

# Strengthening Laboratory Diagnostic Capacity to Support Cancer Care in Uganda

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## ABSTRACT

**Objectives:** An accurate cancer diagnosis is critical to providing quality care to patients with cancer. We describe the results of a laboratory improvement process that started in 2017 to improve access to cancer diagnostics at the Uganda Cancer Institute (UCI). The overall objective of the project was to build capacity for the provision of quality and timely laboratory diagnostics to support cancer care in Uganda.

**Methods:** A phased multistep approach was used to improve laboratory capacity, including staff training, additional staff recruitment, equipment overhaul, and optimization of the supply chain.

**Results:** The program led to the establishment of a pathology laboratory that handled 5,700 tissue diagnoses in 2019. Immunohistochemistry services are now offered routinely. Turnaround time for histopathology has also reduced from an average of 7 to 14 days to 5.4 days. The main clinical laboratory has also increased both the test volume and the test capacity, with the additional establishment of a molecular diagnostics laboratory.

**Conclusions:** Our project shows a pathway to the improvement of laboratory diagnostic capacity in cancer care centers in sub-Saharan Africa (SSA). Improved laboratory diagnostic capacity is critical to improving cancer care in SSA and more rational use of targeted therapies.

## Key Points

- Cancer diagnostics are a big challenge in sub-Saharan Africa (SSA), and even when they are available, there are significant quality challenges. There is a need to improve cancer diagnostics in SSA.
- We demonstrate that having quality cancer diagnostics under one roof significantly reduces delays associated with diagnosis in Africa.
- Quality laboratory diagnostic capacity can be successfully built up in cancer centers in sub-Saharan Africa. Enrollment in accreditation programs and government support are important in this area.

Incidence of cancer has increased disproportionately, with developing countries accounting for the majority of the new cancers. Developing countries make up about 56% of all new cancer diagnoses and 70% of all cancer-related mortality worldwide.<sup>17</sup> The Global Burden of Disease Study estimates that between 1990 and 2013, there was an estimated increase of 20% in the incidence of cancer in countries in sub-Saharan Africa (SSA).<sup>2,3</sup> However, this increase in cancer incidence in SSA has not been matched by an increase in resources invested in cancer care, and significant challenges exist in accessing timely and accurate diagnosis.

The lack of timely and accurate pathology and diagnostic laboratory services has negative impacts on the delivery of cancer care services. For example, a study of patients with breast cancer in Sudan showed a median time from presentation to diagnosis of 2 to 108 months.<sup>4</sup> Such diagnostic delays have been reported in different countries in SSA. In a study from Rwanda, patients with breast cancer had a median delay of 15 months from presentation to diagnosis.<sup>5</sup> In some studies, it has been shown that the physician delays in diagnosis are

sometimes longer than patient delays or primary delays before patients present to the hospital. In South Africa, it was shown that there was a median diagnostic delay of 34 days (range, 2-1,826 days), of which physician delay was 20 days (range, 0-924) and patient delay was 5 days (range, 0-457 days).<sup>6</sup> These health system delays have been associated with the likelihood of late-stage disease presentation, which affects the type of care and the clinical outcomes of care.<sup>7</sup> Shorter diagnostic delays are associated with earlier stage presentation and better prognosis for patients.<sup>8</sup>

Compounding diagnostic delays are the quality and accuracy of histopathologic diagnostics in SSA. In comparison to other laboratories in developed countries, there has been significant diagnostic discordance of results from laboratories in SSA and reference laboratories in the United States and Europe. In a study comparing diagnoses of Burkitt lymphoma made in Uganda and those made in a reference laboratory in the Netherlands, the agreement of the pathology diagnoses between the 2 laboratories was just 36%—the diagnostic discordance rate was more than 60%.<sup>9</sup> These diagnostic discrepancies significantly affect the quality of cancer treatment being provided and increase the costs of care because many patients will likely progress as a result of inadequate treatment.

