Strengthening capacity building in data analysis in West African Universities and research institutions: A three-year experience of the Master Programme in Biostatistics at the University of Abomey-Calavi, Benin

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ABSTRACT

Scientific research plays a key role in development, especially in economic growth of countries. Scientific innovations, the main outcome of scientific research, require the use of modern statistical and mathematical methods in research works. In Africa, especially sub-Saharan Africa, Statistics is underutilized and some situations misused in biological researches. The master programme in Statistics, major Biostatistics at the University of Abomey-Calavi has been created and implemented by the Laboratory of Biomathematics and Forest Estimations at the Faculty of Agronomic Sciences in order to fill this gap. This master programme has four semesters and is taught in English with lecturers mainly coming from Benin and Togo, but also some come from United States of America (USA) and Belgium. Analysis of the three-year experience of this programme reveals an increasing trend of the number of students involved with a total of 44 students coming from 12 African countries. Defense of the first batch of students in this master programme (24-29 February, 2016) targeted some modern statistical and mathematical methods including linear and non-linear mixed effects models, matrix projection models, ordination methods, generalized linear models, survival analyses and efficiency analyses with applications in biology. The current challenges linked to this master programme can be lessened through a partnership with the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), universities and research institutions in other countries in West Africa (Ghana, Nigeria), Eastern Africa (Uganda, Kenya) and Southern African (South Africa) to share and improve curricula in Biostatistics training.

Key words: Biological researches, innovations, modern statistical and mathematical methods, scientific research

RÉSUMÉ

La recherche scientifique joue un rôle clé dans le développement, en particulier dans la croissance économique des pays. Les innovations scientifiques, le principal résultat de la recherche scientifique, nécessitent l'utilisation de méthodes statistiques et mathématiques modernes dans des travaux de recherche. En Afrique particulièrement l'Afrique Subsaharienne, la statistique est sous-exploitée et certaines situations mal utilisées dans les recherches biologiques. Le programme de Master en Biostatistique à l'Université d'Abomey-Calavi a été créé et mis en œuvre par le Laboratoire de Biomathématiques et d'Estimations forestières à la Faculté des Sciences Agronomiques, afin de combler ce vide. Ce programme de master se fait en quatre semestres et est administré en anglais avec des enseignants venant principalement du Bénin et du Togo, mais aussi quelques-uns provenant des États-Unis d'Amérique (USA) et de la Belgique. L'analyse de l'expérience de trois ans de ce programme révèle une tendance à la hausse du nombre d'étudiants avec un total de 44 étudiants venant de 12 pays africains. La soutenance de la première promotion de ce programme de master (24-29 Février, 2016) s'est porté sur certaines méthodes statistiques et mathématiques modernes, y compris les modèles à effets mixtes linéaires et non-linéaires, les modèles de projection matricielle, les méthodes d'ordination, les modèles linéaires généralisés, l'analyse de survie et d'efficacité avec des applications en biologie. Les défis actuels de ce programme de master peuvent être surmontés grâce à un partenariat avec le Régionale forum des Universités pour le renforcement des capacités en agriculture (RUFORUM), les universités et les institutions de recherche dans d'autres pays d'Afrique de l'Ouest

(Ghana, Nigeria), d'Afrique de l'Est (Ouganda, Kenya) et de l'Afrique australe (Afrique du Sud) afin de partager et améliorer les curricula de la formation en Biostatistique.

INTRODUCTION

Scientific research is defined as the investigation in some field of knowledge, undertaken to discover or establish facts or principles. The economic development theory shows that scientific research is the source of economic growth (Bayarçelik and Ta°el, 2012). Indeed, there is a long-term equilibrium relationship between scientific innovation and economic growth, and both have interactivity meaning that scientific innovation promotes economic growth and economic growth boosts scientific innovation (Zhang *et al.*, 2012). Moreover, in the study of development economics, it is known that the advance in science and technology is the most important motive that enhances the economic growth and social development (Yang and Boriand, 1991).

Statistics as a field of applied mathematics involves the development of solid foundation in techniques and underpinnings of probability theory and statistical modelling by focusing on theoretical aspects to produce well-rounded, knowledgeable scholars. For instance, it is known that most of terrestrial systems follow theoretical distributions (Micceri, 1989; Brandon, 2013) such as Chi square, Weibull or Student distributions. These probability laws fall under the field of study of Statistics. Specifically, Biostatistics which is a discipline that involves the application of statistical theory and methods in a better understanding of biological phenomena and finds applications in agriculture, ecology, animal science, medicine and pharmacy, among others. It involves managing and handling data, from the design of research studies (experiments and surveys) to data collection and management, and finally to data analysis and interpretation.

