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Radiotherapy Planning and Peer Review in Sub-Saharan Africa: A Needs Assessment and Feasibility Study of Cloud-Based Technology to Enable Remote Peer Review and Training

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INTRODUCTION

A major challenge for radiotherapy centers in low- and middle-income countries (LMICs) is ensuring that the treatment delivered is consistently of high quality. The WHO,[1] the American Society for Radiation Oncology (ASTRO),[2] and the Royal College of Radiologists (RCR)[3] have all addressed the importance of peer review in radiotherapy in recent years, recommending it as a vital quality-assurance measure for any radiotherapy center to ensure safe, high-quality treatment. It is therefore imperative that multidisciplinary radiotherapy teams in LMICs receive adequate training in radiotherapy planning and have access to ongoing expert input and peer review to achieve this.

In centers where peer review is an established part of the workflow, regular appraisal of target volume delineation (TVD) can result in an observable learning curve[4] which, if applied to LMIC centers, may safely accelerate their adoption of more complex techniques, such as 3D conformal radiotherapy and intensity-modulated radiotherapy (IMRT).

Agarwal et al[5] recently published the results of an audit of radiotherapy planning and treatment errors in India. This highlighted a vulnerability of LMICs to radiotherapy errors and emphasized the need for the development of processes to improve quality and educational opportunities for radiotherapy providers.

Despite the benefits of peer review, however, barriers to its implementation exist in LMICs—for example, a lack of expertise in technical radiotherapy planning when compared with high-income settings,[6] or inexperience in setting up peer-review programs.

Information and communication technology (ICT) solutions may provide a means to address these issues.[7] Cloud-based technology is an example of an ICT solution[8] that can function as a tool for facilitating peer review by providing a platform for confidential transfer of planning data sets between radiotherapy centers for external review and feedback. Such platforms can also be used for training and education purposes and can facilitate participation in international clinical trials, such as those coordinated by the International Atomic Energy Agency (IAEA).[9,10]

Crispen et al[11] analyzed the use of web-based peer review in three Caribbean radiation oncology centers. The review noted the positive attitude of users to introducing web-based peer review to small or isolated radiotherapy centers, and recommended that identifying the appropriate technology to achieve this could result in the successful implementation of peer review.

Following recommendations by the Global Task Force on Radiotherapy for Cancer Control in 2015,[12] a number of multidisciplinary international workshops were hosted by CERN in collaboration with the Science & Technology Facilities Council (STFC) and the International Cancer Expert Corps (ICEC).[13] Through these workshops, we identified four partner radiotherapy centers in sub-Saharan Africa and formulated a collaborative project with the developers of the Gen X Viewer cloud software (TSG Innovations). Through this project, we sought to investigate the feasibility of using a cloud-based platform for radiotherapy peer review and training in these LMIC centers, according to their local needs and capabilities. Specific aims included:

1. To undertake a needs assessment to understand the specific requirements and uses for a cloud platform in the clinical setting in each center
2. To assess the local IT infrastructure and equipment that is currently available to support a cloud platform
3. To pilot the use of Gen X Viewer cloud software in all four centers
4. To develop the framework for adapting the cloud platform, given the conditions.

ASSOCIATED CONTENT

Data Supplement

Author affiliations and support information (if applicable) appear at the end of this article.

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CONTEXT

Key Objective

Does cloud-based technology have a role in facilitating radiotherapy peer review and education in sub-Saharan Africa? This article describes a collaborative project assessing the utility of cloud-based software for use as a remote radiotherapy peer review and training tool in four African radiotherapy centers.

Knowledge Generated

Technological constraints precluded installation and full functioning of the cloud software in three of the four centers during this pilot study, and further technical issues prevent its ongoing use in the center where installation was completed. The four centers involved in the study do not yet have formal peer review processes in place for radiotherapy planning and could benefit from the educational and quality assurance aspects of cloud-based technology if it is tailored to the needs and capabilities of low-resource settings.

Relevance

Information and Communication Technologies may play an important role in advancing the safe and effective delivery of radiotherapy treatment in low- and middle-income countries; however, improved IT infrastructure—particularly internet capability—is necessary to realize the educational and quality improvement opportunities that cloud-based remote peer review software can provide. Further work is required to define the most appropriate platform for achieving this and to embed routine quality assurance practice into routine care in these settings.

