



Design and Implementation of Postgraduate Programs in Health in a Resource-Limited Setting in Mozambique (The Lúrio University)

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Purpose: To describe the strategies used to design and implement three postgraduate programs at Lúrio University (UniLúrio), a resource-limited setting, in northern Mozambique.

Methods: We conducted a longitudinal, descriptive case study from 2011 to 2018 in two phases: 1) needs assessment (2011–2012), 2) implementation strategies (2013–2018), taking into account innovations whenever necessary.

Results: Several obstacles and barriers to the establishment of postgraduate programs were identified. These included a lack of a core curricula aimed at postgraduate programs, shortage of human resources for teaching and mentorship, limited teaching and research infrastructures, limited financial resources, and lack of administrative capacity. With the support of the Medical Education Partnership Initiative (MEPI), three Master degree programs were designed and implemented. During the period of 2013–2018, UniLúrio enrolled 202 students, distributed as follows: Master degree in Tropical Medicine and Global Health (55), Master degree in Health Professional Education (99), and Master degree in Nutrition and Food Security (48). Of those, 152 (75.2%) obtained a Postgraduate Diploma as they did not present a master dissertation, 89 (44.0%) obtained their Master degree, 30 (14.8%) dropped out, and 20 (9.9%) are awaiting decision. UniLúrio's staff trained a Master's degree or a Postgraduate Diploma in 34 (16.8%) and 15 (7.4%), respectively. Our strategies allowed us to improve research capacity building, and set the basis for long-term sustainability by allowing for the establishment of other postgraduate programs, and offered UniLúrio a strong role in its internationalization.

Conclusion: By sharing multiple resources, long-lasting partnerships were established with multiple institutions, and competency-based training and postgraduate studies management were developed. Research and eLearning were leveraged, retention and faculty development was enhanced, and some inequalities within the country were reduced. These strategies and innovations can be applied to other resource-limited settings, allowing the scaleup of health professional's training and research capacity building.

Keywords: faculty development, health professionals education, health system strengthening, research capacity building, implementation science, MEPI

Introduction

Mozambique, as many other low-income countries (LICs), is still characterized as having one of Africa's lowest per capita rates of higher education at both the undergraduate and the postgraduate levels.¹ With 28.8 million people, life expectancy for males is of 53 years which is well below the African average (59.1 years).^{2,3}

The adult literacy rate is of 60.7%, ranks 181st out of 189 countries, according to the UN Human Development Index. About 66% of the population lives in rural areas and rely on subsistence farming under rain-fed conditions which are severely affected by the cyclical occurrence of droughts and floods, causing unbalanced food and nutritional income. A large part of the population, (62.9%) lives below income poverty line.⁴⁻⁹

Further, the country has one of the lowest worldwide densities of health workers (0.4 physicians, 4.12 nurses and midwives per 10,000 people).^{10,11} The distribution of health professionals across the country is not uniform, with more deficits in the north and central provinces, such as Nampula, Niassa, Cabo Delgado, and Zambeze.^{12,13} To further exacerbate the scarcity of the health workforce in the country, the average academic qualifications are low. In 2016, out of the total health professionals employed by the Ministry of Health, 10% were of early primary school level, 51% of basic level, 32% of high school level, and 7% of University level.⁹ This indicates a visible need for additional health professionals in quality and academic qualifications to meet Mozambique's efforts to develop a proper health coverage, thus achieving sustainable development goals (SDGs).^{9,14-16}

The disease profile which is dominated by infectious and neglected tropical diseases is not uniform across the country. Higher prevalences are found in the north and central regions.¹⁷⁻²¹ Taken together HIV/AIDS and malaria account for over half of the deaths in the general population, with 27% and 29% of the rate mortality, respectively. More specifically, in 2018 Mozambique shows a general seroprevalence of 12.6% for HIV/AIDS in the age group of 15 to 49 years old, 55.2% for malaria, 52% for diarrheal infection and respiratory infections, and 43% for chronic malnutrition.^{16,17,22,23} Further, Mozambique is amongst the countries with a high burden of active tuberculosis infections with 559/100,000 inhabitants active cases.²⁴

Though neglected tropical diseases such as intestinal parasites (53%), lymphatic filariasis (13%), schistosomiasis (47%) are not direct causes of mortality, they lead to physical and mental disabilities in children and are correlated with anemia and malnutrition in general.^{6,18,19,23}

Mozambique has very limited information on distribution and prevalence of these diseases though a number of restricted area information can be found.

