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COUNTRY REPORT

Diagnostic Radiology in Liberia: A Country Report

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Introduction

LIBERIA is a tropical country located south of the Sahara Desert in coastal West Africa. It lies at 6°30' North Latitude and 9°30' West Longitude and is bordered by Guinea, Cote d'Ivoire, Sierra Leone and the Atlantic Ocean. Liberia has three distinct topographical areas: 1) coastal plain, creeks, lagoons and mangrove swamps; 2) rolling, forested hills with elevations up to 500 feet that cover most of the country; and 3) low mountains and plateaus in the Northern highlands with elevations reaching 4,748 feet (Nimba Mountains). Liberia is home to approximately four million people and is roughly the size of the US state of Tennessee. Named after former US President James Monroe, Liberia's capital Monrovia is a coastal city with a population of one million (1).

There are two major seasons in Liberia: dry and rainy. The dry season occurs between December and March, and is characterized by warm days and cool nights, with risk of sand storms from the Sahara Desert (2). The rainy season occurs between mid-April and mid-November. The average annual rainfall is 200 inches on the coast and decreases to 80 inches in areas farthest inland, and the average temperature is 27 degrees Celsius (81 degrees Fahrenheit) (1). Liberia is a low-income country that relies heavily on foreign aid (3). Liberia is the seventh poorest nation in the world, ranking 31st among 46 sub-Saharan African countries in national income. In 2013, Liberia's per capita GDP was \$900 US (3). Liberia's economy depends heavily on natural resources, with mining and agriculture being the dominant industries. Iron exportation has grown and in 2013 overcame rubber as Liberia's top export. According to the 2013 Central Bank of Liberia (CBL) Annual Report, iron ore and rubber represent 82% of Liberia's total exports (4). Civil war destroyed much of Liberia's economy, including critical infrastructure in and around Monrovia. Although conditions are favorable for agriculture, Liberia does not produce nearly enough food to meet the demands of its population. The country imports large quantities of food, with rice alone accounting for 10% of its overall imports (5).

Civil wars

Freed slaves of American, Americo-Liberian and Caribbean descent founded Liberia in 1817 with the help of the American Colonization Society. The settlers were promised greater freedom and equality, but these ideals were not extended to the indigenous population. Although settlers made up only 5% of the total population, they controlled the country's government and resources for over a century and granted the natives only limited rights (6). This ultimately led to internal conflict and eventually civil war, beginning in December 1989. Charles Taylor, an Americo-Liberian educated in the US, launched a popular uprising against the sitting president, Samuel Doe. The First Liberian Civil War lasted seven years and resulted in the deaths of over 200,000 Liberians (7). Peace was restored in 1997, and a national election held that year brought Taylor to power. However, fighting resumed in 2000, and, after another wave of bloodshed and devastation, the Second Liberian Civil War ended with the signing of the Accra Peace Agreement in August 2003. Taylor was forced to resign, and was eventually tried and sentenced to 50 years in prison (8).

Ebola in Liberia

Liberia experienced an Ebola outbreak from March 2014 to September 2015, and was one of the West African countries worst hit by this deadly viral infection. There were at least 10,672 confirmed, suspected and probable cases of infections and more than 4,000 deaths (9). While the African continent has endured a number of Ebola outbreaks since the 1970s, the most recent outbreak was the first to reach epidemic proportions. In this case, a combination of delayed realization of the magnitude of the problem among African governments, tardy response by the international community, and extreme poverty and poor health care infrastructure led to the highest number of deaths from Ebola since the disease's emergence in 1976. August and September of 2014 were the worst months on record, with up to 400 new cases reported each week. During

Figure 1. Liberia Map No.3775 Rev.9.



United Nations, Department of Field Support, Cartographic section. September 2014. Available from: <http://www.un.org/Depts/Cartographic/map/profile/liberia.pdf>

this two-month period, hospitals in Monrovia were locked down and patients died in large numbers (10). Without hospital beds to treat Ebola patients, infected individuals and dead bodies were kept in homes and community centers, leading to further spread of the disease (10). The Liberian government declared a state of emergency that lasted for three months (10). International assistance provided for the construction of new treatment centers, implementation of contact-tracing programs and raising of public awareness. By the end of 2014 the outbreak began to subside as the infection rate continued to decline. By March 2015 no new cases had been reported. The World Health Organization (WHO) declared Liberia free from Ebola on May 9, 2015, after 4,808 total deaths (10).

