15 Telemedicine in Cancer Control Programs in Developing Countries

Karolyn A. Wanat, Kelly E. Quinley, and Carrie L. Kovarik

Abstract

The success of a cancer screening and early diagnosis program is critically dependent on the skill of the healthcare professionals involved. Initial training, continuing education, and consultation as needed are best achieved via telemedicine. The various components of such support for screening and diagnosis of breast and gynecological cancers are discussed.

Abbreviations

CCPPZ	Cervical Cancer Prevention Program in Zambia
CIDRZ	Center for Infectious Disease Research in Zambia
DAD	Data acquisition device
DART	Digital camera assessment of the reproductive tract
eC3	Electronic cervical cancer control
EDI	Enhanced digital imaging
HIV	Human immunodeficiency virus
HPV	Human papilloma virus
LEEP	Loop electrosurgical excision procedure
Pap	Papanicolaou
PIA	Photographic inspection with acetic acid
SMS	Short message service
VIA	of the cervix with acetic acid
VILI	Visualization of the cervix with Lugol's iodine, i.e., Schiller's test

K.A. Wanat • K.E. Quinley • C.L. Kovarik (✉)
Hospital of the University of Pennsylvania, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA 19104-6056, USA
e-mail: Karolyn.Wanat@uphs.upenn.edu; kquinley@mail.med.upenn.edu; carrie.kovarik@uphs.upenn.edu

Introduction

Developing screening programs for cancer in developing countries relies upon improving capacity of the local health systems for early detection and treatment of cancer as well as providing education to the population and preventative services [1]. There are multiple strategies to

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provide these services as part of cancer control programs, and one of the strategies is incorporating telemedicine for expanding access to care, providing educational services to providers and patients, diagnosing disease, and continuing management of these patients. This chapter highlights the use of telemedicine in developing countries for screening and diagnosis of breast, external genital cancer, and cervical cancer.

Breast Cancer

In developing low and middle income nations, there is a higher incidence of breast cancer, with an annual rise of at least 7.5 %, more than double that observed on a global level [2]. The challenges facing these countries and their women include access issues with prolonged wait times for diagnosis and treatment, and lack of education on the diseases and potential impact. The women in developing countries often present with more advanced disease associated with higher mortality, often due to lack of preventative and screening services and to the focus on infectious diseases of more acute onset [3]. In addition, misconceptions and stigma about the ability to treat, as well as the various treatment options available, exist and deter women in some populations from getting treatment. In other cases, women have awareness of breast cancer, but no programs exist for treatment [3]. For breast cancer prevention, screening with mammography and treatment of all stages have recently been demonstrated to be cost effective in sub-Saharan Africa and Southeast Asia [4]. Several methods have been explored to help expand access to these populations, including increasing awareness among the public and health authorities, increasing education about breast self-examination, improving access to rapid diagnosis, and improving education about the disease in order to remove any associated stigma [5]. Various telemedicine tools have been piloted and explored in this capacity.

The definition of telemedicine can be broad and applicable to various aspects of breast cancer education, screening, diagnosis, and management. The explosion of mobile phone availability has provided an inexpensive mode of communication, including to those individuals in remote areas. The improved access to this resource is one way to improve communication among physicians to each other and with patients. In addition, the increased access to internet availability also has provided increased means and modes of communication.

Diagnosis: Teleradiology

The ability to efficiently diagnose breast cancer requires access to imaging technology for evaluation of breast masses. In addition, breast cancer screening with mammograms is centered on medical imaging. According to the World Health Organization reports, the majority of the world population lacks access to health technologies, especially medical imaging technologies. In addition, even when medical imaging devices are available, they may be inadequate, nonfunctional, or personnel may lack expertise in management of the systems or interpretation of results. Broadly, teleradiology is a means of electronically transmitting radiographic images for interpretation at another site, and this can be an essential tool to increase access to interpretation of radiographic images in resource-poor settings. For example, in sub-Saharan in 2003, the majority of countries did not have a single radiologist.

