

Reported needs of information resources, research tools, connectivity and infrastructure among African Pharmacological Scientists: A web-based Survey.

Article Title: **Reported needs of information resources, research tools, connectivity and infrastructure among African Pharmacological Scientists: A web-based Survey.**

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Abstract

Introduction: The potentials of the African continent for growth and economic transformation through applications of science remains challenging because of existing gaps in knowledge and infrastructures. The Africa Pharmacological Science Gateway project and the Medicines Utilization Research in Africa (MURIA) Group seeks to meet the research needs of African pharmacologists. This study was undertaken to identify available resources and priority areas of needs of African pharmacological scientists that might be fulfilled by access to information and tools through e- infrastructures.

Methods: A web- based cross sectional questionnaire study using the free open source survey tool; *LimeSurvey*[®] conducted among 472 identified members of pharmacological societies in Africa to obtain information on their research interests, available research skills and resources and expressed needs and knowledge gaps. Results were explored using descriptive analysis.

Results: A total of 118 responses from 13 countries were received, mostly from Nigeria (48.3%) and South Africa (21.3%) giving a response rate of 25%. Respondents had wide range of

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research interests predominantly in drug utilization research. The resources desired includes drug utilization research methods trainings and tools, pharmacokinetics and pharmacometrics modelling training and tools, drug-drug interaction and medicine prices resources, statistical analysis resources, access to journals, trainings in specific laboratory techniques, several equipments and funding for research related activities.

Conclusions: Key priority areas of needs not currently provided in the African Pharmacological Science Gateway e- infrastructure were identified. These will guide further provision of resources on the e-infrastructure project and potentially enhance research capacity within the African continent.

Keywords: African Pharmacologists, e- infrastructure, priority needs, Africa Pharmacological Science Gateway.

Introduction

Africa constitutes approximately 12% of the world's population and has a considerable potential for growth and economic transformation through the application of scientific and technological innovations driven by research [1]. The continent has recorded a number of gains and progress in recent years in this respect. The sub-Saharan Africa (SSA) region more than doubled its yearly research output between 2003 and 2012, raising its global research share from 0.44% to 0.72%, whilst the total number of scientific papers emanating from Africa tripled to over 55,400 a year in 2013 with reported rising quality. However, this number still only accounts for 2.4% of the world's total publication output [2]. An estimated 45% of all research activities on the African continent are in the health sciences, a reflection of the prevailing health challenges in the continent [3]. Currently over 80% of the world's HIV patients live in the SSA region [4] and currently, 3 out of 4 patients with hypertension live in low and middle income (LMIC) countries, with the highest prevalence in the African Region where prevalence rates are as high as 30% of the population in SSA [5-7]. The areas of focus of African biomedical researches are predominantly in diseases like HIV/AIDS, tuberculosis, malaria and some neglected tropical diseases, where funding is often available [2],[8-9].

Despite these advances, Africa's reputation for scientific innovations remains poor. It is a weakness that most of the region's research activities are due to collaboration with non-African partners; nearly 80% in South Africa and 70% in East Africa [2]. This reflects a lack of internal capacity among African scientists to attain the gold-standard of independent and transparently-funded research and strengthen cross-national collaboration within Africa.

Africa is currently not producing enough well trained young medical scientists [9]. Similarly, there is gross lack of training in state of the art skills such as proteomics and genomics in some settings [10]. A few who have had opportunities of training in high income countries often return to face the problem of limited resources available to develop and maintain strong research programs and use the skills they have acquired, thereby becoming scientifically isolated with limited opportunities for cross-African interaction. Nearly half of South African researchers and 39% of East African researchers have become highly mobile spending less than two years at institutions in their regions, an action that prevents building local relations and reduces the impacts of their researches locally [2-3]. This migratory nature of African medical scientists could explain the findings of general shortages of faculties in basic and clinical sciences in a survey of African medical schools with over 146 institutions studied [11]. There is a need to

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address capacity building in human resources for health research across Africa, which has remained small scale and uncoordinated, driven largely by support from outside Africa. This will require evolving systematic ways of defining, coordinating and growing such human resources through global partnerships, research networks and shared learning in an interconnected world. [12 – 14].