In 1978, the Statistical Training Program for Africa (STPA) was created to increase the supply of statisticians in Africa by 1990 (Ching'anda, 1998). However, Biostatistics still constitutes a key gap area throughout sub-Saharan Africa and this negatively impacts quality of research findings of African researchers. Indeed, very few African universities offer training programme in Biostatistics and the available statisticians are too theoretical and not well equiped to handle biologists problems. However, it is known that most of biological systems are modelled based on combination of biological sciences and mathematical and statistical tools. Therefore, choosing an accurate

statistical analysis constitute an important issue for researchers so as to avoid misleading results from misspecification in statistical modelling and erroneous conclusions. This highlights the importance of design of experiments and statistical analyses to study the effects of multiple drivers of biological systems. Developing an objective understanding of phenomena by using appropriate statistical methods is critical for maintaining biological processes linked to human development.

However, to incorporate and consider statistical tools in research in biological sciences, one needs to strengthen availability of capable professionals in universities, research centers and industry in the area of experimental design and/or sampling techniques and data analysis. This will be possible by increasing the offer of specific training in Biostatistics in African Universities. This will also help in creating an environment in Africa where lecturers and researchers can carry out high quality research work and harmonize teaching methods in order to demystify Statistics for biologists.

The master programme in Biostatistics at the University of Abomey-Calavi has been created to fill the above gap. The goal of this training programme is to produce specialists and competent graduates to guide in the methodological design and research and development programmes so as to ensure impact of investment in research projects and programmes but also and especially in the processing, analysis and proper interpretation of data from various areas. The objectives of this paper are to (i) describe the master programme in Biostatistics at the University of Abomey-Calavi, (ii) show the current achievements after three years' experience, and (iii) discuss current challenges and way forward for better use of statistical methods for data analysis in biological research in Africa.

METHODS

We used the Internet as the primary source of information to find on the web African universities that offer a Master programme in Biostatistics. We also used data on number of students involved in the Master Programme in Biostatistics at the University of Abomey-Calavi and their country of origin to obtain key data linked to the programme. Further, we reviewed the curricula of the programme.

RESULTS

Current scope of Biostatistics training in Africa

A number of African universities offer nowadays Master and PhD programmes in statistics (Thabane *et al.*, 2008). However, training programmes in Biostatistics are still scarce on the continent, especially in West Africa. Table 1 lists some universities offering Biostatistics training in Africa and reveals that most of the African universities which offer trainings in Biostatistics are located in southern and eastern Africa. Training in Biostatistics in French speaking African countries has been possible by the programme Statistiques pour l'Afrique Francophone et Applications au Vivant (STAFAV). This programme started in 2004 at the initiative of a group of French universities and research organizations and coordinated by the University of Paris-Sud Orsay (Department of Mathematics). However, the Master Programme in Biostatistics at the University of Abomey-Calavi does not belong to STAFAV.

The Master of Biostatistics at the University of Abomey-Calavi: An overview

The Faculty of Agronomic Sciences of the University of Abomey-Calavi (Republic of Benin), through the Laboratory of Biomathematics and Forest Estimations, offers graduate training for Biostatisticians as a two years of study for the Master degree in Statistics, major Biostatistics. Applicants are selected through a call for application on May 1st every year. The place of application is (i) the Secretariat of the Laboratoire de Biomathématiques et d'Estimations Forestières (LABEF) for Beninese and applicants living in Benin, and (ii) the website of LABEF for foreign applicants (http://labef-uac.org/en/apply). The number of students is limited to 25 per intake to allow enough follow-up of each student. The deadline for application is June 20th every year and the starting date of the training at Faculty of Agronomic Sciences, University of Abomey-Calavi (FSA/UAC) is December 8th every year after the English training for French speaking students.