The use of teleradiology has been utilized to increase access to services, but technology has been a limitation to its own incorporation. Recently, the feasibility of using mobile technology in order to create an integrated part of a medical imaging system for the interpretation of breast images has been demonstrated [6]. This technology consists of a simple data acquisition device (DAD) on the patient side, as well as an advanced image reconstruction unit at a central site. The mobile phone transmits unprocessed raw data from the patient site DAD to a central site where the end system would process the raw data; then the data would be interpreted by the end user and expert. This technology was tested on simulated breast cancer and shown to be feasible [6]. By dividing the imaging system into smaller components, the complexity and operation of the system at the remote patient site is decreased, and the data processing is centralized, thus increasing access to this state of the art imaging to patients who do not otherwise have access to advanced medical imaging. Earlier attempts at tele-mammography failed because of technical problems and the need for images to be processed at the site of the patient, but newer studies with more advanced technology have demonstrated that high-quality and multisite telemammography systems can exist within these technological constraints [7]. Increasing access to mammography in developing countries by centralizing data processing and interpretation would dramatically improve the ability to diagnose breast cancer in resource-limited settings.

Diagnosis: Telepathology

When a suspicious breast mass or nodule is identified, a tissue diagnosis is essential to confirm malignancy. Telepathology is the electronic transmission of digital images, either previously taken and stored ("store-and-forward") or live images, that can be used for education and diagnostic purposes. A successful store-and-forward system requires a microscope, digital camera or slide scanner, computer, internet connection, as well as the ability to process quality histology slides. The remote diagnosis of frozen sections, histology, and cytology from fine needle aspirations and surgical biopsies via telepathology is currently being practiced on a global level for multiple tissues, include breast lesions [8–11]. Although there are several roles for telepathology in the developing world, the use of telepathology as an alternative to an on-site pathologist for interpretation of fine needle aspiration or surgical biopsy specimens is attractive. Studies have demonstrated that the diagnostic accuracy of remote diagnosis of fine needle aspiration ranged from 80 to 95% with improvement to continued training and to use of the system [12, 13]. Reviewing specimens as part of a multidisciplinary team and having access to telepathology in general improve diagnosis and treatment of patients.

Although the ability to remotely interpret pathologic specimens may increase access to subspecialists, care must be taken in establishing this arrangement, as technical difficulties and time for transmission of the image can lead to frustrations with the system and impede timely diagnosis. The initial cost of a system set-up with a microscope and transmitting capacity is not minimal. Once established, having a local pathologist can help streamline diagnoses and interpretation of specimens, with more difficult samples sent for further interpretation. However, as systems become less expensive and more streamlined in transmission, telepathology will continue to be an important tool for diagnosing and establishing cancer centers in the developing world.

Management: Multidisciplinary Teams

In the developed world, multidisciplinary team management including a group of clinicians from different specialties or disciplines has been an important element in improving breast cancer outcomes [14]. These healthcare team members may not all be in the same location, and telemedicine provides a flexible platform to link professionals in different geographical locations, including more remote and further locations, and saves time and money associated with travel. In addition, it allows access to experts who are not in a geographic area in a more efficient manner. The feasibility of connecting multidisciplinary teams from cancer centers and remote cancer units with telemedicine was initially demonstrated for breast cancer, colon cancer, and lung cancer in Wales [15]. More recently, the TELEMAM trial consisting of a 473 patient discussion cluster randomized to telemedicine or in-person meetings to discuss breast cancer management demonstrated that there was similar clinical effectiveness between these two methods in Scotland [16]. The trial also studied the levels of satisfaction of the members of the multidisciplinary trial with the quality of the decision making, which were not statistically different between teleconferences and in-person meetings. Several other studies also have focused on health professional satisfaction with telemedicine and have found that to be generally supportive of tele-oncology [17–19]. One of the significant benefits highlighted was the reduced need for highly specialized clinicians to travel, which provided greater flexibility for meeting times. A challenge posed was technical support, which is an initial up-front cost [16]. In addition, telemedicine was shown to be clinically effective, in terms of the quality of decision making and adherence to best practices in the treatment of breast cancer.

Although this has not yet been studied in the developing world, similar principles of establishing multidisciplinary teams in a country with limited specialty physicians and staff would provide additional flexibility and increased access to these resources and services. Key components for success include technical performance of the equipment, quality decision making, communication between team members, and resource usage [20]. Establishing a multidisciplinary team or tumor board in a developing country to provide this specialized care for patients diagnosed with breast cancer is plausible. Remote physicians and subspecialists also could provide expert opinion and advice across countries and continents with this multidisciplinary approach and telemedicine.