To improve the quality of cancer care, the Uganda Cancer Institute (UCI) embarked on a process to improve its pathology and laboratory diagnostic capabilities through the establishment of a new pathology service for cancer and the expansion of the capabilities of the clinical laboratories. In this article, we describe the process of expanding diagnostic capacity at the UCI and the impact of this improved capacity on patient care.

## Methods

### Setting

This project was implemented at the UCI in Kampala, Uganda. The UCI was established in 1967, initially as a lymphoma treatment center associated with the Makerere University School of Medicine, following the description of Burkitt lymphoma.<sup>10</sup> The lymphoma treatment center was started to support lymphoma research. In 1969, the solid tumor center was established, and the 2 together formed the UCI. Started as an 18-bed cancer center, the UCI is now a comprehensive cancer center with all requisite cancer services including medical oncology, pediatric oncology, hematology, gynecologic oncology, radiotherapy, and cancer support services.

## Laboratory Capacity Development

Our capacity building program had 3 components: (1) human resource capacity development, (2) quality assurance and accreditation, and (3) laboratory equipment overhaul.

### *Human Resource Capacity Development*

As a first step toward the improvement of laboratory services, the UCI embarked on a capacity-building program to improve the technical capacity of the laboratory staff to undertake different tests. The UCI undertook several training programs. With funding from the African Development Bank, the UCI provided scholarships for students and staff members pursuing laboratory and diagnostic programs at several universities in Uganda. The UCI also undertook short-term, in-service training programs across the country to improve the capacity for diagnosis of cancer. To support capacity building, the UCI laboratories were opened up for use as training sites for students from several local health-training institutions.

At the start of this laboratory improvement program, the UCI laboratory had only a skeleton staff, and there was a need to increase staffing capacity to handle the increasing demands of cancer diagnosis. Similarly, the establishment of new laboratories such as the pathology laboratory necessitated the recruitment of additional staff to run the service. The institute has recruited staff with different training and skill sets to increase the versatility of the laboratory.

### *Quality Assurance and Accreditation*

The UCI enrolled in laboratory accreditation programs and undertook external quality assurance and local interlaboratory comparison to ensure the quality of results.

### *Laboratory Equipment Overhaul*

Technological leaps in the diagnosis and treatment of cancer required the UCI to acquire new equipment to manage cancer patients. The UCI acquired new analyzers to expand the testing capacity of the laboratory.

## Equipment and Establishment of a Pathology Laboratory

To expand the testing capacity of the existing clinical laboratory, the UCI procured additional equipment to provide additional testing capacity. The institute also established a pathology diagnostic laboratory to further support and improve cancer diagnosis in Uganda. The pathology laboratory added an immunohistochemistry (IHC) testing platform to address the demand for

therapeutic target testing in such cancers as breast cancer and lymphoma and to assist in accurate diagnoses of other cancers.

### Establishment of Telepathology Services

With the support of the American Society for Clinical Pathology (ASCP), the UCI established a telepathology consultation service and digitization of slide storage. Tissue slides are prepared and scanned at the UCI and shared with pathologists in Uganda and with pathologists from the ASCP.

### Laboratory-Based Research

As the laboratory diagnostic capacity has expanded, the UCI has started to undertake laboratory-based research to build capacity and to generate funds to support the diagnostic program.

### Leveraging Collaborations and Partnerships

Given the limited number of pathologists, the UCI has embraced a collaborative approach so that pathologists at Makerere University, Mbarara University, and Mulago Hospital can perform histopathologic analysis of samples from the UCI. In addition, the pathology residents of Makerere University have the UCI as one of their rotations, and they provide service as part of the training program. The UCI is also collaborating with the department of pathology at the University of Cambridge to improve the quality of pediatric pathology in Uganda.

