



COUNTRY REPORT

Imaging in the Land of 1000 Hills: Rwanda Radiology Country Report

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Introduction

RWANDA is an equatorial country in central Africa (Figure 1), and part of the East African Community of Burundi, Kenya, Uganda and Tanzania. It is a small country, just over 10,000 square miles. Its population of nearly 12,000,000 makes it the most densely populated state in continental Africa. Rwanda's capital, Kigali, is a mile-high city. Its elevation makes the climate much cooler and more comfortable than a typical equatorial climate. The average annual temperature is 20.5 degrees Celsius with a narrow range – April, the coldest month has an average temperature of 20 degrees, whereas August, the warmest month has an average temperature of 21.5 degrees. Economically, Rwanda functions as a subsistence agricultural country but has been actively striving to emerge as a middle-income country. Its primary exports are coffee and tea.

In 1994, the majority Hutu population carried out mass genocide of the ethnic Tutsi minority. In a coordinated slaughter committed by neighbors against each other, and with low-technology weapons like machetes, nearly 1,000,000 people were killed in 100 days (1). The country was devastated. Immediately post-genocide, Rwanda was one of the poorest countries in the world with nearly 70% of the population living below the poverty line (2). Until 1997, Rwanda had the lowest life expectancy of any country in the world (3). The physician work force was depleted due to the direct and indirect consequences of the Rwandan Genocide. Since this time there has been a steady economic recovery (4), along with remarkable medical recovery. Average life expectancy nationwide, only 27 years in the early 1990s, has now reached 63 years (3).

Since the 2012 publication (5) highlighting its advances, radiology in Rwanda has benefitted from the capital infusion that has helped to propel the overall growth in the economic and health sectors. As of 2012, there are five national referral hospitals, 41 district hospitals, one military hospital and 451 health centers (6). The health centers are staffed primarily by nurses, while the district hospitals are staffed by general practitioners (graduates of

medical school without a post-graduate education). Of the 625 total physicians in the country in 2011, 150 had completed residency (3).

The radiology environment

Radiologists in Rwanda

There are 11 practicing radiologists in Rwanda (Table 1), and one additional retired radiologist. There are six Rwandan nationals and five 'ex-patriot' radiologists.

Of the Rwandan nationals, all practice in Kigali. One works principally at the university-based public hospital, University Central Hospital of Kigali (CHUK). Four of the Rwandan radiologists split time between a partially private hospital (King Faisal Hospital) and the Rwandan Military Hospital (RMH), and one is in private practice in Kigali. None of these radiologists were trained in Rwanda. Some were trained in Europe (Belgium and France), and others were trained elsewhere in Africa (Kenya, Tanzania, and South Africa).

Of the five ex-patriot radiologists, one is Tanzanian and was trained in Tanzania, one is American, two are Ugandan, and one is Indian. The Tanzanian and American radiologists are funded by the Human Resources for Health Grant, and both work at CHUK. One of the Ugandan radiologists works in the south at the University Teaching Hospital of Butare (CHUB). The other Ugandan radiologist, along with the Indian radiologist, works in private hospitals in Kigali.

Only one radiologist in the country has a full-time academic appointment, with some having honorary appointments. The medical community looks to African journals for publication, although there are a few researchers, particularly the Minister of Health, who have collaborated internationally and published in top medical journals.

Technologists in Rwanda

There are 118 technologists or "radiographers" in Rwanda. All have their primary training from the University of Rwanda College of Medicine and Health Sciences, and received an Advanced

in 2014 (7). The goal is for 70% access by 2017. This is compared to Africa's average of 40% access (7).

The cost of electricity is high and most is sourced by hydropower, leaving Rwanda's energy sector vulnerable to drought. The government has also utilized diesel generators, which, despite their high cost, have helped to expand the supply. The result is a cost of between US \$0.14-0.25 per kWh (depending on time of day and tax-exempt status) (8), as compared to a regional cost of around US \$0.10-0.12 per kWh (9). The government has had to subsidize the costs in order to maintain current growth rates (7).

