



## Physiology Research in Africa: Current Trends, Challenges, and Future Directions

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### ABSTRACT

The growth in physiology education and research in Africa over a century ago has been characterized by the continent's unusual chronicle. To satisfy the human insatiable quest for knowledge, it is necessary and unavoidable to engage in research which is a complex scientific enterprise. However, factors that include physical, political, socio-economic, legislative, and educational environmental play pivotal roles in research processes directly or indirectly. Despite the major issues facing us, this era predicts rapid progression in medical education, research, and quality healthcare delivery in Africa. This review aims to provide an overview of the current trends in physiology research in Africa, the challenges facing it, and proffer possible solutions for future directions. With the constant evolution of *in vitro*, *in vivo* and *in silico* experimental models, the need for continuous training of motivated young scientists in these fields is imperative to cope with the fast-rising research trends. Recent data have demonstrated a huge rise in the use of computer-based systems and web-based technologies in physiology research globally. Nevertheless, some of the challenges faced by physiology research include funding, expertise, regulations, and laws guiding the use of experimental models. Furthermore, the demand for international collaborations, industrial links, and public support for physiology and biomedical research in Africa cannot be overemphasized.

**Key words:** Africa, Challenges, Physiology, Research

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### INTRODUCTION

Africa consist of 54 countries with a human population of approximately 1.3 billion as of 2018, thereby accounts for about 16% of the world's human population [1]. There are about 2600 medical schools globally, with nearly 200 in Africa representing an estimate of one school per 5.0 million population [2]. The growth in medical education in Africa over a century ago has been qualified by the continent's unusual chronicle [3-10]. Despite the major issues we have faced, this era predicts rapid progression in medical education and quality healthcare delivery in Africa [6], [7].

In driving the endless limits of the human

insatiable quest for knowledge, it is necessary and unavoidable to engage in research which is a complex scientific enterprise. Important factors such as the physical, legislative, social, political, economic, and educational environments play fundamental roles in the research process directly or indirectly. These factors have profound consequences on the feasibility, success, advancement of scientific projects, and their application in society or otherwise. These conditions differ greatly between countries around the globe.

Normally, every nation should furnish its research base with maximal support via adequate and competitive funding. This includes smooth coactions to exchange knowledge and technical know-how, and aid for academic and industrial efforts synergistically [8]. A working relationship may also be established between developed and developing countries to boost the development of critical research infrastructures,

expertise, and knowledge. These efforts will promote local and international research collaborations and partnerships, which tends to establish an effective and functional research scheme that will also be of immense value to the larger society.

With the constant evolution of *in vitro*, *in vivo*, and *in silico* experimental models, continuous training of motivated young scientists in these fields is imperative. This will in no small measure help to bridge the gaps and shortage in technical know-how, resources, and information base. Besides, physiological societies from different regions of the world should also encourage its members to endeavor to carry out their research following the global conduct of research in physiological sciences. This can be achieved via organizing scientific conferences, symposia, workshops, and meetings. This review aims to provide an overview of the current trends in physiology research in Africa, the challenges facing it, and proffer possible solutions for future directions.

#### Current trends in physiology research

##### Use of computer-based systems in physiology research

Considerable interests had aroused recently regarding the various ways in which the conduct of research in physiology can be enhanced with the use of computers. The use of computer-based data acquisition systems in life and biomedical sciences have widely substituted antique oscilloscopes, kymographs, chart recorders, and polygraphs resulting from its' ease of use, cost, size, care, and consumables; and have been reported to enhance research and contextual learning of basic scientific concepts [11].

Computer-based data acquisition systems now offer novel opportunities for recording data in physiology research and experiments. Notable among these computer-aided hardware and software systems is the PowerLab system developed by AD Instruments (Dunedin, New Zealand) [12]. There is a widespread increase in the awareness level of researchers concerning these systems and are now employed in research laboratories and healthcare institutions across Africa.

##### Use of web-based technology in physiology research

The importance of web-based technology to African research and researchers cannot be

over-emphasized. It has been immensely useful in stimulating researchers' discussions of difficult scientific concepts and for supporting knowledge sharing and ideas exchange [8].

An overview of the research publications in the field of physiology in Africa between the year 1996 to 2018, as obtained from Scimago (country rankings) is presented and illustrated in Table 1 and Figure 1 respectively.

