Survey of Clinical and Anatomic Pathology Laboratory Infrastructure in Mozambique

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ABSTRACT

Objectives: *Pathology services are limited in most areas of sub-Saharan Africa. This study's aim was to survey anatomic and clinical pathology services and laboratory infrastructure in Mozambique.*

Methods: *A survey was conducted from October-December 2018 across the four central hospitals of Mozambique to determine infrastructure and pathology services available.*

Results: *Most laboratory/pathology services in Mozambique are limited to the four central hospitals. Only 14 pathologists practice in the country despite a population of 29.5 million for the world's fifth worst workforce/population ratio. Approximately 35,000 anatomic pathology specimens are evaluated annually. Standard services across chemistry, hematology, microbiology, and blood bank are available at the four central hospitals. Esoteric laboratory testing and immunohistochemistry are generally only available in Maputo.*

Conclusions: *While most pathology services are available in Mozambique, many are available only at the Maputo laboratory. Expansion of pathology services and infrastructure will improve provision of effective and efficient health care as access to timely and accurate clinical diagnoses increases in Mozambique.*

Key Points

- Most general clinical and anatomic pathology services are available in Mozambique; however, they are often only present at the four central hospitals, limiting utility and efficiency.
- Lack of critical infrastructure outside of the urban centers and limited availability of adequately trained laboratory staff and pathologists are among the reasons why pathology service expansion is difficult in Mozambique.
- The insights gained through this study should be of value to pathologists and ministries of health in other African countries.

Pathology and laboratory medicine (PALM) services from basic clinical laboratory testing to anatomic pathology, including diagnosis of malignancies and performance of autopsies, are essential to adequate and equitable medical care. It is estimated that at least 70% of medical decisions (especially entailing accurate diagnoses) in high-income countries depend on laboratory data or pathologic services.[1] PALM services (both clinical and anatomic) are underdeveloped or limited in availability in most areas of sub-Saharan Africa. To this end, African Strategies for Advancing Pathology conducted a survey of basic pathology services and oncology care in sub-Saharan Africa from 2011 to 2013. They reported that pathology services are underserved on the African subcontinent, with most countries having fewer than one pathologist per million people.[2] They also identified a lack, or underutilization, of more advanced pathologic techniques such as immunohistochemistry or molecular testing essential for accurate diagnosis to guide treatment decisions in high-income countries. While this survey

focused on anatomic pathology services and oncology care, it is widely accepted that clinical pathology services are also lacking or of poor quality. Laboratory services are often limited at the initial point of care such as in health clinics. Even those available at large or tertiary care centers may be poorly managed or not adequately quality controlled.[3] Given that accurate laboratory testing has been shown to reduce the cost of treatment in both adults and children, this is especially concerning given the resource constraints and high burden of disease in sub-Saharan Africa.[4] We believe surveys such as these can yield valuable information for managing pathology resources and in implementing improved services.

In this article, we report results of a survey of PALM services in Mozambique. The aim of this survey was threefold: (1) to survey the current anatomic and clinical pathology infrastructure across Mozambique, (2) to identify regions in need of additional pathology services, and (3) to determine impediments to expansion of PALM services in Mozambique. It is our hope that the revelations and insights provided through this study may be of interest and value to pathologists and ministries of health in other African countries.

Background

Mozambique is a low-income country (LIC) located on the southeast coast of Africa with approximately 29.5 million people, ranking 181 out of 185 countries in the United Nations Human Development Index, indicating huge unmet needs in health, education, and basic living standards.[5] Like other LICs, Mozambique also faces significant challenges in the provision of health services due to a shortage of human and financial resources as well as adequately equipped laboratories and other infrastructure. The Mozambique National Health System is structured into four levels: primary, secondary, tertiary, and quaternary. The primary health care is delivered through rural health centers that typically cover the health needs of an area of 8 km^2 but may cover more than 50 km^2 through mobile health care agents. The secondary level consists of rural hospitals that provide emergency medical care, primary surgical care, basic laboratory and radiologic services, and initial treatment of other complex nonsurgical conditions referred from the primary health units. The rural hospitals are staffed by at least one or two general physicians and cover populations of 50,000 to 900,000. Provincial hospitals provide tertiary care and serve as referral centers for the rural hospitals while quaternary care is provided by the so-called central hospitals, of which there are only four for the entire country. The four central hospitals that support anatomic pathology departments and clinical laboratories in Mozambique are located in Maputo, Beira, Nampula, and Quelimane.