Inconsistency in the power supply is also a source of frustration. A 2008 report indicated that Rwanda experienced 80 days per year without power (10), and data in 2011 suggested four days per month without power (11). Many hospitals also utilize power generators and uninterruptible power supply (UPS), which can back up in case of power failure, although this is typically for controlled shutdown time rather than prolonged continued use.

Radiology equipment in Rwanda

The majority of high-end equipment in Rwanda is found in Kigali. Equipment service contracts depend on the suppliers, as well as the original negotiation. A large majority of the equipment in Rwanda is manufactured by Siemens (Siemens Healthcare Global, Germany; Table 2, Table 3).

Table 1. Radiologists in Rwanda, 2014

Country of Origin	Countries of Training	Number
Rwanda	Belgium, France, South Africa, Kenya, Tanzania	6
Uganda	Uganda, Germany	2
Tanzania	Tanzania	1
India	India	1
United States	United States	1

Table 2. Radiology equipment in Rwanda, 2014

Equipment	Private	Public	Other
MRI	2	0	0
CT	2	2	1
Nuclear	0	0	0
Ultrasound	Unknown	See Table 3	
X-Ray	Unknown	See Table 3	

PACS

King Faisal hospital has had a picture archiving and communication system (PACS) installed since 2011. The PACS is web-based and accessible both locally and remotely. It is not fully backed up, and thus a recent crash resulted in the loss of patient data. Wisely, the same PACS was chosen for the 2014 PACS installation, allowing for potential interoperability during PACS expansions in the future. Ultrasound images are not currently being uploaded to PACS at CHUK, but further investment will eventually resolve this issue. More nodes can be added to allow centralized interpretation of images on a national level, as the number of radiologists grows sufficiently to meet demand.

MRI

There are two MRIs in Rwanda, both located in Kigali. One is a 1.5T Philips, installed in 2010 at King Faisal Hospital. This is accessible to those with private insurance and who privately pay for services. Under certain conditions, a patient with public insurance (Mutuelle de Santé) can access this magnet. A second MRI, a 1.5T Siemens, has just been installed in 2014 at Mediheal, a Nairobi-based private hospital newly opened in Kigali.

Computed tomography

There are five total CT scanners in Rwanda, three of which are located in Kigali. The busiest by far is the 64-Slice Siemens Somatom Definition, installed at CHUK in July 2011. The other publicly available scanner, a 16-Slice GE Multiplanar scanner, is located in Butare, and was installed in 2013. The first CT installed in Rwanda was the 6-Slice Siemens Somatom, installed at King Faisal Hospital in 2005. A new 64-Slice scanner, identical to the one at CHUK, has been installed at the private Mediheal clinic in 2014. No current replacement plan is in place for any of these scanners, and the scanners can go down for prolonged periods of time. At the time of this writing, the scanner in Butare is non-functional. .KFH is planning to buy a 128-Slice scanner, and Kanombe also is planning to buy a 64-Slice scanner, both by next year.

Fluoroscopy

There are six fluoroscopes in the country, with four located in Kigali, one in Kibungo in the east, and one in Butare in the south. Five are Siemens Duo Diagnostics installed in 2012 at CHUK, and two others are located at Rwanda Military Hospital and King Faisal Hospital. Additionally, a Philips Duo Diagnostic was installed at Rwanda Military Hospital in 2013. At the time of this writing in 2014, one fluoroscope is being installed in Butare, and another in Kibungo.

X-ray

There are approximately 60 total X-ray machines in various hospitals in Rwanda. Most of the major referral hospitals have more than one. Of the district hospitals, 33 use an analogue system, eight utilize a digital system and two utilize both. Twenty-five are manufactured by Siemens, ten by General Electric (General Electric, USA), 12 by Philips (Philips, USA) and 12 by various other companies. It is difficult to obtain a date of installation or working condition of these machines. A recent survey demonstrated that there were various challenges in keeping the X-ray equipment functional.