This study was conducted at Lúrio University (UniLúrio), located in the north of Mozambique in Nampula province. It was created to serve the most populated province of Mozambique, with approximately 6.1 million inhabitants, an

illiteracy rate of 62.3% with most of the population (71.4%) living in rural areas. According to the most recent demographic health survey, in 2011 the prevalence of malaria in children aged 6–55 months is of 55.2%, while in Maputo province is of 4.8%. Nampula is also amongst the provinces in the country with higher rates of intestinal parasites (95%), lymphatic filariasis (12%), cysticercosis (15–57%), schistosomiasis (c.a. 78%), and leprosy (0.006%). Nampula is one of the provinces with the highest number of active cases of tuberculosis (13,938 cases in 2019) inhabitants with the majority of cases due to co-infection with HIV/AIDS.^{16,18-21,24,25}

Furthermore, the northern and central provinces are less served by health professionals. In 2016, the country national average, was 100.2/100.000 inhabitants, in Nampula with 75.6/100,000 while in Maputo province and Maputo city, the number of healthcare workers was 92.8 and 242.7/100.000 inhabitants, respectively.⁹

Despite Mozambican governmental investments in higher education, since independence from Portugal in 1975, by 2010 there were only three public medical schools in Mozambique. These were located at Eduardo Mondlane University (UEM) from a previous well-established University created during the colonial era, in 1963, and located in the capital Lourenço Marques, now called Maputo. Later on, two new public Universities were established, UniLúrio in 2006 and Zambeze University (UniZambeze) in 2009. Both Universities included instructions in several health-related subjects including medicine.^{12,16,26-28}

Postgraduate training programs in health sciences only began in 1999, at UEM-FoM with introduction of three Master programs in Public Health and, later on, in Mental Health and in Field Epidemiology. The first Doctoral program was established in 2006 at UEM Faculty of Humanitarian Sciences. It was recognized a limited capacity to train both undergraduate and postgraduate students in Mozambique, due to a limited number of faculty members with didactic, research, and mentorship skills, with proven training requirements. Research teaching infrastructure and financial resources were also necessary.^{26,28-30}

For the period of 2004–2010, only 67% of Mozambican University faculty members had a University level degree, 22% a Master degree and only 11% had a PhD degree. Most of this were obtained abroad. A number of private institutions, mostly located in Maputo city, have also offered graduate and postgraduate training programs, though quality control of these programs and certification by the Ministry of Higher Education is ongoing.^{28,31} In 2003, a Higher Institute for Health Sciences (Instituto Superior de Ciências

de Saúde (ISCISA) was created, supporting previous training of other mid-level health-related training professionals (nurses, non-physician technicians, dentists, and anesthetists) undertaken by other institutions of Health Sciences in the provinces of Mozambique.

In general, it was noted that most investments in higher education were concentrated in and around Maputo, the capital located at the extreme southern end of Mozambique (see Figure 1).^{9,26,28,29,32–35}

Under, the Medical Education Partnership Initiative (MEPI), a collaboration was established with UEM, and the University of California San Diego (UCSD) and

supported by the US Department of State through the President's Emergency Plan for AIDS Relief (PEPFAR) and the National Institutes of Health (NIH). A number of postgraduate programs were created at UniLúrio, aiming at scaling up training of physicians, improving research capacity and bioinformatics, and developing inter collaborative communities of practice in 12 sub-Saharan African countries.^{11,26,30,36}

The aim of this manuscript is to describe the strategies and processes adopted to design and implement three new postgraduate programs at UniLúrio, located in a geographically resource-limited setting of Mozambique.

