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GLOBAL BREAST CANCER (AB CHAGPAR, SECTION EDITOR)

Bridging the Gap in Training and Clinical Practice in Sub-Saharan Africa

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Abstract

Purpose of Review As medical knowledge and innovation reaches new heights, there is a growing gap in medical advancements between low- and middle-income countries (LMICs) and high-income countries (HICs). The former has lack of basic health care and preventive or diagnostic services for early cancer while the latter has access to novel diagnostic and therapeutic modalities.
Recent Findings Key to overcoming this disparity is finding ways to bridge this divide across distances and continental divides through innovative technology and sharing of knowledge by committed individuals and through public private partnerships. Many initiatives that include onsite and online training programs for regional healthcare providers have shown that the gap in medical training between HICs and LMICs can be narrowed.
Summary The following article shines a light on this disparity and provides exemplary case studies of ways in which this gap between LMICs and HICs can be bridged.

Keywords Medical training · Low and middle income countries · Sub-Saharan Africa · Cancer · Tele-radiology

Introduction

Medical knowledge is growing exponentially. While the world grows smaller with communication and travel connecting people from across the globe, it seems that the gap between low- and middle-income countries (LMICs) and high-income countries (HICs) in terms of medical knowledge, diagnostic and therapeutic capabilities, and patient-oriented research is growing wider.

A root cause for this widening gap include inadequate governmental funding for health care in the LMIC, inadequate human resources and clinical expertise, and lack of technical infrastructure/equipment to deliver optimal health care. This disparity is compounded by a lack of health education and awareness in the general population, for whom food, clean water, and safe habitat are daily existential unmet needs.

In this chapter, we have invited authors who have worked both in HICs and LMICs to each provide insights into ways to reduce this gap from their perspective as clinicians involved in patient care. The article takes a practical and pragmatic approach to bridging the gap, written from the lens of practitioners, who have personally experienced the implications of this gap in access to knowledge, resources, and diagnostic and therapeutic tools in LMICs—assets that each took for granted as being readily available during their training in HICs. In this context, information technology (IT) provides an ideal platform to bridge both distance and knowledge, with the use of tele-training, tele-pathology, tele-radiology, and tele-consultation working across time zones and continental divides. Clinical research represents a watershed area for most

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in LMICs. Studying the effectiveness and toxicity of novel therapeutic in patients in LMICs will require basic training in clinical investigation and human subject protection, an area often neglected.

The following articles does not address the deeper issues of medical education or workforce development in LMICs, but seeks to showcase examples of how one can bridge the gap between HICs and LMICs, thereby helping to improve patient care and outcomes in lower resource settings. This exchange will also prepare clinicians in HICs to better manage a patient from the developing world who shows up in their clinic. Sharing of time and knowledge is indeed a mutually beneficial bilateral investment!

Diagnosis

Training in LMICs—Focus and Gaps

In 2013, the global count of health workers was approximately 43 million which was 17.4 million less than the estimated workforce needed for universal health coverage [1]. These estimates include a shortage of 2.6 million doctors, the majority of which are in Southeast Asia due to population size but the most severe shortage in relative terms is in Africa [1]. The WHO Global Health Observatory estimated that an additional 200,000 physicians would be required in the African region—essentially doubling their existing workforce in 2013 [1]. The limited physician workforce in Sub-Saharan Africa (SSA) is largely a result of limited training programs in the region and a significant brain drain to HICs.

Physician training in the region is offered as a 5–7-year degree after high school and in 2011, the Sub-Saharan African Medical School Study estimated that there were just over 160 medical schools to serve a population over nearly 900 million population in the Sub-Saharan Africa region [2••]. By comparison, the USA has a similar number of medical schools for one third of that population. Fortunately, the number of medical schools in Africa is on the rise but the capacity to scale training remains stifled by a number of factors including limited faculty, limited training sites, and the lack of a learning resources [2••]. The challenges with retaining graduates are also significant. One study published in 2009 estimated that between 25 and 50% of graduates who had been trained in 9 African countries had left these countries to practice in HICs [3].

For graduates from LMICs who choose to stay in-country, the opportunities to continue with post-graduate medical education are limited. In Kenya, for example, after graduation, doctors are posted to various stations for 1 year of required internship. A significant proportion then become medical officers (MOs), either within the public or private sector. Prior to devolution of healthcare system in 2013, MO were appointed by regional government with no predefined criteria and led to inefficiencies and incompetency. Since the devolution, MO is now appointed by counties using a competitive and incentivized application and selection process [4]. The vast majority of physicians will continue to work as MOs, some rising in the administration ranks through acquisition of managerial skills and qualifications. However, there is no requirement for an MO to obtain further training and many will receive no further training for the duration of their career. A proportion of MOs may opt to obtain diplomas or certificates in specialty areas. The Kenya Medical Practitioners and Dentists' Board (KMPDB) typically reviews each case and makes a decision whether to award a specialist license. Roughly 10% will enroll into the few Master of Medicine (M. Med.) programs available in Kenya, the equivalent to a graduate medical education program in the USA [5]. Due to the highly competitive nature of these programs, successful applicants tend to be those who score highly on the entry written examinations, and who have a few years' experience as a MO. Upon completion of the M. Med degree program, the respective candidate will then work under supervision for a period determined by the Kenya Medical Practitioners and Dentists' Board before being considered a specialist.