Different initiatives aimed at addressing the global health inequality include the concerted efforts of the United States of America National Library of Medicine and the Multilateral Initiative on Malaria (MIM) in the beginning of the twentieth century to bridge the digital divide between the North and the South. The MIM initiative established internet connection between SSA malaria research sites to facilitate communication and access to electronic information resources [15]. Another example is the Pan University Network for Global Health, an initiative of the Penn State University in 2014, aimed at equipping local researchers and facilitating collaborations in more than 10 Universities globally with specific areas of need identified to form the basis for the collaboration [16].

Similarly, the European Union framework program for research and innovation has also established e-infrastructure projects aimed at achieving a single and open European space for online connections where researchers enjoy leading-edge, ubiquitous and reliable services for networking and computing, and seamless and open access to e-Science environment and global data resources by 2020 [17]. The project further seeks to increase creativity and efficiency of research and bridge the gaps between researchers in the developed and less developed regions of the world including Africa [17]. African research communities are increasingly involved in e-infrastructure activities [18-19] with records of 34 planned or on-going e- infrastructure activities in 13 (22.4%) of the 58 African countries in a 2014 survey revealing the focus of user communities to be mainly in natural sciences and life sciences [19]. The European Union funded projects like the joint Trans Africa Network Development (TANDEM) and The West and Central Africa Research and Education Network (WACREN) project, an offshoot of the AfricaConnect project continue to progress in building and operating a world class network infrastructure, developing state of the art services and promoting collaborations among the research and education communities both regionally and internationally [20]. Furthermore, the potential usefulness of information technology in specific areas of need including the rational use of medicines, drug supply, continuing medical education and decision support tools in rural Africa have been established [21-22].

In an attempt to address the challenges faced by African researchers studying the quality of use of medicines, the Medicine Utilization Research in Africa (MURIA) Group [23] sought to facilitate access to relevant resources for Drug Utilization Researchers and other Pharmacological scientists in Africa via an e-infrastructure platform named ‘The African Pharmacology Science Gateway (APSG). The APSG is a collaborative project initiated by the African Institute of Biomedical Sciences and Technology in collaboration with the ei4Africa consortium [24]. The needs of African scientists in this field could be complex and diverse. It was therefore deemed necessary to identify priority areas of need of resources for pharmacological scientists. Consequently, this study was undertaken to identify the areas of research interests among African biomedical scientists, the currently available research capacity, skills and resources as well as identifying their specific priority areas of need that might be fulfilled by access to information and tools through e- infrastructures.

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Methodology

This was a cross sectional web based questionnaire study conducted over six months from December 2015 to May 2016. The questionnaire was developed by the study team comprising of experienced researchers in pharmacological and biomedical sciences. It was pilot-tested among a group of 20 medical scientists in Lagos, Nigeria, different from the target group of respondents to enhance the validity, reliability and robustness of the questionnaire. The questionnaire was modified prior to the commencement of the study and then edited into a web-based *LimeSurvey*[®] tool using the West and Central Africa Research and Education Network (WACREN) information and communication staff and resources. The *LimeSurvey*[®] is a free open source software survey (FOSS) tool developed and maintained by LimeSurvey partners headquartered in Germany (<https://www.limesurvey.org>). The questionnaire had 4 sections (A, B, C and D). Section A obtained the biographical data and other relevant personal information of participants, Section B obtained information on their current research areas and interests, Section C on the available research skills and resources including those that are transferable, i.e. those that can be shared and taught to others. Section D obtained information on the expressed needs and knowledge gaps of the respondents [25].

Potential respondents were identified through the available e-mails of members of continental and regional pharmacological societies known to the authors. These included The Medicines Utilization Research in Africa (MURIA) Group and affiliate societies of the International Union of Basic and Clinical Pharmacology (IUPHAR): Pharmacology for Africa Initiative (PharfA), West Africa Society for Pharmacology (WASP) and The South African Society for Basic and Clinical Pharmacology (SASBCP) (See <http://www.iuphar.org/index.php/societies>). In addition, individuals known to the research team who had participated in regional pharmacological meetings and trainings were also included.

Potential participants were invited through their 'emails' with background information, instructions and a link to the web based survey [25]. A total of 472 individuals were invited to participate in the survey with a spread across West, South, East and North Africa sub-regions. Pre-programmed reminders were sent to these individuals at three time points with six weeks interval.