Management: Compliance and Coordination of Care

After diagnosing and initiating treatment, the coordination of care and continued management of patients also are crucial in cancer control programs. Poor compliance and follow-up of patients after an initial visit to a physician are a problem in developing and low resource countries. Monitoring compliance and potential side effects of therapy is an essential component of oncologic care. In Nigeria, the mobile phone was used as a tool to improve communication and increase patient follow-up in African cancer patients, the majority having had breast cancer. High numbers (97.6%) of patients found the use of the phone worthwhile and preferred this mode of communication as it gave them a feeling that they had increased social support from their provider [21]. Because the majority of the patients in developing countries are poor, illiterate, and may travel long distances to be evaluated, access to a streamlined form of communication with their provider in between visits is helpful. Similar to compliance with antiretroviral and antituberculosis medications, adherence to treatment plans for breast cancer patients when using mobile technology has been shown to be effective. For women with breast cancer, this improved communication also is important from a cultural perspective, as in many developing countries women can travel to the doctor only when accompanied by or with permission from their husbands [21]. This mode of communication and social support relies upon the physician being able to speak patients' native language, which may be difficult in more resource-limited settings.

There is considerable ability to expand the use of mobile technology in resource-limited settings as a way to improve communication between providers and patients. This is essential in the care of breast cancer patients and coordination of cancer care, especially if therapy such as chemotherapy and radiation are employed. This extends from social support to counseling to coordination of care. Because cancer patients often have to manage a significant amount of information for coordination of their care, several mobile phone applications also exist to help manage care-related information, including applications that manage appointments, create reminders for taking medications, and communicate laboratory results [22]. Similarly, managing symptoms related to chemotherapy toxicity and potentially dangerous side effects can be difficult for both patients and physicians in any setting. A mobile phone-based advanced symptom management system was developed and demonstrated to be able to support the management of symptoms in patients with breast cancer who were receiving chemotherapy, increasing compliance and identifying patients who needed more emergent intervention [23]. Patients also reported significant benefit in using this system and felt more closely monitored and able to communicate with their physician [24]. This platform can extend from being a formal application to a simpler platform that can be incorporated on basic mobile technology.

External Genital Cancer

The incidence of external genital malignancies, including vulvar, penile, and anal cancer, has been increasing substantially in recent years in the both the developing and developed world. The association of the human papilloma virus (HPV) in these cancers is becoming stronger with current data suggesting HPV infection is potentially associated with 90–93% of anal cancers, 36–40% of penile cancers, and 40–51% of vulvar cancers. HPV is estimated to be involved in 5.2% of all cancers that occur worldwide [25, 26]. The human immunodeficiency virus (HIV) epidemic is also thought to play a role in the rising incidence of HPV infection and related malignancies, as these individuals are at increased risk for HPV-related cancers. This incidence is notable in the HIV-infected population, where rates can be 7–28 times higher than the general population and present as more advanced disease [27]. HIV-infected individuals have been reported to have a 35-fold increased risk of anal cancer among men, 15-fold increased risk of anal cancer among women, and a 5–6-fold increased risk of cancers of penis, vagina, and vulva [27, 28]. Because the rates of HIV are often higher in developing or underserved countries, these problems are becoming an increasing burden to these populations. Screening and diagnosis of external genital malignancies is lacking in developing countries, and specialists with expertise may not be available. Innovative strategies, such as telemedicine, may provide increased availability for screening and early diagnosis of these lesions in the high risk population. Because these malignancies are visually apparent, the use of telemedicine similar to that in dermatology is an attractive solution.

The use of telemedicine for patients with skin diseases and skin cancer screening in both developing and developed countries has been explored and shown to be an effective tool. Many projects and studies that initially incorporated teledermatology as a platform encountered barriers related to the information technology infrastructure and limitation of internet connectivity [29–31]. More recently, the use of mobile telephones or other handheld devices has been incorporated in various settings into dermatologic consultation, skin cancer screening, and the provision of on-going management for dermatologic diseases [29, 32–34]. In a resource limited setting within Egypt, a feasibility study of the use of a mobile telephone for teledermatologic consultation proved to be technically feasible and diagnostically reliable compared to in-person consultation for dermatologic diseases. Similarly, studies in resource-limited settings have demonstrated that the use of mobile phones to capture digital images for clinical diagnosis was feasible, provided good diagnostic accuracy, and served as comparable screening tools for diagnosing melanoma and non-melanoma skin cancers [35–37]. In these studies, high management decision making concordance between teledermatology and in-person consultation was observed, and this was of importance because of the direct impact it would have to patient care and outcomes [38].