METHODS

We undertook five site visits between June 2018 and September 2019 at four collaborating centers, which were chosen to reflect a range of public and private facilities across western, eastern, and southern Africa:

1. Komfo Anokye Teaching Hospital (KATH), Kumasi, Ghana
2. Sweden Ghana Medical Centre (SGMC), Accra, Ghana
3. Ocean Road Cancer Institute (ORCI), Dar Es Salaam, Tanzania
4. Gaborone Private Hospital (GPH), Gaborone, Botswana.

Two visits to ORCI were undertaken because of the installation of two new linear accelerators following the first study visit.

For the initial needs assessment, we reviewed the existing radiotherapy treatment facilities, including treatment machines,

FIG 1. Gen X Cloud Platform Functionality. CT, computed tomography.

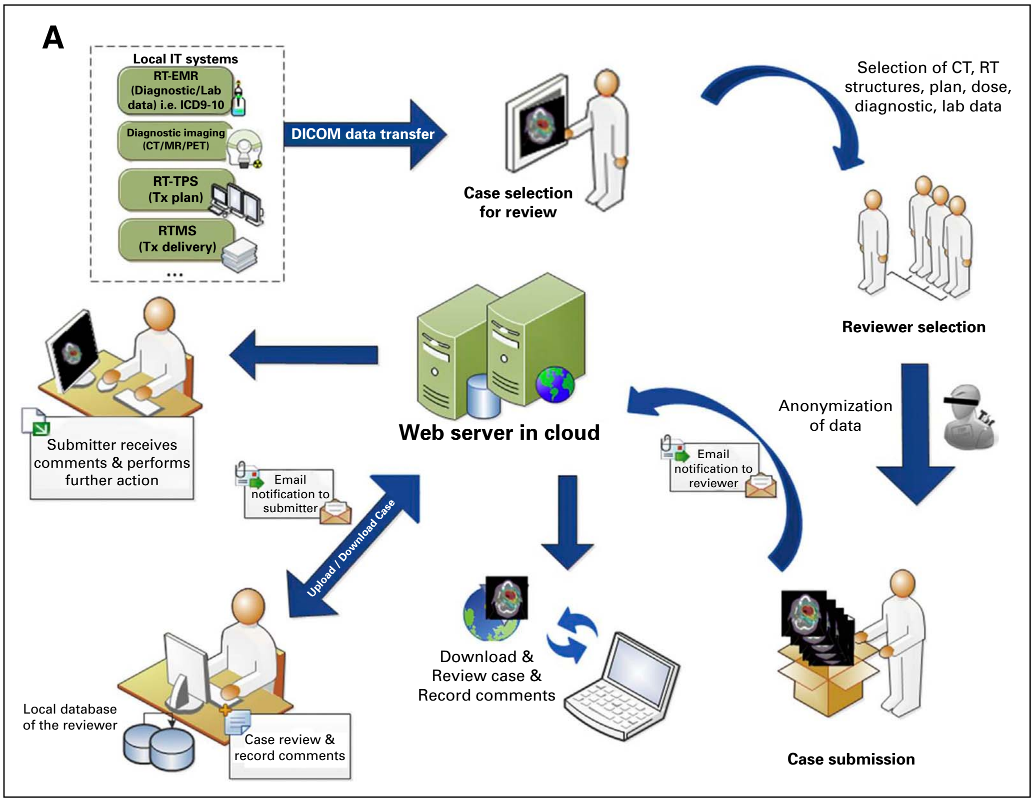

FIG 2. Process-oriented view of the Gen X Cloud Platform workflow from users' perspective. Adapted from Feain et al.[6]

treatment planning systems, simulators, and treatment capability (ie, 2D, 3D conformal, IMRT, and brachytherapy).

The informatics infrastructure was also assessed at each center, including:

- IT hardware
- Windows operating systems and capability to install software
- Electronic information systems
- Treatment planning systems and ability to export DICOM files and radiotherapy data sets
- Internet access and average download speeds.

Installation of the Gen X software was attempted at all sites. Where installation was successful, we subsequently attempted each stage of the radiotherapy data set transfer to the cloud as outlined in Figure 1. This sequence of steps formed the premise of the feasibility study to assess the capability of the local infrastructure to support the use of these functions of the cloud platform. Further details on the architecture of the software platform are described in the Data Supplement (pages 14 to 19) and in Figure 2.