Specific target groups included the following:

- MURIA Group: An inter-disciplinary and multi-national group of academia and healthcare professionals from various countries across Africa, Europe, the United Kingdom (UK) and North America who came together in January 2015 to foster research in various aspects of drug utilization research in Africa. MURIA had a total of 102 members in December 2015 which has since grown to 130 currently. The group has been active since inception including two Pan African scientific symposia, with currently several scientific publications to its credit and a number of planned and on-going research projects in different African countries. [23],[26-28]
- PharfA: An initiative starting in 2006 with the aim of organising and promoting pharmacology in all countries in African. The group seeks to stimulate and coordinate local societal organisations, promote research in basic and clinical pharmacology and teaching of pharmacology. An activity of this group is the development of a database and network of pharmacologists (including Pharmacology Training Institutions) in Africa.

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The group derives its membership from national pharmacology societies in Africa and it is affiliated to IUPHAR. (Available at: <http://iuphar-africa.org/en/member-societies/>)

- WASP: This society was founded in 1971 for the purpose of advancing the science of Pharmacology and Allied Sciences in the West Africa sub-region. Members are from the whole sub-region and includes medical doctors, veterinarians, pharmacists, molecular biologists, biochemists, phytochemists, botanists. The society holds annual conferences geared towards sharing new ideas and human resources development in research, teaching and community services related to the science of pharmacology. It is a member of the International Union of Basic and Clinical Pharmacology (IUPHAR). (Available at: <http://www.waspsoc.org/>)
- SASBCP: A member of the International Union of Basic and Clinical Pharmacology (IUPHAR) established in 1966 with currently about 144 active members. The society promotes the science of basic and clinical pharmacology in general with support from academia, industrial and professional practice spheres. It is actively involved in promoting pharmacology among young scientists and was instrumental to the formation of PharfA.(Available at: <http://www.sapharmacol.co.za/>)

At the close of the survey, data obtained were downloaded from the survey site and analyzed using The Statistical Package for Social Sciences (SPSS) 17.0 version. [29]. The results of the analysis were summarized mainly into categorical variables expressed as proportions and percentages.

Results

A total of 118 responses were received, giving a response rate of 25% (118/472). Of the 118 responses, 50 were complete while 68 were incomplete. The 89 respondents who mentioned their country of residence were from 13 countries; 11 African countries with a spread across the sub-regions, as well as Canada and Finland. The majority of respondents were from Nigeria; 43 (48.3%) and South Africa; 19 (21.3%) as shown in Table 1. The respondents have their background academic qualifications in Basic Pharmacology (BSc), Pharmacy (B. Pharm) and Medicine (MD) as shown in Table 2.

Table 1: Country of residence of respondents (n = 89)

Country	Number of individuals	Percentage (%)
Nigeria	43	48.3
South Africa	19	21.3
Botswana	8	9.0
Ethiopia	5	5.6
Egypt	4	4.5
Kenya	2	2.2
Canada	2	2.2
Others*	6	6.6
Total	89	100

*Others include: Angola, Finland, Morocco, Namibia, Tunisia and Zambia with one respondent each.

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Table 2: Academic qualifications of respondents (n = 90)

Qualification	Number of Respondents	Percentage (%)
MSc	21	23.3
BSc/PhD	18	20.0
B Pharm/PhD	13	14.4
BSc/B Pharm	11	12.2
MD/PhD	9	10.0
MD/Post Graduate Fellowship	9	10.0
PhD Students	9	10.0
Total	90	100.0

Reported Areas of Research Interests, Transferable Skills and Available Resources

A number of current research interests and activities were listed by the respondents covering a wide spectrum of areas in basic and clinical pharmacology and other biomedical research areas as shown in categories in Tables 3a. The specific areas of interests and research activities are shown in Table 3b with predominant areas including drug utilization research and pharmacoepidemiology (11.8%), pharmacokinetics, pharmacodynamics and pharmacometrics (7.1%), diabetes mellitus and metabolic syndrome/endocrine pharmacology (7.1%), toxicology (6.2%), ethnopharmacology (6.1%), neuropharmacology and HIV/AIDS research constituting 5.6% each .