Mobile teledermatology platforms could be applied for the screening, diagnosis, and even management of external genital cancers by incorporating the same principles used for screening melanoma or other skin cancers. Because these malignancies often present with visible abnormalities, digital imaging could capture the photos of lesions, which could then be submitted to a specialist for triage and management decisions. The portability and convenience of capturing high resolution clinical images with expanding technology and network coverage for expert opinion would be significant advantages in the screening and diagnosis of external genital cancers, similar to the more common skin cancers [38].

Patients have been extremely satisfied overall with care and accepted this platform as a means to care because of the increased access; some patients had reservations regarding photographs taken with identifying features, which would not be an issue for this type of screening system [39, 40].

Similar to melanoma and non-melanoma skin cancer screening, evaluating patients for external genital cancer requires a provider to evaluate these patients; however, one teleconsultant can reach multiple patients across multiple underserved areas. If screening is effective, then earlier detection of less advanced external genital cancers would allow for earlier and possibly simpler interventions and improved patient care.

Cervical Cancer

Background

Cervical cancer continues to play a major role in cancer-related mortality in the developing world, where it remains the number one cause of cancer-associated death among women [41]. In resource-poor areas, the degree to which the burden of this cancer falls upon women is due to insufficient laboratory, financial, and provider resources, which often lead to either inefficient screening programs or a complete lack of cervical cancer screening [42]. Pioneers in the field of telemedicine have identified the critical role that technology can play in filling current gaps existing in cervical cancer screening services, and they have begun to develop cervical cancer screening training, quality assurance, and provision of programs using telemedical approaches. These programs are helping to bring remote gynecological screening expertise to areas currently lacking sufficient numbers of women's health providers and experts.

Challenges of Conventional Cervical Cancer Screening in Resource-Poor Areas

Cancer screening programs utilizing conventional Papanicolaou (Pap) smear cytology, in conjunction with colposcopic cervical visualization, have proven highly effective and have markedly reduced mortality from cervical cancer in developed countries [43]. In Pap smear screening, cervical and endocervical cells are collected during a vaginal speculum exam, after which the collected cells are examined microscopically by a cytologist to determine whether cellular abnormalities suggest cervical precancerous or cancerous changes, usually caused by sexually transmitted HPV. In the case of the United States, Pap smear-based programs have reduced cervical cancer rates by 74% [43]. However, these cytology-based programs, which are standard of care for cervical cancer screening in the industrialized world, remain scarce in resource-poor countries where decreased awareness of cervical cancer, insufficient laboratory and testing facility infrastructure, substantial loss to follow-up owing to prolonged wait time for results, and the cost and need for trained gynecological experts and cytologists needed to interpret Pap smear results often render them not feasible [42, 44, 45]. HPV DNA testing frequently used in developed countries are also impractical in resource-poor areas, where its high cost makes routine implementation not feasible [46, 47]. Additionally, high rates of HIV-HPV coinfection contribute to the burden of cervical disease in many developing countries [45].

As upwards of 80% of cervical cancers may be prevented by routine screening [48] and simply screening women in resource-poor countries a single time, at age 35, has been shown to decrease the risk of cervical cancer by 25–36% [49], it is imperative for the health and longevity of individual women, as well as the cohesion of families, to continue to increase cervical cancer screening programs in these areas. Telemedicine specialists have stepped into this role and have pioneered programs specifically targeted to developing communities in order to increase the provision of cervical cancer screening services by bringing the providers' services to the patient, in a virtual fashion.

