

# Advancing Pharmacy Practice in Tanzania: A Descriptive Report of Pharmacy Education and Practice Models in 3 Institutions

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**Christian Mbilinyi, BPharm<sup>1</sup>, Deus Buma, BPharm, MPharm, PhD<sup>2</sup>, Solobi Ngasa, BPharm<sup>2</sup>, Rose Maingu, BPharm, MSC Pharmaceutical Management<sup>3</sup>, Betty Maganda, BPharm, Msc. PhD<sup>4</sup>, Wellu Kaali, BPharm<sup>1</sup>, Mtoke Uledi, MPharm<sup>2</sup>, Bryceson Mkinga, BPharm<sup>3</sup>, Bruno Njonjo, BPharm<sup>2</sup>, Jumanne Amiri, PharmD<sup>2</sup>, and Autumn D. Zuckerman, PharmD, BCPS, AAHIVP, CSP<sup>3</sup> **

## Abstract

Understanding models of pharmacy education and practice in low-to-middle income countries (LMIC) can drive best practices and resource utilization. However, there is a paucity of literature in this setting. The purpose of this report is to describe the length and breadth of pharmacy education and training in Tanzania as well as pharmacy practice models at 3 institutions. Lessons learned and implications for global pharmacy practice described herein aim to advance the profession and pharmacists' impact in LMIC settings. The Muhimbili campus is located in Dar es Salaam, the largest city in Tanzania, a LMIC in East Africa, and is comprised of 3 institutes and a health professions school. Despite variance in patient populations, all Muhimbili institutions have developed pharmacy services in outpatient and inpatient pharmacies, central pharmacy stores, intensive care units, and operating theaters. Unique pharmacy practice areas result from a variance in patient populations serviced and include services in pharmacovigilance/drug information, compounding, oncology, nephrology, and emergency departments. Medication availability and the complexity and time commitment of patient billing are consistent challenges, and multidisciplinary collaboration a common strength across the 3 institutions. Pharmacists at Muhimbili perform innovative and critical functions to support optimal patient care tailored to specific patient populations. The detailed review of these services can serve as a model for pharmacy practice at other health systems in LMIC and beyond.

## Keywords

education, pharmacy, global health, pharmaceutical services, Tanzania, developing countries, patient care

### What do we already know about this topic?

Literature describing pharmacy practice models and pharmacists' impact on patient outcomes is primarily generated from high-income western countries. Pharmacists practicing in low-to-middle income countries face unique challenges requiring innovation to meet patient and health-system needs. A better understanding of low-to-middle income pharmacy practice models could advance the profession and pharmacists' impact in these settings.

### How does your research contribute to the field?

The comprehensive description of pharmacy practice models within 3 unique hospital settings facilitates the opportunity for replication of successful pharmacy services in a low-to-middle income setting. A summary of pharmacy education in Tanzania details the training and preparation required of Tanzanian pharmacists. Lessons learned and recommendations for other low-to-middle income health systems from the Muhimbili experience can guide the growing number of pharmacists in these settings in advancing pharmacy practice.

### What are your research's implications toward theory, practice, or policy?

The detailed review of pharmacy services across 3 institutes can serve as a model for pharmacy practice at other health systems in low-to-middle income countries and beyond.



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## Background

Pharmacists are integral members of the healthcare team, highly trained in development, selection, and appropriate use of medications. Pharmacy practice varies widely across settings (ie, hospital, ambulatory, industry) and countries.<sup>1</sup> The majority of literature regarding pharmacy education and training, practice roles and responsibilities, and outcomes of patient care involvement is in high-income western countries. Pharmacists in low-to-middle income countries (LMIC) face unique challenges and have developed tailored practices to address the needs of a less-resourced population.<sup>1-4</sup> In this setting, pharmacists have demonstrated improved clinical outcomes such as blood pressure, blood glucose, triglyceride levels, and asthma outcomes, improved quality of life, and reduced health service utilization.<sup>5</sup>

However, the paucity of literature describing pharmacy practice in LMIC limits growth and development of the pharmacy profession in these areas. Specifically, very few studies have described pharmacy education and practice in Africa, and even fewer in East Africa.<sup>2,4,6-8</sup> In a survey of pharmacists from 9 African countries, Viberg et al<sup>9</sup> found varying views on pharmacy practice, ranging from a “life saver” to a “dissatisfied dispenser.” Elucidating those practices that have advanced pharmacy and the challenges that remain to pharmacy growth will aid pharmacists in these countries to enhance and evolve services that improve patient care.