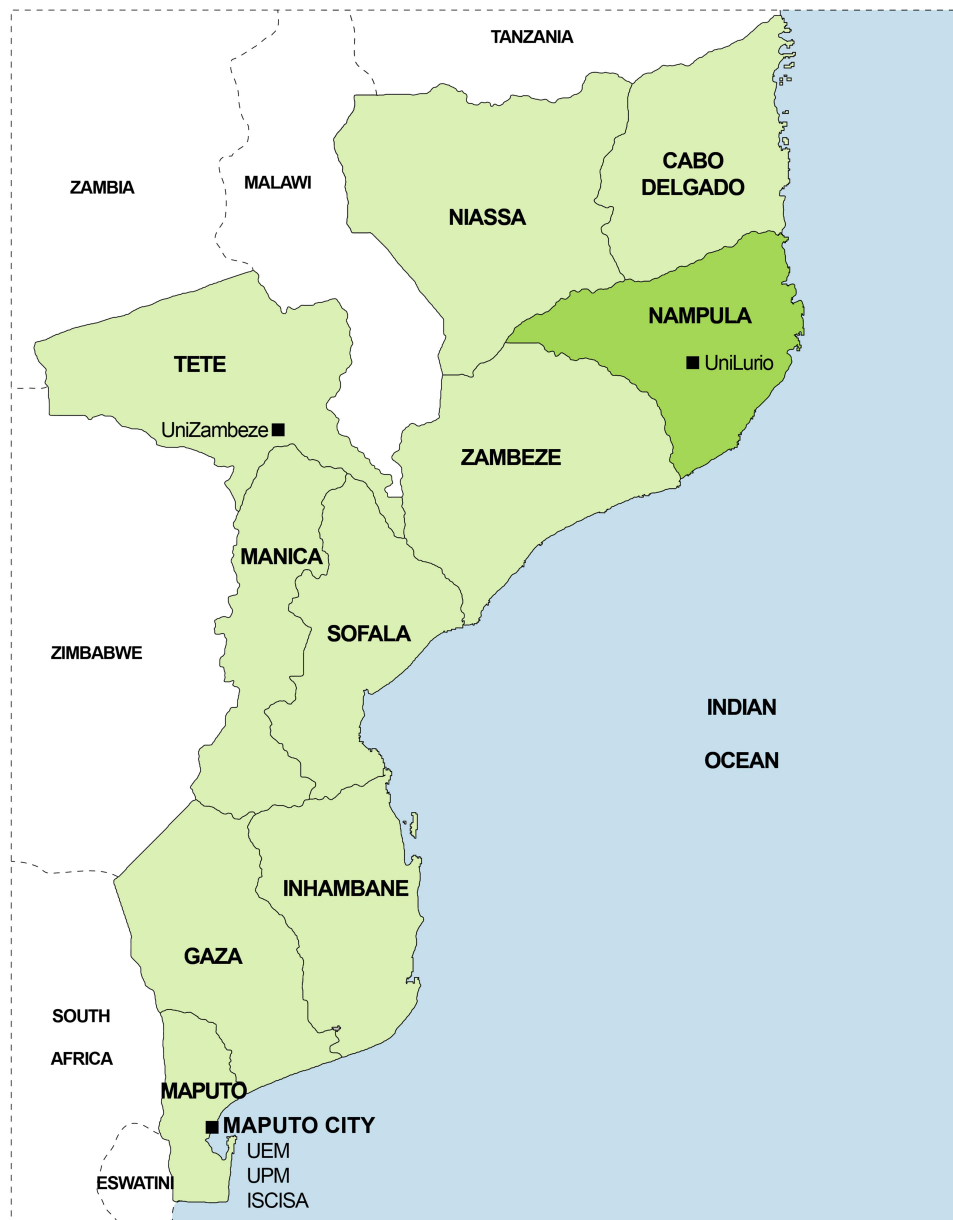


Figure 1 Mozambique map and location of all public health training institution.

Methods

We conducted a longitudinal descriptive case study from 2011 until 2018 in two phases: 1) needs assessment (2011–2012), 2) implementation strategies, taking into account innovations (2013–2018), whenever necessary.

For the design and implementation of strategies, we defined 2 main targets: the design of a curricula for the three Masters degree programs and the selection of the teaching staff, according to their curriculum vitae.

The primary expected outcomes of our strategy was to increase the number of postgraduate programs as well as the number of students registered in each program. The expected outcomes were defined in relation to a time outline.

In general, each Master program included a first year of teaching, a second year of seminar discussions of potential dissertations, and the research itself aiming at a final examination. Students who were not successful in obtaining a Master degree were awarded a Postgraduate Diploma. UniLurio awarded scholarships to its faculty members. Registration and monthly fees were paid by the students.

In relation to our secondary outcome related to institutional capacity building, we took into account: a) most of UniLurio faculty members had only a University graduation Diploma with little research experience or training, b) that UniLurio lacked adequate and modern laboratory infrastructures, updated libraries and needed to improve access to internet capacity. These points were discussed and included in the implementation plan of the Masters programs.

Once the Masters program was established, outcomes were analyzed, discussed, and improved strategies were defined.

The tertiary outcome was the creation of communities of practice to warrant a national and international networking at UniLurio, with retention of faculty members and other health professionals in Nampula.

The main outcomes were assessed by a scientific board, using descriptive statistics.

Phase I: Needs Assessment

The first phase was conducted by the Rector of UniLurio and his Board of Directors, the UniLurio and the UEM-UCSD faculty members. A number of site visits took place between May 2011 to July 2012, to evaluate the learning environment and better describe needs and expectations.

Information and data were collected on a) training and research experience of UniLurio staff members to be registered in the three master programs, b) an existing postgraduate curriculum program, c) existing human resources related to the three master programs, and d) other issues related to academic and institutional administration and research infrastructure.

Finally, the need for establishing postgraduate training programs was well intended but, the Higher Education Ministry demanded the requirement of 1/3 of its faculty members to hold a doctoral degree, which was not the case at UniLurio.^{31,37}

Concerning human resources, by 2013, the FHSc had a total of 60 full-time teaching faculty members. Among these, 52 (86.7%) had a University graduation degree, 5 (8.3%) had a Master degree and within this 3 (5%) were doctoral students registered in Universities abroad.

Experience in research was quite limited and only 10% of UniLurio's faculty members had produced scientific publications in peer-reviewed journals. Furthermore, the majority 42 (70%) of UniLurio's faculty members were expatriates from various countries, including Cuba, Brazil, Denmark, Italy, Portugal, and Russia. Only 18 (30%) were Mozambicans.

English language proficiency was poor. This hampered scientific writing and, strongly limited access to publication in peer-reviewed international journals or grant applications.²⁶ Moreover, most students entering postgraduate training required scholarships.

Further, there was an absence of trained laboratory technicians to perform and support research activities.

With regard to teaching and research infrastructure, UniLurio's libraries and classrooms had limited access to modern textbooks, scientific journals, and internet, limited either by lack of knowledge or by lack of updating. Awareness of access to digital resources at lower prices and interchange with other national or international institutions was extremely limited.

Furthermore, UniLurio lacked well-equipped biomedical laboratories to support research activities carried out by its faculty members and researchers.

Concerning financial resources, and despite the pressure to scale up teaching and research programs directed at training health professionals, there was a paucity of financial resources to support teaching and there was no dedicated budget for research. UniLurio's few research activities were supported by sporadic donations from a few external partners and Mozambican Government

ministries. These included the Ministry of Education and the Ministry of Science and Technology.