Current Cervical Cancer Screening Approaches in Developing Countries

In the developed world, colposcopy is used as an adjunct to Pap smears to visualize the cervix following abnormal Pap results; this enhances the sensitivity of cytology alone (which can be as low as 50%) [48]. To perform colposcopy, a medical provider uses a colposcope to illuminate and magnify the cervix between 10 and 40 times in order to visually evaluate the cervical tissue for precancerous or cancerous changes. In developing countries, however, many screening programs that lack the necessary resources for Pap smears are based solely on the "see-and-treat" method, where acetic acid and Lugol's iodine solution are used to grossly visualize the cervix without the use of cytology, and women with small lesions can be treated on site with cryotherapy. Those with larger lesions are referred to a tertiary referral center for a cervical biopsy or loop electrosurgical excision procedure (LEEP) [50].

To help visualize cervical dysplasia, acetic acid is applied to the cervix during a speculum exam. In this practice, called visualization of the cervix with acetic acid (VIA—also called Direct Visualization or Cervicoscopy), the acetic acid is applied to the cervix for 3–5 min; this serves to eliminate superficial cervical mucus to improve visualization and causes the whitening ("acetowhitening") of any superficial cervical cells that are abnormal or precancerous, as their higher than normal nuclear crowding causes cellular dehydration in the face of acetic acid (Fig. 15.1) [51].

Lugol's iodine can also be placed on the cervix during speculum examination to enhance the identification of precancerous lesions. In visual inspection of the cervix with Lugol's iodine (VILI), also known as Schiller's test, glycophilic Lugol's iodine is applied to the cervical tissue and stains the normal, healthy squamous epithelium that has high amounts of glycogen brown, but renders precancerous and metaplastic regions of the cervix as well-defined saffron-colored yellow areas, as they contain abnormally low levels of glycogen and do not uptake the iodine [52].

Numerous studies from developing countries have illustrated largely divergent sensitivities and specificities for detecting early cervical cancer. However, trends show VIA to have superior sensitivity when compared to cytologic screening, with sensitivity of 50–90% vs. 44–85%, respectively; trends also show that VIA has inferior specificity, with VIA at 56–96% vs. cytology at 80–98% [49, 53–56]. Though VIA's low specificity can equate to high numbers of false-positives and raises concerns about overtreatment, resource scarcity often renders Pap smear cytologic screening not feasible. Thus, many programs in developing countries rely on VIA and VILI for screening, as these remain the most appropriate options in the face of resource scarcity.

Fig. 15.1 Example of cervical acetowhitening following topical application of acetic acid

VIA-focused programs and screening trials have been implemented in countries such as Ghana, India, Kenya, Peru, South Africa, Thailand, Zambia, and Zimbabwe [44, 49, 53, 57, 58]. There are also programs using VIA in conjunction with VILI in Botswana, China, Democratic Republic of the Congo, El Salvador, and India [50, 54, 55, 59, 60].

The high cost of colposcopes, which are needed to capture images of the cervix, as well as the need for trained specialists often preclude the use of a colposcope in developing countries [48, 61]. Programs in Botswana, El Salvador, and

Zambia have utilized store-bought digital cameras to approximate colposcopes and to capture images of the cervix, magnifying areas questionable for premalignant or malignant changes [44, 50, 60]. The ability to take cervical photos of sufficient quality for reading colposcopy as well as the ability to save, store, and send these images to gynecological experts for colposcopic readings are the developments that have enabled the field of telemedicine to enhance cervical cancer screening programs in developing countries.

How Telemedicine Is Used for Cervical Cancer Screening

As an image-based screening modality, colposcopy lends itself to telemedical approaches. The utilization of telemedicine for cervical cancer screening is founded on the basis of the capturing of digital cervical images (also called cervigrams), which are saved and transmitted to off-site gynecological experts where they can be viewed for distant real-time or delayed primary or secondary evaluation [44]. At the patient's bedside, these images can also be projected onto a television screen for patient viewing and for enlargement to more accurately characterize cervical lesions, often referred to as digital camera assessment of the reproductive tract (DART) [60].

Telemedicine is increasing women's access to cervical cancer screening services. Apart from laboratory and technology resources, one of the main resource scarcities for programs using VIA or VILI is the lack of available healthcare providers who have the knowledge and expertise to read cervical images. Therefore, one main advantage that telemedicine provides is the ability to transmit cervical images to off-site gynecological experts with the knowledge to diagnose precancerous or cancerous cervical changes. In this way, telemedical approaches help alleviate the shortage of women's health professionals who are needed to diagnose and triage cervical changes that may lead to cervical cancer.