#### Challenges facing physiology research

Though remarkable progress has been recorded in the last two decades of physiological research

**Table 1: Showing Scopus indexed particulars physiology publications from Africa from 1996 to 2018.**

Rank	Country	Documents	Citable documents	Citations
1	South Africa	634	574	23313
2	Nigeria	504	491	2201
3	Tunisia	351	328	3103
4	Morocco	56	54	482
5	Algeria	27	23	300
6	Kenya	24	24	346
7	Cameroon	18	18	430
8	Senegal	17	17	278
9	Ghana	16	14	307
10	Sudan	15	15	170
11	Uganda	14	12	222
12	Congo	12	12	150
13	Mozambique	12	10	705
14	Ethiopia	11	11	84
15	Libya	10	10	141
16	Tanzania	10	10	106
17	Benin	10	10	72
18	Côte d'Ivoire	9	8	127
19	Zimbabwe	7	7	475
20	Namibia	6	6	122
21	Gabon	6	6	109
22	Madagascar	5	4	53
23	Rwanda	4	4	46
24	Niger	4	4	31
25	Reunion	4	4	312
26	Botswana	3	3	232
27	Zambia	3	3	212
28	Malawi	2	2	1
29	Burkina Faso	2	2	17
30	Mali	2	2	46
31	Mauritania	2	2	33
32	Seychelles	2	2	83
33	Chad	1	1	1
34	Togo	1	1	0
35	Sierra Leone	1	1	29
36	Saint Helena	1	1	3
37	Angola	1	1	0
38	Mauritius	1	1	3
39	Gambia	1	1	0
40	Democratic Republic Congo	1	1	1
	Total	1810	1700	34346

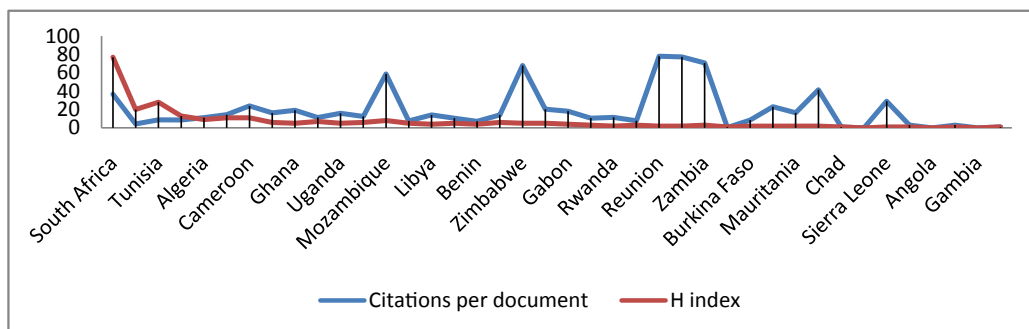


Figure 1: Citations per document and H index of Scopus indexed publications from Africa from 1996 to 2018.

in Africa, a series of challenges have militated against the level at which success would have been recorded.

**Funding**

Most research conducted in physiological sciences in many African countries, especially in sub-Sahara Africa, are impeded by insufficient resources [13-15]. Therefore, most of the researchers depend on personal funds to conduct research. Robust funding from governments, public, donors, and commercial sources helps researchers in no small ways, which include, personnel and infrastructural costs, thereby leading to an increase in research outputs.

The availability and access to funding differ largely around the world contingent upon the economic strengths and government priorities. Most research in physiology is funded by charities or philanthropists. Nevertheless, skill in accessing these funds to undertake research also varies across different nations. Additionally, there are enormous concerns concerning the availability and accessibility of funds to do physiological research in Africa.

The funding position in some countries outside Africa such as Bangladesh, Nepal, Brazil, and Russia had been described to be challenging, largely attributed to economic instability. Similarly, the economic downturn in most African has reflected in reduced funding for universities and scientific endeavors. This adversely affects the access of scientists and researchers to valuable equipment and products required for quality research [14,15]. Furthermore, the scientific exchange programs that usually exist between local/international institutions and universities across the globe have also been severely affected.

Conversely, in few countries such as South

Africa where funds are readily available, there is a problem of accessibility, as few scientists can apply since the funds are limited to targeted areas of research [13-15]. This can be attributed to the perception that basic research is an arcane academic quest with little or no applied value and so does not deserve funding. Related to the former is the timing for the release of these funds causing difficulties in planning and creating a viable and agonistic research process.

The general subject matter represented here is that the state of research funding is all together, becoming more difficult. This is particularly the example of basic research, into which physiological sciences belong. This persists despite developing evidence and recognition that research is required to solve the challenges confronting our present world. There is a possibility that research funds may drastically decline in years to come if economies and governments continue to be stretched farther, and actions are not directed at providing adequate funds [13].

