Thomas G	R24	University of Ghana, Kwame Nkrumah University of Science and Technology; Ministry of Health, Ghana	University of Michigan	Postdoctoral research training	2010-2012
8	Cu-Uvin, Susan	D43	University of Ghana, Ghana	Brown University	HIV/AIDS training and research	2010-2015
9	Olaleye, David Olufemi	D43	6 Nigerian Universities: Universities of Ibadan, Lagos, Jos, Nigeria, Maiduguri and Ahmadu Bello University Zaria.	Harvard and Northwestern Universities	Optimizing medical education curriculum, research training	2010-2015
10	Donkor, Peter	D43	Kwame Nkrumah University of Science and Technology, Ghana	University of Michigan	Emergency medicine training	2010-2015
11	Owoaje, Eme Theodora	G11	University of Ibadan, Nigeria	Not applicable	Research administrative infrastructure	2010-2016
12	Ogedegbe, Gbenga; Cooper Richard Stanley; Binka Fred, Amoah, Albert	D43	University of Ghana School of Public Health, Noguchi Memorial Institute for Medical Research, Ghana	New York University	Chronic, non-communicable diseases and disorders, research training	2011-2016
13	Adebamowo, Clement Adebayo	D43	University of Ibadan	University of Maryland Baltimore	Chronic, non-communicable diseases and disorders, research training	2011-2016
14	Gureje, Oyewusi	U19	University of Ibadan, Nigeria	Not applicable	Mental health	2012-2013
15	Abimiku, Alash'le	UH2	Institute of Human Virology Nigeria, Nigeria	Not applicable	Biorepository initiative	2012-2015
16	Ogunniyi, Adesola; Epstein, Leon G; Ragin, Ann B; Sammet, Steffen	R25	University of Ibadan, Nigeria	Not applicable	Neurologic outcome measurement	2012-2016
17	Adu, Dwomoa ; Ojo, Akinlolu Oluseun	U54	Noguchi Memorial Institute for Medical Research, Ghana	Not applicable	Kidney disease research	2012-2017
18	Ampofo, William Kwabena	U01	Noguchi Memorial Institute for Medical Research, Ghana	Not applicable	Influenza and other respiratory infections	2012-2017

(*continued on next page*)

Table 3. continued

	Principal Investigator(s)	Grant Type*	West African Partner(s)	US Partner(s)	Focus Area	Duration of Award
19	Olopade, Olufunmilayo F; Olapade, Christopher O	D43	University of Ibadan, Nigeria	University of Chicago	Chronic non-communicable diseases	2012-2017
20	Dewey, Kathryn G	D43	University of Ghana, Ghana	University of California at Davis	Nutrition and chronic diseases	2012-2017
21	Robins, Thomas	D43	Kwame Nkrumah University of Science and Technology; Ministry of Health, Ghana	University of Michigan	Global health research capacity for innovation	2012-2017
22	Idigbe, Emmanuel	U01	Nigerian Institute of Medical Research, Nigeria	Not applicable	HIV drug resistance	2013-2015
23	Adebamowo, Clement Adebayo	U54	Institute of Human Virology Nigeria, Nigeria	Not applicable	Microbiome and genetics research	2013-2017
24	Happi, Christian T	U01	Redeemer's University, Nigeria	Not applicable	Determinants of febrile illness	2013-2017
25	Owolabi, Mayowa Ojo; Ovbiagele, Bruce	U54	University of Ibadan, Nigeria	Not applicable	Stroke	2013-2017
26	Taiwo, Babafemi O; Robertson, Kevin R	D43	University of Ibadan, Nigeria	Northwestern University	NeuroAIDS research training	2013-2018
27	Murphy, Robert L	D43	Northwestern Global Health Foundation, Nigeria	Northwestern University at Chicago	Biomedical engineering	2013-2018
28	Adebamowo, Clement Adebayo	U01	Institute of Human Virology Nigeria, Nigeria	Not applicable	Indigenous and cultural concepts of genomic research	2014-2017
29	Murphy, Robert L; Hou, Lifang	D43	University of Jos, Nigeria	Northwestern University	AIDS malignancies	2014-2019
30	Adedeji, Adebayo Abel	U19	Federal Ministry of Health Nigeria	Not applicable	Public Health	2014-2019
31	Olaleye, David Olufemi Adewole, Isaac F	D43	University of Ibadan, Nigeria	Harvard School of Public Health, Northwestern University	Junior faculty research training	2015-2020
32	Sagay, Atiene Solomon	D43	University of Jos, Nigeria	Harvard School of Public Health, Northwestern University	Training and mentoring for academics	2015-2020
33	Ogunsola, Folasade Tululope	D43	University of Lagos College of Medicine, Nigeria	Harvard School of Public Health, Northwestern University	Research and innovation	2015-2020
34	Robins, Thomas; Fobil, Julius N	U2R	Kwame Nkrumah University of Science and Technology, Ministry of Health, Ghana	University of Michigan	Occupational and environmental research training	2015-2020
35	Wall, Stephen P	R25	University of Ghana, Ghana	New York University	Information and communication technology for cardiovascular research training	2015-2018
36	Fobil, Julius Robins, Thomas G	U01	University of Ghana, Ghana, Kwame Nkrumah University of Science and Technology, Ghana Ministry of Health, Ghana Health Service	University of Michigan	Training and research in occupational and environmental health	2015-2020

