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COVID-19 Radiology Preparedness, Challenges & Opportunities: Responses From 18 Countries

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Purpose: Radiology departments around the world have been faced with the challenge to adapt, and recover to the COVID-19 pandemic. This study is part of a worldwide survey of radiologists’ responses to COVID-19 in 18 different countries in Africa, Asia, Europe, and Latin America. The purpose of this study is to analyze the changes made in international radiology departments and practices in response to the pandemic.

Methods: The 18-item survey was sent via email from April to May 2020 to radiologists in Africa, Asia, Europe, and Latin America to assess their response to COVID-19. Our survey included questions regarding imaging, workforce adjustments, testing availability, staff and patient safety, research and education, and infrastructure availability.

Results: Twenty-eight survey responses were reviewed. Of the 28 respondents, 42.9\% have shortages of infrastructure and 78.6\% responded that COVID-19 testing was available. Regarding the use of Chest CT in COVID-19 patients, 28.6\% respondents used Chest CT as screening for COVID-19. For staff safety, interventions included encouraging use of masks in patient encounters, social distancing and PPE training. To cope with their education and research mission, radiology departments are doing online lectures, reducing the number of residents in rotations, and postponing any non-urgent activities.

Conclusion: In conclusion, there are disparities in infrastructure, research, and educational initiatives during COVID-19 which also provides opportunity for the global radiology community to work together on these issues.

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Introduction

The worldwide radiology community has been faced with the challenges of continuing care during the Coronavirus Disease 2019 (COVID-19) pandemic since December 2019.\textsuperscript{1,2} Radiology societies including Radiological Society of America, American College of Radiology, and Fleischner Society developed consensus statements and guidelines to help radiologists and clinicians with appropriate use of imaging for this disease.\textsuperscript{3-5} Radiology departments around the world have been faced with the challenge to prepare, adapt, and recover in different parts of the world. Academic institutions and private practices in every continent have had to take immediate measures to prevent spread and provide safe patient care. We wanted to analyze what changes were made in international radiology departments and practices for COVID-19 in 18 countries in Africa, Asia, Latin America, and Europe. At these times, there are important lessons that we can learn from each other in order to collaborate and find innovative solutions.

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Materials and Methods

The 18-item survey was sent via email from April to May 2020 to radiologists in Africa, Asia, Europe, and Latin America (Table 1) to assess their response to COVID-19. Our survey included questions regarding the use of imaging, workforce adjustments, testing availability, staff and patient safety, research and education as well as infrastructure availability.

The majority of the responding radiologists had been working with the Health4TheWorld initiative, which has been focusing on creating educational and technological solutions for radiologists in different countries for the last 4 years. Some of the radiologists were part of Health4TheWorld Chapters while others collaborated in our online educational programs. Many radiologists forwarded the survey to colleagues, hence, accurate determination for the total number of surveys cannot be reliably made.

Results

We received 28 separate responses from 18 countries including Algeria, Bhutan, Cameroon, Chile, Cyprus, France, Honduras, India, Italy, Kenya, Mexico, Netherlands, Nigeria, Rwanda, Saudi Arabia, South Africa, Sri Lanka, and Tanzania (Fig 1). 

Table 2 indicates the countries that the radiology health care professionals are from, whether the health professionals work in a
university hospital or private practice, how many radiologists they have in their department, whether the healthcare professional is taking care of COVID-19 patients, and if so, please indicate your role.

Testing
1. Do you have COVID testing available?
2. What kind of imaging do you use for COVID patients?
3. When do you do Chest CT for COVID patients?
4. When is Doppler ultrasound done in COVID patients?

Staff Safety/clinical operations
1. What are you doing to protect front-line staff?
2. Does your community understand the value of social distancing?
3. Are masks available for the community?
4. Have you had health care professionals who have COVID in your department?
5. What are you doing to change clinical operations to cope?
6. How have you dealt with workforce adjustments?

Research and education
1. Do you have a residency or postgraduate residency training program?
2. How are you coping with the education & research mission of your program?
3. What challenges are you facing in education?

Infrastructure
1. Do you have availability of Teleradiology services?
2. Are you experiencing shortages of any infrastructure?