The objective of this report is to describe pharmacy education in Tanzania and pharmacy practice models within 3 institutes in Dar es Salaam, Tanzania: Muhimbili National Hospital (MNH), Muhimbili Orthopaedic Institute (MOI), and Jakaya Kikwete Cardiac Institute (JKCI). Lessons learned and implications for global pharmacy practice described herein aim to advance the profession and pharmacists’ impact in LMIC settings.

## Practice Setting

The Muhimbili campus is located in Dar es Salaam, the largest city in Tanzania with a population of approximately 6.3 million.<sup>10</sup> Muhimbili is comprised of 3 institutes and a health professions school. An overview of these institutes, all of which are Joint Commission International accredited, is found in Table 1. MNH, the oldest and largest hospital on

campus, was the first hospital to establish pharmacy services (1958), followed by MOI (1996), and most recently JKCI (2015). MOI is the only stand-alone Orthopaedic and Neurosurgery Institute in the country, and JKCI is the elite cardiac institute in Tanzania. All institutes service both adult and pediatric patients.

Pharmacy staff at each of the institutes may include a health/medical assistant, pharmacy technician, pharmacy intern, volunteer pharmacist, or an employed pharmacist. Pharmacists are those who have achieved a bachelors in pharmacy (BPharm) or higher and completed 1 year of internship. The education, training, and requirements to become a pharmacist in Tanzania are detailed in Figure 1. The number and type of staff at each institute varies based on size and resources needed (Table 2).

## Pharmacy Education within Muhimbili

The Muhimbili University of Health and Allied Sciences (MUHAS), situated on the Muhimbili campus, trains medical, pharmacy, nursing, and dental students. The MUHAS school of pharmacy (SOP), established 1974, is the first and only public-owned academic institution which trains pharmacists from a baccalaureate up to doctorate degrees. To date the SOP has graduated approximately 1000 pharmacists in the country and averages 70 graduates per year. Currently, the SOP has 5 departments namely; Clinical Pharmacy and Pharmacology, Medicinal Chemistry, Pharmaceutical Microbiology, Pharmaceutics and Pharmacy Practice and Pharmacognosy.

Over the course of 4 years, BPharm training includes coursework, laboratory practical sessions, field works, and a research project. The first year of the SOP curriculum is mainly didactic coursework. In year 2, students are exposed to pharmaceutical botany field work, and start practical sessions primarily with pharmaceutical calculations and compounding, powder technology, applied chemistry and pharmaceutical botany. In year 3, students complete practical sessions, rotations and field works which may include pharmaceutical technology, applied pharmacology, quality control as well as at least 8 hours on an inpatient clinical pharmacy rotation and 2 weeks in a community pharmacy. Finally, fourth year students complete clinical rotations throughout the Muhimbili institutes, research projects and field

<sup>1</sup>Jakaya Kikwete Cardiac Institute, Dar es Salaam, Tanzania

<sup>2</sup>Muhimbili National Hospital, Dar es Salaam, Tanzania

<sup>3</sup>Muhimbili Orthopaedic Institute, Dar es Salaam, Tanzania

<sup>4</sup>Muhimbili University of Health and Allied Sciences, School of Pharmacy, Dar es Salaam, Tanzania