Another advantage of telemedicine is its use in bolstering patient education on cervical anatomy and physiology as well as cancer etiology. This is of tantamount importance in areas with common misconceptions about the etiology of cervical cancer. In Botswana, for example, one study illustrated that a common belief is that intravaginal medicines and intrauterine contraceptive devices can cause cervical cancer [62]. The use of digital cervical images in DART to project a patient's cervix onto a television screen in the clinical setting can help educate the patient on the location and appearance of the cervix, as well as catalyze conversations on the reduction of cervical cancer risk factors by practicing protected sexual intercourse and taking part in smoking cessation programs.

Digital cervical images also contribute to more comprehensive medical records. They can be saved in patient charts, which in turn become part of medical databases containing more complete patient information that can be used to track progression of cervical changes as well as recurrence events and location of cervical biopsy sites.

Telemedical approaches to cervical cancer screening can greatly contribute to provider training as well as quality-control programs. Training nurses, midwives, and physician's assistants to be able to read and assess VIA or VILI enhanced cervical images can help alleviate the shortage of trained colposcopic providers in developing countries. Such approaches have been used in Zambia and Botswana [44, 50].

Telemedicine's use in cervical cancer screening can increase access to a colposcopic-like examination by providing an alternative to the use of expensive and often cost-prohibitive colposcopes. The use of store-bought digital cameras to capture cervical images and project them onto television or computer screens in DART and enhanced digital imaging (EDI) approaches, respectively, circumvents the need for colposcopes and provides a means of cervical visualization that is more affordable. Additionally, mobile health efforts in other areas of healthcare provision have extended medical services by using community health workers to address patient needs in the fields of HIV care, prenatal care, health education, and medication adherence, as seen with Dimagi, Inc., a global health

Fig. 15.2 High-quality cervical image taken by mobile phone camera

and technology company focused on mobile health [63]. A study in Botswana demonstrated that cervical images taken with mobile phone cameras were efficient for approximating colposcopy and provided images of high enough quality for remote diagnosis of premalignant cervical changes (Fig. 15.2) [45].

Overview of Telemedicine's Current Use in Cervical Cancer Screening

Though many community-based, hospital-based, and nongovernmental organizations are now utilizing telemedicine in such diverse fields as dermatology, ophthalmology, radiology, and critical care, current telemedicine programs focused on cervical cancer screening remain few in number. However, the Cervical Cancer Prevention Program in Zambia (CCPPZ) at the Center for Infectious Disease Research in Zambia (CIDRZ) provides the most successful model for a thriving see-and-treat approach to cervical cancer screening, which is based on telemedical remote consultations and trains providers from other areas in implementing similar telemedical cervical cancer screening programs worldwide.

Founded in 2006 in Lusaka, Zambia, the CCPPZ utilizes the see-and-treat approach to screening. This program was produced in collaboration with the University of Alabama at Birmingham, the University Teaching Hospital (UTH) in Lusaka, the research-focused CIDRZ, and the Zambian Ministry of Health, with the goal of creating a locally and nationally owned program with the support of foreign expertise and funding [46]. It is currently run by Dr. Groesbeck Parham, a gynecological oncologist from the University of Alabama at Birmingham. In 18 clinics, nurses utilize the electronic cervical cancer control (deemed "eC3") program to screen patients for cervical cancer and refer necessary cases to a tertiary hospital-based referral center [44]. The eC3 program is based on affordable mobile technology, where store-bought digital cameras are used to project real-time cervical images (following application of 5% acetic acid) onto large television screens for evaluation of cervical lesions; the images also serve as a background for patient education [44]. Digital cervigrams are taken with 6-megapixel resolution using store-bought digital cameras. Nurses bring these full size 6-megapixel images to weekly post-analysis quality-control training sessions for continuing education. The images can also be transmitted electronically to remote experts or to a secure website accessed by consultants for off-site evaluation (telecervicography, also known as photographic inspection with acetic acid—PIA [45]); the images can be resized to appear by default as a 1-megapixel image on the secure website, though they can be again enlarged to full size if desired. Images are also uploaded to the patient's electronic medical record [44]. Following the see-and-treat approach, patients eligible for cryotherapy are treated directly on site or referred to the UTH for cervical biopsy or LEEP. Since January 2006, the CIDRZ CCPPZ has provided over 100,000 screenings with the initiation of the see-and-treat prevention program.