Throughout most of SSA, the M. Med. training programs offer specialty training along with an academic degree. Trainees are required to produce a dissertation based on a significant research study. By contrast, the post-graduate training programs in the West are heavily service-based, in which the trainees rotate through all specialties equipping them with the tools to handle day to day work as a competent medical practitioner or surgeon. In addition to the required research element, the other difference in graduate medical education in LMICs is the variability in the training environments. Some health facilities are well-resourced with updated diagnostic equipment and adequate therapeutic options while many health facilities are resource-strapped and diagnostic and treatment options are guided by what is available (Fig. 1).

The challenges in producing a well-trained sufficient physician workforce for the LMIC population is a complex issue that stems from a limited capacity for training and difficulty in retaining graduates. Long-term solutions to this issue will require significant investments in educational institutions. There are, however, a number of potential short-term measures that could help in the interim until more definitive solutions are reached. For physician graduates who have not gone through graduate medical education (MOs, in the case of Kenya), building consultative networks to provide timely support in the management of complex cases is key. This kind of mentorship not only helps the patients, but also enables peer-to-peer

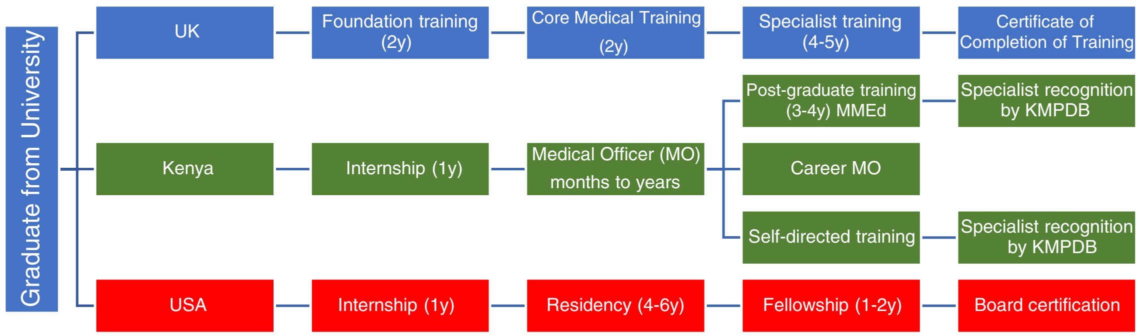

Fig. 1 Comparison between post-graduate training stages in the UK, USA, and Kenyan medical graduates

learning. Consultant networks can be supported by cell phone companies [6] or through confidential social media platforms that would allow physicians to asynchronously seek input on difficult cases while others in the community learn from the exchange. The latter has the advantage of involving a wider group of doctors in the peer-to-peer learning as discussed below in section on tele-radiology.

It is critical to support practicing clinicians in LMICs to keep up with advances, ensuring their capacity to provide specialist care. Presenting at Continuous Medical Education (CME) meetings nationwide, and other society meetings on various practical aspects of patient management and guideline implementation goes a long way in teaching and instilling confidence in doctors around the country. Additionally, making it easier for physicians from LMICs to seek internationally recognized qualifications such as the Membership of the Royal College of Physicians (MRCP) may lay the groundwork for them to develop a more structured and evidence-based practice. The MRCP also gives these physicians the ability to benchmark one's knowledge on an international platform. This examination is taken by candidates from various countries of the world [7]. It is now offered by the Aga Khan University Hospital in Nairobi, Kenya which has become an international exam center, making this credentialing more accessible for those in the region.

For the long-term, there will need to be a significant investment in post-graduate training for the region. This includes increasing capacity in existing programs as well as initiating new programs, some of which may follow the western model of training without requiring the dissertation of a master's degree. The College of Surgeons of East, South and Central Africa (COSESCA) has led the way for this model offering training programs where surgical trainees rotate through various accredited departments in towns outside the capital in Kenya [8]. After the 5-year training program they are eligible to sit the COSESCA exit examinations and qualify as surgeons. Significant expansion of specialist training for LMICs will require programs to follow the lead of COSESCA and develop training models that facilitate a rapid, yet credible expansion of the physician workforce.

Bridging the Gap in Medical Education Through an Information Technology Platform—The dHRC Model

Despite great efforts, health outcomes remain unacceptably poor in LMICs with widening international health inequalities. A trained workforce of health care professionals is critical to ensuring resilient and responsive health systems; however, there is a lack of adequate human resource capacity and a shortage of health workers, especially in LMICs. The lack of quality educational training opportunities for health care professionals also contributes to poor health outcomes [1]. Clinical expertise must be enhanced to keep pace with best clinical practice specific to the local contexts, as well as to improve countries' capacity to monitor and evaluate health outcomes. The UN Sustainable Development Goal (SDG) 3: "ensure healthy lives and promote wellbeing for all at all ages," emphasizes the need for a significant increase in the recruitment, development, training, and retention of health workers, especially in least-developed countries [9].