The Maputo Central Hospital, located in the south of the country, is the biggest (~1,200 beds) and oldest central hospital and serves as a countrywide referral hospital and the main teaching hospital for students of Eduardo Mondlane University Faculty of Medicine, both of which were created during Mozambique's colonial period under Portuguese rule (pre-1975). The Beira (1,114 beds) and Nampula (529 beds) Central Hospitals, located in the central and north parts of Mozambique, respectively, were also created during colonial times and serve as referral hospitals within the regions they are located. In 2016, the Quelimane (~600 beds) Central Hospital was built in the central Zambezia region of Mozambique **Figure 1**.

To oversee the functionality of the pathology services, including the training and supervision of pathology services in country, the Ministry of Health created the National Program of Pathology in 2005. Furthermore, in recognition of unmet needs of pathologists and limited capacity to train physicians in sufficient numbers to meet the needs of the population, the Ministry of Health introduced the cadre of nonphysician pathologists (NPPs) in 2004. This NPP cadre is a 3-year intensive training program for residents at the Superior Institute of Health Science (Instituto Superior de Ciências de Saúde) in Maputo with two incoming residents per year. In general, they are recruited from laboratory technicians or those trained in other bioscience fields with secondary school/preuniversity degrees, most of whom have background experience in health care within the country. They work within the anatomic pathology department and support the pathologists in gross dissection, histology, and cytopathology. Apart from this, a 4-year training program for pathology residents was created in Maputo in 2000. During 2000 to 2020, 11 pathologists were trained in Maputo, with seven residents currently in training. Unfortunately, there have been a relatively small number of applications for this residency program at Maputo Central Hospital.

Materials and Methods

The surveys were conducted from October to December 2018 across the four central hospital laboratories in Mozambique located in Maputo, Beira, Nampula, and Quelimane. Respondents were anatomic pathologists at each of these sites for the anatomic pathology survey and one clinical pathologist (Maputo) or senior laboratory staff at the other three sites for the clinical pathology survey. Only one anatomic and clinical

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Figure 1 Location of pathology laboratories in Mozambique.

survey was requested from each site, with a 100% response rate. All surveys were written and completed in English.

The survey questions and structure were developed by subject matter experts in anatomic and clinical pathology. We developed two separate surveys: one for anatomic pathology and a second for clinical pathology/laboratory medicine. Both surveys requested specific information on institutional characteristics, personnel/staffing, equipment, and utility availability, as well as included open-ended questions addressing strengths, needs, and other important features of the institution/laboratory. The anatomic pathology survey contained specific sections to determine surgical pathology services, cytopathology services, intraoperative consultation, procedural services, and the use of telepathology. The clinical pathology survey contained specific sections to determine testing and services in blood bank/transfusion medicine, chemistry, microbiology, hematology/coagulation, and point-of-care/rapid diagnostic testing. Respondents were informed that survey results would be reported in the medical literature and were therefore given the option of submitting their responses anonymously, although no one exercised this option. There were no required responses, and respondents could opt out of the survey at any stage.

Results

Anatomic Pathology Laboratory Services

Personnel and Laboratory Infrastructure

The survey revealed there are only 14 pathologists in Mozambique, 9 locally trained and 5 foreign trained, with 9 of them in Maputo and at least 1 pathologist in each of the other three central laboratories. Two other pathologists trained in Maputo migrated to Europe after training. The Maputo Anatomical Pathological Department commonly welcomes visiting pathologists from other countries in Africa, North America, and Europe. **Table 1** shows the number and profile of pathologists working in Mozambique. Only four cytopathologists currently practice in Mozambique, with three in Maputo and one in Beira. Two of the four institutions surveyed thought they had less than 50% of the laboratory staff expected based on the number of specimens received.