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Table 3a: Current areas of research interests and activities of respondents (N = 118)

Category	Number of Responses (n=183) *	Proportion (%)
Drug Research	59	31.2
Infectious and Tropical Diseases	23	11.8
Non Communicable Diseases/Systemic Pharmacology	40	20.3
Genomics and Related Feilds	7	3.5
Toxicology	12	6.2
Medicinal Plants/Natural Products	18	9.1
Special Population/Special Interest Areas	9	4.6
Others	15	7.5

*A total number of 183 responses were reported by 118 respondents

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Table 3b: Specific Areas in each Category of research areas and interests:

Areas of Research Interest	Specific Areas	Percentage (%)
Drug Research	DUR +PEpid	11.8
	PK+PD+PM	7.1
	PV	4.6
	Clinical Trials	3.1
	PEcons+Ores	3.1
	Drug Discovery	1.5
Infectious and Tropical Diseases	HIV/AIDS	5.6
	Malaria	3.6
	Tuberculosis	2.1
	Filariasis	0.5
Non Communicable Diseases/Systemic Pharmacology	DM+MS+Endocrine Pharmacology	7.1
	Neuropharmacology	5.6
	Oncology	4.6
	Hypertension/Cardiovascular Pharmacology	1.0
	Immunopharmacology	1.0
	Reproductive pharmacology	0.5
	Gastro intestinal pharmacology	0.5
	Genomics and Related fields	Pharmacogenomics
	Nutrigenomics	1.5
	Proteomics	0.5
Medicinal Plants and Natural Products	Ethnopharmacology	6.1
	Natural Products	1.5
	Herbal Medicines	1.5
Special Populations and Special Interest Areas	Medical Education	3.1
	Pediatric Pharmacology	0.5
	Geriatrics Pharmacology	0.5
	Research Ethics	0.5
Others	Analgesics/Anti-inflammatory drugs	2.5
	Substance Abuse/Alcohol dependence	2.0
	Pharmaceutical Analysis/Supply Chain	1.5
	Antioxidants therapy	1.5

PK = Pharmacokinetics, PD = Pharmacodynamics, PM = Pharmacometrics, PV = Pharmacovigilance, DUR = Drug Utilization Research, PEpid = Pharmacoepidemiology, PEcon = Pharmacoeconomics, ORes = Outcome Research, DM = Diabetes Mellitus, MS = Metabolic Syndrome,

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The skills possessed by respondents which could be taught to others and propagated are referred to as 'transferable skills' and are as listed in Table 4. The most important transferable skills include Clinical Research Skills, Laboratory and Analytical Skills and Techniques. Other available resources were human resources in the form of postgraduate students who assists in research projects.

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Table 4: Categories and Types of Available Transferable Skills.

Skills Categories	Specific Skills Available
Clinical Research Skills	
	Design of studies: proposals, questionnaires, focus group discussions, qualitative research methodology, ethics.
	Laboratory and Clinical Data Management
	Manuscript preparation and use of reference management software
	Evidence Based Medicine Techniques: Clinical Guidelines, Costing Studies, Health Economics Models, Budget Impact Analysis
	Good Clinical Practice Knowledge
	Scientific Presentations
Laboratory Techniques and Analytical Skills	
	Receptor Binding Studies
	Langendorff Heart Preparation
	Animal Experiments
	High Performance Liquid Chromatography (HPLC)
	Separation Techniques/Chromatographic Methods
	Phytochemistry
	Immunoassay Models
	Determination of parameters in Toxicological Studies
	Flow Cytometry
	Polymerase Chain Reactions
	Elisa Based Techniques
	Atomic Mass Spectroscopy
	Invivo Culture Techniques
	Parasite Isolation and Culture
Other Resources	
	Drug Information System
	Formulary Preparation Experience
	Human Resources: MSc, PhD Students, Post Doc Fellows and Research Scientists

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Desired Resources and Knowledge Gaps

Table 5 shows the various resources desired by the respondents. Training needs were highly asked for, including training in specific research areas. Other needs were access to specific tools and resources on-line, various laboratory equipment and infrastructure, as well as funding and networking opportunities.