Relevant and regular training, with the help of effective support and supervision, has the potential to build a healthy workforce, who can expand the reach of quality health care, specifically in poor, marginalized populations. While medical education opportunities are scarce in remote, isolated regions, nontraditional educational methods, including the use of digital technology, can play a pivotal role in addressing this issue [10]. The goal of using technology in medical education is to improve continuous professional development opportunities for health care workers and reduce professional isolation.

The Aga Khan Development Network Digital Health Resource Centre (AKDN dHRC) has been involved in development and implementation of numerous eLearning initiatives in South-Central Asia and East Africa.

For over a decade, AKDN dHRC has made its mission to build professional capacity of health care professionals who are otherwise subject to harsh climate and sociopolitical challenges in the most underprivileged, remote regions of the world. The AKDN Learning Programme, active in South-Central Asia and East Africa, began in 2010 with the virtual connection between the Provincial Hospital in Bamyan and the French Medical Institute for Children (FMIC) in Kabul, both in Afghanistan but separated by mountain ranges and dangerous terrain. Over the years, the Programme has grown considerably, offering eLearning opportunities to health care professionals in six countries, including Afghanistan, Kyrgyz Republic, Pakistan, Tanzania, Kenya, and Tajikistan [11]. The Programme aims to address major barriers in health care provision by leveraging information and communication technologies (ICTs) to build capacity of health care professionals.

The Programme is designed to reduce professional isolation of health care professionals, including doctors, nurses, community midwives, allied health professionals, biomedical engineers, researchers, and academicians to ensure they receive a continuum of learning and professional development opportunities. Using video conferencing technology, eLearning courses on medical, allied and nursing topics are offered by experts at the "hub sites" to health care professionals at the "spoke sites" located in remote, rural areas. Between 2010 and April 2019, the Programme has been able to train 16,187 health care professionals through 1484 eLearning sessions across the six countries.

For example, in East Africa in 2018, the Aga Khan Hospital in Dar es Salaam, Tanzania and the Aga Khan Hospitals in Mombasa, Kisumu, and Nairobi in Kenya were connected to the Ismaili Health Professionals Association (IHPA) in the USA for eLearning sessions in Oncology and Pediatrics. In Kenya, the Aga Khan Hospital, Mombasa is currently connected as a hub site to four primary health care centers in rural parts of Kenya for eLearning courses on practice improvement topics.

Since 2017, AKDN eLearning initiatives in East Africa have successfully benefitted 2223 health care professionals through 118 eLearning sessions.

The Process of Establishing an eLearning Program

The following describes a basic framework for the establishment of an eLearning Program, as followed by AKDN dHRC:

1. Needs assessment: A needs assessment consists of the assessment of the language and type of content to be delivered through the eLearning activity, which further determines the method of delivery. A session-based program is either offered live (using any virtual platform) or through pre-recorded sessions (does not require an interactive platform); whereas, a module-based program allows the use of online content in the form of PowerPoint files, Word documents, videos, and the use of pre- and post-session quizzes, but requires a platform, such as Moodle, to store the content (see below) [12]. Moodle platform is a free learning platform designed for educators, administrators and learners and it has a robust, secure and integrated system that can be used in any part of the world and any device [12].
2. Technology readiness assessment: The technology readiness assessment assesses the IT requirements of the target audience—whether the activity is site-based for a group of learners or for individual access. If the activity is site-based, a designated eLearning room needs to be equipped with required video conferencing technologies and tablets/PCs for quizzes and test. Alternatively, individuals who access content remotely, should have access to a personal computer (PC) with an internet connection.
3. Curriculum development: To develop the curriculum, based on the objectives of the course, a storyboard of the course is developed. Thereafter, a structure is defined for the delivery of course content, e.g., PowerPoint slides, quizzes, and videos. If videos are required, they are gathered and/or developed at this stage. Additionally, the requirement to upload recorded sessions online for later access is also identified at this stage. An accompanying software package can also be developed to monitor student's on-line activity and progress, and provide real-time quality control.
4. Technology platform development: AKDN dHRC primarily uses Moodle, an open source eLearning platform, to store course content. AKDN dHRC customizes Moodle in terms of the language of delivery and defined activities. Moodle has a structured theme; however, in some instances, it is customized as a result of specific course requirements, such as notifications, student/teacher calendars, and games.
5. Implementation and technical support: AKDN dHRC provides training to end users on the use of the platform, translation of the content into a digital form, and its uploading. Furthermore, technical support is provided for the hosting of the content on Moodle, which is usually stored on virtual private network (VPN) cloud server. However, based on requirements, it can also be hosted in a location with a lower latency rate. Furthermore, technical support for Zoom, which is used for video conferencing, is also provided to ensure the Zoom sessions are running smoothly. The sessions are monitored closely by technical support personnel (Fig. 2).