Table 1 lists the availability of COVID-19 testing and imaging modalities used for COVID-19 patients.

**Table 1**
List of radiology survey questions

| General questions and workforce |
|--------------------------------|
| 1. Are you a university hospital or private practice? |
| 2. How many radiologists do you have in your department? |
| 3. Do you care for COVID-19 patients? If so, please indicate your role |

| Testing |
|---------|
| 1. Do you have COVID testing available? |
| 2. What kind of imaging do you use for COVID patients? |
| 3. When do you do Chest CT for COVID patients? |
| 4. When is Doppler ultrasound done in COVID patients? |

| Staff Safety/clinical operations |
|---------------------------------|
| 1. What are you doing to protect front-line staff? |
| 2. Does your community understand the value of social distancing? |
| 3. Are masks available for the community? |
| 4. Have you had health care professionals who have COVID in your department? |
| 5. What are you doing to change clinical operations to cope? |
| 6. How have you dealt with workforce adjustments? |

| Research and education |
|------------------------|
| 1. Do you have a residency or postgraduate residency training program? |
| 2. How are you coping with the education & research mission of your program? |
| 3. What challenges are you facing in education? |

| Infrastructure |
|----------------|
| 1. Do you have availability of Teleradiology services? |
| 2. Are you experiencing shortages of any infrastructure? |

“Do you have COVID-19 testing available?” Of the 28 responses, 22 (78.6%) responded “yes” to having COVID-19 testing available; 5 (17.8%) responded “no”; 1 (3.6%) did not know.

“What kind of imaging do you use for COVID-19 patients?” Of the 28 responses, 1 (3.6%) reported using only chest x-ray; 3 (10.7%) reported using only chest CT for COVID-19 patients; 15 (53.6%) reported using both chest x-ray and CT; 9 (32.1%) reported using all three modalities.

“When do you do Chest CT for COVID-19 patients?” Of the 28 responses, 15 (53.6%) reported using chest CT only for cases in which the diagnosis is uncertain; 8 (28.6%) reported using chest CT routinely for screening; 5 (17.8%) reported rarely using chest CT for COVID-19 patients.

“When is Doppler ultrasound done in COVID-19 patients?” Of the 28 responses, 15 (53.6%) reported doppler ultrasound was rarely used; 12 (42.8%) reported doppler ultrasound was performed on few high-risk patients; 1 (3.6%) reported using doppler ultrasound routine (Italy).

Table 3 lists the safety measures and protocols utilized by various countries to reduce viral spread.

What are you doing to protect front-line staff? (can select multiple options) Of 24 total responses, 22 (91.6%) reported “encouraging use of masks in all patient encounters”; 21 (87.5%) reported utilizing “social distancing”; 20 (83.3%) engaged in “PPE training”; 13 (54.1%) utilized “screening measures”; 13 (54.1%) respondents reported “calling patients before they came in.”

Does your community understand the value of social distancing? Of 28 total responses, 20 (71.4%) responded “yes”; 7 (25.0%) responded “no”; 1 (3.6%) responded “Don’t know.”

Are masks available for the community? Of 28 total responses, 15 (53.6%) responded “Yes”; 11 (39.3%) responded “No”; 2 (7.1%) responded “Don’t know.”

Have you had health care professionals who have COVID in your department? Of 28 total responses, 9 (32.1%) responded “Yes”; 16 (57.1%) responded “No”; 3 (10.7%) responded “Maybe.”

What are you doing to change clinical operations to cope? (can select multiple options) Of 23 total responses, 23 (100%) responded “Reduce...
traffic of outpatient through inpatient area”; 21 (91.3%) reported “social distancing”; 18 (78.3%) responded “Postpone non-urgent exams.”

How have you dealt with workforce adjustments? Of 28 total responses, 20 (71.4%) responded “Minimizing staff in hospital”; 5 (17.9%) responded “Working from home”; 3 (10.7%) responded “Cohorting.”

Table 5 indicates if the surveyed radiology departments had a residency training program, how were the radiology departments coping with the education and research mission of their program, what challenges they were facing in education, their availability of Tele-Radiology, and whether they had any shortages in infrastructure.

