Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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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.

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.[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.[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.

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

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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?

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, what their role is in care.

Most of the radiology health care professionals (82%) were affiliated with University Hospitals, while the remaining 18% have private practices. On average, there were about 16 radiologists working in the respondents' departments. Of the 28 participants, 15 (54%) are currently directly taking care of COVID-19 patients, while 13 (46%) are not involved in direct care.

Table 3 lists the availability of COVID-19 testing and imaging modalities used for COVID-19 patients.

"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 4 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

FIG 1. The map demonstrates the countries from which radiologists were surveyed in this study.

TABLE 2
General questions & workforce

Countries	Are you a university hospital or private practice?	How many radiologists do you have in your department?	Do you take care for COVID-19 patients?	If so, please indicate your role
Algeria	University Hospital	48	Yes	Diagnosis, follow up
Bhutan	Government Hospital	6	Yes	Interpretation of Xrays and CT
Cameroon	University Hospital	5	No	
Chile	Private Practice	17	Yes	Radiologist
Cyprus	University Hospital	10	No	
France	University Hospital	15	Yes	Chest CT
Honduras	University Hospital	1	Yes	Imaging Diagnosis
India	University Hospital	20	No	
Italy	University Hospital	30	Yes	Radiologist
Italy	University Hospital	50	Yes	Interventional radiologist
Kenya	Private Practice	1	Yes	Radiology
Kenya	University Hospital	10	Yes	If imaging is required it is done under strict safety measures and findings discussed
Mexico	Private Practice	3	No	
Mexico	Private Practice	31	No	
Mexico	Public Hospital	9	No	
Mexico	University Hospital	32	No	Diagnostic Imaging
Mexico	University Hospital	18	Yes	Radiologist
Netherlands	University Hospital	40	No	
Nigeria	University Hospital	10	Yes	Radiologist
Rwanda	University Hospital	3	No	
Rwanda	University Hospital	4	No	
Saudi Arabia	Academic staff at University		Yes	Researcher and academic staff
South Africa	University Hospital	35	No	
South Africa	University Hospital	10	Yes	Imaging
South Africa	Private Practice	5	No	
Sri Lanka	University Hospital	14	Yes	Imaging support
Sri Lanka	University Hospital	4	No	
Tanzania	University Hospital	9	Yes	Reading Chest X-rays and CTs

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 were they 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.[6,7] 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.[8,9] 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.[10]

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)

TABLE 3
Testing

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;Doppler ultrasound for DVT	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	Rarely	Rarely
India	Yes	Chest XRay;Chest CT;Doppler ultrasound for DVT	Only for cases where the diagnosis is uncertain	Few Patients with High Risk
Italy	Yes	Chest XRay;Chest CT;Doppler ultrasound for DVT	Rarely	Routinely
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;Doppler ultrasound for DVT	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 XR, Chest CT	Routinely for screening	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;Doppler ultrasound for DVT	Routinely for screening	Few Patients with High Risk
Nigeria	Yes	Chest XRay;Chest CT	Rarely	Rarely
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;Doppler ultrasound for DVT	Only for cases where the diagnosis is uncertain	Few Patients with High Risk
South Africa	Yes	Chest XRay;Chest CT;Doppler ultrasound for DVT	Only for cases where the diagnosis is uncertain	Few Patients with High Risk
South Africa	Yes	Chest XRay;Chest CT;Doppler ultrasound for DVT	Rarely	Few Patients with High Risk
South Africa	Yes	Chest XRay, Chest CT, Doppler ultrasound for DVT	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; (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.[1] On April 7, 2020, a multinational consensus statement was published by the Fleischner Society, describing the role of chest imaging in the setting of the COVID-19 pandemic.[2] 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 indications of using chest CT, more than half of the respondents reported using chest CT only for cases in which diagnosis is uncertain, while less than one-third reported using chest CT routinely for screening. Out of these 8 responses who were using Chest CT for screening, 37% of those had also reported the lack of testing availability. So, in part the use of Chest CT for screening could be because of the lack of availability of PCR testing.