Specialty Needs—Bridging the Gaps in Pathology—Telepathology

Several recent papers have emphasized the crucial role of Pathology and Laboratory Medicine (PaLM) services in LMICs for the successful implementation of universal health coverage [13–15]. Although the gaps in efficient delivery of PaLM services appear insurmountable, significant gains have been made on multiple fronts. Examples include the development of task-shifting and task-sharing programs to provide

Key Requirements	Key Obstacles	Key Solutions
PROGRAM		
The program should have a clear, structured format and be user-friendly, allowing participants to conveniently access content.	Participants lack clarity on the structure of the course content and are unaware of the content's location.	The use of Moodle, a free and open-source learning management system.
The participants should be able to effectively interact with trainers, who are delivering live presentations.	Participants lack a platform to ask questions during sessions. As a result, they ask multiple questions simultaneously, leading to low audio quality.	The use of Zoom video conferencing software.
The participants should have a clear view of the mannequin demonstrations while simultaneously interacting with the trainer.	Participants have a limited view of the trainer/facilitator due to the use of a single camera at the hub site, allowing them to focus on one activity at a time.	The use of Zoom video conferencing software with multiple cameras.
Senior surgeons should be able to provide training on surgical procedures to junior surgeons.	Junior surgeons lack a holistic view of the actual region of interest during the surgical procedure and of the operating room.	The use of Zoom video conferencing software; Polycom video conferencing equipment; Open broadcast software; VR box and 360 degree camera to provide a complete view of the surgical procedure.
The participant should be able to access content round-the-clock, regardless of the availability of internet connectivity.	The participant is required to have basic computer literacy skills.	The use of Moodle, a free and open-source learning management system.
The participant should be able to attend live eLearning sessions, when internet connectivity is available.	Minimum internet bandwidth should be of 512 kbps with a low latency rate (less than 100 milliseconds).	The use of Zoom video conferencing software.
TECHNOLOGY		
The trainer/facilitator should be able to observe, assess and record the skills of the participant in the ward area, through the use of technology, regardless of the availability of internet connectivity in the ward area.	The participant must synchronize data of the application through internet connectivity on initial use.	The use of AKDN dHRC Observation Tool Android Application.
POLICY		
The Pakistan Medical and Dental Council requires health care professionals (physicians) to complete a certain number of Continuing Medical Education (CME) hours annually to main their professional licenses.	Geographical barriers, harsh weather conditions, remote locations and long travel times prevent efforts of health care professionals to avail CME opportunities.	The availability of eLearning opportunities through the AKDN eLearning Programme.
INFRASTRUCTURE		
The trainer/facilitator should be able to record telesurgery sessions, which the participants have round-the-clock access to.	Electrical power must be available during the surgical procedure for the recording and internet connectivity is required to upload the session.	The use of a high resolution zoom-in camera; open broadcast software; VR box and 360 degree camera for the surgical procedure.
The trainers/facilitators should be able to conduct live telesurgery sessions for participants.	Electrical power must be available during the surgical procedure and the minimum internet bandwidth must be of 2 Mbps with a low latency rate (less than 50 milliseconds).	The use of Zoom video conferencing software; Polycom video conferencing equipment; high resolution zoom in camera; open broadcast software; VR box and 360 degree camera.

Fig. 2 AKDN eLearning Programme—Key Requirements, Challenges and Solutions

wider access to cancer diagnostics [16, 17], establishment of national laboratory strategic plans [18], and nationwide implementation of the ISO 15189 laboratory accreditation program [19, 20••]. Capacity building efforts in improving cancer diagnosis in SSA have also been established [21, 22].

In the recent Lancet series on PaLM in LMICs, Wilson et al. [15] highlighted the limited availability of a skilled pathology workforce as a major barrier in PaLM service delivery. Provision of training opportunities for personnel, skills transfer from HICs to LMICs and South-to-South partnerships were some of the solutions proposed by the series authors to bridge this gap [20••]. A successful example of an HIC-LMIC skills transfer is illustrated by the Aga Khan University Health in Nairobi (AKUHN), the only College of American Pathologists (CAP)-accredited clinical laboratory in SSA, and collaborators from Massachusetts General Hospital (MGH). Beginning in 2012, the surgical pathology department at AKUHN partnered with a MGH-based hematopathologist to provide diagnostic support for challenging cases in this subspecialty area. Because of this collaboration, over 90 lymphoma cases originating from AKUHN have been accurately diagnosed and subsequently treated over the past 5 years. Furthermore, this partnership has supported both diagnostic capacity and joint research efforts resulting in several publications [23, 24, 25•, 26]; presentations at regional, national, and international conferences; and supervision of two AKUHN pathology resident dissertations [27].