Service

There is a local Siemens tech representative who can troubleshoot software and some basic hardware issues. Response time is usually same day, although given a single representative's workload, responses may arrive the following day. Local repairs and system fixes are often accomplished by the next working day. Any repairs involving parts replacement can take longer. On more than one occasion during the past year, the CT scanner at CHUK has been nonfunctional for over one month. This issue is not unique to CHUK. One problem lies in moving materials from Europe to Rwanda. Customs in Rwanda exacerbates the challenge, as materials need to pass through receiving and clearing processes before moving on to the hospital. It is rare that an issue resulting from a part that is not local to the country can be solved in under three weeks.

The MRI is also locally serviced. This young machine has been reliable to this point, with little unplanned downtime. A recent need for coolant replacement resulted in ten days of downtime.

Occasionally, the equipment functions but certain supplies are lacking. For example, the hospital may be without contrast medium or film for a month at a time. Although both King Faisal and CHUK function now with PACS, the lack of film is a significant patient-care issue for many reasons, such as their referring physician likely has no way to read an image on a CD.

Job opportunities

Radiologists

There is a clear need for more radiologists in the country, as demonstrated by the government's decision to allocate precious limited resources to creating a radiology residency. Although a full description is a topic for another paper, this residency is being created under the rubric of the Human Resources for Health (HRH) program (3). A single American radiologist has been working onsite with the local radiologists to write a curriculum, have it accepted through the relevant channels, and then recruit a first class for a four-year residency program. The program intends to utilize both local resources and supplemental e-learning in order to achieve education in all subspecialties of imaging.

At least one of the private hospitals is currently hiring for part-time work. Although the Ministry of Health is not currently advertising radiology job openings, one would likely find an interested partner in the government health sector, should they offer quality services.

Technologists

The supply of technologists currently exceeds the demand for their employment. Most are employed through the Ministry of Health or in the public sector, with a small percentage employed by private institutions. One would anticipate that as the Minister of Health continues to prioritize growth of the imaging sector, employment opportunities for technologists would also continue to grow.

Economics and imaging

Readiness for radiology entrepreneurship

To understand the local medical economy, it is important to first understand the Rwandan economy in general. There has been massive growth of the economy since 1994, and more specifically

since 2003. According to the World Bank, per capita GDP was US \$131.56 in 1994, US \$186.64 in 2002, and at last report in 2013, it had reached US \$632.76 (12).

Another measure of the economy for the purpose of potential investment is income distribution. The GINI index is a measure of income distribution and how it varies from perfect equality (13). A GINI index of 0 represents perfectly equal distribution, whereas 1 represents perfectly unequal distribution (one person would have all of the money) (13). In the late 2000s, all GINI coefficients in the OECD countries ranged from 0.24 to 0.49 (13).

The highest GINI coefficients are seen in Africa, with the world's highest in South Africa, estimated to be between 0.63 and 0.7 (14). In 1985, Rwanda's GINI was 0.289, and in 2011 it was 0.508 (15). Ten percent of the population holds 43.2% of the total income share (16). The lack of income equality, as well as overall low GDP (despite impressive growth), translates into a relatively small population who can electively purchase high-cost services.

There are high-end restaurants, cafés, hotels and private hospitals in Rwanda. Such amenities are likely accessible to less than one percent of the population. Within this rubric, a new private fertility hospital has opened with a 64-Slice scanner and 1.5T magnet. Two foreign radiologists are performing interpretations. It is unclear the number of examinations being performed, and what segment of the population is able to access these services.

Radiology market and service capacity

In a country of 12 million people, there are four clinical CT scanners in use – two in the private sector and two in the government sector. This compares with 34.3 scanners per million population in the USA in 2007, or 13.9 per million population in Canada in 2011 (17). There are, in fact, fewer X-ray machines per million population in Rwanda than there are CTs or MRIs in Canada or the USA.