Regarding academic and institutional administration, management was centralized and carried out solely by state funds and run directly through the Rector's Office. With the introduction of these postgraduate programs, it became clear that a more responsive and flexible administrative structure was required since national funds and international donations were being invested and required active management.

Phase 2: Design and Implementation of Strategies

Following a comprehensive assessment of the needs for the establishment of postgraduate training at UniLúrio, a postgraduate working group (PGWG) was created.

This was composed of 12 experienced faculty members from UniLúrio, UEM, UCSD, and the Institute of Hygiene and Tropical Medicine-Universidade Nova de Lisboa (IHMT-UNL), Portugal as well as Oporto University, Portugal. Foreign guest members were selected according to their experience in developing similar programs.^{26,35} Since a multidisciplinary and transdisciplinary team with pedagogical, administrative skills was necessary, other lecturers and administrators were included.

The PGWG was then divided into three sub-groups specific to each scientific area: Health Professionals Education, Tropical Medicine and Global Health and Nutrition and Food Security. These scientific areas were in agreement with policies and priorities of the Mozambican Government, as defined for the health sector, higher education as well as with sustainable development goals. It takes into account the epidemiological profile of diseases in Nampula, as well as other Southern African countries (infectious and neglected diseases, malnutrition, and food insecurity).^{16–24,37}

An extensive literature review related to strategies and innovations, used in similar conditions, was carried out.^{26,32,33,35,38–40}

For the design of a core curriculum model, the PGWG held several on-site and teleconference meetings to discuss and identify for each of the proposed Master programs specific objectives and strategies for its development. These Masters were as follows: in Tropical Medicine and Global Health (MTMGH), in Health Professionals Education (MHPE), and in Nutrition and Food Security (MNFS).

The teaching methods and contents included classical methods, eLearning teaching. The UEM-FoM Public Health Master program was adapted to UniLúrio.

Each of the three Masters programs specified two-year of activity with a total of 120 academic credits. The credits were divided in 3 modules: Preparatory modules (15 credits), Basic modules (45 credits), and Advanced modules (60 credits). We followed the National Credit Transfer and Accumulation System in which each academic credit corresponds to 30 hours of interaction with the lecturer/mentor/supervisor.⁴¹

Each Preparatory modules was administered in 10 weeks (15 credits). This was common to all Master programs and introduced to the students scientific English, biomedical terminology, sources of health information, and distance learning. The limited proficiency English of the students in Mozambique, a Portuguese-speaking country was taken into account. Since most up-to-date scientific literature is initially presented in English, on digital platforms the preparatory module included extensive contact with peer-reviewed journals in both English and Portuguese.

The Basic modules were administered in 30 weeks (45 credits) and covered topics associated to each of the three scientific areas (MTMGH, MHPE, MNFS) (Tables 1–3).

These topics addressed local and regional health problems, including neighboring countries with similar health issues.

Upon completion of all Preparatory and Basic modules, a Postgraduate Diploma degree of the specific program is awarded.

The Advanced modules were administered in 40 weeks (60 credits) to each Master program, including seminars that implemented scientific discussion of research ideas for dissertation. Each student could then present their research proposal under two supervisors (Tables 1–3). Finally, examination required a jury of three scientists in the area, one being the supervisor, the second one an external examiner, and the third one being the chairman who is also within the scientific area and also engaged in questioning. Students are awarded a Master's degree Diploma, after approval by the jury.

Only one of the three Master programs, MNFS, was designed to have two branches: Clinical Nutrition and Food Technology Science. The students selected one or the other, after a common Basic module (Table 3).

In exceptional situations, students living outside Nampula, with access to university laboratories and

Table 1 Master in Tropical Medicine and Global Health: Study Plan

	Code	Module	N Weeks	Contact Hours	Credits
Preparatory modules [10 weeks; 15 Credits]	PM1	Introduction to Biomedical Scientific English Terminology. Sources of information in Health	2	40	3
	PM2	Scientific presentation methods	2	40	3
	PM3	Health Sciences Pedagogy	2	40	3
	PM4	Distance learning and teaching methods	2	40	3
	PM5	Ethics in Health Sciences	2	40	3
Basic modules [30 weeks; 45 Credits]	BM1	Challenges in Global Health. Historical perspectives	2	40	3
	BM2	Development and Cooperation	2	40	3
	BM3	Public Health and Health Systems	2	40	3
	BM4	Tropical Medicine	4	80	6
	BM5	Maternal and Child Health Care	2	40	3
	BM6	Principles of Epidemiology and Demography	2	40	3
	BM7	Principles of Biostatistics	2	40	3
	BM8	Disease Prevention and Control	2	40	4
	BM9	Scientific Research Methodology	2	40	4
	BM10	Research grant proposals	2	40	3
	BM11	Data communication. Scientific writing	2	40	3
	BM12	Seminars	6	120	9
Advanced modules [40 weeks; 60 Credits]	AM1	Research project and Dissertation	40	60	60
	AM2	Oral Examination. Submission of Manuscript			

Abbreviations: PM, preparatory modules; BM, basic modules; AM, advanced modules; N, number; Contact hours, contact hours with lecturer or mentor; Credits, academic credits.

eLearning, could enroll in the program under local approved supervision. These rare cases were associated with teaching staff in other universities and requested by the heads of their Departments.