### Procurement of Laboratory Consumables and Reagents

The UCI laboratory is a government-funded laboratory under the UCI. The procurement of laboratory reagents and supplies follows the normal government-established procedures, and the laboratory runs on a financial budgetary plan for the acquisition of most reagents and consumables. The UCI laboratory also received a significant number of reagent donations from partners such as the ASCP and the Max Foundation that made it possible to defray the cost of some expensive reagents. We also adopted the principle of direct negotiation with manufacturers of reagents, and these relationships allowed us to obtain significant quantities of reagents.

## Results

### Capacity Building

With support from the African Development Bank, the UCI offered scholarships to students undertaking

laboratory-related master's degree studies at both Makerere University and Mbarara University of Science and Technology. In total, the UCI funded 16 students to pursue master's degree programs in different disciplines (Table 1). In addition, the UCI funded 4 students who were already staff members to upgrade their training from diploma to the bachelor level.

### In-Service Training Workshops

With the support of the East Africa Public Health Laboratory Networking Project, the UCI undertook in-service/on-the-job skills enhancement workshops for staff members of different cadres across the country. We conducted training at 7 sites, including the UCI, that targeted trainees in Kampala and surrounding districts. We also conducted training in the northern region at Gulu Regional Referral Hospital, in the eastern region at Mbale and Jinja Regional Referral Hospitals, in the western region at Mbarara Regional Referral Hospital, and in the northwestern region at Arua Regional Referral Hospital.

In total, we trained 168 health workers, including surgeons, gynecologists, and pathologists, as summarized in Table 2. The topics covered included specimen collection, sample processing, and sample transportation.

As part of the in-service training program, our laboratory staff was supported to attend multiple short courses including topics such as IHC, laboratory biosafety, quality control and assurance, flow cytometry, and polymerase chain reaction (PCR) techniques. These in-service training courses were meant to strengthen staff skill sets and improve performance.

### Establishment of a Pathology Laboratory

In May 2017, the UCI established a histopathology laboratory to serve cancer patients. In the first month of operation, the UCI histopathology laboratory processed 2 histology samples and 2 cytology samples. By the end of 2018, after the first full year of operation, the UCI pathology laboratory had processed 390 histology samples and 279 cytology samples, for an average of 33

**Table 1**  
Students Supported for Training in Laboratory-Based Courses With Funding From the African Development Bank

Program	Total No. of Trainees
MMed in pathology	12
Master of laboratory technology	6
Master of science in chemistry	1
Master of cytotechnology	2
Bachelor of laboratory technology	3
Diploma in laboratory technology	1

histology samples and 21 cytology samples per month. In 2019, the laboratory processed 1,893 histology samples and 1,240 cytology specimens, averaging 158 histology samples and 103 cytology samples per month. In September 2018, the UCI laboratory added an IHC platform and in 2019 performed 2,538 IHC tests for cancer patients. For the year ending December 2019, the UCI pathology laboratory performed a total of 5,711 pathology investigations.

The government of Uganda supported the procurement of an initial batch of antibodies, which was supplemented by a donation of more antibodies from the ASCP. We implemented a stepwise introduction of IHC in the laboratory, with an initial focus on those markers that had a therapeutic target. In our first 2 months of IHC testing, breast cancer receptor testing comprised 55% of all IHC tests performed. This approach was required to provide prescription of hormonal and targeted therapy for breast cancer patients. Gradually, we increased the antibody testing panel as the demand for both prognostic and therapeutically relevant targets increased. However, the demand for IHC testing increased drastically, and we rapidly expanded to other antibodies and have continued to provide tests free of cost to patients (Figure 1). The antibodies are still supported by the government of Uganda and further

donations from the ASCP. The UCI pathology laboratory now has available antibody panels covering a large number of the cancers currently seen at the institute, as listed in Supplementary Table S1 (all supplemental material can be found at *American Journal of Clinical Pathology* online).

**Assessment of Turnaround Time**

At the beginning of 2019, the average turnaround time for histopathology diagnosis was 14 days. As of January 2020, the turnaround time for histopathology diagnosis was 5 to 6 days.