Surgical Pathology

All four of the surveyed laboratories receive and/or process surgical pathology material, including specimens, blocks, and/or slides. Surgical pathology samples are usually fixed with 4% formalin. Samples collected at facilities other than the four laboratories surveyed were generally sent to Maputo, which performs a greater amount of routine diagnostic activities such as autopsies, surgical pathology, exfoliative cervicovaginal cytology, and fine-needle aspirations (FNAs) than Beira and Nampula **Table 2**. The Quelimane laboratory is relatively new and has only been in operation since 2017, so data on caseloads were not yet available. Autopsy services are available at all surveyed sites. **Table 3** presents the five most commonly diagnosed neoplasms on biopsy specimens in men and women in Mozambique from 1991 to 2008.[6]

Cytopathology Services

Papanicolaou smears are performed and evaluated in Maputo and Beira with human papillomavirus testing

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Table 1
Human Resources in Mozambique Pathology Departments[a]

Professional	Maputo, No.	Beira, No.	Nampula, No.	Quelimane, No.	Total, No.
Mozambican pathologist	6	1	1	1	9
Foreign pathologist	3	1	1	0	5
Residents	7	0	0	0	7
Pathology technicians	10	4	3	1	18
Laboratory technicians	1	1	3	1	6
Cancer registry	4	1	0	0	5

[a]Source: National Program of Pathology, Ministry of Health, Mozambique, 2018.

available only in Maputo. Bronchial brushings and/or washings are only available in Maputo. FNAs were the only cytology specimen type reportedly available at all sites. FNA is a commonly used, cost-efficient diagnostic method used for cervical and axillary adenopathy, accessible breast lumps, and soft tissue tumors. FNA is commonly performed by a pathologist, and the needle target is guided by ultrasound when needed for cases such as thyroid nodules, mobile breast lumps, and some deep tumors of the kidney and liver.[7] Table 4 presents the most common diagnosis types and anatomic sites on FNA in Mozambique from 2009 to 2010.

Table 2
Routine Specimens in Anatomic Pathology Departments in Mozambique, 2015[a]

Specimen	Maputo, No.	Beira, No.	Nampula, No.
Exfoliative cytology	7,505	1,647	0
Fine-needle aspiration	3,201	1,322	2,362
Surgical pathology	8,407	7,505	2,052
Autopsy	561	15	7
Total	19,674	10,489	4,421

[a]Source: National Program of Pathology, Ministry of Health, Mozambique, 2018.

Table 3
Five Most Commonly Diagnosed Neoplasms on Biopsy Specimens in Mozambique From 1991 to 2008[a]

Men		Female	
Organ System	Frequency, %	Organ System	Frequency, %
Prostate	43.8	Cervix	26.8
Liver	6	Breast	11.4
Skin	5	Esophagus	6.4
Kaposi sarcoma	4.6	Liver	6.2
Esophagus	4.5	Skin	5

[a]Adapted with permission from Lorenzoni.[6]

Table 4
Most Common Diagnoses and Anatomic Sites for Fine-Needle Aspiration in Mozambique From 2009 to 2010 (n = 3,234)[a]

Diagnosis Type	Frequency, %	Anatomic Site
Inflammatory condition	22.2	Lymph nodes
Hyperplasia condition	20.6	Breast
Unsatisfactory specimen	14.0	Soft tissues
Benign tumors	13.4	Thyroid
Malignant tumors	12.3	Salivary gland

[a]Adapted with permission from Carrilho et al.[7]

Histology Services

Maputo and Beira use tissue and stain processors, but the other laboratories manually process surgical pathology specimens. Use of H&E, Papanicolaou, and silver stains such as Grocott's methenamine silver were reported by all four sites. Maputo has a wide selection of additional stains available, including Ziehl-Neelsen, Fite-Faraco, Masson's trichrome, periodic acid–Schiff, Alcian blue, Giemsa, Fontana-Masson, and reticulin.