To resolve these funding situations, there may be a need for physiology researchers to formulate a solid evidenced case for the benefits of health, wellbeing, and importantly wealth, granted to countries by a vibrant research base in basic and applied sciences. This effort may gear governments of countries to establish research agencies that will oversee and ensure more effective fund disbursal for basic research [13-15].

**Technical know-how and expertise**

The ability to carry out cutting edge research in physiology demands undeniable access to knowledge and hands-on expertise of advanced systems including computer-modeling techniques. The accessibility of technical

expertise in African countries differs and is distributed at varying rates, which is largely due to available resources and specialization of current research [13-15].

Technical know-how and expertise are readily present and adequate in high-resourced environments in Africa, such as South Africa [14-17]. Some countries possess expertise in various fields but have deficient experience and knowledge in state-of-the-art technology; while others especially small countries have sound expertise only in peculiar disciplines where there is a national specialty.

African countries with better resources and accomplished research infrastructures usually pride themselves in expertise and knowledge in wide ranges of physiological techniques and methodologies. To a good extent, South Africa has a considerable range of expertise that covers almost the entire physiological sciences and employs traditional and cutting-edge tools and techniques for interdisciplinary scientific initiatives [13-15].

However, there are great concerns regarding the decrease in practical skills and applications for animal-based research and *in vivo* techniques, which is attributed largely to cost and difficulty in technical know-how. Thus, there is a high demand for basic training especially for graduates and young researchers in Africa. Furthermore, drastic, and consistent efforts must be put in place to provide specialists in all areas of physiological sciences.

#### **Experimental models**

Experimental models are central to physiological research and their intricacy is fast growing with the latest advances in experimental techniques and genetic techniques (manipulations). The use of experimental models for research in Africa can be discouraging due to available resources and regulations. Most regulations forbid cross border movement of animals, which in turn impedes the growth in the use of experimental animals for research, as there are little or no facilities to accommodate and handle them [14,15].

Although, there exists a wide range of models for use in physiological research to center upon mechanisms of life in invertebrates, complex vertebrates, and humans. There is a need to introduce and embrace novel techniques in basic

research such as the use of *in silico* models, as employed in well-resourced institutions and universities in South Africa. The use of *in silico* models is a huge gain for physiological research; however, it may be limited because of financial constraints. Also, there is a steady growth in the use of animal models such as *Caenorhabditis elegans*, *Drosophila melanogaster*, zebrafish, birds, marmosets, and macaques in brain research. The use of cell culture models which include cell lines is getting more pronounced in many African research laboratories.

#### **Regulations**

Basic and clinical research are performed in physiological sciences all over the world, however under different regulations which can be an encumbrance on the use of animal models. These regulatory structures may be peculiar to individual African countries and usually come with attendant effects. Most countries have national and/or local research ethics committees that are set up to regulate, approve, and supervise all studies carried out using animals or human subjects [13,15].

Some of these regulatory frameworks appear to be too difficult and strict resulting in delays in accessing project licenses and registration. Most countries set up research agencies and ministries, likewise the establishment of the Institutional Animal Care and Use Committee in universities, which oversees the monitoring of animal management in research, research ethics, and other matters relating to occupational safety [13].

In many African nations, ethical clearances are necessary for conducting both animal and human research. However, the strict legislative structures and the constant rise in audit requirements needed to demonstrate conformity with the existing laws are discouraging.

#### **International collaboration**

Mounting evidence has indicated that strong international collaborations result in more valuable and successful science. A metamorphosis of the experiences and in-depth knowledge of the global community is a powerful trademark of contemporary science. Nevertheless, this demands efficient and effective connections, regulations, management, and administration. It is also necessary for the physiological societies



of African nations to formulate collaborative research links and programs between other countries in and outside the continents [13,14]. Research centers having special technical expertise should be known to allow the creation of partnership networks for collaborative research and training purposes. One of the many ways of promoting international partnerships is to establish effective connections with other non-African research organizations via inter-university understanding and possible exchange programs for students and researchers.

Besides, the International Union of Physiological Sciences (IUPS) and most importantly, the African Association of Physiological Sciences (AAPS) can promote international collaboration through the organization of joint symposia/conferences during their annual and/or regional meetings. The development of joint research ties can also occur between two or more physiological societies in African countries [13].

International collaboration should be at the head of research in Africa. The creation of bilateral research links between physiologists and international institutions, renowned study groups, and individual researchers or scientists with local/international research programs and training should be strongly advocated and pursued. Continents such as Europe, Asia, and America play hosts to many big research infrastructures, which are usually available for collaborative research. A typical of such infrastructural facilities are available in specific universities in few countries like South Africa and can be accessed via research collaborations [13-17].