Do you have a residency or postgraduate residency training program? Of the 28 respondents, 82.1% (23) reported having a residency or postgraduate residency training program.

How are you coping with the education & research mission of your program? (Open ended question) To cope with the education and research mission of their program at these challenging times, a wide spectrum of coping measures was implemented. These measures included continuing research despite pandemic, running online lectures and webinars when infrastructure was available, reducing the number of residents in rotations and on call, and postponement of non-urgent activities. There were 16 (57.1%) responses to this question.

What challenges are you facing in education? (Open ended question) Some of the challenges reported were inadequate apprenticeship, difficulties setting up online education, postponement of academic programs and exams, lack of financial support, improper guidance in research, and obstacles on follow up and treatment due to lock down. There were 13 (46.4%) responses to this question.

Do you have availability of Tele-Radiology services? Half of the 28 respondents have no availability of Tele-Radiology services.

Are you experiencing shortages of any infrastructure? Of the 28 respondents, 42.9% (12) reported having shortages of infrastructure, 46.4% (13) reported no shortages of any kind, and 10.7% (3) were unsure.

Discussion

The results of this survey demonstrate the profound impact that the COVID-19 pandemic has had on radiology healthcare systems globally, specifically demonstrating the contrast in infrastructure, available resources, protocols, and specialists. As the standard of care is currently being written and constantly revised, many countries face challenges in adhering to the most current standards. The results of this survey are beneficial to understanding what measures have been adopted by radiology departments and practices around the world and what can we do better as a global radiology community.

COVID-19 Testing

Most of the respondents (78.6%) reported availability of COVID-19 testing. The implication of this finding is that at this point in the pandemic, the countries that have been most successful in achieving a noticeable decline in the predicted number of infections share that they have been all performing mass testing. Universal repeated testing is a very close substitute of quarantine and can substantially reduce the need for indiscriminate quarantines and their implied strain on the economy. Three radiology departments reported that there was not ready access to COVID-19 testing, likely due to the problematic geographical spread of laboratory testing facilities in low-middle income countries. In many of these countries, most hospitals are in cities, while the majority of the population lives in rural areas.

COVID-19 Imaging

Although chest radiography (CXR) and computed tomography (CT) are key tools for pulmonary disease diagnosis and management, their role in the screening of COVID-19 is limited. On March 11, 2020, the American College of Radiology (ACR) published recommendations regarding the use of CXR and CT for suspected COVID-19 infection: (1)
CT should not be used as a screening tool or a first-line test to diagnose COVID-19; (2) CT should be used sparingly and reserved for hospitalized, symptomatic patients with specific clinical indications for CT; (3) portable radiography units may be considered in ambulatory care facilities when CXRs are considered medically necessary. On April 7, 2020, a multinational consensus statement was published by the Fleischer Society, describing the role of chest imaging in the setting of the COVID-19 pandemic. The use of CXR and CT should be based upon clinical severity, change over time, test availability/result (PCR or PoC test), and local resources. Our survey demonstrates that nearly one half of the respondents reported using both CXR and CT. With regards to when Doppler ultrasound is used, one respondent from Italy said they used it routinely, while more than half of the respondents reported that it was rarely used, and the rest of the respondents reported performing Doppler ultrasound on few high-risk patients. The higher use in the radiology department in Italy could have been due to the high volume of COVID-19 cases that were under their care.