We then conducted a series of informal interviews with radiotherapy staff (total number of interviews = 14) to ascertain the typical radiotherapy workflow from patient referral to treatment. Questions asked referred to three broad categories:

1. Radiotherapy Planning and Protocols
   a. Radiotherapy treatment pathways
   b. Time assigned to radiotherapy planning
   c. Protocols used to guide treatment planning
2. Education and Training
   a. Specific barriers to achieving more complex planning
   b. Residents' training programs
3. Peer Review
   a. Time allocated to reviewing target volumes and physics plans
   b. Formal peer-review processes
   c. Processes for seeking external advice for challenging or complex cases.

The participant responses were used to provide an understanding of the specific needs of each department in these areas and to ascertain the potential for incorporating cloud technology into their existing workflow.

RESULTS

The results are discussed in two sections:

- Radiotherapy equipment and infrastructure, IT capability, and Gen X Viewer operability
- Themes emerging from staff interviews, with respect to radiotherapy planning, education and training, and existing peer-review practice.

Radiotherapy Equipment and Infrastructure, IT Capability, and Gen X Viewer Operability

Table 1 details the radiotherapy equipment available at each of the four centers; Table 2 provides a summary

TABLE 1. Radiotherapy Equipment and Infrastructure at Collaborating Centers

Radiotherapy Center	External-Beam Radiotherapy	Brachytherapy	Treatment Capability	TPS	Simulation	Funding
Komfo Anokye Teaching Hospital, Kumasi, Ghana	No functioning LINAC 1 Cobalt	1 HDR Machine—No source 1× LDR machine	2D open fields	Prowess	No functioning CT or X-ray simulator	Government
Sweden Ghana Medical Center, Accra, Ghana	1 LINAC	1 HDR machine	3D conformal (MLCs)	Oncentra	Dedicated CT simulator	Private
Ocean Road Cancer Institute, Dar Es Salaam, Tanzania	2 LINACs 2 Cobalt machines	2 HDR machines	3D conformal (MLCs)	Eclipse	Diagnostic CT used for RT simulation	Government
Gaborone Private Hospital, Gaborone, Botswana	1 LINAC	1 HDR machine	3D conformal (MLCs)	Monaco	Diagnostic CT used for RT simulation	Private center—provides treatment to government-funded patients

Abbreviations: CT, computed tomography; HDR, high dose rate; LDR, low dose rate; LINAC, linear accelarator; MLC, multi leaf collimator; RT, radiotherapy; TPS, treatment planning system.

Note: Unless specifically noted, all equipment reported in these results were functional at the time of writing.

overview of the Gen X Viewer operability. The outcome of the pilot testing is described in more detail below for each individual center. Please refer to the Data Supplement (pages 20 to 22) for a detailed description of the radiotherapy infrastructure at each center.

KATH, Kumasi. At KATH, internet access was limited to a very low-bandwidth signal (mean download speed in Ghana is 3.2 megabits per second (Mbps) compared with a UK average of 22.37 Mbps),[14] which was insufficient to support the download of the software or file upload necessary for day-to-day use of Gen X Viewer for peer review. The center uses the Prowess treatment planning system (TPS), which was not supported by the cloud software. The limited IT facilities prevented further testing of the operability of Gen X Viewer in this setting.

SGMC, Accra. At SGMC, wireless internet was available throughout the center and functioned reliably on all computers. The IT infrastructure was able to support the successful download and installation of Gen X Viewer onto 2 PC terminals, and a number of test cases were successfully exported from the Oncentra TPS and uploaded to the Gen X software. These cases were then submitted for external review and subsequently downloaded back to the submitter's account with annotated feedback. In this way, a complete feedback loop was achieved. During this process, one incident of anonymization failure occurred. This required a software reconfiguration, which prevented any further incidents.