The government-funded portion of the health sector is more

Hospital	Beds	X-Ray Units	Ultrasound Units
Bushenge	143	1	2
Butaro	167	1	1
Byumba	180	1	2
CHUB	N/A	N/A	N/A
CHUK	500	4	2
Gahini	200	1	1
Gakoma	83	2 (both mobile)	1
Gihundwe	205	2(1 given to Mibirizi)	1
Gisenyi	346	2	2
Gitwe	200	1(0 functioning)	1(0 functioning)
Kabaya	130	1(0 functioning)	1
Kabgayi	400	1	3
Kabutare	235	1	1
Kacyiru	N/A	N/A	N/A
Kaduha	N/A	N/A	N/A
Kibagabaga	230	1	3(1 functioning)
Kibilizi	N/A	N/A	N/A
Kibogora	245	2	2
Kibungo	242	2	3
Kibuye	218	2	2
Kigeme	178	1	2 and 2 portable
Kinihira	300	1	2
Kirehe	154	1	3
Kirinda	N/A	N/A	N/A

Table 3, Part 1. Rwanda hospital summary, 2014

Hospital	Beds	X-Ray Units	Ultrasound Units
Kiziguro	82	1	2
Masaka	100	2	2
Mibirizi	N/A	N/A	N/A
Mugonero	121	2(1 functioning)	2(1 is functioning)
Muhima	153	1	5(2 are functioning)
Muhororo	112	1	2
Munini	65	1	2
Murunda	127	1	2
Ndera	N/A	N/A	N/A
Nemba	173	2(1 is mobile)	3
Ngarama	110	2(1 functioning)	3
Nyagatare	200	1	3
Nyamata	N/A	N/A	N/A
Nyanza	182	4(2 functioning)	3
Remera Rukoma	N/A	N/A	N/A
RMH	250	3	3
Ruhango	128	1	2
Ruhengeri	385	2	3
Ruli	178	1	3
Rutongo	106	1	1
Rwamagana	236	1	3(1 is functioning)
Rwinkwavu	130	1	3
Shyira	N/A	N/A	N/A

Table 3, Part 2. Rwanda hospital summary, 2014

developed, as the vast majority of the population earns an income that primarily grants them access only to the public system. In 2011/2012, enrollment in public insurance (Mutuelle de Santé) was 90.7% (18). In 2012/2013 it was 80.7%, and in 2013/2014 it was 73% (18). It is likely that a substantial portion of the population not covered by Mutuelle de Santé still accesses the public health care system, with far less than 10% having sufficient income or insurance to access the private sector.

However, recent legislation and regulation are encouraging private sector growth in order to expand the economy, as evidenced by the increasing appearance of new private hospitals and clinics.

Radiology volunteerism

Ideally, Rwanda would be entirely self-sufficient, and to that end the country is investing heavily in creating residencies, including one in radiology. That said, the government is realistic and knows it will be quite some time before it has the workforce to properly serve the population. For this reason there is a legitimate and enthusiastic interest in medical volunteerism.

It is critical to note, however, that Rwanda is not interested in volunteerism that is not aligned with the national goals outlined in President Kagame's vision for the future of Rwanda, Vision 2020 (19). Over the next several years, contact with any of the authors or with the Human Resources for Health leadership would serve as a first step for entre into volunteering in the system.

Internet access

Rwanda was ranked first in Africa for download speeds and 62nd globally with speeds of 7.88Mbit/s in February 2013 (20). The Rwandan Internet functions on an updated 3G system, now including 3.5G and 3.75G. An upgrade to 4G is currently well underway (21).

Internet access exists in a few major cities but is primarily limited to Kigali. Most who can afford access do so via mobile devices and USB-based modems. A 20 GB data plan with the largest provider,

MTN, costs 43,000 RWF or approximately \$62 US. No larger packages are readily available. One can purchase a WiMax solution, with unlimited downloading at 2 Mbit/s speeds, at a cost of \$120 per month.

Although maximum Internet speeds are up to 7.88Mbit/s, these are rarely available to most people. For example, at CHUK, the largest hospital in Rwanda, the maximum download speed is quoted as 3Mbit/s. Because the entire hospital depends upon one connection, individuals usually cannot achieve download or upload speeds that even approach this number.