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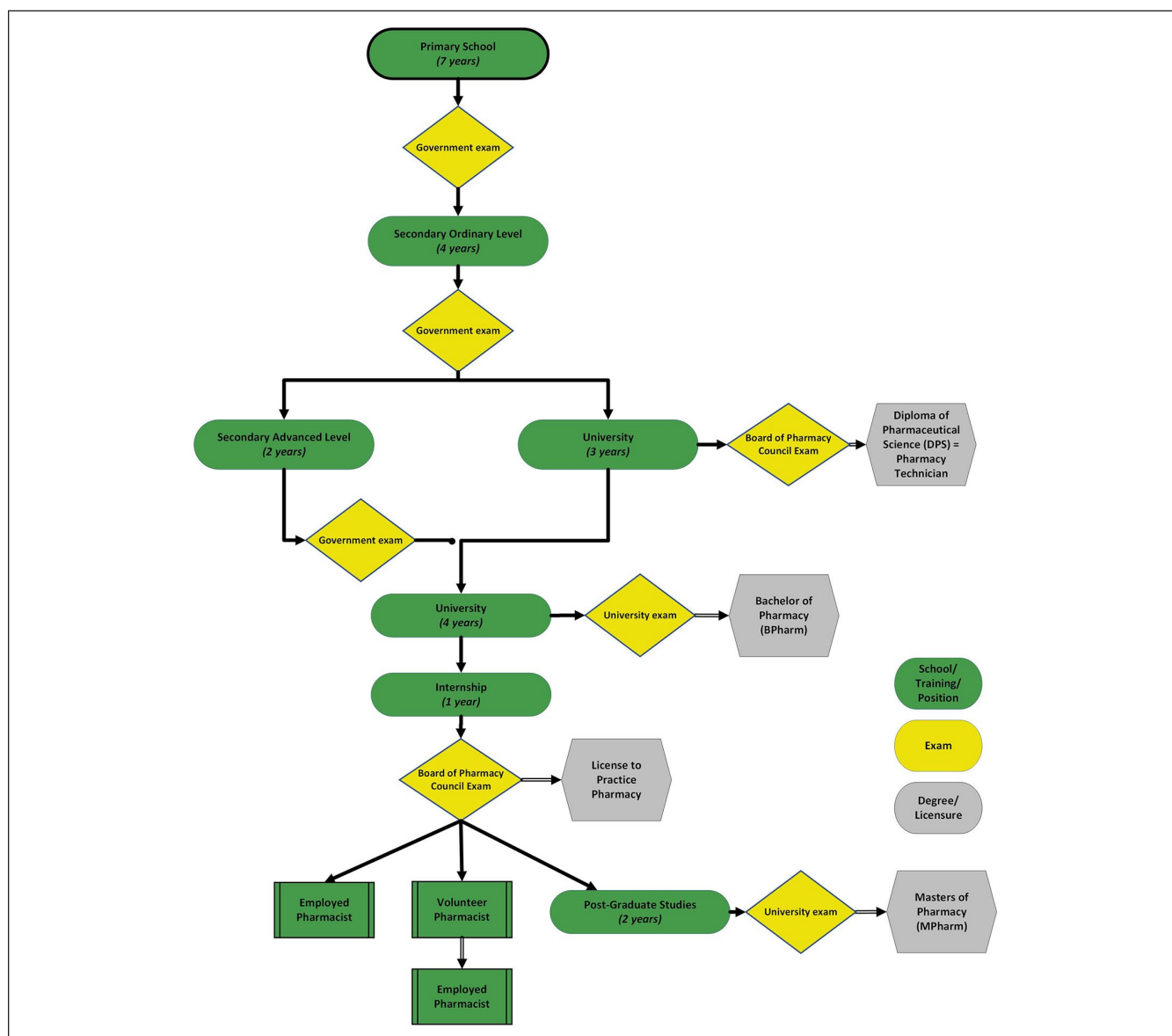
### Corresponding Author:

Autumn D. Zuckerman, Department of Pharmaceutical Services, Vanderbilt University Medical Center, 1301 Medical Center Dr., TVC 2661, Nashville, TN 37232, USA.

Email: Autumn.Zuckerman@vumc.org

**Table I.** Muhimbili Institutions Overview.

|  | Muhimbili National Hospital                               | Muhimbili Orthopaedic Institute       | Jakaya Kikwete Cardiac Institute   |
|--|---|---------------------------------------|------------------------------------|
| Year established   | 1958  | 1996                                  | 2015                               |
| Number of hospital beds  | 1530  | 340                                   | 208                                |
| Number of operating theaters                                   | 17  | 9                                     | 3                                  |
| Primary patient population                                     | General medicine<br>Specialty medicine<br>General surgery | Orthopaedic<br>Neurosurgery<br>Trauma | Cardiac surgery<br>Cardiac medical |
| Number of pharmacy staff                                       | 48  | 22                                    | 32                                 |
| Approximate number of outpatient medications dispensed per day | 1000  | 180                                   | 300                                |



**Figure I.** Pharmacy education in Tanzania. Pharmacy education and training in Tanzania may follow multiple routes, as displayed above. Oblong green circles represent education. Yellow diamonds represent exams that must be passed to progress further. Gray hexagons represent degrees or licensure achieved. Finally, green rectangles represent pharmacy positions following education, training, and licensure.