| Country         | Do you have COVID testing available? | What kind of imaging do you use for COVID patients? (multiple answers) | When do you do Chest CT for COVID patients? | When is Doppler ultrasound done in COVID patients? |
|-----------------|--------------------------------------|------------------------------------------------------------------------|---------------------------------------------|-----------------------------------------------|
| Algeria         | Yes                                  | Chest CT                                                               | Only for cases where the diagnosis is uncertain | Rarely                                         |
| Bhutan          | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Rarely                                         |
| Cameroon        | Yes                                  | Chest CT                                                               | Routinely for screening                     | Rarely                                         |
| Chile           | Yes                                  | Chest XRay; Chest CT                                                   | Routinely for screening                     | Rarely                                         |
| Cyprus          | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Rarely                                         |
| France          | Yes                                  | Chest CT                                                               | Routinely for screening                     | Rarely                                         |
| Honduras        | Yes                                  | Chest XRay                                                             | Routinely for screening                     | Rarely                                         |
| India           | Yes                                  | Chest XRay; Chest CT                                                   | Rarely                                      | Few Patients with High Risk                    |
| Italy           | Yes                                  | Chest XRay; Chest CT                                                   | Routinely for screening                     | Few Patients with High Risk                    |
| Italy           | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Few Patients with High Risk                    |
| Kenya           | No                                   | Chest XRay; Chest CT                                                   | Routinely for screening                     | Few Patients with High Risk                    |
| Kenya           | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Rarely                                         |
| Mexico          | No                                   | Chest XRay; Chest CT                                                   | Routinely for screening                     | Few Patients with High Risk                    |
| Mexico          | No                                   | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Rarely                                         |
| Mexico          | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Few Patients with High Risk                    |
| Mexico          | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Few Patients with High Risk                    |
| Netherlands     | Yes                                  | Chest XRay; Chest CT                                                   | Routinely for screening                     | Few Patients with High Risk                    |
| Nigeria         | Yes                                  | Chest XRay; Chest CT                                                   | Rarely                                      | Few Patients with High Risk                    |
| Rwanda          | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Rarely                                         |
| Rwanda          | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Few Patients with High Risk                    |
| Saudi Arabia    | No                                   | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Few Patients with High Risk                    |
| South Africa    | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Few Patients with High Risk                    |
| South Africa    | Yes                                  | Chest XRay; Chest CT                                                   | Rarely                                      | Few Patients with High Risk                    |
| South Africa    | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Rarely                                         |
| Sri Lanka       | Yes                                  | Chest XRay; Chest CT                                                   | Rarely                                      | Few Patients with High Risk                    |
| Sri Lanka       | Yes                                  | Chest XRay; Chest CT                                                   | Only for cases where the diagnosis is uncertain | Rarely                                         |
| Tanzania        | Don’t Know                           | Chest XRay; Chest CT                                                   | Routinely for screening                     | Rarely                                         |

CT should not be used as a screening tool or a first-line test to diagnose COVID-19. With regards to when Doppler ultrasound is used, one respondent from Italy said they used it routinely, while more than half of the respondents reported that it was rarely used, and the rest of the respondents reported performing Doppler ultrasound on few high-risk patients. The higher use in the radiology department in Italy could have been due to the high volume of COVID-19 cases that were under their care. To our knowledge, there are no definitive guidelines on the use of Doppler ultrasound in COVID-19 patients.