**Telepathology and Teleconsultation**

In 2019, ASCP donated and installed a MoticEasyScan Pro telepathology platform at the UCI. This digital pathology system enabled the UCI to scan slides for banking and to do consultations with pathologists both in Uganda and in the United States. By March 2020, we had scanned 2,282 slides from 1,128 patients into our bank for review by local pathologists. Seventy-two of the banked cases were submitted for secondary consultation, and there was only 1 diagnostic discrepancy (1.4%), which was subsequently resolved through IHC.

**Expanding the Capacity of the Clinical Laboratory**

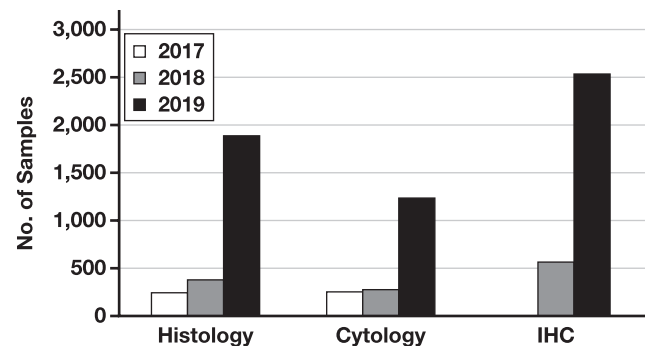
In 2016, the UCI clinical laboratory had limited capacity to undertake diagnostic testing, with only clinical chemistry and CBC, and minimal capacity to undertake microbiology testing, mostly for malaria. Between 2017 and 2020, the UCI clinical laboratory acquired additional capabilities including 2 new combined immunochemistry platforms, a new hematology platform with an automatic slide stainer, and PCR platforms that we currently use for a variety of tests. In 2017, the laboratory performed 269,475 combined tests (CBC, chemistry, HIV tests, urine and stool analysis, peripheral films, and blood slides for malaria). In 2019, the UCI clinical laboratory performed 425,772 assorted clinical tests (CBC, chemistry, virology tests [HIV, human papillomavirus (HPV), hepatitis B virus (HBV)], urine analysis, hemoglobin electrophoresis, peripheral films, blood sample for malaria, cytology, microbiology). The turnaround time for tests has also improved, with CBC now taking 30 minutes and chemistry provided within 4 hours. The laboratory also established a partnership with the department of medical microbiology at Makerere University to offer blood cultures for our patients.

As of May 2020, the UCI clinical laboratory can perform BCR-ABL translocation testing, hemoglobin electrophoresis, serum protein electrophoresis,  $\beta$ -2-microglobulin,

**Table 2**  
**Personnel Supported for In-Service Training in the Uganda Cancer Institute Laboratory Improvement Project**

Cadres Trained	No. of Personnel Trained
Doctors <sup>a</sup>	61
Laboratory personnel	66
Nurses	32
Hub coordinators	7
Theater assistant	2
Total	168

<sup>a</sup>Surgeons, pathologists, obstetricians and gynecologists, etc.



**Figure 1** Sample volume in the Uganda Cancer Institute pathology laboratory from 2017 to 2019. IHC, immunohistochemistry.

coagulation profile, immunoprecipitation, and testing for molecular cancer markers such as *PIC3CA*, *KRAS*, *BRAF*, and *EGFR*. In addition to these molecular cancer markers, our laboratory can now perform HIV viral load testing, HPV genotyping, HBV, herpes simplex virus 1 and 2 (HSV1/2), cytomegalovirus (CMV), and hepatitis C virus (HCV) testing, and methicillin-resistant *Staphylococcus aureus* (MRSA) molecular testing. These tests have greatly improved our capacity to diagnose cancer and provide information to clinicians to better manage patients ■ **Figure 2**■.

### Staffing

As the testing capacity and the number of services offered by the UCI laboratories have increased, the need for staffing has increased. The staffing capacity has more than doubled, from a total of 12 to 27 staff members ■ **Table 3**■.