Additional efforts to create a South-to-South skills transfer have been developed between AKUHN and Mbarara University of Science and Technology (MUST) in Uganda, supported by the MGH Pathology Global Health Program. The MGH Pathology-MUST collaboration, initially established in 2012, filled an unmet need and was a public private partnership between AKUHN and MUST with advisory oversight from MGH. This partnership has resulted in a robust cytology/fine needle aspiration (FNA) service and build immunohistochemistry capacity for breast cancer receptor analysis at MUST. Subsequently, the AKUHN-MUST collaboration focused on ongoing quality assurance support provided onsite by a senior AKUHN technologist who has made several recommendations for workflow and quality improvement at MUST. On the local front, AKUHN has supported diagnostic and immunohistochemistry services (including predictive and prognostic biomarkers for breast cancer) at markedly discounted rates for eight faith-based health facilities within Kenya and provided second opinions for complex cases referred from the network of Aga Khan Hospitals in East Africa.

The use of technology, through image-sharing tools and "smart" advances over traditional microscopy may be helpful in settings where pathology diagnostic resources are limited. Static telepathology has been used in a multitude of ways as a tool for diagnostic support and training [28•] (Table 1). Dynamic telepathology programs in the form of live international multidisciplinary tumor boards serve as examples of

HIC-LMIC collaborations [29, 30], while similar image-sharing approaches may be used in South-to-South collaborations, helping to establish regional diagnostic centers for excellence in SSA [25•]. However, the use of technology goes beyond light microscopic imaging, as exemplified by the recent development of a point-of-care device designed for use with a smartphone that tests fresh lymph node FNA material. The device's ability to accurately classify aspirated cells into broad diagnostic categories (lymphoma vs. reactive) can potentially help identify patients requiring further workup [31]. Similarly, stimulated Raman scattered microscopy represents a fresh tissue-based imaging modality whose output mimics the appearance of hematoxylin and eosin (H&E)-stained slides without the need for tissue processing, sectioning or actual staining [32]. Both are examples of early-stage technologies with future field-based applications that may represent game changers in rapid onsite evaluation for the benefit of patients in LMICs.

Our experience practicing pathology or providing support to pathologists in the global health setting has consistently demonstrated the need to develop and implement programs and technologies that involve, rather than usurp, the role of pathologists practicing in LMICs and that support the development of regional centers of diagnostic excellence equipped to render pathological consultative services and quality assurance oversight to neighboring institutions (Table 2). Although the path ahead is fraught with challenges, the way forward must focus on building local capacity for diagnosis and test interpretation. This is best accomplished through enhanced training, broadening the pool of providers able to render certain aspects of PaLM services, establishing HIC-LMIC and South-to-South collaborations, and implementing "smart" technological tools that can be used in rapid onsite evaluation and identification of patients requiring additional or enhanced testing.

Bridging the Gaps in Radiology Through Tele-Radiology

Continuing advances in digital technologies combined with increasing interest amongst healthcare professionals for global travel enable unique opportunities for providers in HICs to augment the infrastructure for training and clinical practice in LMICs. A case study may serve to illustrate the global radiology initiatives we have pursued in East Africa over the past 10 years of collaboration.

In 2008, a team of healthcare professionals of IHPA USA, including one of the co-authors (MG), visited Kenya and Tanzania to establish a collaboration with in-country healthcare professionals and facilitate knowledge transfer. The team was very keen to first learn about the state of clinical practice, available imaging equipment and digital infrastructure support at Aga Khan University Hospitals in Nairobi (AKUHN) and Dar es Salaam (AKHD), two cities where our team spent most of the time. We instantly discovered that the training and clinical practice needs of these two sites were strikingly different. For example, AKUHN had a thriving radiology residency program, advanced imaging equipment and an established picture archiving and communication system (PACS). In contrast, AKHD has no radiology residency program, no PACS and some but not all modalities of advanced imaging equipment. For example, nuclear medicine equipment was available at AKHN but not at AKHD. Forging collaborations with these two sites would involve very different combinations of emphasis on infrastructure vs educational/research needs, the former being a priority at AKHD and the latter being a priority at AKUHN.

To meet the infrastructure needs of radiology at AKHD, we have launched several initiatives including the transition from films to a digital system, the installation of radiology information system, and the provision of a radiology reporting using voice recognition system. We organized several CME sessions, trained radiologists and technologists, and participated in various multidisciplinary conferences. In 2014, we worked with AKHD to procure nuclear medicine equipment for SPECT imaging, and in 2018, we assisted in the selection and installation of a fully functioning PACS. As an extension of this partnership, an endowed scholarship for advancement of nuclear medicine services in Tanzania was established in 2014 and is offered to senior trainees or junior faculty in the USA to travel to AKHD each year and provide nuclear medicine educational support and organize outreach activities with the referring physicians to increase awareness of nuclear medicine in clinical management.

At AKUHN, which had access to advanced imaging technology, we initiated a monthly webinar series called International Rad-Path Correlation Conference (IRPCC) using a GoToWebinar account (Citrix). Cases from both East Africa and the USA, complete with clinical history and imaging findings are presented, following which an assigned radiologist from the other side reviews the findings and formulates a working diagnosis. A pathologist then shows the biopsy findings. The webinars are recorded in the HIPAA compliant manner, archived online, and made available for viewing at a later time [33] . This collaboration has been since extended to provide research mentoring of junior colleagues at the AKHN [34].