Applicants should hold a Bachelor or a Master degree in agronomic sciences, biological sciences, pharmaceutical sciences, environment sciences or mathematics. Admission to the training is usually done on study of application documents (and if necessary an interview). Selection, based on application documents, takes into account academic records or professional course, prerequisites in Statistics/ Mathematics, and motivation letter. The training is also open to postgraduate students with high professional experience and whose work often needs statistical tools. Application documents include: motivation letter to the Coordinator of the Master programme, academic degrees, academic transcripts, certified copy of the Certificate of Birth, certified copy of a certificate of capacity to pay training fees or scholarship certificate, *curriculum vitae* and programme of the courses already followed by the applicant. The cost for the master programme includes (i) fees for application (15 Euros), (ii) English course at the University of Abomey-Calavi (183 Euros), and (iii) annual fees for registration and training (1,000 Euros for national applicants, 1,297 Euros for non-national applicants and 1,600 Euros for scholarship recipients). The starting date for English courses is on September 1st every year. Funding for the Master Programme is mainly based on the registration fees of the students and other sources such

Table 1: Some universities offering Masters in Biostatistics

University	Programmes
University of Abomey-Calavi, Benin	MSc & PhD programme in Biostatistics
University of Ghana	MPhil in Applied Epidemiology and Disease Control
University of Yaoundé, Cameroon	Master of Applied Statistics
Kwame Nkrumah University of Science and Technology, Ghana	Master of Philosophy in Biostatistics
Jomo Kenyatta University of Agriculture and Technology, Kenya	Masters of Science in Research Methods and Masters of Science in Applied Statistics
University of Nairobi, Kenya	Master of Science in Biometry, PhD in Statistics and PhD in Biometry
Makerere University, Uganda	Master of Statistics (M.STAT) - A regional programme
University of Zimbabwe	Master and PhD programmes in Biometry
University of the Witwatersrand (South Africa)	Master of Sciences in Epidemiology; PhD in Biostatistics
University of KwaZulu Natal (South Africa)	Master of Sciences in Biostatistics; PhD in Biostatistics
University of Malawi (Malawi)	Master of Sciences in Biostatistics; PhD in Biostatistics
Kilimanjaro Christian Medical University College	Master of Sciences in Biostatistics; PhD in Biostatistics
Stellenbosch University	Master of Sciences in Biostatistics; PhD in Biostatistics
University of Rwanda	Master in Data sciences

as involvement in the Intra ACP mobility programme, which allowed small administrative fees per foreign student registered in the programme.

Students enrolled in this Master programme will have strong theoretical basis in statistical methods and be able to apply them in life sciences. The language of instruction in this Master Programme is English. For participants from French speaking countries, a three-month English training is offered while participants from English speaking countries have a three-month French training. All the courses are taken in Benin in the morning from 08-12 a.m. to allow students to deepen their knowledge through their own literature review as well as cohort-learning in the afternoon.

The Master in Biostatistics is a four-semester programme (Table 2) and is designed to provide advanced training in applied statistical methodology needed for studies and applications in Agriculture,

Table 2: Codes and titles of Biostatistics courses by semester at University of Abomey-Calavi

Semester I

Code	Course Title
MAT7411	Analysis
PDE7411	Partial Differential Equation
PRO7411	Probability
SCS7411	Statistical Computing and Simulation
QGE7411	Quantitative genetics
GEO7411	Geostatistics
SRB7411	Introduction to multivariate statistical methods

Semester II

Code	Course Title
DIR7412	Database and Informatics Resources
SRM7412	Sampling and Resampling Methods
BAY7412	Bayesian Statistics
ANA7412	Survival analysis
LIM7412	Linear Models
SME7412	Statistical Methods in Economy

Semester III

Code	Course Title
DOE7413	Design Of Experiments
EPI7413	Pharmaco-cinetics
LGM7413	Linear and Generalized Linear Mixed Models
STB7413	Populations matrix models
MSM7413	Multivariate Statistical Methods
SCW7413	Scientific writing