State of healthcare

Fourteen years of civil war (1989-2003) left Liberia's healthcare system in tatters. During the conflict many health professionals either fled the country or were killed in the fighting. In 1988 there were 3,526 employees working in the health sector. Ten years later, the total number of healthcare workers had been reduced by 60% to 1,396 employees, including only 89 physicians and 329 nurses (11). Around this time, non-governmental organizations (NGOs) began arriving in Liberia, with Doctors without Borders (Medecins Sans Frontières) being the first organization to establish healthcare facilities with the help of foreign aid. More NGOs arrived, and by the end of the Second Liberian Civil War in 2003, Liberia had a total of 420 medical institutions: 12 public hospitals, 32 public health centers, 189 public clinics, 10 private hospitals, 10 private health centers and 167 private clinics (11). NGOs and faith-based

organizations managed nearly half of these facilities, with 21 NGOs active in the health sector of Liberia in 2005. Four of these NGOs were national and the rest were international. In 2005, almost all the functioning healthcare facilities were supported by these NGOs or UN agencies (12). Meanwhile, Liberians were relocating to Monrovia in large numbers, causing the city's population to double in size. Still reeling from worker shortages and lack of infrastructure, Monrovia's health industry was unable to meet the increased demand for health services. During periods of conflict, most of the healthcare training institutions would close and re-open at the cessation of the hostilities. Lack of resources and fewer qualified professors led to further disruption in the training of healthcare workers. Though the political situation has been relatively stable since Ellen Johnson Sirleaf, Africa's first female president, began her term in 2006. Overall, Liberia's health sector has suffered major losses, with only 20 physicians left to serve the entire nation, down from the pre-civil war figure of 237 physicians in 1998. Currently, much of the country's health rests in the hands of 668 registered nurses, 297 certified midwives and 1091 nurse aides (11).

Diagnostic radiology services and equipment

There is a paucity of diagnostic equipment in the majority of sub-Saharan African countries, and Liberia is no exception. An absence of diagnostic services makes it difficult for medical practitioners to accurately diagnose disease or administer appropriate treatment.

General radiology

As depicted in Table 1, hospitals and clinics run their own X-ray

equipment with hand processing. There is no automatic processing in the country. Bedside radiography is non-existent. There is no functioning fluoroscopy machine except at the Jackson F. Doe Memorial Regional Referral Hospital in Tapitta. This machine breaks down frequently and repairs take months to complete.

A typical radiography setup would include a 15-25 KW machine with a horizontal table and an upright cassette stand for chest radiography. Contrast radiography, such as intravenous pyelography or upper or lower barium GI series, are rarely performed.

Two digital radiography systems with the ability to print images on the films are installed at two hospitals in Monrovia: the John F. Kennedy Memorial Center (JFKMC) and Redemption Hospital. Both units are U-Arm multipurpose digital systems, and, at the time of this writing, both have been out of order for several months. Instead, both facilities conduct radiography of the plain abdomen, extremities and chest, as well as pediatric studies. For this work, cassettes with grids are employed on tabletop and upright cassette stands. Secondary to long exposure times, blurring of radiographic images is a rule.

Table 1. Hospitals in Liberia, 2015.