(*continued on next page*)

Table 3. continued

	Principal Investigator(s)	Grant Type*	West African Partner(s)	US Partner(s)	Focus Area	Duration of Award
37	Ogunsola, Folasade Tolulope	D43	University of Lagos, Nigeria	Harvard School of Public Health, Northwestern University	Junior faculty research training	2015-2020
38	Sagay, Atiene Solomon	D43	University of Jos, Nigeria	Harvard School of Public Health, Northwestern University	Junior faculty research training	2015-2020
39	Olalaye, David Olufemi; Adesola, Ogunniyi	D43	University of Ibadan, Nigeria	Northwestern University	Junior faculty research training	2015-2020
40	Zakariah, Afisah	U19	Ghana Ministry of Health, Ghana	Not applicable	Public health	2015-2020
41	Kwara, Awewura Jacob	D43	University of Ghana, Ghana	University of Florida	Tuberculosis and HIV research	2016-2020
42	Oladeji, Bibilola	K43	University of Ibadan, Nigeria	University of Washington	Perinatal depression	2016-2020
43	Charurat, Manhattan E; Abimiku, Alash'le G	D43	Institute of Human Virology Nigeria, Nigeria	University of Maryland Baltimore	Epidemiology research training	2016-2021

Abbreviations as in Table 1.

* D43, International Research Training Grant; G11, Resource Programs-Extramural Associate Research Development Award; K43, International Research Career Development Award; R24, Resource-Related Research Project; R25, Research Education Project; U01, Research Project Cooperative Agreement; U2R, International Research Training Cooperative Agreement; U19, Research Program-Cooperative Agreement; U54, Specialized Center-Cooperative Agreement; UH2, Exploratory/Developmental Cooperative Agreement.

model for research funding applications fits well into the collaborative aspect of global health as described by Beaglehole and Bonita.[2] The NIH has established the multiple-PI model as follows[65]:

- The need for multiple PIs has to be justified in the application.
- It requires a leadership plan describing the roles, responsibilities, and working relationship between the PIs.
- All PIs share equal responsibility and authority for leading the study.
- One PI is designated the contact PI for the purpose of communications with the funder.
- Awards involving multiple PIs at different institutions are managed using subcontracts.
- There is no limit to the number of multiple PIs for NIH applications; however, the inclusion of each PI should be justified. The most successful multiple-PI protocols have only 2 to 3 PIs.

Other major research funding sources, such as the Wellcome Trust, have adopted similar multiple-PI options for selected grant applications.[66] This strategy accelerates the development of independent researchers and maximizes the establishment of a critical mass of competent mentors prepared to build research capacity for local up-and-coming scientists.

Remaining Gaps that Need Addressing. West African research capacity and productivity gaps will not be closed without the building, establishment, and maintenance of adequate research infrastructures (RIs). RIs refer to facilities, resources, and related services used by the scientific community to conduct maximal-impact research. RIs are at the center of the knowledge triangle of research, education, and innovation, producing knowledge through research, diffusing it through education, and applying it through innovation.[67] These RIs can be unique to an institution, distributive across a country or region, eg, Ghana, Nigeria, or West Africa, or can be virtual, to allow true international collaboration and cooperation.

New knowledge and, by implication, innovation, can only emerge from high-quality and accessible RIs.[67] Besides team building, networking, and personal exchanges, the RIs are to create data resources with effective exploitation of the data for PIs, their mentees, and future generations. National and regional research priorities can be set or revised within the RIs and allow for meaningful adaptation and implementation from the respective countries and/or to global health.