Students selected for the Master programs were University graduates in the following areas: Medicine, Veterinary, Biology, Agronomy, Chemistry, or other related areas, with final score of not less than 14/20. Exceptionally, and considering issues of merit, candidates who had a final average in the University degree with final scores not less than 12/20 could be admitted to enter any Master program. All selected students were required to pass Portuguese and English proficiency tests. The number of candidates per program could not exceed 30 and a final list was produced according to the individual average

score.³⁷ Admission priority was given to faculty members at UniLúrio or other public Mozambican Universities or to workers of the National Health System.

The UniLúrio Board of Directors approved MTMGH and MHPE in October 2013 and approved MNFS in November 2014.

A core group of experienced faculty members with content knowledge directly related to the Master programs were recruited for the programs. These individuals were from national and international institutions, including UEM, Mozambique's Pedagogic University (UPM), IHMT-UNL, Oporto University, the University of Granada (Spain), and UCSD. Ninety percent of these external faculty members had doctoral degrees with ongoing teaching and research activities in their own

Table 2 Master in Health Professional Education: Study Plan

	Code	Module	N Weeks	Contact Hours	Credits
Preparatory modules [10 weeks; 15 Credits]	PM1	Introduction to Biomedical Scientific English Terminology. Sources of information in Health	2	40	3
	PM2	Scientific presentation methods	2	40	3
	PM3	Health Sciences Pedagogy	2	40	3
	PM4	Distance learning and teaching methods	2	40	3
	PM5	Ethics in Health Sciences	2	40	3
Basic modules [30 weeks; 45 Credits]	BM1	Principals of Pedagogy	2	40	3
	BM2	Methods and strategies in teaching in Health and learning Health Sciences	2	40	3
	BM3	Leadership and management of competencies	2	40	3
	BM4	Evaluation and assessment in Health Sciences	2	40	3
	BM5	Development of communication competence	2	40	3
	BM6	Pedagogic Planification in Health Sciences	2	40	3
	BM7	Curriculum design	2	40	3
	BM8	Principles of Epidemiology and Demography	2	40	3
	BM9	Principles of Biostatistics	2	40	3
	BM10	Scientific Research Methodology	2	40	3
	BM11	Research grant proposals	2	40	3
	BM12	Data communication. Scientific writing	2	40	3
	BM13	Seminars on Health Professionals education	6	120	9
Advanced modules [40 weeks; 60 Credits]	AM1	Research project and Dissertation	40	60	60
	AM2	Oral Examination. Submission of Manuscript			

Abbreviations: PM, preparatory modules; BM, basic modules; AM, advanced modules; N, number; Contact hours, contact hours with lecturer or mentor; Credits, academic credits.

institutions, with well-established curriculum vitae and ongoing experience in areas related to the Master. In some cases, staff members without PhD degrees were recruited to support laboratory research activity.

We also recruited a number of UniLúrio faculty members with Masters degrees whenever necessary. We paired them with external faculty members in the implementation of the programs.

In addition, one UniLúrio faculty member participated in a US NIH grants management workshop in South Africa's KwaZulu-Natal province, in 2016. Four received training in qualitative and quantitative research methods, through distance learning at IHMT-UNL, to support teaching and research activities.

Seminars on bioethics, manuscript and research protocol writing, research methods, didactic, and student's evaluation methods, were organized and delivered to all faculty members, on a regular basis. These activities provided faculty development opportunities for program faculty members while at UniLúrio.²⁷

With regard to teaching and research infrastructures required by the program support was also provided for: a) training of technical staff, b) continuous updating of equipment and its maintenance and, c) regular improvement of laboratory conditions adapted to the Master program.

Students were sent to other institutions for further training during the development of their research, aimed at their

Table 3 Master in Nutrition and Food Security: Study Plan

	Code	Module	N Weeks	Contact Hours	Credits	
Preparatory modules [10 weeks = 15 Credits]	PM1	Introduction to Biomedical Scientific English Terminology. Sources of information in Health	2	40	3	
	PM2	Scientific presentation methods	2	40	3	
	PM3	Health Sciences Pedagogy	2	40	3	
	PM4	Distance learning and teaching methods	2	40	3	
	PM5	Ethics in Health Sciences	2	40	3	
Basic modules [30 weeks = 45 Credits]	BM1	Nutrition and Public Health. Policy legislation in Food Issues	2	40	3	
	BM2	Microbiology, Hygiene and Security	2	40	3	
	BM3	Principles of Biochemistry and Physiology. Food Processing. Food Conservation	4	80	6	
	BM4	Principles of Epidemiology and Demography	2	40	3	
	BM5	Principles of Biostatistics	2	40	3	
	BM6	Research grant proposals	2	40	3	
	BM7	Data communication. Scientific writing	2	40	3	
	BM8	Scientific writing	2	40	3	
	BM9	Seminars on food Security	6	120	9	
	Clinical Nutrition branch	BM-CN10	Maternal and Child Nutrition	2	40	3
		BM-CN11	Metabolic interactions	2	40	3
		BM-CN12	Nutritional programs and project management	2	40	3
	Food and Science Technology branch	BM-FST10	Technology products of Animal origin I	2	40	3
		BM-FST11	Technology products of Animal origin II	2	40	3
		BM-FST12	Technology products of Vegetable origin	2	40	3
Advanced modules [40 weeks = 60 Credits]	AM1	Research project and Dissertation	40	60	60	
	AM2	Oral Examination. Submission of Manuscript				

Note: BM10, 11, and 12 correspond to common basic modules.