**Table 2.** Pharmacy Personnel at Each Muhimbili Institute.

|   | Operating theater                                     | Outpatient   | Inpatient   | Central pharmacy store | Other  |
|---|---|--|---|------------------------|--|
| <b>MPharm/BPharm</b>                                      |   |  |   |                        |  |
| Muhimbili National Hospital                               | Pediatric: 7<br>OBGY: 5<br>General: 6<br>Emergency: 4 | IPPM: 3<br>New OPD: 8<br>Methadone/psychiatry: 5<br>NHIF clinic: 4 | Oncology: 4<br>Dialysis: 6<br>ICU: 5<br>Other specialty/general: 36 | 6                      | Emergency: 5<br>Drug information: 4<br>Inpatient/outpatient<br>Maternity: 5<br>Pediatric: 6<br>Psychiatry: 6<br>Emergency: 2 |
| Muhimbili Orthopaedic Institute                           | 2   | 8  | 3   | 3                      | Emergency: 2   |
| Jakaya Kikwete Cardiac Institute                          | 2   | 10   | 5   | 1                      | Compounding: 2   |
| <b>Pharmaceutical technician/health/medical attendant</b> |   |  |   |                        |  |
| Muhimbili National Hospital                               | Pediatric: 1<br>OBGY: 2<br>General: 2                 | IPPM: 1<br>New OPD: 1<br>Methadone/psychiatry: 1<br>NHIF clinic: 2 | Dialysis: 1<br>ICU: 1<br>Other specialty/general: 5                 | 0                      | Emergency: 1<br>Inpatient/outpatient<br>Maternity: 2<br>Pediatric: 1<br>Psychiatry: 1<br>Emergency: 1                        |
| Muhimbili Orthopaedic Institute                           | 2   | 5  | 3   | 2                      | Emergency: 1   |
| Jakaya Kikwete Cardiac Institute                          | 0   | 1  | 0   | 0                      | Billing: 1   |

OBGY = obstetrics and gynecology; IPPM = intermural private practice at Muhimbili National Hospital; OPD = outpatient department; NHIF = national health insurance fund; ICU = intensive care unit.

placements for 8 weeks in various areas of pharmacy (ie, hospital and clinical pharmacy, industrial pharmacy, supply chain management with Tanzania Medical Store Department (MSD), and regulatory bodies such as Tanzania Medicines and Medical Devices Authority (TMDA) and Tanzania Pharmacy Council).

Following school of pharmacy graduation, BPharm graduates complete 1 year of internship, often at 1 of the 3 institutes on the Muhimbili campus. Interns are assigned a supervisor to mentor the student throughout the year. Following internship, MUHAS BPharm graduates are highly trained professionals who can provide quality pharmaceutical and consultancy services and carry out research.

## Practice Description






### Muhimbili Pharmacy Services Consistent Across Institutes

Consistencies in pharmacy practice across institutions exist, with distinct opportunities based on care setting. Each institution has an inpatient pharmacy, outpatient pharmacy, a central pharmacy store (CPS), an intensive care unit (ICU) presence, and an operating theater (OT) pharmacy. An overview of these services is presented in Figure 2.

*Outpatient pharmacy services refer to pharmacies that are located separate from an inpatient ward and service primarily*

*clinic or discharged patients.* Each institute has at least 1 outpatient pharmacy with similar dispensing processes among institutes (Table 2). Upon hospital discharge or following a clinic visit, patients are provided a prescription, typically up to a 30-day supply, by a physician, which is taken to the outpatient pharmacy by the patient or patient's family. Pharmacy staff determine product availability using the pharmacy management software. If available, the patient is provided the prescribed amount of product, and billed either by cash payment or through insurance. If a product is unavailable, the prescription may be entered into a government portal for patients to obtain in the community (MOI), or the patient is instructed to wait until the medication may be procured by the institution (MNH, JKCI). Pharmacists write administration directions on the medication packaging and educate patients and their families.

*Inpatient pharmacy services refer to tasks completed by the pharmacy team while a patient is admitted to the hospital.* In most cases, a prescription or a patient's file is brought to the inpatient pharmacy, either by a family member or nurse, respectively. Inpatient pharmacists review the patient file to assess the appropriateness of the prescribed medication, dose, formulation, possible medication interactions, and product availability. Concerns during this review or product availability issues are communicated to the prescribing doctor. Once the medication is deemed safe and appropriate, the pharmacist bills and dispenses the medication to the family member or nurse (MNH only allows dispensation to the nurse).