#	Hospitals	Beds	X-Ray Units	Ultrasound Units
1	A.M.E. University Clinic		No	Yes
2	Bong Mines Medical Center	105	Yes	Yes
3	Bensonville Hospital	30	Not installed	No
4	SDA Cooper Memorial Hospital	48		Yes
5	Curran Lutheran Hospital	120	Yes	Yes
6	Chief Jallalone Memorial Hospital	10	No	No
7	C.H. Rennie Hospital	50	Not functional	No
8	C.B. Dunbar Hospital	69	No	Yes
9	Cavalla Medical Center	10	No	No
10	Duside Hospital	300	Yes	Yes
11	Eternal Love Winning Africa (ELWA) Hospital	50	Yes	Yes
12	E. J. Grant Hospital	60	Yes	No
13	Firestone Hospital	200	Yes	Yes
14	Ganta United Methodist Hospital	150	Yes	Yes
15	G.W. Harley Hospital	60	Yes	Yes
16	Hope for Women International Health Center	30	No	Yes
17	John F. Kennedy Medical Center	500	Yes	Yes
18	James N. Davis Jr. Memorial Hospital	100	Yes	Yes
19	Jackson F. Doe Memorial Regional Referral Hospital	206	Yes	Yes
20	J.J. Dossen Memorial Hospital	65	No	No
21	Liberia Government Hospital - Bassa	50	No	No
22	Liberia Government Hospital - Bomi	60	Not functional	Yes
23	Liberia Agriculture Company (LAC) Hospital		Yes	Yes
24	Médecins Sans Frontières (MSF) Children's Hospital	46	No	Yes
25	Martha Tubman Memorial Hospital	50	Yes	Yes
26	Mittal Steel Hospital, Bassa	100	Yes	Yes
	Mittal Steel Hospital, Yekepa	40	Yes	Yes
27	Phebe Hospital	200	Yes	Yes
28	Redemption Hospital	200	Yes	Yes
29	Sanquellie Government Hospital	50	No	Yes
30	Rally Time Hospital	26	No	No
31	Saint Joseph's Catholic Hospital	141	Yes	Yes
32	Saint Timothy Government Hospital	50	No	Yes
33	Saint Francis Hospital	40	No	Yes
34	Telewonyan Hospital	120	Yes	Yes
35	Zoe Geh Medical Center	10	No	No

Ultrasound

Ultrasound scanning is available at a large number of facilities in Liberia (see Table 1). Ultrasound is frequently the only imaging modality in many hospitals and clinics. Ultrasound scanning is generally done by treating specialists on their own patients, without printing images. A short report of positive findings is usually written in patients' medical records. At JFKMC a Chinese-trained physician sinologist (non-radiologist) performs and interprets ultrasound studies. Fifteen cases are scheduled every day, after which no ultrasound service is available until the next working day. Color Doppler imaging capability is a standard in most ultrasound machines, but technique and interpretation of Duplex Doppler is generally lacking.

At some of the teaching hospitals, on-the-job trained technologists perform ultrasound scanning for the referring physicians to interpret. The skill levels of these technologists vary depending on whether they were trained by an internist or an OBGYN physician. An ultrasound technologist at Redemption Hospital, a 200-bed teaching hospital in Monrovia, was trained by hospital OBGYN physicians. There is no PACS (Picture Archiving and Communication System) for images or report archiving in the country. Hence, the possibility of follow-up, clinical feedback or quality improvement is limited. A majority of the ultrasound equipment is either refurbished or base models. The US imaging studies available are abdominal, pelvis and obstetrical ultrasound. Studies such as fetal anatomical survey, neonatal head ultrasound and transrectal ultrasound are not provided (13).

Computed tomography (CT)

There is one CT scanner available in the country, installed at the Jackson F. Doe Memorial Regional Referral Hospital in Tappita. This Neusoft brand (Neusoft, Shenyang, China) scanner was donated by the Chinese government in 2011 (14). Tappita is 134 miles from Monrovia, though due to road conditions, it takes 6-8 hours to drive between cities. There is no CT scanner in Monrovia. The scanner in Tappita has been out of order for several months at the time of this writing. The local engineers were not able to repair the scanner. Due to poor Internet services, remote access to the scanner has not been possible. A foreign government reportedly donated a 64-slice CT scanner and MRI scanner to JFKMC in 2009 (13), but these machines have not yet been installed. Construction of a building to house this scanner in JFKMC began but was not completed due to design flaws, such as corridors too narrow to accommodate patients' stretchers (13).

MRI

There is no MRI service available in Liberia. The Jackson F. Doe Memorial Regional Referral Hospital reportedly received an MRI scanner in April 2015.

Vascular and interventional radiology

There are no angiography or interventional radiology services available in Liberia.