International collaborative research can also be given high priority among African governments through initiatives and funding streams that will drive national research groups to attend to science and health challenges facing the continents. Physiologists in Africa should endeavor to create effective partnership links by initiating investigator-driven collaborations.

#### **Industrial links**

Generally, science is not all about keeping academia, quality research spans across the industrial sector of many nations. The need for strong partnerships and knowledge-sharing between academia and industry cannot be over-

emphasized. Collaborations of these sorts will result in more efficient and effective research outputs and marketing of intellectual holdings. Regulations and environments which can make or mar connections between industry and academia vary from country to country [13].

Regrettably, there is hardly any present aid for research collaboration with industries in most African countries [14]. This may be attributed to strict legislation and the cost implications that will be incurred by each partner to carry out such research, thereby making potential links with industries a great challenge in most countries. Nonetheless, few industries, organizations, and government ministries and parastatals in Nigeria conduct, and/or support science in physiology or related fields of research.

Few physiologists have enjoyed joint research projects with specific industries especially in areas such as basic, clinical, and translational research, while the majority have limited privileges for industrial research partnerships. This may be because most industries either do not provide financial aids for research or they establish their research and development (R&D) laboratories to solve existing and peculiar problems. For instance, researchers in Italy enjoy support from industrial partners, and most Chinese physiologists engage in collaborative studies with industries that specialize in the formulation and development of medical equipment and pre-clinical testing of potential novel drugs and therapeutic agents.

The recent partnership between ADInstruments (New Zealand) and the African Association of Physiological Sciences (AAPS) to support and equip early career researchers in elite research institutions in Africa is highly commendable. This will open channels for possible industry-academia partnerships in government and public-owned laboratories in many African countries in the nearest future. These relationships are aimed at bettering innovation and connecting academia with industry and give room for healthy competition.

#### **Public support for research**

In most African countries, the daily experiences of the public and citizens are far away from scientific research. This may be an issue if the populace does not know the benefits of research

to their health and daily life, rather see it as careless experimentation or mere pet projects. In some clines, the use of animals for research can be open to public outrage.

The absence of awareness and talks between basic science researchers and the public produces society's misconception of physiology, thus few prospective students choose to study physiology. Therefore, more partnerships via health education between physiological research and societal practice are highly encouraged. There is a need to enhance the understanding of the long-term significance of basic research that is not directly connected to any immediate benefits to the public.

In most African countries, societal issues surrounding basic research centers on the use of animals, humans, or genetically modified organisms instead of the details of the research. However, the current trend in stem cell research may change the tide. The action of animal rights activists in certain countries such as India is a leading hindrance to basic research regarding animals, so many students avoid basic research and opt for clinical or patient-directed studies [13].

Despite the low perceptions of the public to the need for basic research, the pressure mounted by environmental and societal problems like global warming, metabolic diseases, environmental pollution amongst others has propelled African researchers to deal with these challenges via scientific pursuits. Though there is public support for basic research in few African countries like South Africa [13,15-17], political will and blessing are falling as evident through reduced funding support from the government.

Public participation and engagement with science is the goal of expanding local, national, and international support for research activities. The level of public participation in most African countries is affected by general literacy levels, media views or reports of research and science, and the degree of educational outreach and sensitization.

There is an urgent need to build all efforts together to create scientific engagement and participation among the populace. This is particularly important for the physiology discipline as it has been enveloped by "biology"

due to little or no public recognition. Massive outreach events geared to stimulate interest in physiology will produce affirmative results which include public support for research and a large chunk of prospective students wanting to study physiology.

#### **Future directions/recommendations**

Concerning funding challenges, African universities and research institutions should endeavor to advocate for continued funding of basic research from the government, public, and philanthropists. It is equally important that researchers ensure they collect pieces of evidence from their research, to document its state in their respective countries.

Concerning international collaboration, there is a need for all physiological societies in Africa to establish scientific networks and working groups domestically within their domain, and internationally among other scientists from Africa and all around the globe. Furthermore, these networks and working groups should be empowered and equipped to facilitate the interchange of knowledge, ideas, and best practices in teaching and research.

Regarding public support for physiology research, physiological societies in African countries must endeavor to conduct outreach programs across all levels of the societal spectrum to increase support for research initiatives. Also, African physiologists should unite to further strengthen the World Health Organization's Health for All agenda through their research.

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