### Accreditation and Quality Assurance

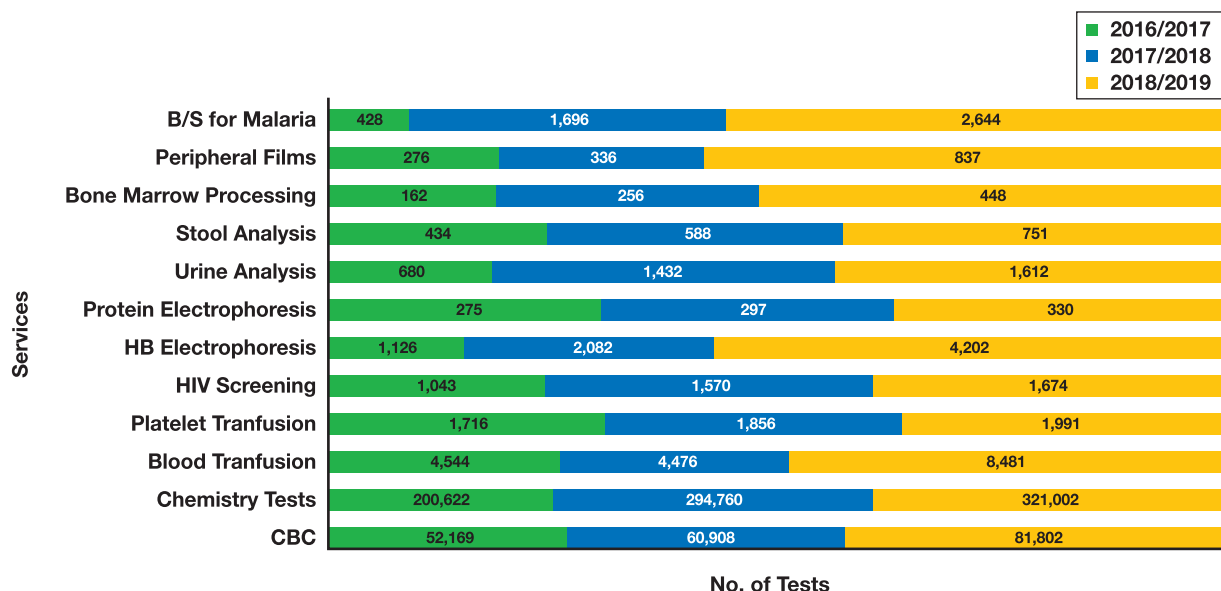
The UCI enrolled with UK National External Quality Assessment Service (NEQAS) for external quality assurance for chemistry, hematology, and IHC (breast cancer) to ensure the quality of results provided to patients. Over the past 2 years of enrollment, all of the UCI's results have been within acceptable ranges.

In March 2018, the UCI enrolled in the World Health Organization's Strengthening Laboratory Quality Improvement Process Towards Accreditation (SLIPTA).<sup>11</sup> The SLIPTA checklist assessed 12 different sections of the laboratory: (1) documents and records, (2) management reviews, (3) organization and

personnel, (4) client management and customer service, (5) equipment, (6) evaluation and audits, (7) purchasing and inventory, (8) process control, (9) information management, (10) identification of nonconformities and corrective and preventive actions, (11) occurrence or incident management and process improvement, and (12) facilities and biosafety.

We enrolled all laboratory tests and processes in the SLIPTA evaluation. In a baseline audit undertaken in March 2018, the laboratory scored 0 (no stars) on a scale of 0 (lowest) to 5 (highest). In this particular audit, the laboratory scored no points in 4 of the sections of the SLIPTA checklist (ie, management reviews, evaluation and audits, identification of nonconformities and corrective and preventive actions, and occurrence or incident management and process improvement). This baseline assessment was important for identifying gaps and instituting corrective measures in preparation for the full audit. In the baseline audit in 2018, the laboratory scored 31% (84/269 points), and in the recent audit in March 2020, the laboratory scored 61.3% (165/269 points), a 1-star rating.