| Outpatient Pharmacy  | Inpatient Pharmacy   | Central Pharmacy Store  | Intensive Care Unit   | Operating Theater  |
|--|--|---|---|--|
|  <ul style="list-style-type: none"> <li><b>• Role:</b> <ul style="list-style-type: none"> <li>• Distribution of medications to patients upon discharge</li> </ul> </li> <li><b>• Hours of operation:</b> <ul style="list-style-type: none"> <li>• MNH: 8a- 8p</li> <li>• MOI: 7a - 7p</li> <li>• JKCI: 6a - 8p</li> </ul> </li> </ul> |  <ul style="list-style-type: none"> <li><b>• Role:</b> <ul style="list-style-type: none"> <li>• Review of inpatient pharmacy orders for safety and efficacy</li> <li>• Distribution of medications to admitted patients</li> </ul> </li> <li><b>• Hours of operation:</b> <ul style="list-style-type: none"> <li>• MNH: 24 hours</li> <li>• MOI: 7:30a - 6:30p</li> <li>• JKCI: 24 hours</li> </ul> </li> </ul> |  <ul style="list-style-type: none"> <li><b>• Role:</b> <ul style="list-style-type: none"> <li>• Medication and medical supply management and distribution</li> </ul> </li> <li><b>• Hours of operation:</b> <ul style="list-style-type: none"> <li>• MNH: 8a- 6p</li> <li>• MOI: 7:30a - 6:30p</li> <li>• JKCI: 6a - 8p</li> </ul> </li> </ul> |  <ul style="list-style-type: none"> <li><b>• Role:</b> <ul style="list-style-type: none"> <li>• Provide pharmacy expertise during multidisciplinary clinical rounds and ensure timely medication availability and administration</li> </ul> </li> <li><b>• Pharmacy Presence:</b> <ul style="list-style-type: none"> <li>• MNH: 24 hours</li> <li>• MOI: Morning rounds</li> <li>• JKCI: Patient review and consultation</li> </ul> </li> </ul> |  <ul style="list-style-type: none"> <li><b>• Role:</b> <ul style="list-style-type: none"> <li>• Medication and medical supply management for the operating theater</li> </ul> </li> <li><b>• Hours of operation:</b> <ul style="list-style-type: none"> <li>• MNH: 24 hours</li> <li>• MOI: 24 hours</li> <li>• JKCI: 24 hours</li> </ul> </li> </ul> |

**Figure 2.** Shared pharmacy services overview. Though some pharmacy services vary amongst the 2 institutes based on the patient population serviced, all institutes have at least 1 outpatient and inpatient pharmacy, a central pharmacy store, intensive care unit presence, and an operating theater pharmacy. The role of pharmacists in these areas and the hours of operation are displayed.

Another critical responsibility of inpatient pharmacists is review and completion of patient billing forms. At the time of discharge, all the medications consumed by a patient are documented on a medication use sheet. These sheets are completed by a pharmacist (MNH) or nurse (MOI) and input into the national insurance system by either the pharmacist (MNH) or billing department (MOI). At JKCI, all billing forms are completed by the pharmacy technician volunteer.

In January 2019, MNH piloted the One-Time-Taking (OTT) program in which pharmacists, present in the ward, manage administration of each dose. Pharmacists review patient charts after rounds daily and create a list of patients and medications needed at each dosing hour. Pharmacists prepare patient-specific medication bins indicating the timing of each dose. At the prescribed time, the pharmacist provides the dose to the nurse who administers it to the patient. The pharmacist records the administration and bills the patient. Medications taken as needed are requested, when needed, by the nurse from the pharmacist present on the wards. The OTT program has proven to be highly effective in reducing waste and patient cost, improving adherence and nurse satisfaction, and reducing length of hospital stay from a median of 11 to 7 days. The impact of the OTT program is still being evaluated and plans for publication are pending.

Inpatient pharmacists at each institution have also developed methods to provide consistent and timely communication regarding the availability of medications through medication availability lists that are either provided to nursing and physician staff weekly (JKCI, MOI) or are accessible in real-time through the hospital electronic system (MNH). Given frequent drug shortages, this is a key role in improving multidisciplinary communication.

Patients in Tanzania frequently struggle with medication affordability. To help address this need, the inpatient

pharmacy team at JKCI developed a medication exemption stock sourced from unused medication at the time of patient discharge or death and medication supplier donations. The inpatient pharmacist prepares a list of admitted patients that qualify as exempt (determined by the social work office to be unable to afford medical or pharmacy services) and a list of current medications available free of charge from the exemption stock daily. These lists are distributed to the social workers who inform the doctors weekly or more if a commonly used medication is procured.

*Central pharmacy stores located within each institute provide necessary management of medications and medical consumables.* Pharmacists working in the stores coordinate with MSD to obtain medication approved by the TMDA. If unavailable by MSD, CPS pharmacists, through the hospital procurement unit, resource medication and supplies from local suppliers.