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Table 5: Desired Resources and Knowledge Gaps Expressed by Respondents

Categories of Resources	Specific Resources
Pharmacological Science Related Needs	
	Taining in drug utilization research methods
	Access to DU 90% calculation tools
	Training in pharmacokinetics modelling and pharmacometrics
	Access to pharmacokinetics and pharmacodynamics softwares
	On line access to pharmacometrics softwares: NONMEM, Monolix, PopEd e.t.c
	On line access to drug-drug interaction softwares e.g micromedex
	Access to database of international medicine pricing
Research and Statistical Training Needs	
	Training in Qualitative Research
	Advance On-Line Training in Statistical Analysis Techniques: STATA, R, SAS
Laboratory Technique Training Needs	
	Advanced Tissue Culture Technique Training
	DNA Sample Analysis
Access to Laboratory Equipments	
	Molecular Biology equipments
	HPLC
	TDM laboratory
	GC/Atomic Mass Spectrophotometer
	High Capacity Vacuum Pump and Rotatory Evaporator
	Water Cooling Circulatory System
	Heating Mantle
	Cell Culture Facilities
	Genomics and Informatics Equipments
	Beta Scintillation Counter
Other Needs	
	Access to Journals
	Funding for Research and Collaboration
	Sponsorship of Attendance at International Conferences
	Payment of Publication Fees

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Discussion

This web-based survey of the needs for research tools, information resources, connectivity and infrastructure focused on African pharmacological scientists. The most frequently mentioned pharmacological science based needs were on-line training programmes in drug utilization research techniques, pharmacokinetics modelling and pharmacometrics training, access to DU 90% calculation tools, access to pharmacokinetics and pharmacometrics softwares, access to drug-drug interactions softwares and international medicines pricing. Other desired resources include laboratory equipments and trainings in specific laboratory techniques, access to journals and funding for research related activities among others as summarized in Table 5.

We had a total of 118 respondents from 11 African and 2 non-African countries. There were representation of the respondents from Western, Northern, Eastern and Southern African sub-regions. The 3 respondents from outside Africa were likely African scientists who were away in those locations at the time of the survey. As mentioned, it is an established fact that in recent years, a number of African scientists have become migratory in search of trainings and other desired opportunities[2]. Despite this, the majority of the respondents were from Nigeria and South Africa. This can be explained by the fact that Nigeria is the most populous black nation of the world while South Africa takes the lead in scientific activities on the continent of Africa [1],[2].[30].

The response rate of 25% is consistent and perhaps higher than the documented average response rate obtainable from similar studies. Surveys distributed internally (i.e to employees) are said to have generally a higher response rate of 30-40% compared to an average of 10-15% for external audiences similar to our study [31].

The respondents constituted a mix of individuals with basic science degrees, pharmacy and medicine as foundational degrees. Most respondents were holders of Master of Science degree (23.3%), while 10% were doctoral students suggesting about one-third of the total number of respondents were currently in training. This is not surprising, however, as such groups are expected to express a great enthusiasm towards opportunities that could potentially meet their training needs as this study sought to achieve ultimately. While the distribution of the qualifications of the respondents in this study can not be said to be representative of the current state of human resources in the scientific sectors in Africa, or the educational levels of African pharmacological scientists in general, it may be suggestive of the prevailing situations in some areas. Kokwaro has stated that the majority of prominent African medical scientists of the sixties and seventies are either retired or will soon retire to leave behind a vacuum characterised by institutions which are so run down that proper research and training are no longer feasible, and are unable to produce enough well trained young medical scientists and to cutting edge standards to sustain the legacies of the past years.[9] However, the findings of 20% each of respondents in the categories of BSc/PhD holders and combination of MD/PhD and MD/Postgraduate fellowship holders is noteworthy. These are individuals who have obtained terminal degrees and qualifications and are therefore expected to be able to make meaningful contributions to science

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given the necessary infrastructure and enabling environment. The aim of this study is to identify critical and priority areas of needs that if met would empower such individuals and revolutionize their research potentials and capacity.

The current areas of research interests and activities of the respondents cut across various aspects of drug research, the basic medical sciences, clinical sciences, infectious and tropical diseases, non communicable diseases, medicinal plants, toxicology, genomics, special population pharmacology and other areas (Tables 3a and 3b). Drug utilization research was the most frequent area of interest among the respondents. This finding is again not surprising as the target groups for the survey were groups working in pharmacologically related research. However, irrational use of medicines, and its consequences, are a growing challenge [32]. Widespread drug resistance, adverse drug reactions, increased hospitalization rates and death, unaffordable costs of medicines, and an overall increase in the cost of health care among a population that predominantly pay 'out of pocket', remains a major challenge in African countries requiring urgent solutions. The response to this call brought about the formation of the interdisciplinary and multinational MURIA group [26-27]. Current research interests of African scientists are in part informed by the prevailing health challenges as well as areas of priorities of funders who are mostly external [2],[9].