Immunohistochemistry

Immunohistochemistry (IHC) has been performed routinely only in Maputo since 1990. The high cost of supplies and reagents limits its use, a constraint that is partially overcome through existing collaborations and research projects that support at least the acquisition of basic reagents. Pan-cytokeratin, CK7, CK20, LCA (CD45), CD3, CD20, CD15, CD30, CD34, TTF1, vimentin, desmin, actin, human herpesvirus 8, cytomegalovirus, estrogen/progesterone receptor, human epidermal growth factor receptor 2 (c-erbB2), chromogranin, synaptophysin, and HMB45 are typically available, and aminoethyl carbazole chromogen is used. Between 2018 and 2019, training courses discussing the role of IHC in the diagnosis of soft tissue tumors as well as breast and prostate cancer were delivered by a professor from Universidad Autonoma of Barcelona to all Mozambican and resident pathologists to stress the importance of IHC in the diagnosis and management of these tumors. These courses were supported by the International Agency for Spanish Cooperation and the Institute of Molecular Pathology and Immunology of the University of Porto, which is a part of the Portugal and the Brazilian National Institute of Cancer.

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Telepathology Services

Telepathology services are currently available only in Maputo. Videoconferences for histopathology case consultation with the Clinic Hospital of Barcelona are commonly held on a weekly basis, and all pathologists and residents participate in these sessions. Since 2014, Project ECHO Mozambique, a partnership of the MD Anderson Cancer Center (United States), Maputo Central Hospital (Mozambique), and Barretos Cancer Hospital, Albert Einstein Hospital, and A. C. Camargo Cancer Center (Brazil), is working to increase clinical capacity through a comprehensive training program including regular telementoring, hands-on training workshops, and professional exchanges. Minimal invasive autopsies under the Child Health and Mortality Prevention Surveillance Program (CHAMPS) with Emory University and Instituto de Salud Global de Barcelona (ISGlobal) are discussed monthly in Maputo by videoconference. E-learning using the Moodle platform and digital microscopy has been introduced to assist in the teaching of undergraduates, medical students, and residents in collaboration with Oporto University and Universidade Eduardo Mondlane.[7]

Clinical Pathology Laboratory Services

Blood Bank and/or Transfusion Medicine Services

Fresh-frozen plasma, packed RBCs, and whole blood are appropriately stored and used at all institutions; cryoprecipitate is not used. Patient family members are the most common donors in a system with a one donation for one transfusion requirement. Only volunteer (unpaid) blood donors are used. All clinical laboratories perform ABO and Rh (D antigen) typing. Infectious disease screening tests for blood products include human immunodeficiency virus (HIV), hepatitis B virus, hepatitis C virus, syphilis, and malaria, which are routinely carried out at all clinical laboratories. To detect syphilis in blood products, the *Treponema pallidum* hemagglutination and Venereal Disease Research Laboratory assays are used. To prevent transmission of malaria via blood products, thick blood film preparation for parasitemia screening of donated blood is performed in all laboratories of the surveyed hospitals.

Hematology/Coagulation

All laboratories provide traditional hematology and coagulation services, including hemoglobin/hematocrit, CBC, WBC differential, peripheral blood smear, prothrombin time, partial thromboplastin time, fibrinogen, sickle cell testing, and hemoglobin electrophoresis. Esoteric testing for hematologic diseases such as inherited RBC/hemoglobin defects (glucose-6-phosphate dehydrogenase deficiency and thalassemia) and inherited coagulopathies (hemophilia) is performed only in Maputo. Flow cytometry and karyotyping are offered in Maputo.

Chemistry

Troponin is performed in only Maputo; cardiac enzymes are not available. Hormone studies, including thyroid-stimulating hormone, triiodothyronine, thyroxine, follicle-stimulating hormone, cortisol, estrogen, progesterone, and testosterone, are also available in Maputo only.

Microbiology

Maputo has an advanced microbiology laboratory with full bacteriology, virology, and mycology sections. Basic bacterial identification, antibiotic susceptibility testing, and purified protein derivative skin testing are available at all four sites. Microscopic evaluation for blood parasites (malaria, trypanosomes, and filariae) and stool parasites is widely available.