**Staff Safety**

Protection of front-line staff: Various prophylactic measures may be undertaken to combat COVID-19. Furthermore, multiple initiatives must be used in concert to appreciably reduce disease burden. Our data suggests that most surveyed countries engaged in some form of prophylaxis, the most common being encouraging mask usage (91.6%); only half of all respondents utilized screening measures or contacted patients prior to their arrival. A large number of respondents (83%) said they had PPE training in their department or practice.
| Country       | What are you doing to protect front-line staff? | Does your community understand the value of social distancing? | Are masks available for the community? | Have you had health care professionals who have COVID in your department? | What are you doing to change clinical operations to cope? (can select multiple options) | How have you dealt with workforce adjustments? |
|--------------|-------------------------------------------------|---------------------------------------------------------------|----------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------|
| Algeria      | PPE training; Encouraging use of masks in all patients; Social Distancing | Yes                                            | Yes                                      | Yes                                      | Reduce traffic of outpatient through inpatient area; Social Distancing          | Cohorting                                  |
| Bhutan       | PPE training; Encouraging use of masks in all patients; Social Distancing | No                                             | No                                       | No                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Cameroon     | Encouraging use of masks in all patients; Social Distancing | Yes                                            | Yes                                      | Yes                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Chile        | PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing | Yes                                            | No                                       | Maybe                                   | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Cyprus       | PPE training; Encouraging use of masks in all patients; Social Distancing | Yes                                            | Yes                                      | Yes                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Working From Home                          |
| France       | PPE training; Encouraging use of masks in all patients; Social Distancing | Yes                                            | No                                       | Yes                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Honduras     | PPE training; Encouraging use of masks in all patients; Social Distancing | Yes                                            | Yes                                      | No                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Italy        | PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing | Yes                                            | Yes                                      | Yes                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Italy        | PPE training; Encouraging use of masks in all patients; Social Distancing | Yes                                            | Yes                                      | Yes                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Cohorting              |
| Kenya        | Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing | Yes                                            | No                                       | No                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Working From Home                          |
| Kenya        | PPE training; Encouraging use of masks in all patients | Yes                                            | Yes                                      | No                                      | Reduce traffic of outpatient through inpatient area | Minimizing Staff in Hospital                |
| Mexico       | PPE training; Encouraging use of masks in all patients; Social Distancing | No                                             | No                                       | No                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Mexico       | PPE training; Encouraging use of masks in all patients; Social Distancing | No                                             | Yes                                      | No                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Mexico       | PPE training; Encouraging use of masks in all patients; Social Distancing | Yes                                            | Yes                                      | No                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Mexico       | PPE training; Encouraging use of masks in all patients; Social Distancing | Don’t Know                                      | No                                       | No                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Netherlands  | Screening: calling patients before they come in; Social Distancing | Yes                                            | No                                       | No                                      | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Minimizing Staff in Hospital                |
| Nigeria      | Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing | No                                             | No                                       | Maybe                                   | Postpone non-urgent exams; Reduce traffic of outpatient through inpatient area; Social Distancing | Working From Home                          |

(continued)
available. The majority of respondents indicated that social distancing (87%) was followed in their departments.

Understanding the value of social distancing in community: Despite having measures in place such as lockdowns and social distancing, a quarter of our respondents indicated that their community does not understand the value of social distancing. This suggests the importance of education in these communities in order to increase adherence to these public safety measures.

Clinical Operation: The transmission and spread of COVID-19 has been heterogeneous and unprecedented for healthcare systems across the world. As healthcare systems have been overwhelmed by the number of cases and constraints in resources (diagnostic testing, hospital beds, ventilators, personal protective equipment, and healthcare providers who have been afflicted by the virus), they must redirect their clinical operations and triage in order to cope. Our results suggest that three-quarters to all of the respondents reported that their radiology department minimized outpatient imaging services and postponing non-urgent exams while practicing social distancing.

Mask availability: Global access to PPE was limited with the advent of the novel coronavirus, with demand exceeding supply in many areas. In addition, available supplies were preferentially routed to healthcare workers and susceptible patients, further restricting access to the general population. Roughly half of all respondents reported sufficient mask availability for their respective communities.

COVID-19 Amongst Healthcare Workers: COVID-19 prevalence amongst healthcare workers is thought to be due to a variety of mechanisms. At pandemic onset, personal protective equipment reserves, especially in poorer areas, were inadequate to meet increased demand. In addition, risk of transmission from patient to healthcare workers was elevated given that such individuals were tasked with caring for multiple infected patients. Other cited factors include inadequate training of staff and poor understanding of viral transmission mechanisms, particularly during the early stages of the pandemic.

Our results indicate that nearly one-third of all respondents were aware of COVID-19 positive coworkers. Unfortunately, the total disease burden at each department is unknown. Departments with COVID-19 positive workers were more often located in African countries (44.4%). In addition, nearly half of all countries with COVID-19 positive radiologists also reported either insufficient mask availability or poor community understanding of social distancing requirements. What role these may have played in the observed disease prevalence amongst surveyed radiologists has yet to be determined.

Workplace adjustments: The majority (71.4%) of respondents reported minimizing staff in their departments. The remaining might have dealt with workforce adjustments?
and inability to maintain required isolation standards. In addition, working from home was only seen in 18% respondents. This could be due to lack of technology for teleradiology especially as the majority are developing countries.