The specific sections assessed on the SLIPTA checklist management reviews that initially scored 0 of 14 points in 2018 had each improved to 10 of 14 points in March 2020. Equipment that scored 10 of 35 points in 2018 improved to 22 of 35 points, and facilities and biosafety improved from 19 of 43 to 34 of 43 points. In the waste management audit, the laboratory scored 33 points (3%) in 2019 and improved to 79.1% in 2020. The results of the waste assessment are summarized in **Supplementary Table S2**. Some areas that have not improved from 2018



■ **Figure 2** ■ Assorted test volume in the Uganda Cancer Institute clinical laboratory from 2016 to 2019. B/S, blood sample; HB, hemoglobin.

**Table 3**  
**Staffing of the Uganda Cancer Institute Laboratories Over a 3-Year Period**

Cadre	No. of Staff in 2017	No. of Staff in 2020
Molecular biologists	0	1
Pathologists	0	3
Laboratory technologists	12	18
Histotechnicians	0	4
Laboratory receptionists	0	1

to 2020 include evaluation and audits, which moved from 0 to 2 of 15 points, and occurrence management, which moved from 0 to 4 of 12 points.

These external quality assessments are coordinated by the East Africa Public Health Networking project, under the Uganda Ministry of Health, by providing mentorship, quality-related improvement training, and external assessors. These audits also resulted in a number of the laboratory staff members being trained in different areas, including 3 as laboratory internal auditors, 3 as safety auditors, and 1 certified as a national assessor and auditor. Other trainings included process control, identification and control of nonconformities, and quality management systems. These engagements have greatly improved the capacity of our personnel in managing and implementing operational quality documents for ISO 15189 certification, which the UCI is working toward.

The UCI is also currently enrolled in interlaboratory comparison with the 2 local laboratories, Ebenezer Clinical Laboratories (South African National Accreditation System [SANAS] accredited) and the Uganda Virus Research Institute. This exercise has greatly helped in maintaining the competency of the laboratory staff and ensuring that the laboratory preanalytic, analytic, and postanalytic processes are up to date throughout the calendar years of participation in the process.

The laboratory is in the process of enrolling the molecular assays introduced in 2020 into the external proficiency testing program.

### Laboratory-Based Research

As the capacity of the laboratory has expanded, we have attracted research studies. In 2019, we supported 5 studies with a total of 1,500 samples.

In addition to supporting external studies, the laboratory staff has also started to undertake original research. Four laboratory-initiated studies are currently being conducted in the laboratory on different aspects of cancer. To further support research, in collaboration with the department of pathology at the University of Cambridge, and with support of the African Development Bank, we

have acquired equipment that will help establish a pan-cancer biobank at the UCI.

### Collaborations

The UCI laboratory has also established collaborations to further improve service. Flow cytometry samples are currently processed through a partnership with the Uganda National Hemepath Laboratory as the UCI continues to build local capacity. In addition, partnerships with Mulago National Referral Hospital and the department of pathology at the College of Health Sciences, Makerere University, provide access to pathologists and students, which the UCI does not have. Externally, the institute collaborates closely with the Fred Hutchinson Cancer Research Center and the University of Cambridge. Three staff members from the laboratory each spent 3 months at the University of Cambridge learning different skills that they are now implementing at the UCI. The pathologists at the Fred Hutchinson Cancer Research Center also actively participate in our multidisciplinary tumor boards and offer secondary consultation, which has greatly improved the quality of UCI's output. Two students and 1 laboratory technologist plan to go to the University of Cambridge in 2020 as we continue to expand the capacity of our laboratory to offer high-quality service and conduct cutting-edge cancer research.

### Academic Training and Education

Partly as a result of the location within the Mulago Hospital complex, near the College of Health Sciences, Makerere University, the UCI laboratories are currently used to train students in different laboratory training programs, as summarized in **Table 4**. In 2019, we trained a total of 229 students from different programs. As the capacity of our laboratory has expanded, students have come from several institutions, and we currently support the training of students from Mbarara University of Science and Technology and several other local training institutions.