Rapid Diagnostic and/or Point-of-Care Testing

Creatine kinase MB and troponin are the cardiology tests available. Hemoglobin A_{1C} is available only in Maputo and Beira. Fecal occult blood, glucose, pregnancy testing, hemoglobin, electrolytes, and arterial blood gas are available in all clinical laboratories. **Table 5** lists the many infectious disease–related rapid diagnostic and/or point-of-care tests available in Maputo.

Equipment and Supporting Services

Maputo and Beira have microscopes including multiheaded scopes, centrifuges, biological safety hoods, refrigerators, –20°C and –80°C freezers, electrical generators, electricity backup, and tap water. The newer two laboratories do not have access to most of this equipment and may have an irregular supply of electricity, distilled water, and internet access **Table 6**.

Discussion

Our survey of the four central hospital laboratories in Mozambique illustrates the wide variability in access to different levels of pathology services across the country as well as the possibility for a high level of capabilities as seen in the Maputo laboratory. Laboratory infrastructure enhancements, new equipment purchases, and additional training of the technical staff through the President's Emergency Plan for AIDS Relief Medical Education

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Partnership Initiative and others have contributed to the proficiency of the Maputo Pathology Laboratory and to the education and training programs of its Department of Pathology, which is considered one of the better such programs and pathology departments in Africa. The Maputo Pathology Laboratory has experience in routine diagnosis, under- and postgraduate training of physicians and other health professionals, and research in topics related to relevant areas of pathology in Mozambique.

The greatest barrier to the expansion of pathology services is the lack of human resources and appropriate infrastructure necessary to support current medical technology and best practices in anatomic and clinical pathology. Challenges enrolling new resident pathologists could be related to lack of incentives, misperception of the specialty, and social stigma. We would encourage increased education of the public and medical community to the importance of the field of PALM in hopes of alleviating much of this stigma and demystifying the field of pathology. Allowing recruitment of graduating physicians straight into pathology residency while forgoing the standard period of internship may also increase pathology residency numbers. Gaps in information technology are widespread given the nonexistent, dysfunctional, or slow internet capabilities and networks that preclude pathologists from taking full advantage of online resources and impede incentives to collect, analyze, report, and archive results. Stock disruptions of basic reagents such as formaldehyde, ethanol, or expensive immunohistochemistry reagents are some additional barriers to overcome. Improved equipment, electric systems, and informatics support could contribute to better maintenance and long-term durability of all capital investments. There is no residency training program for clinical pathologists in Mozambique, and the only three such pathologists currently working in the country were trained in Brazil.

In response to the above concerns and deficiencies, a strategic plan to improve and expand PALM services and management in Mozambique began in 2000 based on the Strengthening Laboratory Management Toward Accreditation program. While improvements in quality have taken significant time to realize and more work remains, these improvements have been durable and encouraging. Table 7 gives the current star rating in each area (some areas were combined) of the Stepwise Laboratory Quality Improvement Process Towards Accreditation for each of the laboratories surveyed. These results are similar to those reported from other sub-Saharan countries, with most laboratories falling in the one- to three-star range.[8-10] In the future, we would like to expand on our work with more detail relative to clinical pathology test numbers and availability and how this compares with other low- and middle-income countries.

Collaborations with international groups and partners have heavily contributed to the advancement and growth of pathology services in Mozambique. In 1944, Portuguese pathologists Dâmasos Prates and Oliveira Torres carried out the first population-based cancer registry in Lourenco Marques (now Maputo) in collaboration with South Africa and later the Albert Einstein Israelite Hospital in São Paulo, Brazil. With support from the World Health Organization (WHO), International Agency for Research on Cancer, and the African Cancer Registry Network Population Cancer Registry, Beira

Table 5
Rapid Diagnostic and/or Point-of-Care Infectious Disease Testing Available in the Maputo Laboratory

HIV antigen	Group A *Streptococcus*
HIV antibody	Hepatitis C
CD4 cell count	Influenza A and B
African trypanosomiasis	Parainfluenza
Chlamydia	Respiratory syncytial virus
Cryptococcus	Schistosomiasis
Cryptosporidium	Syphilis
Falciparum malaria	Tetanus
Giardia	Trypanosomiasis

HIV, human immunodeficiency virus.