CPS staff receive orders from each of the institute's pharmacies, evaluate current CPS supply, then initiate an order from MSD or local suppliers through the head of department and procurement unit. Each pharmacy satellite provides CPSs with a medication order throughout the week (JKCI: 1/week, MOI: 2/week, MNH: 1/week). Upon receipt of medication and consumables from MSD, staff inspects medication integrity and fitness, organizes and stores stock, then dispenses to each satellite pharmacy.

*As large referral hospitals, the ICUs at Muhimbili are critical patient care areas with significant opportunity for pharmacy involvement.* MNH implemented satellite pharmacies staffing 1 pharmacist 24 hours per day in all 7 ICUs. Pharmacists in this setting follow the OTT model and are responsible for monitoring and filling the ICU emergency trolley, medication billing, and consultation during ward rounds. ICU responsibilities were recently developed at MOI



(November 2019) and JKCI (December 2019) and performed by the inpatient and operating theater pharmacists, respectively. At each institute, the pharmacist participates in multidisciplinary clinical rounds by making recommendations for treatment regimens and dosing, mitigating drug interactions, and ensuring the supply and appropriate use of critical care medications (example patient work-up sheeting in Supplemental Appendix A and B). Physicians and nurses have noted the importance of pharmacists in the ICUs to ensure optimal medication use and improve patient care.

*Medication waste, mismanagement, and lack of patient billing in the operating theaters led to the development of 4 satellite operating theater pharmacies at MNH (pediatric, obstetrics and gynecology, general, emergency medicine department (EMD)), 2 at MOI, and 1 at JKCI.* OT pharmacists provide medication management from procurement to administration. The satellite pharmacies' proximity to the theater allows for timely provision of necessary medications. Pharmacy integration in this area has led to improved pharmacovigilance (including recognizing and preventing the use of expired medications), improved availability of necessary stock, and reduced opportunities for diversion or wastage. Additionally, prior to OT satellite pharmacy implementation, patients were not billed for medications utilized during a procedure or surgery. Nurses now complete patient-specific medication usage forms and pharmacists bill patients for medications utilized. Appropriate billing has led to increased revenue and reduced institution losses, allowing these public hospitals to treat more underserved patients. Nurses, anesthesiologists, and surgeons have also noted an improvement in medication availability, timely delivery of medicines when needed especially in emergency cases, multidisciplinary communication that enhances interdisciplinary relationships, and medication organization in the OT.

### ***Distinct Institution Pharmacy Practices***

Unique pharmacy practice areas result from a variance in patient populations serviced by each institute.

*As the oldest, largest, and most diverse institute on the Muhimbili campus, the pharmacy program at MNH is the most expansive, with pharmacists integrated into multiple clinical areas.* MNH has 6 outpatient pharmacies and 11 inpatient pharmacy satellites. Unique aspects of MNH pharmacy services include 4 mixed outpatient/inpatient clinic pharmacies, inpatient pharmacy services in oncology and nephrology, and a 24-hour service for pharmacovigilance and drug information.

The outpatient/inpatient pharmacies at MNH cater services to the clinical areas in which they are located including the maternity, psychiatric, and pediatric specialty clinics and the private practice clinic. Within inpatient wards that do not practice the OTT program, nurses bring patient files to the pharmacy where pharmacists review the patient file, bill the patients, and dispense medications to the nurse

(typically a 5-day supply for oral medications and 1 day supply for injectables). Patients seen in the outpatient clinic bring prescriptions to the pharmacy which are fulfilled like the outpatient pharmacy processes previously described. Pharmacists in the pediatric MNH pharmacy compound products for both pediatric and adult patients such as pediatric doses, syrups, peritoneal dialysis fluid, and hypertonic saline. The most common compounds at MNH include chloral hydrate, hypersonic Saline (3%NaCl), dermatological products (podophyllin 5%, 10%), pediatric oral doses (digoxin, spironolactone, furosemide), and cough syrups. Compounding enables MNH to administer many medications otherwise inaccessible to patients.