A prevalence of 7.1% of the researchers in Diabetes Mellitus, Metabolic Syndrome and Endocrinology Pharmacology Researches is highly instructive. It is an indication of the current epidemiological transition being experienced in developing nations as a consequence of rapid westernization of lifestyle and urbanization resulting in reduced physical activity and over consumption of energy-dense foods. This leads to a higher prevalence of the non communicable diseases like diabetes mellitus and hypertension [33-34]. As discussed, HIV/AIDS research is still a key research area with 5.6% of respondents in this area of research. This is explainable partly by the current global HIV/AIDS pandemics which, as mentioned, is most prevalent in the African continent and partly by researchers interests occasioned by the priorities of the funders [2],[9], [35]. However, there is growing interest in non communicable diseases.

There are pockets of respondents who stated possessing a number of research skills and laboratory competencies that are transferable, which is encouraging. These, however, might be sparsely and unevenly distributed across Africa, which is a concern. In addition, the corresponding expression of desires by the majority of the responders for provision of a wide array of laboratory equipments is indicative of the possibility that these expressed skills might have been dormant or sub-optimally utilized owing to lack of equipments and infrastructure.

The respondents expressed overwhelming desires for training in their identified areas of knowledge gaps in form of on-line courses as well as provision of on-line resources and tools to facilitate their research activities, as summarized in Table 5. There was also expression of overwhelming need for funding support and grants for research, attendance at international conferences and scientific publications in peer reviewed journals, and a passionate desire for networking and collaboration with scientists outside Africa. These are clear indications of a lack of adequate support for research within Africa and the existence of gaps to be addressed. African Pharmacological Scientists will benefit greatly from e-Infrastructure platforms providing drug

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utilization research tools and trainings, a database of international medicine prices and costing tools, pharmacokinetic, pharmacodynamics and pharmacometric tools and trainings, on line resources on statistical analysis, drug-drug interactions software, access to journals and enhanced opportunities for networking with the global research communities in relevant areas.

Other areas including access to guidelines and on-line supports for decision making in health care will also be relevant to such projects [14-15]. These will potentially reduce the brain drain syndrome that has plagued the African scientific communities in recent years and revolutionize the pursuits of pharmacological sciences within the benefitting communities [36].

Application of Results to the development of the Africa Pharmacological Science Gateway (APSG)

The Africa Pharmacological Science Gateway as presently constituted has the following sections already operational: Genomic & Bioinformatics and Pharmacokinetics & Pharmacometrics Resources while the following sections are still under development: Bioanalysis, Drug Analysis & Metabolism, Clinical Trial Sciences, Digital Library and Multimedia contacts & e-Learning Tools [37].

The expressed pharmacological science based needs by the respondents have been met in part with the availability of pharmacokinetics and pharmacometrics resources. However, there is currently no availability of resources on Drug Utilization Research (DUR), which was the most frequently expressed area of need in this survey. Consequently, there is a need to create a DUR Resources section to accommodate specific tools including DU 90% calculation tools for assessing current adherence rates to medicines listed on a formulary [38], DDD methods for calculating defined daily doses (DDDs) [39-40], database of international medicine pricing and tools for assessing drug-drug interactions including Micromedex as expressed by respondents.

Furthermore, the section on Digital Library being developed could accommodate access to journals while the section on Multimedia and e-Learning Tools could be used to meet the various training needs expressed in the following areas: drug utilization research methods, qualitative research methods, statistical analysis, pharmacokinetics and pharmacometrics modelling. Other training needs in laboratory techniques including advanced tissue culture and DNA sample analysis, as well as equipment and infrastructure needs, could be addressed with a different approach.

Conclusion

Our study employing a web-based survey has proven useful in identifying key priority areas of needs of African Researchers within the field of pharmacology. These identified areas of need will guide further provision of resources on the e-infrastructure project being executed through the African Pharmacological Science Gateway. Furthermore, information generated could also assist in mapping available resources (human and material) that could be used to facilitate collaborations and optimize the use of scarce research resources within Africa. This web-based survey approach could also be applied to identifying areas of needs of other groups of researchers in different fields within the African continent.

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Competing Interests

The authors declare there is no competing interests.

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