Table 6
Pathology Equipment and Laboratory Support Services in Mozambique

Equipment/Facilities	Maputo	Beira	Nampula	Quelimane
Microscopes	✓	✓	✓	✓
Multiheaded microscopes	✓	✓	—	—
Centrifuges	✓	✓	—	—
Tap water	✓	✓	✓	✓
Distilled water	✓	✓	Irregular	Irregular
Electrical generators	✓	✓	—	—
Refrigerators	✓	✓	✓	✓
–20°C and –80°C freezers	✓	✓	—	—
Biological safety hoods	✓	✓	—	—
Internet	✓	✓	Intermittent	Intermittent

✓, available; —, not available.

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Table 7

Laboratory Performance Assessed by the Stepwise Laboratory Quality Improvement Process Towards Accreditation Checklist in Mozambique[a]

Characteristic	Maputo	Beira	Nampula	Quelimane
Document and records	***	***	**	*
Organization, personnel, and management	***	***	**	*
Internal audit	***	**	*	*
Client management and customer service	***	**	**	**
Equipment	***	**	*	*
Purchasing and inventory	***	**	*	*
Process control/improvement and corrective action	***	**	**	*
Facilities and safety	***	***	*	*

[a]One star = 55% to 64% of points awarded in area of interest; two stars = 65% to 74%; three stars = 75% to 84%; four stars = 85% to 94%; five stars = 95% to 100%.

established its population-based cancer registry in 2005. These institutions provide technical and scientific support to the Beira and Maputo laboratories by delivering tailored training in population-based cancer registration and use of data as well as facilitating associations and networks of cancer registries. They also train Mozambican health professionals on integrated, multidisciplinary care of oncology patients through a course on diagnosis and staging through clinicopathologic case discussion and therapeutic management. Seventy years later, Maputo and Beira's population-based registries show the importance of infections on the rate of cancer development, especially the effect of the HIV epidemic, which even further challenges the lack of human resources and infrastructure.[11-13]

From 2013 to 2015, these laboratories were enrolled in the Cause of Death Through Minimally Invasive Autopsy project which validated minimally invasive autopsies (MIAs) for the investigation of infectious causes of death in different cultural, religious, and geographical contexts. The Pathology Department of Maputo and ISGlobal validated MIAs as a tool to determine main causes of death in rural areas with no pathologist or laboratory, although some limitations are noted compared with autopsies. The project is a collaboration of the Maputo Central Hospital, the Manhiça Health Research Centre, and the Barcelona Institute of Global Health. Currently, this team collaborates in the CHAMPS project, which uses an international network for the surveillance of causes of death in children in developing countries by sampling tissues and fluids by minimally invasive techniques.[14,15] This is coordinated by the Emory University Institute of Global Health along with the US Centers for Disease Control and Prevention and funded by the Bill and Melinda Gates Foundation.

Conclusion

This survey revealed a great need for increased pathologist training, human resources at all levels, and infrastructure to allow for the expansion of pathology services in Mozambique. There is a significant need to increase pathology resident/faculty recruitment as well as introduce robust laboratory and information systems to aid in correct diagnoses and treatment. Although PALM deficiencies are commonly focused on in sub-Saharan Africa, we do want to highlight that most PALM services present on the WHO Essential In Vitro Diagnostics List are available in Mozambique, albeit often at limited sites.[16] Infrastructure growth and international collaborations have positioned the Maputo laboratory to begin training the first clinical pathologists in Mozambique. Despite the limitations identified in this survey, there is a generally positive outlook regarding the impact that the next generation of pathologists in Mozambique, produced by an ever-improving national training program, can bring about by being committed stakeholders and excellent leaders.

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