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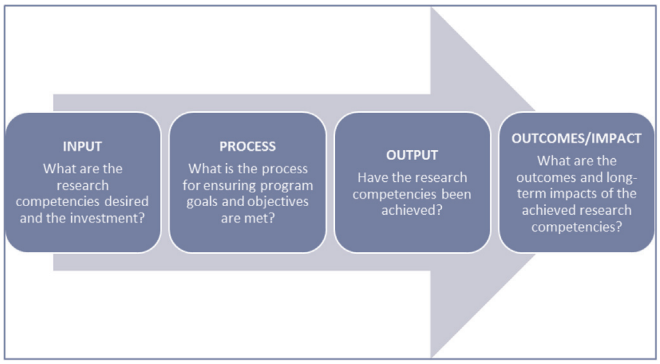

Figure 1. Logic Model for Evaluation of Research Capacity-Building Programs and Initiatives.[63,64]

Based on the narrative findings in the previous sections, we find that in the 2 countries, there exists a lack of capacity to compete for international and local funding, limited sources of sustainable, local funding opportunities, and limited production of impactful publications (that in turn make bidding for grants more successful). Underlying these issues are research environments that lack a systems approach to evaluation and that struggle to maintain a critical mass of competent and dedicated local mentors to produce the subsequent successive generations of independent investigators.

Additionally, challenges with access to scientific literature, payment for publication in high-impact journals, and support to attend regional and international conferences limit exposure to the global scientific community and, therefore, academic growth for researchers who may not yet be supported by large grants. Finally, weak research-environment academic institutions need to develop and/or strengthen their research environments in order to attract research funding, especially from foreign funders.

Strengthening these research environments is a long-term endeavor that includes establishing availability of institutional support (eg, experienced and competent finance and grants management services), equipment (eg, well-supplied and staffed biomedical laboratories), and other physical resources (eg, database and data storage support). All of the aforementioned issues are structural-level barriers that cannot be minimized or eliminated without institutional and country-level RI solutions.

Bridging the Gaps for Research Capacity Building in West Africa. There is a need to move along multiple fronts, simultaneously, to create a large positive paradigm shift with regard to the volume and impact of West Africa's contributions to research evidence in global health. The regional approach will provide built-in efficiencies for the utilization of limited resources and funding and avoid fragmentation. It also ensures a wider collaboration for relatively rapid bursts of meaningful research output within a short time span. Based on experience, lessons learned, review of the literature, and exposure to successful models, we recommend the following institutional and country-level recommendations:

- Ensure consistent and sustainable private and public fund generation for supporting global health research: This includes providing accessible, sequestered, public-level funding as well as lobbying private foundations to direct or increase funding for local health research.
  Funded projects should be selected through a fair and transparent competitive process.
- Develop standards for mentorship and scientific development and productivity at both the graduate and postgraduate level in addition to increasing funding.
- Create more opportunities for long-term research capacity development: Beyond using traditional training programs to develop researchers, we recommend deliberate integration of high-level mentored research training into current and future funded local and foreign research projects. The multiple-PI mechanism is one such strategy.
- Ensure steady availability of active, competent, and motivated research mentors at research institutions. Only active, engaged, and competent mentors can develop vibrant, successful, independent researchers. There is an unacceptable shortage of West Africa–based faculty mentors with adequate expertise and academic maturity to mentor young investigators.
- Development and strengthening of regional RI to provide and disseminate all of the above strategies and

opportunities: Regional RIs can facilitate standardization, protocol sharing, collaborative agreements, ownership/access to information, dissemination, and licensing/patents if any economic benefits do arise to allow sustainability. This may include the development of a regional consensus panel series such as the NIH consensus panel and publications of meta-analyses, systematic reviews, and comparative syntheses that summarize the state of the science, public health, and social science relating to the region. Regional RI development can be facilitated by patronization of available platforms, such as the National and Regional Research and Education Networks[68]; the West and Central African Research and Education Network[69] (members include the Ghana Academic and Research Network[70] and the Nigeria Research and Education Network[71]).

CONCLUSIONS

Ethically and practically, the collective response to global health problems requires the participation and collaboration of populations and countries that bear the burden of these diseases. Unfortunately, much like in West Africa, many of these countries are significantly resource limited in both funding and human capital to conduct research and contribute evidence for disease control and eradication. While sub-Saharan Africa as a whole has challenges in this regard, West Africa as a region has more ground to cover in forming functional, durable collaborations and infrastructure for impactful evidence generation. While some funding, training, and collaborative opportunities exist, these opportunities need to be strengthened, consolidated, transparent, well publicized, and supported at institutional and national levels.

The relationship between local disease control and global health is at best bidirectional, interdependent, and mutually beneficial. Evidence generated from outside West Africa can be and is being contextualized and applied for local health. However, West Africa should increase its capacity to generate new knowledge locally that can be integrated into global health and implemented on a much wider scale outside the region. Global health goals and priorities often overlap with local health needs, especially in developing countries. Global health, therefore, should strengthen the drive to achieve the best outcomes for local health, and vice versa, and West Africa should be poised and ready to participate in this exchange.

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