Abbreviations: PM, preparatory modules; BM, basic modules; AM, advanced modules; CN, Clinical Nutrition; FST, Food and Science Technology; N, number; Contact hours, contact hours with lecturer or mentor; Credits, academic credits.

dissertation. Thus, we partnered with: a) the UEM FoM Infectious Disease Laboratory which had previously been refurbished and its technicians trained with the Gilead Foundation (Foster City, CA, USA), the James B. Pendleton Trust (Bellevue, WA, USA), MBio

Diagnostics (Boulder, CO, USA) and MEPI support;²⁶ b) the UEM Biotechnology Center Laboratory; c) the Universidade Federal de Minas Gerais in Brasil; d) the Centro de Estudos interdisciplinares-UniLúrio; e) the IHMT-UNL; and f) the UCSD Division of Infectious

Diseases Laboratories, all of which hosted technical staff and students for training. Physical improvements of UniLúrio's Laboratories were also initiated, one for Microbiology and one for Nutrition.

Two classrooms at UniLúrio were selected and equipped with internet facilities for distance eLearning. This was accomplished by using MEPI, support which allowed to connect the original campus in Nampula to the new campus, 4.1 Km away.

The "Go-To-Meeting" platform from UCSD was installed and configured to support teaching and research mentorship of the ongoing Master programs, as well as to the UniLúrio faculty.³⁶

A number of other digital online resources, such as Up-To-Date, were made available to students through the e-Library or granted by agreement with the UCSD library and capacityplus.org. Both supported institutional subscriptions to several key journals. Training in how to use the available World Health Organization HINARI online platform was also given to faculty members and students.

Concerning financial resources mobilization, funds for this endeavor came mostly from MEPI (\$ 96,730.00.00) and later on from the Enhanced Advanced Biomedical Research Training in Mozambique (EABRTM) (\$104,857.00), from NIH-US program and other joint research grants between the UEM and UCSD faculty members. These funds supported the purchase of computers, LCD projectors and software for use in eLearning activities, fiber optic, external faculty travel, lodging and supplemental salary as an incentive for their teaching, didactic and research mentorship activities.³⁶ Two on-campus houses at the University were offered as lodging for visiting Professors.

Furthermore, a fee equivalent to \$200 USD per month was established for each student entering the programs, to further ensure future sustainability of the programs beyond external funding. In addition, UniLúrio co-participated and supported 50% of the fees of its own faculty and administrative staff who enrolled in any of the Master programs.

With regard to the establishment of administration infrastructure, due to the dynamics of establishing three Master programs at UniLúrio, it was necessary to create a secretariat specific to the master's activities, which included contact with students, as well as regular contact with national and international collaborators. A scientific committee was created, composed by UniLúrio Faculty members and other teaching staff. Furthermore, fiscal

and administrative management capacity at UniLúrio was developed through the Mozambique Institute for Health Education and Research (MIHER- www.miher.org), the Research Support Center, created in Mozambique by the MEPI program. This Center supported the scientific community of UEM and other public universities in fiscal and grant management and to identify funding agencies.^{26,32}

Results

At UniLúrio three Master programs were established, MTMGH, MHPE, and MNFS. The two first ones were initiated in 2013 and run every two years until 2018. The MNFS program was initiated in 2014–2016 and 2016 until 2018 with two branches, Clinical Nutrition and Food Technology Science and run until 2018.

From 2013 up to 2018, 202 students were registered of which 152 (75.2%) obtained a Postgraduate Diploma associated to the first year of the academic studies and from this 89 (44.0%) pursued with success a Master degree/Diploma.

Further details can be seen in [Table 4](#).

Out of the 202 registered students, 61 (30.1%) were UniLúrio faculty members, of which 34 (55.7%) were awarded a Master degree. This represents a 6.8-fold increase in the number of faculty members with a Master degree.

Concerning institutional capacity building, it is important to stress that 5 UniLúrio faculty members with a Master degree selected as co-supervisors or co-mentors in these programs were also working on their PhD studies. Four of these have since successfully completed their PhD studies.

In the network created with other public Universities in Mozambique, 5 faculty members from those universities were awarded Master degrees at UniLúrio, (1) MTMGH, (3) MHPE, and (1) in MNFS.

The topics of these dissertations included infectious and neglected tropical diseases, medicinal plants and traditional medicines, entomology, curriculum evaluation, teaching and learning processes and pedagogical supervision, nutrition and food technology and conservation.

Research work of four master students was published in international peer-reviewed journals,^{4,42–44} two published in other local journals while nine abstracts by UniLúrio faculty members were presented at International meetings. Several additional manuscripts are in preparation.