Bridging the Gaps in Gynecology Through Tele-Case Conferences

The need for gynecology consultation arose when a team of clinicians, including a gynecologist specializing in gyn-cancers and infertility, from the Aga Khan Health Board, USA (AKHB, USA) visited Gorno Badakshan Autonomous Oblast (GBAO), Tajikistan in 2017. The family medicine physicians and gynecologists in GBAO requested assistance with

Table 1 Requirements for a telepathology initiative

Telepathology types and definition	Minimum requirements	Advantages and disadvantages of approach
Static: sharing of still microscopic images of glass slides using store and forward technology	Originating site/facility: • Compound light microscope with low- and high-magnification objectives. • Digital camera to capture high-resolution digital images (at least 300 dpi recommended). • Internet access to allow for uploading of image files to a web browser or password-protected email software to send images via the internet. Receiving site/facility: • Desktop computer with monitor of sufficient resolution to display images. • Means of sharing interpretations with referring facility/pathologist (e.g., reply email, posting to a password-protected website used for image-sharing purposes).	• Relatively low-cost: uses existing lab equipment, with additional cost of digital camera with microscope attachment (USD $100–5000). • Requires an internet connection, but a workable solution in regions where internet may be inconsistent or unstable. • Since accurate interpretation of still images is highly dependent on microscopic fields selected for image sharing, this is best done by a pathologist or pathologist-in-training present at the referring site.
Dynamic synchronous: real-time sharing of live microscopic images of glass slides via microscopy or whole-slide imaging	Originating site/facility: • Compound light microscope with low- and high-magnification objectives. • Digital camera to capture high-resolution digital images (at least 300 dpi recommended). • Internet access to allow for desktop sharing software, such as GoToMeeting or Skype. Receiving site/facility: • Desktop computer with monitor of sufficient resolution to display images. • Internet access to allow for desktop viewing software, such as GoToMeeting or Skype.	• Relatively low-cost: uses existing lab equipment, with additional cost of digital camera with microscope attachment (USD $100–5000). • Promotes education, teaching and training. • Requires sufficiently stable and consistent internet connection, which may not be available in all regions. • Requires real-time presence of individuals at both locations, which may be challenging over long distances due to time zone differences. • Individual at the referring site does not need to be a pathologist, but should be familiar with operating a microscope.
Dynamic asynchronous: sharing of whole-slide images of glass slides previously acquired using specialized slide scanning software	Originating site/facility: • Specialized slide-scanning/whole-slide imaging equipment and software sharing platform. • Personnel trained on maintenance and use of the equipment. Receiving site/facility: • Compatible software sharing platform to access and view high-resolution whole-slide images. • Means of sharing interpretations with referring facility/pathologist (e.g., reply email, posting to a password-protected website used for image-sharing purposes).	• Relatively high-cost (most commercially available whole slide scanners in range of USD $100,000 or more). • Requires sufficiently stable and consistent internet connection to upload/send whole-slide images, which may not be available in all regions. • Maintenance of specialized slide-scanning equipment may require ongoing service contracts and proximity to personnel familiar with its use, in the event of a breakdown requiring servicing or replacement of parts.

the evaluation and management of various women's health topics. This need was addressed through monthly didactic videoconference sessions using GoToMeeting. Teaching slides were prepared by the AKHB gynecologist while cases were submitted by the team from GBAO. The interaction was both educational as well as patient centered with a specific context relevant recommendation being made for each case together with evidence-based justification with appropriate modification for the LMIC setting. Key to the success of these sessions was the development of evidence-based algorithms for some of the more frequent consultation cases, e.g., infertility and pelvic inflammatory disease (PID). The biggest barrier was language given the most GBAO gynecologists did not speak English and the US-based clinicians did not speak Russian or Tajik. However, resourceful bilingual nurses trained outside GBAO provided live translation. While some of the flow and rhythm of this interactive discussion was lost during translation, the enthusiasm of clinicians on both sides ensured a productive learning experience for all involved.

Key to this partnership were:

- Establishing rapport: Building good relationships and trust between the visiting consultants and the local providers requesting consults is paramount to the success of a tele-consultation program. This can be accomplished through visits to the country, ongoing engagement with the providers and the larger community prior to the launch of the tele-consultation program.
- Understanding local and national cultural norms and limitations: Consultants need a good understanding of what is

Table 2 Challenges, opportunities, and proposed sustainability for pathology in LMICs for improved cancer care*

Issues	Suggested solutions	Sustainability plan
Variable pathology training standards in LMICs	Harmonize training curricula through regional and national colleges of pathology for best practice standards. Leverage partnerships with international pathology organizations.	Train and build skills of local faculty.
Poor quality of cancer reports, long turnaround times	Train pathologists to adopt synoptic reporting format for all cancers.	Establish star rating accreditation system for AP laboratories similar to WHO SLIPTA program.
Unregulated pathology practices	Work with technology and/or scientist boards to develop and establish minimum standards for various categories of laboratories.	Work with international partners to establish consortia for common cancers in LMICs. Work with regulatory bodies to monitor and evaluate plans to maintain laboratory standards.
Overworked pathology staff, poor infrastructure, substandard AP practice in centers away from major cities	Create centers of excellence using hub-and-spoke model.	Lone practicing pathologists connect to hubs via dynamic real-time telepathology, which can be a platform for training and diagnostic support.
Pathology as an invisible specialty	Encourage multidisciplinary research as a platform for collaboration with clinical colleagues.	Sustain advocacy, create public awareness about the role of pathology and pathologists in cancer screening and early diagnosis.