ORCI, Dar Es Salaam. At ORCI, internet connection is available via ethernet cables, but not all PCs are automatically connected. Mean download speed in Tanzania is 2.34 Mbps (compared with a UK average of 22.37 Mbps).[14] Download and installation of the cloud software was extremely slow, and timed out after a number of hours on five separate occasions. The software was eventually installed successfully after approximately 6 hours. Export of files containing DICOM data for planning CT scans and structure sets was not achieved because of a lack of previous experience in creating and exporting DICOM files. For this reason, although the software was successfully downloaded at ORCI, full use of the platform to upload and review radiotherapy volumes could not be attempted. It is unclear

TABLE 2. Overview of Site Testing of Gen X Viewer Software

Workflow Feasibility Testing	KATH Kumasi	SGMC Accra	ORCI Dar Es Salaam	GPH Gaborone
Is the internet capability sufficient for download of Gen X software?	No	Yes	Yes	Yes
Can user accounts be created?	No	Yes	Yes	Yes
Can DICOM files be exported from TPS?	No	Yes	No	Yes
Can DICOM data be imported to Gen X?	N/A	Yes	No	No
Are imported images adequately rendered?	N/A	Yes	N/A	No
Is upload of data to cloud supported?	No	Yes	No	No
Are uploaded data anonymized?	No	Yes[a]	N/A	N/A
Is Gen X functioning sufficient to allow completion of a feedback loop?	No	Yes	No	No

Abbreviations: GPH, Gaborone Private Hospital; KATH, Komfo Anokye Teaching Hospital; ORCI, Ocean Road Cancer Institute; SGMC, Sweden Ghana Medical Centre; DICOM, Digital Imaging and Communications in Medicine; TPS, treatment planning system.

[a]See main body of text—one incident of anonymization failure occurred.

whether the internet speed is sufficient to support routine use of the cloud, and further training would be required to achieve successful import and submission of radiotherapy data sets.

GPH, Gaborone. At GPH, all computers have an internet connection that is reliable, although connection speeds were variable. The maximum speed achievable in the center was 0.9 Mbps for download and 0.5 Mbps for upload (figures provided by GPH medical physics team)—this compares with a mean download speed across Botswana of 1.92 Mbps.[14] The department is currently trying to negotiate improved internet connections. Gen X software was successfully installed, taking approximately 1 hour. Import of DICOM files of CT images and a radiotherapy structure set was attempted; however, these files were not accessible through the Gen X Viewer without it requiring software updates for compatibility with Monaco TPS. Once this has been achieved, submission of cases for external peer review will need to be trialed to ensure that the internet connection and functionality of Gen X at GPH is sufficient to support routine use of the platform.

Radiotherapy Planning, Education and Training, and Existing Peer-Review Practice

The responses from the interviews with staff gave context to their individualized needs from a radiotherapy peer review and training perspective. Common themes were evident across all four centers.

Radiotherapy planning and protocols. Time is not routinely set aside for radiotherapy planning, and consultants often find they perform TVD in between other clinical duties with heavy pressure on their time. The exception to this is at ORCI, which, as a bigger center with more oncologists and residents available, allows clinicians dedicated planning time. None of the centers had their own institutional radiotherapy guidelines or protocols, and most clinicians tended to use the Radiation Therapy Oncology Group contouring atlases to aid TVD.

Education and training. Transition to more complex techniques such as 3D conformal planning (where 2D planning still predominates) or IMRT is limited by the availability of functioning equipment that is fully commissioned and has adequate quality assurance measures in place to ensure accuracy of treatment. Residents were present at both public sector departments, but not in the private centers. At ORCI, a 3-year training program in clinical oncology exposes residents to a variety of tumor types and treatment options. Dedicated time is available for them to learn TVD and plan appraisal. Weekly meetings are held where residents present all new radiotherapy referrals, and treatment decisions such as dose or fractionations, patient setup, and suggested beam arrangements are discussed. In Kumasi, there is also a 3-year specialist training program for residents, followed by a 2-year training fellowship. Residents plan radiotherapy alongside consultants, but there is no specific time allocated for planning.

Peer review. None of the centers had a formal peer review process; however, at GPH, each of the two clinicians undertook a second check process by which they were required to approve their colleague's final treatment plan. There is no record of the second check discussions or of any anomalies or errors picked up by this method. In all other centers, informal advice is sought from colleagues for difficult or challenging volumes or dosimetry decisions, and occasionally, external advice is sought (eg, from colleagues in other national or international radiotherapy centers). These discussions, and any volume or plan amendments made as a result of them, are not formally or routinely documented. Occasionally, consultants will participate in AFRONET teleconference meetings[15] for the presentation and discussion of radiotherapy cases among international radiation oncology colleagues. While these meetings are a useful means of continuing professional education, they do not constitute a regular source of external advice or peer review to inform real-time treatment decisions.