Disease profile and differentiating demographic and cultural factors

Rwanda was forever changed by the Genocide of 1994 and the events that followed. With the genocide, the combination of murder and exodus demolished human resources. The country was essentially depleted of physicians and of higher education. The watershed for the national turnaround was Kagame's Presidency, and Vision 2020 specifically. The plan aims to transform Rwanda into a middle-income, knowledge-based economy. So far, the country is on track to meet its ambitious goals, as the desire for systemic change seems to pervade the actions and decisions of governmental authorities. In the general population, too, there is palpable pride in the continued movement towards national improvement.

In recent years, Rwanda has seen a remarkable, unprecedented reported increase in life expectancy and decrease in prevalence of disease. The prevalence of HIV is approximately 3%, but the mortality from HIV has reportedly decreased 78.4% in the last decade (22). Farmer et al. (22) reported a decrease in mortality from tuberculosis and malaria by 77.1% and 87.3%, respectively, and a maternal mortality ratio decrease of 59.5%. Despite these incredible figures, there remains a substantial amount of tropical disease such as tuberculosis, neurocysticercosis and amebiasis, particularly in referral hospitals.

Rwanda is undergoing a transformation of health delivery with

the Human Resources for Health (HRH) program, which was created in 2012 to establish and improve in-country residency training programs in many specialties (23). The program aims to move physicians from the rank of general practitioner to specialist. For the time, though there remains a paucity of sufficiently trained physicians.

As noted, the health centers are staffed primarily by nurses, and the district hospitals by general practitioners. Patients present first to health centers, and the sickest are referred to district hospitals. The most critical of these are then referred to one of the five referral centers. For this reason, cases presented at the referral centers have often reached advanced stages, allowing a view of disease not often afforded in wealthier settings.

Culture and tourism overview

Cultural attractions, languages spoken

Rwanda is a beautiful country to visit. It is one of only three countries in the world where one can 'trek' mountain gorillas, or visit them in their natural habitat accompanied by a guide - a must for any animal lover. Additionally, Nyungwe National Park offers affordable "mini-safaris" on which one can see elephants, giraffes, zebra, hippopotamus and many more animals (more information: www.rwandatourism.com).

To speak of Rwandan culture and tourism without mentioning the Tutsi Genocide would be a mistake. The country gathers every year on April 7th to memorialize those killed in the genocide (24). There is a "never again" understanding of the Genocide and a visit to Rwanda without a visit to the memorials would be incomplete (more information: www.kwibuka.rw).

To the uninitiated North American or European, the thought of a visit to Africa may conjure the image of mud huts and all dirt roads. Although such things exist in much of Rwanda, Kigali, the capital has modern hotels, predominately paved roads, a reasonably reliable power and water supply and most amenities that a traveler (or resident) could need. To those familiar with the development of East Africa this will be unsurprising, but others will be happy to find restaurants of all types - Japanese, Indian, Korean, Chinese, Italian - and most are run by an expatriate of the same nationality as the cuisine.

The official languages of Rwanda are English, French, and Kinyarwanda. In 2008, schools changed the language of education to English (25). Most of your patients will speak Kinyarwanda exclusively. Most of the educated populace speaks French, and many speak at least some English. Because the language of education has changed, the younger population is, on average more proficient in English. In Kigali, a traveler can get by speaking nothing but English. Nonetheless, a simple "Murakoze cyane" (Thank you so much) or a "Mwaramutse, amakuru?" (Good morning, how are you?) can go a long way towards breaking the ice in new conversation.

Travel access, currency, local accommodations

Methods of entering the country vary depending on your country of origin. Americans and many others with a passport valid for at least six months are allowed entry without a visa application (more information: <http://www.rwandahc.org/consular-and-visa-services/visa-information-and-applications/>).