### Laboratory Infrastructure

With the support of the African Development Bank, the UCI is expanding its physical infrastructure

**Table 4**  
**Laboratory Students Trained at the Uganda Cancer Institute**

Training Program	No. of Students
MMed in pathology	13
MSc in laboratory medicine and biotechnology	10
Bachelor of laboratory technology	106
Diploma in laboratory technology	100
Total	229

to accommodate the laboratories under one roof. The structure is being built to a specification that will result in accreditation by the College of American Pathologists. With this support, we are also building research laboratories and new laboratories including a genomics and molecular biology laboratory, a microbiology and infectious diseases laboratory, a flow cytometry facility, and a hematology and transfusion laboratory. This facility is expected to be completed in December 2020.

## Discussion

We pursued a comprehensive approach to improve pathology and laboratory diagnostic programs at the UCI including capacity building, expansion of equipment capacity, and collaboration. Given the importance of pathology in cancer diagnostics and care, it was vitally important for the UCI to start a pathology service. Comprehensive pathology services are even more important with the advent of personalized medicine and targeted therapies, for which a complete description of the tumor is needed to direct therapy.<sup>12</sup> Although we started with just 2 samples per month, we have seen a tremendous increase in the utilization of pathology services. The UCI receives, on average, 5,000 to 6,000 new patients with cancer every year, and the UCI pathology laboratory is now fully processing and diagnosing about one-third of all new patients. Although a significant proportion of our patients are still getting their histopathology diagnoses from private laboratories, the availability of the service at the UCI has improved accessibility for our patients. At present, the services are offered free of cost to patients as part of a comprehensive care package, alongside clinical care. IHC is essential in providing accurate diagnoses of cancer and determining the presence of druggable targets.<sup>13</sup> In 2018, we added IHC capabilities at the UCI pathology laboratory, and this has proved invaluable in the management of cancer. For women with breast cancer, for example, it was difficult to grade and assess prognosis of the tumor without IHC, but this has since changed. The availability of IHC has also improved the utilization of drugs such as hormone receptor blockers for breast cancer. In the past, even patients who were unable to do breast cancer hormone receptor testing were given the benefit of hormone receptor blockers to afford them the beneficial effects of drugs. It is increasingly clear that large financial savings accrue from the complete diagnosis of patients. Nevertheless, over this time of performing IHC at the UCI, we have learned that it is advisable to start with a limited IHC panel. It is relatively easy to interpret the clinical relevance of breast IHC receptor

testing. Clinicians increasingly asked for many different antibodies, and the laboratory rapidly built up that capacity, but results were not always easily interpreted. We recommend a phased introduction of antibodies, and as both pathologists and clinicians gain experience, other antibodies can be added. In addition, an essential IHC antibody list and testing algorithm would be highly beneficial for cancer centers that are starting to perform IHC.

The telepathology platform has enabled us not only to expand the pool of pathologists but also to undertake secondary consultation.<sup>14</sup> It is significant to note that in the 72 cases submitted for secondary consultation with pathology colleagues from ASCP, there was only one discordant diagnosis, accounting for just 1.4% of all cases. This impact is consistent with what has been published in other countries where telepathology consultation has been used.<sup>15,16</sup> The telepathology platform also gives us access to specialist pathologists both inside and outside Uganda, and this access has greatly improved the quality of our diagnoses. The telepathology platform has also served as a training tool for students pursuing their pathology and hematology training.

To further augment our pathology laboratory services, we added molecular testing for several cancers. Our laboratory is now able to do quantitative BCR-ABL testing and *BRAF*, *KRAS*, *EGFR*, *PIK3CA*, and *NRAS* mutational profiling. These capabilities have enabled us to offer diagnoses that can guide targeted therapies for patients at the UCI. As targeted therapies continue to expand, the demand for molecular testing will only continue to increase.