DISCUSSION

Our four collaborating centers represent a spectrum of radiotherapy treatment facilities across western, eastern, and southern Africa, and exemplify practices in both the public and private sectors. They displayed differences in radiotherapy capacity and staffing levels, and varied treatment equipment and planning systems, reflective of the range of radiotherapy facilities in LMICs. The site visits highlighted a lack of formal peer-review practice among clinicians who are delivering 3D conformal radiotherapy. Installation of the Gen X cloud software was achieved in three of the four sites; however, it has only demonstrated full functionality in one center (SGMC).

Poor or variable internet connection speed was the main barrier to achieving full functionality of the software in three of the four centers (KATH, ORCI, and GPH). This was particularly problematic at KATH and precluded installation of Gen X there.

At ORCI and GPH, installation was successful, but subsequent difficulties with data set export from the local treatment planning systems prevented full functionality of the software. While the Gen X Viewer is compatible with multiple treatment planning systems, a lack of familiarity with the data set export function of local planning systems made this step difficult to navigate, particularly in the context of a busy clinical department where clinicians and physicists have high workloads. At SGMC, the IT capability was sufficient to allow download of the software and to achieve transfer of the data sets relatively quickly; however, further technical issues (requiring frequent software updates and changes to database settings) have prevented ongoing reliable functioning.

Further collaboration with Gen X developers in the future may be required to continue to hone the specifications of the cloud software to support its reliable regular use in LMICs.

At present, none of the four centers has a formal process for peer review of radiotherapy volumes or plans. It is important to encourage the integration of peer-review meetings into the radiotherapy workflow in LMICs. In doing so, it should be noted that the culture of peer review should be one of constructive feedback to create a truly educational environment, especially where personnel from different disciplines (eg, medical physics) and different levels of training, including residents and trainees, are present. Sensitivities around having one's work critiqued in a group setting must be taken into account as a potential barrier to engaging in regular peer review, which would be counterproductive. Dedicated time should be set aside for regular departmental meetings for in-house peer review. If external expertise is sought but IT and internet constraints limit the use of cloud-based platforms, alternative low-technology approaches might include email discussion, videoconferencing, and screen-sharing facilities. Any future development of cloud-based technology for the purpose of remote peer review requires an understanding of the issues faced by centers in LMICs, as outlined above, and incorporation of appropriate technological solutions to these challenges.

Where the IT capability allows, Gen X Viewer software offers a potential platform to facilitate a more structured remote peer review, with the ability to document and record amendments made to radiotherapy plans as a result. Creating records of radiotherapy peer-review outcomes can be beneficial in three ways. First, audit of peer-review outcomes is an important way of ensuring ongoing compliance with treatment protocols, which is known to improve patient outcomes.[16] By publishing audits of peer-review outcomes, centers can contribute to the growth of published data on quality assurance from LMIC settings and lend weight to the evidence for its positive clinical impact. Second, the ability to record quality assurance data, including peer-review outcomes, can facilitate a center's contribution to national or international observational studies and participation in radiotherapy research. Third, from an educational perspective, annotation of a radiotherapy plan by an external reviewer, with suggestions for areas of revision, is a function that can create a rich educational resource of specific recommendations for radiotherapy planning. Where the transition from 2D to 3D conformal planning presents a steep learning curve, a databank of reviewed radiotherapy plans can form an e-portfolio of cases for residents to demonstrate learning or could function as a textbook of cases for future reference and teaching.

In conclusion, our feasibility assessments of four radiotherapy centers in sub-Saharan Africa demonstrated that cloud software is not presently a feasible tool for implementation of regular radiotherapy peer review and training. Improved IT infrastructure, particularly internet capability, and the incorporation of clinical quality assurance into day-to-day practice could allow radiotherapy centers in LMICs to benefit from the educational and quality improvement opportunities that cloud-based remote peer review provides; however, there is still further work required to define the most appropriate platform for achieving this. Ongoing sustainable international collaborations that work toward addressing these issues while creating new platforms for cloud-based peer review in radiotherapy must be encouraged, as a way to continue improving expertise and capacity for high-quality radiotherapy delivery in LMICs.

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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