There are many flights in and out of Rwanda. Coming from Europe or the USA, the typical options are KLM through Amsterdam, Brussels Airlines through Brussels, Turkish Airlines via Istanbul, and Qatar airways via Doha. Although not every airline flies every day, with flexibility in carrier, there are daily flights to Europe. It is also, of course possible to travel from within Africa, particularly from Nairobi, Johannesburg, Addis Ababa and Dar es Salaam.

Local accommodation is bountiful and ranges from the five-star Serena hotel, priced around \$500 per night, to guesthouses for under \$30 per night. There are also executive-style apartments for those looking at longer stays and wishing to self-cater.

Local security and safety situation

Security is given high priority nationwide. Most major shops, hotels and restaurants have guards and metal detectors for entry. Most wealthy Rwandan homes, whether occupied by Rwandans or expatriates, are gated and have guards who operate the gates and control entry to the house.

At the time of this writing, there is sufficient stability for a resident or tourist to feel quite safe in Kigali, day or night. Normal precautions against walking alone late at night should be taken, but this is no different from any typical city throughout the world.

At the time of this writing, the political situation in Rwanda is also relatively stable, and certainly in comparison to neighboring countries. There are border skirmishes with the Democratic Republic of Congo and some standing travel warnings from multiple embassies against traveling to certain border regions, but on day-to-day basis, none of this impacts the daily life of someone not living on the border. One should always check with their embassy prior to travel.

Travel within Rwandan borders is exclusively by automotive transport. Kigali has an extensive bus system, but it can be somewhat confusing for the uninitiated. For an ex-patriot or visitor with the means to purchase a car or hire a driver, travel within Kigali and throughout the country can be relatively simple given a few simple rules. The roads outside of Kigali are mostly unlit, making driving after dark a dangerous enterprise. The US embassy forbids its employees from driving outside of Kigali after 6pm. Many locals use motorcycles for short transport within Kigali. This radiologist, who has seen far too much motorcycle ("moto") trauma would strongly urge the reader never to utilize this option, no matter how tempting because of the low cost. The US embassy also forbids their use. There was an attempt in 2006 to ban the use of motos, but the outcry from their drivers and passengers caused the ban to be overturned after only one week.

Health advisories

At the time of this writing, there is a risk of contracting yellow fever in Rwanda, and proof of yellow fever vaccination is required for all entrants in the country except infants. There is also a malaria risk. Some argue that the altitude of Kigali serves as protection from malaria, but this author has seen far too much of the disease among locals and expatriates alike to accept that myth. Malaria prophylaxis is needed while travelling in Rwanda. It is the norm to sleep under mosquito nets. Although Rwandan pharmacies may at times be well stocked, the supply of a given medication is inconsistent. It is advised that a traveler bring all of his or her own medications, including his or her own malaria prophylaxis, and sufficient medication to treat traveler's diarrhea, etc. A medical worker should consider bringing his or her own HIV post-exposure prophylaxis. For up-to-date information, please consult the CDC recommendations.

Tap water is not safe to drink in Rwanda. One should consume only bottled water and clean all fruits and vegetables according to appropriate standards. The typical recommendation is to only eat cooked or peeled foods. One must weigh one's own level of risk tolerance. Most expats eat salads at restaurants, and though all regret it from time to time, a given restaurant is often consistent. Asking colleagues for recommendations is a good first step.

When to visit

Rwanda has "dry" and "rainy" seasons. The rain comes primarily from March to May, and then from September through November. I believe the typical expat would think a priori that the dry season is the more appealing. During the rainy season though, the country is beautifully lush and the rain typically only lasts about an hour of the afternoon. If forced to choose, I would likely come just as a rainy season ends, when the land is still lush, and before the long dry occurs. If one were to combine a trip to Rwanda with a safari in an adjacent country, the timing could be based on animal migrations. Overall, Rwanda is a beautiful country to visit any time of year. □

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Conflict of interest

DR participates in the Human Resources for Health Grant, funding for which flows through the Rwandan Ministry of Health, which is in part responsible for hiring decisions for the grant.

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