The eC3 program is based on an image exchange using camera store-and-forward images, internet-based images, and mobile phone-based digital images. The program's remote consultation services currently rely on the program's secure consultation website, which was created by Dimagi, Inc., in 2008 using open-source Python software (Python Software Foundation, Hampton, NH) and is hosted on the internet server at the referral center in Lusaka. The goal of the website was to streamline the consultation process and increase the security of consult requests, which had previously relied on cervical images saved on laptop computers being uploaded and sent together with patient information in emails to consultants. Utilizing the store-and-forward approach, clinicians can now upload an image to the website directly from the digital camera and can add pertinent de-identified patient data, i.e., age, HIV-positivity, and qualitative assessment of cervical lesions. The website sends automated texts to on-call gynecological doctors notifying them to check the website for consultation cases. These consultants log on, make comments, and make final diagnoses; the on-site clinicians wait for these consultations. The website's physician interfaces allow for access to all patient records, whereas nurse interfaces are limited to their individual patient cohorts [44].

Mobile phones are helping accelerate the receipt of distant consultation, with the goal of obtaining expert opinions and treatment recommendations while patients are still in the clinic. Text messaging is utilized by the website, where a short message service (SMS) is automatically generated and sent to consultants on call, informing them of the images awaiting review; consultants can return a SMS to the nurse following review of the patient image and clinical history [44]. CCPPZ currently plans to expand the use of mobile phones to increase access to off-site consultation for remote clinics. Plans include identifying android phones with cameras or attachments capable of 50–70 mm angles of view and with minimal focal distances of 7–15 cm needed for viewing the cervix down the vaginal canal. The ultimate goal is for nurses to take cervical images with cellular phone cameras and then directly send the image to the remote consultant. A pilot study in Botswana previously illustrated the feasibility of taking high-quality images sufficient for accurate VIA readings with mobile phone cameras [45]. Future expansion of mobile phone technologies could include sending SMS messages to patients to increase outreach and improve patient treatment adherence or follow-up.

One of CCPPZ's goals is to increase the number of cervical cancer screening programs in resource-poor areas, which it does by offering telemedicine training programs to nurses already skilled in VIA and cryotherapy. Training programs consist of a weeklong course in computer training, as well as a 2-week training in digital photography training. The computer training focuses on the use of Microsoft applications, such as Word, Excel and use of Internet Explorer (Microsoft Corporation, Redmond, WA, USA), and the transmission of cervigrams. Cervicography training, which includes instruction on digital camera function, care, accessory use, and the taking of digital cervical photographs, focuses on mentoring participants to take high-quality cervical images with training on storing, resizing and tagging photos with patient identification numbers, as well as the creating of a standardized storage system [44].

Additionally, CIDRZ has published a guide listing the technological materials required for digital cervicography with the goal that future program clinicians will send consults to their website. Table 15.1 comprises their list of necessary hardware and materials, with associated cost, that clinicians would need to set up a similar eC3 program [44].

Limitations and Challenges of Telemedicine and Cervical Cancer Screening

Though telemedicine can extend screening services in resource-poor areas, there are limitations to telemedical approaches that utilize the see-and-treat screening method. Using a two dimensional digital cervigram instead of a live cervix for dysplasia evaluation makes it easier to

Table 15.1 Necessary equipment, with associated cost, needed to set up an electronic cervical cancer control program

	Average cost (US$)
Digital camera (e.g., Canon Powershot™ SX40 HS Digital Camera with built-in flash)	300
58 mm Canon Close-up Macroconverter Lens 500D	100
58 mm Canon SX40 HS Filter Adapter	9
Memory card(s) for cameras	50
Charger [e.g., Energizer® Rechargeable Compact Charger 2500 (NiMH/NiCd)]	20
Rechargeable AA batteries—8 or 12	2
Television or computer monitor (preferably at least 15 in.)	150
Cable for connecting camera to television or computer (usually included with camera)	5
PC Tuner card (if using camera with computer rather than television)	100
Extension cord/surge protectors	5
Laptop computers with external mouse	2,000
Software for integrating photographs into patient's electronic medical records (e.g., DBPix™; redistribution license)	350
Picture resizing software (e.g., Genius Picture Resize™; unlimited business license)	40
Internet source to share images and data electronically (optional)	Variable