Radiology staff in Liberia

Radiologists

There are currently two radiologists working in Liberia: one is a Liberian national and the other is from Ethiopia. The Liberian radiologist works in Monrovia at JFKMC, a teaching hospital of the A.M. Dogliotti Medical College and the largest tertiary public hospital in the country. One Chinese-trained ultrasound specialist works part-time at JFKMC. There is no radiology training program in the country. The Ethiopian radiologist was trained in London and works at Jackson F. Doe Memorial Regional Referral Hospital, the second tertiary hospital established in Liberia. There were five additional radiologists who left the country during the civil wars and never returned.

Technologists

There are a total of 22 trained technologists or "radiographers" in Liberia. All were trained in Liberia under a two-year structured training course, which qualified them to receive a certificate in Medical Imaging (15). There is currently a need for a minimum of 56 technologists to operate the available equipment (15). This gap is partially filled by radiology workers trained on the job.

Equipment maintenance and repair

There are two biomedical engineers available in Liberia to maintain and service all equipment in the country. Response times vary depending on the accessibility of the geographical area in which equipment is located. Repair wait times for hospitals can be days; repairs that involve replacing parts can take even longer. The CT scanner at JFKMC in Monrovia has been non-functional since early 2015. The Chinese manufacturer has promised to fix it via the Internet, but poor Internet service in Liberia has hindered repair attempts (16). Even in instances where equipment is functioning properly, other critical supplies, such as contrast medium, injector supplies and CDs for data storage, may be difficult to come by.

Donated equipment is plentiful. Each public and private hospital has rooms full of broken-down general radiography, fluoroscopic, mammographic, C-Arm, ultrasound and echocardiography machines. JFKMC has a non-functional cobalt radiation therapy unit. Appropriate disposal of the cobalt radioactive source is posing a problem for authorities (13).

Power supply

Uninterrupted power for radiology equipment is made possible in Liberia using diesel generators as the sole power supply, or as a back up to the 'city' electric supply. The government owns and operates the Liberia Electricity Corporation (LEC) (Liberia Electricity Corporation, Monrovia, Liberia), the national electric company of Liberia. Seventy-four percent of the country's population lives in rural areas, and the remaining 26% live in and around the capital city of Monrovia. Rural, less affluent residents tend to use cheaper forms of energy such as oil lanterns, candles and flashlights. About 10% of the urban population and 2% of the rural population obtain energy from petroleum products, though, fortunately, the country's climate does not require heating in the winter. From 2005-2009, only 4.1% of the country had access to electricity, a figure that grew to 9.8% from 2010-2014 (18). The government has plans for rural electrification, with the long-term goal of making Liberia a carbon-free country. Eighty percent of Liberia's total energy production comes from biomass (17).

Prior to its civil wars, Liberia was mainly dependent on hydropower generated at the three main hydroelectric power plants: Harbel (Firestone Natural Rubber Company, LLC, Indianapolis, IN, USA), generating 4MW; Mount Coffee (LEC, Monrovia, Liberia), generating 64MW; and Yandahun (Rural Renewable Energy Agency, Republic of Liberia, Monrovia, Liberia), generating 30KW. The Harbel and Yandahun plants were destroyed during the war, putting a stop to the operation of the Liberia Electricity Corporation (17). The LEC resumed operation in 2010 by commissioning diesel oil electricity generators.

Job opportunities and volunteerism

Radiologists

There is a desperate need for radiologists in Liberia. Full-time, part-time, periodic or voluntary radiologists are welcome. International agencies and philanthropists are quite eager to fund proposals for any help with medical imaging in Liberia. The Academic Consortium Combating Ebola in Liberia (ACCEL), a coalition of academic medical centers led by the University of Massachusetts Medical School (UMMS), has partnered with the Liberia College of Physicians and Surgeons to run the residency

program, which includes training in diagnostic use of ultrasounds. Doctors and technicians from the US regularly visit Liberia to run this course (19). A large number of NGOs fund volunteer trips to providing ultrasound and radiology services and training, typically for 2-12 weeks at a time. In addition, a large number of Western universities, including UMMS, offer programmatic rotation of faculty, fellows and support staff to Liberia.

Technologists

The Ministry of Health and Social Welfare reports the country does not have enough technologists to meet the demand for radiology services (15). The Ministry's Emergency Human Resources for Health Plan is to resume training of the technologists parallel to restoration of the health sector (15).