Table 4 Number of Students Enrolled for MTMGH, MPHE, and MNFS Programs and Outcomes

Master Program	Period in Years for Each Cohort	Registered Students N	Postgraduate Diploma N (%)	Master Diploma N (%)	Dropout Students N (%)	Awaiting Decision N (%)	
MTMGH	2013–2015	21	16 (76.2%)	8 (38.1%)	3 (14.3%)	2 (9.5%)	
	2014–2016	22	15 (68.2%)	7 (31.8%)	4 (18.2%)	3 (13.6%)	
	2016–2018	12	10 (83.3%)	3 (25.0%)	1 (8.3%)	1 (8.3%)	
Sub-total	2013–2018	55	41 (74.5%)	18 (32.7%)	8 (14.5%)	6 (10.9%)	
MHPE	2013–2014	31	23 (74.2%)	22 (70.9%)	7 (22.6%)	1 (3.2%)	
	2014–2016	28	21 (75.0%)	14 (50.0%)	5 (17.8%)	2 (7.1%)	
	2016–2018	40	29 (72.5%)	16 (40.0%)	5 (12.5%)	6 (15.0%)	
Sub-total	2013–2018	99	73 (73.7%)	52 (52.5%)	17 (26.3%)	9 (16.2%)	
MNFS	CN-branch	2014–2016	20	15 (75%)	9 (45.0%)	3 (15.0%)	2 (10.0%)
		2016–2018	5	5 (88.2%)	3 (47.1%)	0 (0.0%)	0 (0.0%)
	Sub-total	2014–2018	25	20 (80.0%)	12 (48.0%)	3 (12.0%)	2 (8.0%)
	FST-branch	2014–2016	11	8 (72.7%)	2 (18.2%)	1 (9.1%)	2 (18.2%)
2016–2018		12	10 (83.3%)	5 (41.6%)	1 (8.3%)	1 (8.3%)	
Sub-total	2014–2018	23	18 (78.2%)	7 (30.4%)	2 (8.7%)	3 (13.0%)	
Total	2013–2018	202	152 (75.2%)	89 (44.0%)	30 (14.9%)	20 (9.9%)	

Abbreviations: MTMGH, Master in Tropical Medicine and Global Health; MHPE, Master in Health Professional Education; MNFS, Master in Nutrition and Food Security; CN, Clinical Nutrition; FST, Food Science Technology; N, number; %, percentage.

Whenever possible seminars in scientific areas of interest to the programs were included, delivered by guest scientists.

Fees totaling \$32,727.00 collected from students between 2013 and 2016 were used to renovate nine former storage rooms into new classrooms, as well as a teaching and mentor's room and an eLearning room. This allowed for the establishment of new Center for Postgraduate Studies and Extension at UniLúrio. The Center was created with the aim of further development in training and research capacity.

By the end of 2018, it was demonstrated that UniLúrio bioinformatics capacity and eLearning platforms to support teaching and research were successfully established. The establishment of an autonomous administrative and fiscal management structure of the master's funds was also well developed. By 2018 a Postgraduate coordinating team was functioning as expected.

Through these Master programs, we have established an enlarged network to consist not only in the initial Universities included in the design and implementation of strategies but others, within and outside the country.

Moreover, the network has been expanded to institutions like Mozambique's Ministry of Agriculture, the World Health Organization, and the Food and Agriculture Organization.

Funds generated from research grants and student's fees were used to pay for renovation or improvement of infrastructure, as well as partial payment of staff from UniLúrio, UEM, and UPM and 17 administrators involved in the teaching and coordination of Postgraduate programs.

Discussion

The manuscript described the strategies and ongoing analysis of three Postgraduate programs established in a newly created University located in an under-served geographical region in the north of Mozambique.

By 2018, out of 202 registered students in the three different programs, 89 obtained their Master Diplomas and we consider this a contribution to the improvement of professional skills and numbers in health-related areas. Therefore, the country would continue to scale up such training with finally improvements and strengthening of the health system.^{11,27,33,34}

The 2012–2020 Strategic Plan for Higher Education in Mozambique defined that at least 25% of Faculty members in public Universities should be trained at the master's level by 2015. Though UniLúrio has not yet achieved this requirement it has increased its percentage of faculty members with Master degrees from 8.3% in 2013 to 17.8 (%) in 2018.

These Postgraduate training programs opened opportunities for expanding advanced biomedical and scientific training within Mozambique, thereby obviating social and economic hardships related to training abroad and substantially reducing faculty travel costs.^{26,28}

Within the country, the program has contributed to a reduction in regional inequities since we were able to create a number of Postgraduate programs which were inexistent before in the region and in the country as well, and trained faculty and staff from other Universities (UEM, UniZambeze, and UPM).

By selecting and involving UniLúrio's staff as co-supervisors and co-mentors of postgraduate students, we substantially strengthened the university mentorship skills. This ensured program sustainability and reduced the costs of requiring external staff.^{11,26,30} This experience should be now translated into policy and guidelines. There are similar initiatives in which students were used to co-lead training of others. One example is India which produced exceptional results. This ensured program sustainability, especially in financially limited settings such as in our case.⁴⁰ Each research project generated knowledge about relevant problems in the region and in the country.^{45,46}

Mozambique is not among the most publishing countries in the WHO African region.⁴⁷ These Postgraduate programs may contribute to the improvement of the research proficiency of UniLúrio's faculty and other health professionals. Strengthening Mozambique's research culture and developing sound investigative practices directed at the most pressing national and regional health problems is a large step in the right direction.^{26,32,48}

The development of a new Center for Postgraduate studies and Extension at UniLúrio is now poised to train a variety of professionals in a variety of priority areas, identify institutions and other sources to continue institutional capacity development beyond MEPI and related grants.