Semester IV

Code	Course Title
MEM7414	Internship and Master's thesis

Biology, Ecology, Medicine and Pharmacy. The aim is to train students to have skills in biometry to work with research professionals in the design and implementation of research studies to improve livelihoods of local populations. More specifically, the courses aim at providing sound training in (i) the mathematical background and statistical methodology needed to analyze biological data, (ii) the methodology for proper acquisition and analysis of biological data using modern computing resources, (iii) the ability to communicate with biomedical or agricultural researchers as a member of an interdisciplinary team, and (iv) professional issues in biometry to enable them to have professional good conduct in practice. The first three semesters are class work based, with students taking courses while the last semester is mainly research based through an internship in a research institution or in industry. The curricula are presented in Table 2. Moreover, monthly seminars are organized at the LABEF on new statistical methods and participation of students is compulsory. This strengthens students' capacity but also their presentations and reporting skills. In addition to lecturers from the University of Abomey-Calavi, the programme engages visiting lecturers from USA, Belgium, France and Togo. The programme also collaborates with some research and professional institutions namely National Institute of Agricultural Research of Benin (INRAB), Centre de Cooperation Internationale en Recherche Agronomique pour le developpement (CIRAD), particularly the Research unit on Genetic Improvement and Adaptation of Mediterranean and Tropical Plants; and the International Institute of Tropical Agriculture (IITA-Benin) for students' internship. The programme is also engaged in partnership with the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) for curricula development and students mobility through INTRA ACP Academic Mobility programme (Agreement Number 2013-4177/001-001).

Current achievements

The current achievements of the master programme in Biostatistics can be summarized in three components: (i) the number of students enrolled, (ii) the number of nationalities that have already participated in the training, and (iii) the research work already done by the first batch of students in this programme. Figure 1 shows the number of students by year, and the three-year experience totalling to 44 students with increasing trend from 10 students during 2013-2014 academic year to 19 students during 2015-2016 academic year. In terms of the nationality of students participating or have already participated in the training, an increasing trend was observed. From two nationalities for the first cohort (Togo and Benin), the programme now involves 12 nationalities for the third cohort, which represents

an expansion in terms of the catchment for students in the Programme from different countries in Africa (Figure 1). The map of Africa showing the countries that have already participated in the training (Figure 2) reveals that already four of the five African sub-regions (Eastern, Central, Southern and Western) are involved in the programme. However, there is very limited participation of women. Indeed, only three women (from the third cohort) are registered for the Master programme.

The defence of the first batch of students in the Master Programme took place from February 24-29, 2016 at the LABEF. The research work done by the students
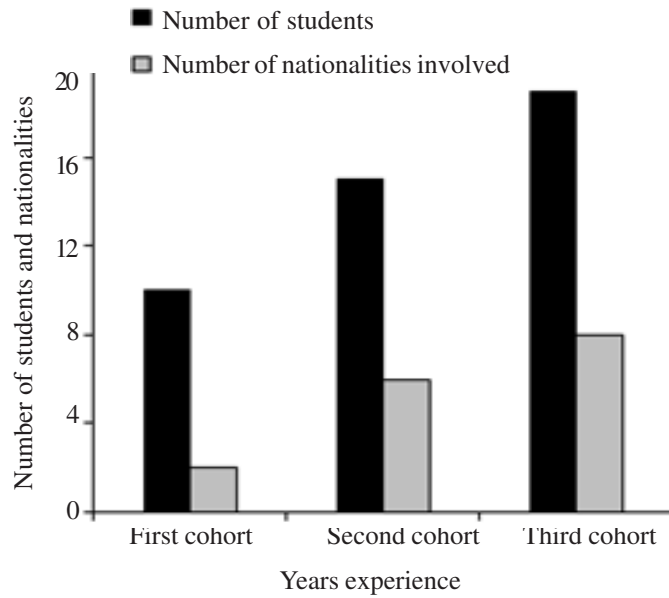

Figure 1: Number of students and nationalities involved in the master programme in Biostatistics

Figure 2: Map of Africa showing the countries involved in the Master Programme in Biostatistics

involved many fields of study including modern statistical and mathematical methods such as: linear and non-linear mixed models, matrix projection models, ordination methods, efficiency analyses, survival analyses, linear and generalized linear models (Amagnide, 2015; Kouagou, 2015; Lokonon, 2015; ChabiAdjobo, 2015; Tchandao, 2015; Hounmenou, 2015; Savi, 2015; Doulabe, 2015). A summary of the areas of research focus is outlined below:

(i) Longitudinal data analysis: fitting an optimal variance-covariance structure under linear mixed effects models framework

(ii) Prospective perturbation analyses in matrix projection models

(iii) Generalized linear models with Poisson family: applications in ecology

(iv) Production unit's efficiency analysis using metafrontier: Application to conventional and organic cotton in Benin

(v) Application of common components and specific weights method to analyse local perception patterns of land degradation in northern Benin (West Africa)

(vi) Estimation of population pharmacokinetic parameters with sparse data in Nonparametric nonlinear mixed effect model

(vii) Empirical assessment of relative performance of three permutation methods in one way analysis of variance framework

(viii) Semiparametric and parametric proportional hazards models: Application to survival of HIV/AIDS patients on antiretroviral treatment.