COVID-19 has an increase in DVT and thromboembolism.[11] From our survey, nearly one-third of the respondents reported using doppler ultrasound in addition to CXR and CT in 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 definite 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

TABLE 4
Staff safety

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		Yes	Yes	Yes	Reduce traffic of outpatient through inpatient are; 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 are; 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 are; Social Distancing	Minimizing Staff in Hospital
Chile		Yes	No	Maybe		Minimizing Staff in Hospital
Cyprus		Yes	Yes	Yes		Working From Home
France	PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing	Yes		Yes	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing	Working From Home
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 are; Social Distancing	Minimizing Staff in Hospital
India	PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing	Yes	Yes	Maybe	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
Italy	PPE training; Screening: calling patients before they come incur testing before hospitalization for elective pts	Yes	Yes	Yes	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
Italy	PPE training; Encouraging use of masks in all patients	Yes	Yes	Yes	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; 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 are; Social Distancing	Working From Home
Kenya	PPE training; Encouraging use of masks in all patients	Yes	Yes	No	Reduce traffic of outpatient through inpatient are	Minimizing Staff in Hospital
Mexico	PPE training; Encouraging use of masks in all patients; Social Distancing	No	Don't Know	Yes	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing; Reduce personal activities at hospital with home office online/streaming activities	Minimizing Staff in Hospital
Mexico	PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing	No	No	No	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing;	Minimizing Staff in Hospital
Mexico	PPE training; Encouraging use of masks in all patients; Social Distancing	No	Yes	No		Minimizing Staff in Hospital
Mexico		Yes	Yes	No	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
Mexico	PPE training; Encouraging use of masks in all patients; Social Distancing	Don't Know	No	No		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 are; 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		Working From Home

(*continued*)

TABLE 4 (*CONTINUED*)

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?
Rwanda	PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing	Yes	Yes	No	Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
Rwanda	PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing; Sterilizing all papers coming in the department trough cooking heated (micro-one)	Yes	Yes	No	Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
Saudi Arabia	PPE training; Encouraging use of masks in all patients; Social Distancing	Yes	No	No	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
South Africa	PPE training; Encouraging use of masks in all patients; Social Distancing	No	No	No	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are	Cohorting
South Africa	PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing	Yes	Yes	No	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
South Africa	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 are, Social Distancing	Working From Home
Sri Lanka	PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing	Yes	Don't Know	No	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
Sri Lanka	PPE training; Screening: calling patients before they come in; Encouraging use of masks in all patients; Social Distancing	Yes	Yes	No	Postpone non-urgent exams; Reduce traffic of outpatient through inpatient are; Social Distancing	Minimizing Staff in Hospital
Tanzania	PPE training; Encouraging use of masks in all patients; Social Distancing	No	No	Yes	Reduce traffic of outpatient through inpatient are; Social Distancing; Closing the schools in all levels	Minimizing Staff in Hospital

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.[12] 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.[13] 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.[12,14]

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 not have been able to do this because of lack of sufficient faculty. However, very few (10.7%) engaged in cohorting, a practice where radiologists sharing a diagnosis are placed in the same hospital location (floor, wing, etc.) to minimize interactions with others. The reasons for this are many and may include poor understanding of cohorting significance, small hospital size, lack of department space

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	N/A	No	No
Cameroon	Yes	Formation of medical personnel and medical students.	N/A	No	Yes
Chile	Yes	N/A	N/A	Yes	No
Cyprus	Yes	N/A	N/A	Yes	Yes
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 moss 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 anticommutation.	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
Mexico	Yes	N/A	N/A	Yes	No
Netherlands	Yes	On distance; WebEx/Microsoft team meetings; on-line webinars; writing manuscripts, the research is completely down at this moment.	Setting up online education.	Yes	No
Nigeria	Yes	Just started webinars for resident presentations.	N/A	No	No
Rwanda	Yes	Residents are only six. They still do presentations in a big conference room observing safety precautions.	The university is closed so no university operations.	No	No
Rwanda	Yes	Online teaching.	Limited internet, computer.	No	Yes
Saudi Arabia	Maybe	N/A	N/A	Maybe	Maybe
South Africa	Yes	On-line	Relevant on-line contents.	Yes	Yes
South Africa	No	N/A	N/A	Yes	No
South Africa	Yes	Slow progress	Postponement academic program and exams.	No	Maybe
Sri Lanka	Yes	N/A	Time for study and facilities.	No	Yes
Sri Lanka	Yes	Continuing with a reduced capacity.	N/A	No	Maybe
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

and inability to maintain required isolation standards. In addition, working from home was also 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.[15,16] 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.[1,2] 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.[16,17]

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.[18] 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.[15]

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.[19]

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.[20] Teleradiology 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.[21,22] 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.[23]

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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