Radiology Residency Training Program

The majority (82.1%) of the respondents have a residency or postgraduate residency training program, but the ones that did not were from Africa and Latin America. This is concordant with our previous results. There is definitely a need for more radiology residency programs and educational resources in these continents. In a worldwide study involving 13 African countries, we previously found that nearly two-thirds of them had fewer than 5 residency programs for radiology. The same survey portrayed a slightly greater number of residency programs in Latin America, with roughly one-third reporting 5 or fewer programs, but the gap in residency training programs is huge when compared to highly resourced countries like the United States, which has 187 total Accreditation Council for Graduate Medical Education (ACGME)-approved radiology residency training programs.

### TABLE 5
Research, education, IT, infrastructure

| Countries           | Do you have a residency or postgraduate residency training program? | How are you coping with the education & research mission of your program? | What challenges are you facing in education? | Do you have availability of Tele-Radiology services? | Are you experiencing shortages of any infrastructure? |
|---------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------|---------------------------------------------|---------------------------------------------------|-------------------------------------------------------|
| Algeria             | Yes                                                                | Research and registration for the follow up of the recovery of the patients. | Follow up of the pandemic (follow up, treatment, lock down). | No                                                | Yes                                                  |
| Bhutan              | Yes                                                                | Ongoing formation of medical personnel and medical students.           | N/A                                         | No                                                | No                                                   |
| Cameroon            | Yes                                                                | N/A                                                                   | N/A                                         | No                                                | No                                                   |
| Chile               | Yes                                                                | N/A                                                                   | N/A                                         | Yes                                               | No                                                   |
| Cyprus              | Yes                                                                | N/A                                                                   | N/A                                         | Yes                                               | No                                                   |
| France              | Yes                                                                | Residents educational programs.                                        | N/A                                         | Yes                                               | No                                                   |
| Honduras            | No                                                                  | N/A                                                                   | N/A                                         | No                                                | Yes                                                   |
| India               | Yes                                                                | N/A                                                                   | N/A                                         | Yes                                               | No                                                   |
| Italy               | Yes                                                                | N/A                                                                   | N/A                                         | No                                                | No                                                   |
| Italy               | Yes                                                                | N/A                                                                   | N/A                                         | Yes                                               | Yes                                                   |
| Kenya               | No                                                                  | Internet                                                               | Access                                      | Yes                                               | Yes                                                   |
| Kenya               | Yes                                                                | We are running Zoom lectures and tutorials. Prospective research has had challenges, but retrospectively it is running well. Clinical rotations are spread to 1 resident from each class a day weekly, as well as on call schedules. Of note is that patients are fewer at the moment. | What we are doing now is not adequate for actual practice knowing that most medical courses are practice oriented (apprenticeship exposure on cases as they come) is paramount. | Yes                                               | Yes                                                   |
| Mexico              | No                                                                  | N/A                                                                   | N/A                                         | Yes                                               | No                                                   |
| Mexico              | Yes                                                                | Online activities and postpone non-urgent activities.                 | Local activities and training on the field. | No                                                | No                                                   |
| Mexico              | Yes                                                                | Seminars, classes, etc. are on-line now.                               | Number of cases, face-to-face discussion, clinical antimutation. | Yes                                               | No                                                   |
| Mexico              | Yes                                                                | N/A                                                                   | On-line class, the hospital have no resources to buy workstations for the radiologists for home office during this quarantine. | No                                                | Yes                                                   |
| Netherlands         | Yes                                                                | N/A                                                                   | N/A                                         | Setting up online education.                      | Yes                                                   |
| Nigeria             | Yes                                                                | Just started webinars for resident presentations.                    | The university is closed so no university operations. | No                                                | No                                                   |
| Rwanda              | Yes                                                                | Residents are only six. They still do presentations in a big conference room observing safety precautions. | Limited internet, computer.                | No                                                | Yes                                                   |
| Rwanda              | Yes                                                                | Online teaching.                                                      | N/A                                         | Maybe                                             | Maybe                                                 |
| Saudi Arabia        | Maybe                                                              | N/A                                                                   | Relevant on-line contents.                  | Yes                                               | Yes                                                   |
| South Africa        | Yes                                                                | On-line                                                               | N/A                                         | Yes                                               | No                                                   |
| South Africa        | No                                                                  | N/A                                                                   | Postponement academic program and exams.   | No                                                | Maybe                                                 |
| South Africa        | Yes                                                                | Slow progress                                                         | Time for study and facilities.             | No                                                | Yes                                                   |
| Sri Lanka           | Yes                                                                | N/A                                                                   | N/A                                         | No                                                | Yes                                                   |
| Sri Lanka           | Yes                                                                | Continuing with a reduced capacity.                                   | Few and busy mentors not enough time, lack fee and financial support, lack of proper guidance in research to mention a few. | No                                                | Yes                                                   |
| Tanzania            | Yes                                                                | Hard, suspended for a while.                                          | Few and busy mentors not enough time, lack fee and financial support, lack of proper guidance in research to mention a few. | No                                                | Yes                                                   |