Oncology pharmacy services at MNH were implemented August 2016. In weekly multidisciplinary committee meetings, the pharmacist recommends therapy plans based on patient comorbidities and interactions, helps inform the department on challenges, new drugs, or side effect management. Pharmacists then manage the timetable for each patient's treatment initiation and administration based on nurse availability and patient volume. Prior to administration, the pharmacist reviews the patient's chemotherapy sheet for completion and appropriate medication and dose, then prepares the medication for administration. Oncology pharmacists are responsible for managing chemotherapy sheets that record a patient's entire treatment course, preparing pre-treatment medications, and managing the emergency supply of fluids and medications that are stored in the ward. Nurses often consult oncology pharmacists on side effect management for patients receiving chemotherapy. Following a discussion with the pharmacist, nurses can administer certain treatments without a prescription if deemed appropriate. The pharmacists prepare a monthly report for the head of the department detailing quantity of medications, patient diagnoses, side effects experienced, consumable use, staff shortages, and how many patients paid. In this way, oncology pharmacists play a key role in maintaining clinic efficiency and preparation to be able to serve patients.

Nephrology pharmacy services at MNH began in June 2018, and are utilized in the dialysis unit, renal transplant unit, and plasmapheresis unit. In the 42-bed dialysis unit, pharmacists play a critical role as part of a multidisciplinary team in managing patient care. Prior to dialysis initiation, the nephrology pharmacist reviews the patient chart to determine the best dialyzer (high vs low flux), size of the needle and syringe needed, ancillary consumables needed, and the appropriate time of dialysis. The pharmacist manages a dialysis pharmacy form for each patient that lists name, vital signs, vascular line, all consumable and medicines to be used, date of attendance, time to start and end dialysis. The pharmacist prepares a monthly budget to ensure the unit maintains adequate funding to operate while serving those with less financial resources. Pharmacists operate dialysis machines when the nursing load is low by changing filters, dialyzers, acids and blood lines as needed. A pharmacist is

present in the dialysis unit to monitor patients and patient labs results such as hemoglobin levels to assess the need for erythropoietin and other medications that may be needed in an emergency. Nephrology pharmacists on the renal transplant service assess patient transplant eligibility based on medication interactions, comorbidities, and ability to afford post-transplant medications. After transplant, the pharmacist reviews immunosuppressant levels and signs of rejection or toxicity each month at the time of patient's refill. On the plasmapheresis nephrology unit, pharmacists assist consumable selection, budgeting and ordering of consumables to ensure availability of key medicines like immunoglobulin G, albumin, and fluids.

The TMDA requires hospitals and pharmacies to collect and report adverse drug events (ADEs). However, this practice is not enforced, resulting in high variability in rates of reporting and methods of collecting ADEs. Recognizing the need to standardize this practice and the potential benefits to patients and the institution, MNH implemented a 24-hour pharmacovigilance (PV) and drug information service in January 2019. This service is composed of 1 Masters of Pharmacy graduate and 3 BPharm interns, termed PV officers, and spans inpatient and outpatient clinics and wards across MNH. PV officers review every admitted patient, assessing for ADEs through patient interview, chart review, and nurse report. PV officers in outpatient clinics collect ADEs through outpatient pharmacist reports and patient interviews as they wait for medication. When ADEs are identified, the team completes a TMDAADE form. Approximately 18 to 20 forms are collected and entered into the TMDA system daily. The drug information service manager reviews weekly ADE reports and develops a monthly report presented to the Head of Pharmacy. Frequent or recurrent issues are addressed. In 2019, the team reported more than 1300 ADEs, an increase of 300% from the previous year.

*Both MNH and MOI utilize an EMD pharmacy.* At MNH, EMD nurses or doctors bring prescriptions to the EMD pharmacy, where a pharmacist reviews the medication for appropriateness and safety, bills the patient, and dispenses the medication needed for at most a 24-hour supply to the nurse/doctor. However, at MOI, EMD pharmacists serve the EMD, admitted patients, and discharged patients, similar to inpatient and outpatient responsibilities previously described; services for the EMD specifically are similar to MNH. Satellite pharmacy presence in the EMD allows for rapid procurement of necessary medications without burdening the inpatient or outpatient pharmacies.

*JKCI is the smallest of the 3 Muhimbili institutes but boasts robust pharmacy services that are continually growing.* Unique aspects of JKCI pharmacy services include an inpatient clinical review team, a newly developed compounding service, and a discharge counseling service. The inpatient pharmacist at JKCI reviews complex patient cases such as patients who have been admitted for more than 1 week, those requiring several medications at once, or

patients who are not clinically improving. After review, the pharmacist discusses opportunities for improved therapy regimens with the nurse and physician.