Economics and imaging

The prospects for Liberia's medical economy are directly tied to the health of its economy overall. Liberia is one of the poorest countries in the world. According to the World Bank, per capita GDP was \$461 US in 2014 (20). In 2007 Liberia's GINI index (a measure of income distribution; a GINI index is to 1 indicates higher inequality) was 0.382, with 63.8% of population falling below poverty line and almost 48% of the population living in extreme poverty (3). Twenty percent of Liberia's population takes home half of household income, while 85% live on less than \$1.25 US per day (21). The majority of Liberians pay out-of-pocket for medical services. Frequently, families pool resources to pay for major health expenses. A chest radiograph costs between \$5-10 US, early obstetric (OB) ultrasounds cost \$10-15 US, and late obstetric and abdomen ultrasounds cost \$15-25 US. It is estimated that the market would sustain a CT study fee of \$50-100 US. For entrepreneur radiologists, Liberia offers opportunities for launching new medical imaging businesses, especially as the cost of doing business is low.

Internet access

Hospitals in Liberia generally do not have Internet connectivity. There are many private Internet providers in Liberia offering subscription plans, but the average cost is \$3.38 US per megabyte. In general, the availability of information and communication technology (ICT) remains limited in Liberia. Globally, Liberia has one of the world's lowest rates of both personal computer and Internet penetration of any country in the world (22). According to a 2010 World Bank estimate, only 1.1% of households own a personal computer (22). Internet access is primarily available at Monrovia, and largely in the city's many cybercafés. Where available, Internet service operates mostly on an updated 3G system. In 2012, Liberia launched its first 4G mobile Internet network (23).

Disease profile and differentiating demographic and cultural factors

Liberia's two civil wars completely changed the country's demography. Many families survived by relocating abroad, or to other regions within the country. Established communities either expanded or totally disappeared, while many new communities were founded. The education system has been unstable for almost 15 years due to civil crisis (24). At present, the Liberian government is working to provide free primary education at all government schools, with priority given to the education of females (24).

Liberia also has environmental problems, including soil erosion, oil residue, raw sewage polluting coastal waters and deforestation (2). Waterborne diseases and malaria are common (26).

Liberia has a relatively young population. In 2007, 29.5% of the population was 5-14 years old (25) and 51% was below the age of 25 (26). The life expectancy averages 45 years, and Liberia has one of the highest fertility rates in sub-Saharan Africa (25).

Sexually transmitted diseases (STDs) are a major public health

problem. More attention was given to this issue after the spread of HIV reached epidemic levels. The prevalence of HIV in Liberia is 1.5% (25).

Poverty is a major factor contributing to poor health in Liberia. In the aftermath of the civil wars there were 297 nurse midwives in the country compared with 51 physicians, with approximately 95% of Liberia's 325 health care facilities partially or totally destroyed during the war. A 2006 survey showed only 10% of the population had access to a healthcare facility in their community (26).

Culture and tourism overview

Liberia is a beautiful country. Beaches are the main attractions, especially in places where surfing is allowed. Popular beaches like ELWA, Silver and Cece Beaches are open to swimmers (27). Mountain Wologizi, located in the northern part of the country, reaches 2,540 feet and boasts views of Guinea, Sierra Leone, and Liberia's large tropical forest (27). Other attractions include deep-sea fishing, as well as a coastal resort that is home to an island inhabited by rescued chimpanzees (27). Liberia's only national park is Sapu National Park, located in a well-developed tourist area outside of Monrovia (27).

While the official language of Liberia is English, only 20% of the population is English-speaking (27). Other local languages include Bassa, Kru, Lorma, Mano, Kpelleh and Dan (Gio) (27).

Travel access, currency and local accommodations

The procedure for entering Liberia depends on a visitor's country of origin. Many foreign nationals, including American citizens, are required to possess a visa, as well as a passport that is valid for at least six months from the time of travel (27). Persons traveling to Liberia are also required to show proof of yellow fever vaccination upon entering the country (27).

There are many flights operating in and out of Liberia. Travelers from the UK, Europe and US can fly British Airways (via London), Brussels Airways (via Brussels), Royal Air Maroc (through Casablanca) and Ethiopian Airways (via Addis Ababa). Although none of these carriers offer daily flights, among them one can find a direct flight from Liberia to Europe almost every day (28). Direct flights are also available from Liberia to African destinations, such as Accra, Nairobi, Abidjan, and Freetown (28).