Education and Research Mission of Programs

The education and research of radiology residency programs has suffered a negative impact in many aspects due to the pandemic. Some of the challenges reported were inadequate apprenticeship, difficulties setting up online education, postponement of academic programs and exams, lack of financial support, improper guidance in research, and obstacles on follow up and treatment due to lock down. This is a challenging time for the educational programs. On the other
hand, online education has been adopted to brace through this challenge. In the last 4 years of experience in online free education in radiology through Health4theworld Academy (https://health4theworld.org/academy/) in 80 countries, we have found that online education can be useful in far reaching corners of the world on a long-term basis. We have weekly virtual education events for the last 4 years in multiple residency sites in Africa. During the COVID-19 pandemic, the value of online education is even more useful. Multiple national societies including RSNA have streamed free webinars to educate about COVID-19 at this time. The availability of the immense array of online educational and clinical opportunities should guarantee continued resident engagement in learning during the pandemic even if on-site learning is completely suspended. Obviously, there are limitations in some developing countries because of their numerous geographic and economic barriers to accessibility, challenges in internet speed, low bandwidth, and high internet service charges.

To cope with the education and research mission of their program, apart from online education, multiple other solutions were suggested in the survey including continuing onsite resident education by reducing the number of residents on rotations and on call rather than abrupt discontinuation of onsite resident education. Some of the respondents have obstacles involving research guidance. This is a highly concerning finding as research is paramount for development, redesigning, and advancement in the field of radiology. Trainees and their mentors can focus on online mentorship meetings for projects able to be worked on during the pandemic, securing grant funding for future studies, presenting and publishing material so as not to lose value from the work already performed.

II. IT and Infrastructure

Merely half of the surveyed population reported availability of Tele-Radiology services. This highlights the challenges especially faced by low-middle income countries due to their lack of adequate technological infrastructures and the relatively high initial costs that come with implementing Tele-Radiology. Tele-Radiology offers immense promise during the pandemic for maintaining workforce safety, achieving geographic, after-hours and multispecialty coverage, as well as improving coverage of underserved areas. During the pandemic, to maintain workforce safety, home workstations and remote reading can be utilized where possible. For example, the University of Washington radiology department has accelerated the process of providing home workstations and upgraded their Picture Archiving and Communication Systems servers to support an increased volume of radiologists doing remote interpretation.

Nearly half (46.4%) of the surveyed population have shortages in infrastructure, suggesting the straining of radiology departments secondary to the pandemic. The limitations of this study include language considerations as this survey was in English. Additionally, COVID-19 is rapidly evolving so some of the responses might have changed with time.

Limitations

The limitation of the study was selection bias. The responses by the radiologists might not be representative of the radiology community of the entire country and the responses reflect the situation in their particular hospital. This was a pilot survey based study to understand COVID-19 preparedness in different countries during the pandemic. We agree that further studies can be done to evaluate the COVID-19 preparedness, challenges and opportunities in more depth and detail.

Conclusion

Hence, after compiling survey results from international radiology health care professionals from different continents, it is clear that there are disparities in terms of infrastructure, PPE, staff safety protocols, research, and educational initiatives, potentially limiting a department or private practice’s response to the ongoing COVID-19 pandemic. We are hopeful that this survey will help elucidate the challenges that countries around the world are facing, and more importantly, will help the global community learn from one another in the face of the ongoing COVID-19 pandemic.

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