AP, anatomic pathology; *LMIC*, low/middle income country; *SLIPTA*, Stepwise Laboratory Quality Improvement Process Towards Accreditation; *WHO*, World Health Organization

available and accessible in the country in terms of supplies and materials. Moreover, it is valuable to understand cultural norms (along with resource constraints, costs, and timing) which can help to contextualize how to setup trainings.

- Language and knowledge sharing: if the language of the target population is not the same as the trainers, it is important to consider having a professional interpreter available. Preferably, the interpreter should be a care provider in the same field as the trainees in order to reduce any loss of context. Alternatively, one could upgrade the English language skills of the local gynecologist over a 3- to 6-month period. The Aga Khan Lycee in Khorog provides such language training for professionals, who have rudimentary English language skills. The training team quickly learned the best option would be to have one of the gynecologists learn English and be the interpreter.
- Learning styles of recipients: It is important to strike a balance between leveraging algorithms, knowledge base, and evidence-based medicine and following protocols that would be relevant to the recipient country. In the case example of GBAO, the initial case discussion included dissecting the pathophysiology of the disease, creating differential diagnosis, and understanding the mechanism of action for pharmacological treatment. This evidence-based approach was overwhelming for the local gynecologist given that the Russian training did not include the basic pathobiology knowledge common in the West. Alternatively, we created algorithms to diagnose and treat common conditions. This approach, while prescriptive, was readily accepted and could be applied in response to other similar clinical scenarios.
- Logistics: It is important to consider logistics when establishing a tele-education program. For example, videoconferencing requires technology equipment, internet connectivity, software, screens, conference lines, and conference rooms, as well as considerations related to the time difference between locations of the trainers and trainees.
- Documentation: In the case example of GBAO, in addition to knowledge-sharing, the team was also focused on building other important processes such as detailed patient documentation. To encourage the completion of documentation, including a detailed history, physical examinations, diagnostic tests, and treatment plans, a consultation form was designed to be completed by the gynecologist. However, patient documentation was a challenge due to lack of individual patient charts and office supplies (e.g., paper) for documentation and handouts.

Reviewing the approach taken, the overall agreement amongst the trainers and trainees was that gynecology consultation videoconferencing was a successful launchpad to connect remote communities with international experts.

Clinical Investigator Training Program—Experience in LMICs

Not too long ago, the American Cancer Society (ACS) and the Clinton Health Access Initiative (CHAI) announced groundbreaking market access agreements with major pharmaceutical companies to expand access to 16 essential cancer treatment medications, including chemotherapies to countries in SSA [35]. Access to novel agents is only the beginning of the process of improving clinical care of patients in Africa. However, the response rates, side effect profiles, impact of compliance (or lack thereof) for novel oral agents, pharmacokinetics, and pharmacogenomics in the African host has not been studied [36]. It may well be different than what is observed in the West and yet Western chemotherapies get applied in LMICs as if there is no difference between patients in HICs and LMICs except for socio-economic differences and ability to afford treatment. It will take African clinical investigators to ask these critically important questions, both in terms of the outcomes using standard chemotherapies that are being provided at subsidized prices, as well as novel and much more expensive therapies that are changing the oncologic landscape in HICs and may well do the same in LMICs. Interestingly, even though HIV-related clinical trials have been conducted in major sub-Saharan Africa (SSA) centers for over two decades, very few of these centers conduct cancer clinical trials [37].

Clinical investigation and clinical trial training in general is not part of most residency curriculum in HICs, and certainly not part of the post graduate training in LMICs [38]. Most trainees in SSA have not been exposed to clinical research and thus are not aware of the concepts and principles of clinical investigation. The concept of informed consent is often foreign to most clinicians and patients in LMICs, where it is often the male head of family who takes decision-making authority on behalf of family members [39, 40].

Only a few centers in SSA are equipped to conduct clinical trials [41]. Pharmaceutical sponsors often handpick those sites to participate in regional phase 2 studies or multi-national phase 3 trials. However, very few centers conduct investigator initiated clinical trials that probe the hypothesis of whether Western data and outcomes can be readily replicated in patients in LMICs. There remains an unmet need to train clinicians in LMICs to conduct clinical trials. There are some non-governmental organizations (NGO) and for-profit entities that function as clinical research organizations (CROs) and conduct Good Clinical Practice (GCP) training in LMICs [42]. Most of these trainers are not practicing clinical investigators, however, and much of the training is focused on the basics of clinical investigation, human subject protection and regulatory compliance. Seldom are trainees taught or guided in writing and implementing an actual clinical trial.