Modified with permission from Parham GP, Mwanahamuntu MH, Pfaendler KS, Sahasrabuddhe VV, Myung D, Mkumba G et al. eC3—a modern telecommunications matrix for cervical cancer prevention in Zambia. J Low Genit Tract Dis 2010 Jul;14(3):167–173. Includes updates by Dr. Groesbeck Parham on May 12, 2012

miss three dimensional cervical changes such as ulcerations; this also makes the accuracy of a diagnosis heavily reliant on the quality of the cervical image [44]. Cervical cameras can become damaged or nonfunctional, and then they usually have to be sent abroad for repair [44]. Intermittent and unreliable internet connectivity can also compromise the speed with which remote consultation can be obtained.

The use of mobile phone cameras for taking cervical photographs presents its own set of challenges, as these phones often have automatic zoom functions. Clinicians using mobile phone cameras need extra training in the use of adequate and appropriate lighting, how to minimize glare from the metal speculum, and how to ensure the camera focus falls on the cervix and not the vaginal walls or hair; this will help them create a photo of sufficient quality to be used in PIA readings [45].

There are also inherent limitations of telemedicine owing to its use in conjunction with VIA. The test's low sensitivity compared to other screening measures increases the possibility of false-positive readings and overtreatment, and the subjective nature of diagnosis translates to a stricter need for well-developed quality assurance measures. However, the strength of VIA with cryotherapy is that it can be performed by many different levels of healthcare professionals, and it provides immediate results, allowing for the treatment of the patient during the same visit, and therefore limiting loss to follow-up of patients [61].

Summary and Conclusions

The adjunct of telemedicine in cervical cancer screening can greatly improve medical care for women in resource-poor areas by reducing barriers to the screening access [64]. The utilization of telemedicine is enabling the establishment of new quality-control programs, providing opportunities for continued development of diagnostic skills, and improving access to real-time gynecological expert advice [44]. The worldwide boom in mobile phone usage, both by patients as well as by clinicians aiming to use new technologies to improve medical care, promises to present new opportunities for increasing the extension of cervical cancer screening services in developing areas where they are most needed.

Tele-Education: Patients, Providers, and Communities

As part of cancer control programs, telemedicine can be an educational resource for patients, providers, and communities in general. This is especially important for some of the gynecologic malignancies that may be associated with a certain unfounded stigma.

For providers, telemedicine has been shown to be an effective and important educational tool in training younger and less experienced physicians to broaden their medical knowledge [31, 65, 66]. In addition, the use of virtual slide technology in providing an entire digital image of a biopsy from a glass slide not only will help with diagnosis but also will assist in pathologic education. This collection of digital images from telemedicine consultations can then create a resource for training local physicians in their home countries with the goal of self-sufficiency [67–69]. On a broader level, telemedicine platforms have been utilized to teach individuals in remote rural settings and to expand access to medical education, with the ultimate goal of improving patient care and survival [70–75].

With the increased access to cellular telephones and the internet, telemedicine also can be expanded to "tele-education" in order to educate individuals on the importance of healthy behaviors such as breast self-examination and basic information on malignancies, including HPV infection. Similar to programs that exist for patients with regards to heart failure, stroke symptoms, and chronic illnesses, tele-education can be applied successfully to teach individuals in developing countries about locally relevant diseases [76–78]. Limitations in developing countries or remote settings may include literacy and translation into multiple languages. However, using community health workers, messages and information can be shared in this innovative way. Similarly, text messaging or updates to general communities or community leaders also could be provided with regards to breast cancer screening importance or opportunities for vaccination against HPV that may help control extragenital and cervical cancer, if such programs are available.

The potential role of telemedicine in cancer control programs in developing countries is vast and adaptable to existing resources and specific demands of countries. Different aspects of the telemedicine program can be implemented and help strengthen the ability of developing countries to improve access and patient care in gynecologic cancers.

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