Bioinformatic capacity and eLearning platforms created to support these postgraduate studies have enabled the expansion of courses and academic interactions among multiple academic institutions and helped to reduce inequities within various institutions in the country. Invested with novel software tools, UniLúrio continues to

expand its capacity to support undergraduate and postgraduate students including health professional staff training.

Building upon the MEPI experience and innovations in establishing postgraduate programs in resource-limited setting, UniLúrio now owns this experience and has established another Master program in 2018. This Master program on Public Health involves two branches: Maternal Child Health and Health Policy branches, based on local needs and available resources.

Thus, we have created an academic capacity to support and sustain training and research activities, developed an infrastructure, and retained staff within each institution in multi-and trans-disciplinary ways. This is expected to support sustained improvement in quality of care. Indeed, the experience of research team members from UEM teaching hospital that was the core part of our program was evaluated through an online survey complemented with telephone interviews to gather additional qualitative data, demonstrating that participation in clinical research has a positive impact on patient management.⁴⁹

Furthermore, we have developed sustainable strategies and a network of national and international academic institutions working together on multiple common goals (UniLúrio, UEM, UPM, UniZambeze, UCSO, UNL-IHMT, Oporto University, Universidad de Granada, Universidade do Aveiro, Universidade Técnica de Lisboa, Universidade Federal de Minas Gerais). We have followed other initiatives which were successful such as the Better Health Information for Better Health Policy (INDEPTH) network, Consortium for Health Systems Policy Analysis in Africa (CHEPSAA), the partnership between Makerere University and Karolinska Institutet, the African/Asian Regional Capacity Development and RAHI-SATHI Indo-US are underway elsewhere. These initiatives have taken slightly different approaches to capacity building resulting in outcomes not directly comparable to ours. However, local ownership and leadership have been key factors contributing to the success of each of these initiatives.^{36,39,40,50}

Despite the progress, several challenges remain possibly affecting further progress. These include: a) the need for additional fluency in written and spoken English, b) the incomplete development of research laboratories, classrooms, and educational teaching materials, c) the 50% depreciation of Mozambique's currency in the subsequent years that has made the courses more expensive than expected, d) the health issues and an inability to pay fees that have challenged some students without fellowships and

led to abandonment of their studies, e) the competing primary professional responsibilities of most of the registered students allowing only half time for study-related activities, f) and finally, the institutional review board for a human subjects approval system at UniLúrio and throughout the country is still a barrier. The review protocol process can take more than six months and significantly delay the initiation of projects involving human subjects.

Ultimately, it is our goal to strengthen these Master programs and to move toward the development of doctoral degree programs.

In summary, we have observed that by sharing human, educational resources, laboratory materials, and equipment among numerous institutions and stakeholders, it is possible to establish training programs in resource-limited setting regions such as at UniLúrio.

The resultant outcomes potentially include enhanced retention and promotion of scientific growth, career development and personal satisfaction of faculty and students as well as allowing the scientific, pedagogical and academic management growth of UniLúrio and UEM faculty as they were challenged to create and run these programs.

Each of the involved institutions and faculty members brought different skills and expertise to these capacity building strategies and innovations and each of the faculty members are now benefiting from the knowledge, experience, networking, and publications emanating from them, thus assuring long-term sustainability.

This model of establishing postgraduate training can be adapted to create other training programs within Mozambican Universities and those in other countries experiencing limited resources.

Abbreviations

LICs, low-income countries; SDGs, sustainable development goals; UEM, Eduardo Mondlane University; FoM, Faculty of Medicine; UniLúrio, Lúrio University; UniZambeze, Zambeze University; ISCISA, Instituto Superior de Ciências de Saúde; MEPI, Medical Education Partnership Initiative; UCSD, University of California San Diego; PEPFAR, President's Emergency Plan for AIDS Relief; NIH, National Institutes of Health; FHSc, Faculty of Health Sciences; PGWG, Postgraduate Working Group; IHMT-UNL, Institute of Hygiene and Tropical Medicine-Universidade Nova de Lisboa; MTMGH, Master in Tropical Medicine and Global Health; MHPE, Master in Health Professionals Education; MNFS, Master in Nutrition and Food Security; UPM, Mozambique's Pedagogic University; EABRTM;

Enhanced Advanced Biomedical Research Training in Mozambique; MIHER, Mozambique Institute for Health Education and Research; INDEPTH, Better Health Information for Better Health Policy; CHEPSAA, Consortium for Health Systems Policy Analysis in Africa.

Ethics Approval and Informed Consent

This work was approved by the UniLúrio Scientific Committee and UniLúrio Board of Directors.

Consent for Publication

Not applicable.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

All authors read and approved the final version of the manuscript.

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