JKCI developed a standalone compounding service in late 2018, which currently averages 25 compounds per day. The most common compounds at JKCI include sodium chloride 3%, hand sanitizer spray, and reconstitution of furosemide, spironolactone, captopril, enalapril, propranolol, digoxin, sildenafil, and carvedilol. After recent international training, the pharmacy team is in the process of expanding to sterile compounding. The compounding pharmacist ensures procurement of and manages stock of medications, excipients, containers, packaging. As compounded products are not insured, pharmacists must complete billing of cash patients prior to dispensation.

Inpatient and outpatient pharmacists also provide discharge medication counseling to all patients using the discharge medication education form in Supplemental Appendix C.

## Continuing Education and Training

The pharmacy teams at all 3 Muhimbili institutes prioritize continuing education and training of pharmacy staff to advance pharmacy practice. Pharmacy departments meet daily (MNH), weekly (JKCI), or twice monthly (MOI). These meetings consist of sharing information from the previous shift, discussing challenges, case reviews and/or continuing medical education, or updates in clinical practice or guidelines. This commitment to continual learning has helped advance pharmacy practice by educating pharmacists in new disease state areas and expanding services at these institutes, such as building an anticoagulation counseling and therapeutic drug monitoring services (JKCI).

## Lessons Learned and Practice Implications for National and Global Pharmacy Practice

As pharmacy services have developed across Muhimbili, challenges and opportunities have emerged that may be applicable to other LMIC countries creating such programs.

Patient billing and medication affordability evokes several challenges for pharmacists. Patients must be categorized as either insured or uninsured, which can be further delineated to exempt, non-exempt, or cost sharing. Based on the funding source for medications, the process of providing these treatments to the patient may vary, creating a complex process of medication dispensing, and administration for both inpatient and outpatient pharmacies. Additionally, if patients are unable to afford treatment and do not qualify for exemption, they may not receive medically necessary treatment. The process of billing patients is also a time-consuming one. Several hours of pharmacists' time are spent on completing and monitoring medication use forms to ensure appropriate billing. This takes away from clinical involvement and practice advancement.

Implementing staffing models, such as a dedicated patient billing technician, can help alleviate some of this burden on highly trained pharmacists to enable more clinical practice.

Pharmacy departments at Muhimbili are dependent on government funding to resource both medication and personnel. Given the great need for pharmacists with limited funding, there is a lack of specialized pharmacists. Though programs such as the PV team and OTT program have helped address these issues at MNH specifically, there still exists a large opportunity for more specialized pharmacy services across all 3 institutes.

Despite challenges, pharmacists at each of the 3 institutes believe a core strength of Muhimbili is the collaboration amongst physicians, pharmacists, and nurses and the teamwork environment of the pharmacy department. Physician partners are eager and accepting of pharmacy interventions and clinical involvement. Nurses and physicians seek out pharmacy staff when there is a medication concern and work collaboratively to improve patient care delivery.

Based on the pharmacy practices developed at Muhimbili, we recommend the following for similar LMIC hospitals hoping to advance pharmacy practice:

1. **Use existing pharmacy services to implement clinical programs.** Outpatient pharmacists can provide discharge counseling and therapeutic medication monitoring at refills. Inpatient pharmacists should comprehensively review patient charts when inpatient medications are ordered to ensure safety and appropriateness of therapy.
2. **Identify areas of greatest need and potential financial improvement.** Development of an OR satellite pharmacy improved patient care while adding revenue to the institute. Physicians and nurses recognized the benefits of pharmacy services beyond inpatient and outpatient dispensing and were more willing to expand pharmacy services to other areas of practice.
3. **Utilize pharmacy learners to expand services.** The collaboration between Muhimbili and MUHAS allows for a mutually beneficial partnership wherein intern pharmacists and pharmacy students help to provide essential pharmacy services in a learning environment. In addition to easing the workload of dispensing medications, pharmacy interns and students can provide medication monitoring services, discharge counseling, and participate in ward rounds.

## Conclusions

Pharmacists at Muhimbili perform innovative and critical functions to support optimal patient care tailored to specific patient populations in Tanzania. The detailed review of these services can serve as a model for pharmacy practice at other health systems in low-to-middle income countries and beyond.

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We would like to acknowledge the outstanding work of pharmacists, interns, and technicians at Muhimbili National Hospital, Muhimbili Orthopaedic Institute, and Jakaya Kikwete Cardiac Institute that advance pharmacy practice and improve patient care.

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## ORCID iD

Autumn D. Zuckerman  <https://orcid.org/0000-0002-8376-0691>

## Supplemental Material

Supplemental material for this article is available online.

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