DISCUSSION

The analysis of the trend over the last three years of the Master programme indicates increased interest and participation across Africa. From initially two countries that participated at the start of the programme students to the current geographical coverage that includes 12 countries across Africa. The number of students admitted to the programme has trebled from 6 in the first cohort to 19 this year in the third cohort, with <50% of the applicants admitted. However, to maintain quality it is planned not to admit more than 25 students per cohort, so as to maintain an effective student-faculty staff ratio. The programme has further been internationalized by the increased involvement of guest lecturers from six African countries and also from USA, France and Belgium. Efforts are underway to further strengthen and broaden participation through the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) network which operates in 26 African countries. The University of Abomey-Calavi is a member of the RUFORUM network and stands to benefit from academic mobility with other universities

in the network as part of rationalising both human and capital resources for graduate training and research.

There are two issues that should be considered as part of sustaining momentum of the Masters Programme in Biostatistics. First, there is still a big gap in terms of meeting the demand for well trained biostatisticians in Africa, but the capacity and opportunities to address this need is still limited. In a related programme run by Jomo Kenyatta University of Agriculture and Technology in Kenya, the University receives as many as 200 applicants but is only able to fund, through RUFORUM, 15 scholarships. This dipicts limitations to absorb more students and graduate level research and training. There is need therefore for increased attention to expand opportunities for training more biostatisticians, and collaboration in this and other fields amongst higher education institutions will help leverage on existing opportunities. It is also an area where increased investment is needed to ensure quality of data and information to guide policy and investments in Africa The second issue is the limited participation of women in the programme. This requires policy support and innovative approaches that enable women to undertake graduate studies. It will also call for modularization of the courses and integrating online delivery of courses so as to allow for more flexible learning opportunities. These are issues that RUFORUM is engaged in as a Network of 60 African universities, to attract more female participation in graduate training and increased participation in the broader agricultural research for development interventions.

The Master Programme in Biostatistics at UAC, however, faces some problems related to establishment of the training programme. These challenges include: (i) Limited participation in general and of women in particular (Gender issue), (ii) English language training for participants from a French country should normally be done in an English speaking country to allow effective learning, (iii) Few participants from research institutions probably because it is not possible for them to find time to engage on daily basis and follow the course every day as normal students, and (iv) limited financial support for the Master Programme (funding issue).

To overcome these problems, some important actions are required to (i) strengthen the capacity of African universities to offer quality graduate training in applied statistics and research methods as well as designing, analyzing and communicating research data, (ii) increasing the pool of quality university lecturers and researchers in the field of Biostatistics to strengthen capacity of these institutions, and (iii) make available data analysis packages for industry and research

institutions in Africa. The following actions will be persued: (i) solicit for scholarships for students and researchers to attend the training, (ii) increase registration of women through sensitization. This will be done by mobilizing special scholarships for women and working with RUFORUM and AWARD (African Women in Agricultural Research for Development) to mobilize women applicants to the programme, (iii) strengthening partnerships with West African countries (Ghana, Nigeria), Eastern Africa (Uganda, Kenya), and South African countries (South Africa, Zambia); (iv) linking with other African Universities in an academic mobility programme to jointly train students and increase access to expertise across the continent. This might require dealing with issues such as accreditation and credit transfers/accumulation, and (v) organizing periodic short skill enhancement training for researchers and other professionals.

CONCLUSION

The Master in Statistics with major in Biostatistics at AUC offers an extensive and unique training in recent statistical methods and tools toward their applications in Life Sciences. At the end of the training, graduated students can easily go into professional life as Biostatisticians or engage in research in Biostatistics. In order to allow those willing to pursue PhD training in Biostatistics, a doctorate program in Biostatistics is available at the University of Abomey-Calavi. The PhD training in Biostatistics is designed to provide the international market, especially in Africa, with a desired labour profile whose quality will be expressed not only in terms of added value to the quality of services and production, but also ability to train young scholars in African universities in the field of experimental design and data analysis.

ACKNOWLEDGMENTS

STATEMENT OF NO CONFLICT OF INTEREST

The author of this paper hereby declares that there are no competing interests in this publication.

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