Local accommodation tends to be expensive, though not exorbitant, for international customers. There are air-conditioned hotels with nightly rates starting at \$110 US, mid-range hotels starting at \$60 US per night, and guesthouses at under \$25 US per night (29). YMCA hostels are an additional, very inexpensive option, but these are frequently full (29).

Local security and safety situation

Since the peace agreement was signed in 2003 the overall security situation in Liberia has improved, but localized instability persists. Public safety has been threatened from time to time by violence among rival political factions, as well as by civil unrest due to socio-economic distress involving workers, civil servants, students and the unemployed youth (30).

Crime, especially armed robbery, is high in Monrovia. Local police have limited resources to respond to or solve crimes. Due to elevated crime rates at night, one should walk alone only during daylight hours and in busy tourist areas (31).

Even in the part of Monrovia where most international tourists stay, there are reports of foreigners being robbed (31). Local transportation should be avoided, as the incidence of rape, especially involving foreign women, is high (31). One should review security arrangements before arriving in Liberia. Always stay in lodging/hotels with security services and arrange for transport ahead of time.

The political situation in Liberia has also stabilized since the end of the civil wars, and the Liberian government is working with the international community to further increase stability (31). However, one should be careful not to discuss political issues

openly. There are occasional border conflicts with neighboring Cote d'Ivoire. Roads between Monrovia and Sierra Leone are closed to the general public and are only used by security forces and health officials (31). One should always check the security situation before traveling to any part of Liberia.

Transportation in Liberia is mostly by land. While roads from Monrovia to the international airport are paved, roads outside of Monrovia are generally unpaved, unlit and unreliable. During the rainy season, driving becomes hazardous and many roads are inaccessible. Most vehicles do not have headlights, which makes it easier to be robbed at illegal checkpoints (31). It is not advisable to drive alone. It is recommended to use local drivers when driving outside of Monrovia, as there are police checkpoints throughout the country (31). Many locals use motorcycle taxis, called pehn-pehns, for transport. The government recently limited access of motorcycles to central Monrovia in an attempt to enforce safety regulations for motorcyclists and reduce traffic accidents (32).

Health advisory

There is a risk of yellow fever in Liberia, and proof of yellow fever vaccination is required for anyone entering the country except infants younger than nine months (33). The CDC recommends travelers of all ages be vaccinated for hepatitis A and typhoid, both of which can be contracted through contaminated food or water (33). Rabies vaccination is also recommended for children, long-term travelers and expatriates (33). In addition, there are non-vaccine preventable diseases such as Chikungunya virus and dengue fever that can pose a threat to travelers. Both diseases can be prevented by avoiding bug bites, wearing long sleeve shirts and pants, using insect repellent, sleeping in air-conditioned rooms and using bed nets. Malaria remains the deadliest infectious disease in Liberia, so prophylaxis is recommended for all travelers. Mosquito (bed) nets are provided to every household by the ministry of health and international NGOs.

As the availability of prescription and over-the-counter drugs is extremely limited in Liberia, it is recommended that all travelers carry all medications needed for the entire length of their stay, including treatment for traveler's diarrhea. Healthcare workers are recommended to bring the HIV post-exposure prophylaxis.

The Ebola outbreak is under control at the time of this writing. All travel restrictions have been lifted for travel to and from Liberia. For the most recent information, refer to CDC recommendations. Tap water and unpasteurized milk are not safe to drink. One should drink only bottled water and pasteurized milk (33). The CDC recommends consuming only food that is cooked, and fruits and vegetables washed with clean water or self-peeled (33). In general, a person should act according to his/her tolerance levels.

When to visit

Liberia has both rainy and dry seasons. Although the land is lush during the rainy season, travel during these months is not recommended due to badly damaged infrastructure. Roads that are visible in dry season become completely impenetrable during the rainy season. The best time to visit is between mid-November and mid-April or mid-May. In particular, January and February are regarded as the best months, when the weather is sunniest and driest (3). □

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Conflict of interest

The authors report no conflict of interest.

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