We undertook in-service training for health workers in different parts of the country regarding the preanalytic management of tissues, such as tissue collection, handling, fixation, and transportation. We trained 168 health workers of different categories, including pathologists, gynecologists, surgeons, laboratory technologists, midwives, and hub coordinators. These different cadres would enable proper handling of tissue, which would contribute to improving the overall quality of the pathology diagnosis offered from the UCI. Working with all of these different teams ensures that the quality of tissue taken is good and that handling and transportation to the UCI maintains the quality.

In the main clinical laboratory, we undertook several steps to improve the overall quality of clinical diagnostics. We acquired additional equipment including CBC and combined immunochemistry analyzers. We have also added capacity to do HPV genotyping, perform HIV viral load, and test for HBV, HCV, CMV, HSV1/2, and MRSA. The UCI clinical laboratory has also established a coagulation section that performs coagulation studies

for patients. Because of the expanded test menu, there has been a significant increase in the number of tests performed in the laboratory over the financial years from 2016-2017 to 2018-2019. As in the pathology laboratory, we have seen a gradual increase in the demand for services, and our laboratory has also expanded and continues to grow to meet this demand.

The UCI has increased staffing capacity in the diagnostic laboratories, from 12 in 2017 to the current staffing level of 27 members. In addition to just increasing the number of staff members, the institute has also increased the quality of the staff through further training. On the laboratory team, several technologists have obtained a master's degree and one has obtained a doctorate.

In a bid to further improve quality, the UCI enrolled in laboratory quality improvement programs, specifically, the WHO's SLIPTA. Over the past 2 years of enrollment, we have registered progress in a lot of areas. The laboratory also enrolled for external quality assurance with the UK NEQAS and undertakes local quality assurance through 2 laboratories that are accredited by SANAS. These programs have improved the service that we offer and streamlined our workflow. These accreditation services offer a pathway to improving quality of service and to enrollment in more rigorous accreditation programs.

The UCI has made these improved services available for the training of students from different tertiary institutions in Uganda. The goals of supporting training are 2-fold: to provide training sites with state-of-the-art equipment and to interest students in working at the UCI. In 2019, the laboratory supported the training of 229 students across many specialties.

The expanded test menu, especially the highly specialized tests (eg, molecular testing) and IHC, is expensive, and laboratories need to have a sustainability plan. Although the UCI expanded capacity on the basis of collaboration and partnerships, this approach is not sustainable in the long term. Continued provision of free services to patients will be contingent on increased government budgetary allocation for cancer laboratory testing at the UCI. In the interim, while we continue to lobby for increased budgetary support from the government of Uganda, we are increasing research testing. The studies will pay the full economic cost of laboratory tests, which will subsidize testing for clinical care using a cost-sharing mechanism. We are also hopeful that when a planned national health insurance program is launched, it will be easier to pay for and sustain these testing services.

## Lessons Learned and Future Plans

Along this journey of improving laboratory services, we have learned multiple lessons that can benefit similar institutions in our region. Our journey has been heavily supported by collaborators who have mentored the UCI in different capabilities and provided in-kind donations. The SLIPTA program, which is free of cost, has also been instrumental in improving laboratory quality standards. Government and institutional leadership support have been critical to achieving our objectives. Phasing and pacing the implementation of the improvement program has allowed us to gradually master different techniques before adding testing capacity.

In moving forward, the UCI, with support from the African Development Bank, is building a core reference cancer diagnostic laboratory. The laboratory is being constructed to international standards, with plans to seek international accreditation for laboratory services. In addition to the existing services, the UCI is also expanding the molecular pathology section and establishing new laboratory sections such as a genomics laboratory and an expanded cancer tissue biobank. It is expected that the new laboratory will offer a comprehensive diagnostic service to support cancer care in Uganda and the region, as well as support cancer research and training. Collaboration will continue to be an important part of our plans for mentoring in laboratory quality improvement. The experience of our collaborators will also be necessary as we add new tests and as we seek to expand research involvement and testing.

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