In an effort to promote awareness about clinical research and provide a practical and pragmatic introduction to clinical investigation, we have successfully established a clinical investigator training program (CITP) at the University of Alabama at Birmingham [43]. In response to the requests by clinicians from a number of developing countries, we piloted a similar program in Kenya in collaboration with local clinicians. A partnership between the Ismaili Health Professional Association (IHPA USA) and the O'Neal Comprehensive Cancer Center at University of Alabama at Birmingham (OCCC UAB) initiated a training program in which participants were expected to have achieved a basic understanding of the fundamental principles underlying clinical investigations and how to develop a clinical research protocol. This was then exported to the AKUHN, where a cohort of 25 individuals were selected from applicants hailing from the entire East African Aga Khan University (AKU) network. Topics covered at the on-site workshop included introduction to human research, ethics and GCP, regulatory issues in clinical research, an overview of drug development (phases 1–4), roles and responsibilities of the clinical study team and protocol development. In addition, the participants formed teams of four to five participants, each dedicated to writing a mock investigator initiated clinical trial.

A pre- and post-assessment of the participants revealed an increased understanding in basic research principles and familiarity with what is needed to develop a successful research protocol. In the process of developing their clinical protocol, the participants also identified some of the barriers that hindered clinical research in the AKU ecosystem. These were similar to what has been observed in other young academic institutions in LMICs, including lack of clinical research training and mentoring, limited funding, and support systems to foster clinical investigation.

Following the on-site program, a 3-month-long on-line program consisting of seven modules was launched as a refresher. At the completion of each module, participants were tested. Candidates who successfully completed the on-line course including passing all the tests were awarded a CITP certificate. Eleven of the original 25 participants successfully completed and passed the on-line course and formed the first graduating class of CITP at AKUHN.

In addition to identifying participants who were interested in clinical investigation as a career path, the program also identified opportunities to foster a culture of clinical research at AKUHN. Similar programs have also been piloted at the Alexandria University in Egypt. There was much enthusiasm from the participants, most of whom were young clinicians at the end of their residency training or junior faculty. Non-physician courses participants, including nurses, became interested in a career as clinical research coordinators. It was gratifying to witness a genuine desire to learn more about clinical investigation and the conduct of clinical trials. GCP training provided by the NIH provides a good platform for such training but most observers have noted that such training is very North American-centric and does not necessarily reflect the context in LMICs, nor does it provide the practical and pragmatic approach linked with real case scenarios and participation by local clinical investigators.

It will take a concerted effort by the academic institutions, CROs and pharmaceutical sponsors to promote and support an unbiased training program in clinical investigation in order to prepare physicians in LMICs to become good clinical investigators such that key clinical questions and hypotheses may be addressed by those who treat patients and have the desire to contribute to better outcomes. LMICs represents a fertile market for pharmaceutical drugs and it is also the responsibility of big pharmaceutical sponsors to support addressing fundamental question about the applicability of Western data to patients from these countries.

Recommendations

eLearning has the potential to cater to various health needs, enabling information sharing, experiential learning, collaboration and in-time support. It is the most cost-efficient and effective way of providing continuing medical education (CME) and continuing nursing education (CNE) opportunities in low resource settings, characterized by a shortage of skilled health care workers and inadequate health system investments. The adoption of these technologies could play a vital role in reducing the burden of disease by improving the quality of specialized care provided. Strong partnerships between policy-making agencies, academia, health care institutes and other stakeholders could benefit from the development of such continuing professional development programs using technology as the potential for the return on investment is high in terms of health gains and lives saved.

Conclusions

As the pace of medical advances accelerates in HICs, expensive tests and treatments become part of the standard of care in the West [44]. Unless such technology can find its way and also be applied for the benefit of patients in LMICs, the healthcare disparity between LMICs and the HICs will continue to widen. Here, we have presented many case studies that exemplify individual as well as public private partnerships initiatives that have successfully contributed to narrowing this divide. Each of these is an example of mentorship and sharing of knowledge across continental divides. One important touchpoint where mentorship could help accelerate scientific inquiry in LMICs is assistance with grantsmanship—the ability to succinctly outline a hypothesis followed by a credible background and rationale, methodology and an innovative plan to answer a clinical question. This is an art that can only be taught by those who frequently write grants and get funded, and remains an area of weakness in LMICs where training in grantsmanship as well as formulating a project remains extremely challenging, especially when measured by Western standards. This gap could well be bridged by having colleagues in HICs guide their colleagues in LMICs through the process and actively collaborating with them through the trial and tribulations associated with each such attempt. It will take committed servant leadership on part of academicians based in HICs to contribute to the growth of a vibrant scientific community in LMICs. As the world grows smaller it is in our self-interest to support our colleagues in LMICs to effectively and efficiently take care of their patients and become partners in the global quest for better health care outcomes for all human beings.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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