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.

Radiology Residency Preparedness and Response to the COVID-19 Pandemic

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This article provides a guideline for radiology residency programs to prepare and respond to the impact of coronavirus disease 2019, by offering specific examples from three programs, and provides a list of resources for distance learning and maintaining well-being.

Abbreviations: ABR American Board of Radiology, **ACGME** Accreditation Council for Graduate Medical Education, **ACR** American College of Radiology, **CCC** Clinical Competency Committee, **CDC** Centers for Disease Control and Prevention, **COVID-19** Coronavirus Disease 2019, **CT** Computed Tomography, **DR** Diagnostic Radiology, **ESIR** Early Specialization in Interventional Radiology, **GME** Graduate Medical Education, **HIPAA** Health Insurance Portability and Accountability Act, **IR** Interventional Radiology, **NRC** Nuclear Regulatory Commission, **MQSA** Mammography Quality Standards Act, **PPE** Personal Protective Equipment, **RRC** Residency Review Committee, **RSNA** Radiological Society of North America, **UCSD** University of California San Diego, **VMMC** Virginia Mason Medical Center

INTRODUCTION

Since March 11, 2020, when the World Health Organization declared the coronavirus disease (COVID-19) outbreak as a pandemic, radiology department preparedness policies in response to COVID-19 have been published (1,2). While operational preparedness is crucial in the functioning of the radiology department in this pandemic, academic institutions with radiology residency programs face an additional dimension in the realm of preparedness and response. Alvin et al provided a perspective from radiology trainees on the impact of the pandemic on residents and fellows (3). The aim of this article is to provide specific guidance for radiology residency program leadership to prepare and respond to the residency-related impact from the pandemic, with focus on safety and education.

Clinical Coverage and Redistribution of Work

The Accreditation Council for Graduate Medical Education (ACGME) has developed an operational framework for graduate medical education (GME) to function at sponsoring institutions and their participating sites, with the safety of patients and residents and/or fellows as the highest priority (4). The spectrum of ACGME stages includes: Stage 1 "Business as Usual," Stage 2 "Increased Clinical Demands," and Stage 3 "Pandemic Emergency Status." At Stage 2, clinical demand is increased but manageable, with special guidance to include education didactics using remote and/or virtual settings and innovative tools; faculty members may provide remote supervision through telecommunications technology. At this stage, minimum rotations may not be met, since cancellation of clinics and outpatient studies would affect the normal volume of patients that seek care in those settings. At the Stage 3 pandemic emergency status, while requirements such as adequate resources and training (including infection protection), adequate supervision, and work hour requirements are in effect, other common program requirements and specialty-specific program requirements are suspended for ACGME-accredited programs to allow for the flexibility of physicians in the clinical care settings. At the time of writing, a number of institutions have activated Stage 2 or are in the process of activating Stage 2, while some programs, such as those in New York City, Philadelphia, and Boston, have activated Stage 3 status, where both diagnostic and interventional radiology (IR) residents may be assigned to direct patient care settings outside of the department of radiology.

To promote physical distancing, ensure the safety of residents, and allow for adequate reserve capacity, a number of residency programs, such as the University of California San Diego (UCSD) in California (resident number = 41 in diagnostic radiology [DR], 10 in interventional Radiology) and

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Virginia Mason Medical Center (VMMC) in Seattle, Washington (resident number = 12 in diagnostic radiology) have divided the residents into two clinical groups, with one group reporting to clinical service, and the other assigned to distance learning; the two groups alternate every other week (one week on, one week off.) The resident group assigned to distance learning may be pulled to cover a resident on clinical rotation who becomes ill or needs to be quarantined. At UCSD, to determine the assignments, the chief residents worked with the division chiefs to determine the minimum number of residents required to support the clinical service, and the maximum number allowed to comply with a six-foot physical distance between persons, as recommended by the Centers for Disease Control and Prevention guidelines (5). Other considerations included the need for contrast and call coverage, minimum requirements for graduation, and underlying chronic conditions which may place the resident at a higher risk. At VMMC, residents working on site are paired each day with one of the radiology attendings on service, rather than assignment to a specific rotation, to adapt to unpredictable and fluctuating volumes. Assignments to procedural rotations have been postponed to support physical distancing and to conserve personal protective equipment (PPE). Due to the lower number of outpatient exams (cancelled elective procedures and screening exams) and postponement of procedural rotations, credentialing requirements for Breast Imaging Mammography Quality Standards Act and Nuclear Regulatory Commission, as well as Early Specialization in IR competency criteria may have to be reassessed; as a specialty, we should look to the radiology Radiology Review Committee (RRC) for guidance on the effects on these training requirements.

Maintaining Healthy Staff and Protecting our Patients

Ensuring resident health and safety during the pandemic is a priority for the residency program. As an ACGME requirement, all trainees must be trained in, and provided with, appropriate infection protection for the clinical setting. Refreshing knowledge of infection protection, such as donning and doffing of PPE and hand washing technique, is recommended. These safety protocols are available from the institution employee health, infection prevention, and GME departments. Campus courses or video instruction on PPE donning and doffing as well as handwashing should be made readily available to residents; however, the utility of this information may be limited due to the shortage of PPE.

Program directors also need to advocate for appropriate PPE for residents while on clinical rotations, and the local GME body may have guiding principles for involvement of residents in procedures during the pandemic. For example, at VMMC in Seattle, such principles include reducing unnecessary risk to those individuals with less experience, allowing experienced clinicians to provide the most expeditious care, and the conservation of PPE. Under this direction, the radiology program directors at VMMC have made adjustments to resident schedules, not only for radiology resident involvement in procedures, but also for involvement of other learners in the department (such as internal medicine residents rotating through the department to learn image-guided procedures.) These rotations have been deferred until the crisis abates to adhere to the organizational guiding principles.

Program directors can consult with institutional Infection Prevention staff to survey work space areas such as reading rooms and provide recommendations on spacing to minimize risk. To promote physical distancing, resident hand-offs and consults can be performed by phone. Temporary signs with a telephone number for radiology consults may be placed on reading room doors to further promote social distancing between referring clinicians and radiologists. Residency program directors can work with the radiology department to identify new potential work areas, move workstations to different locations, and assign residents to a specific workstation for the duration of the rotation. Remote reading stations can be deployed for any senior resident due to the need for less direct supervision. Residents who are immunocompromised or at high risk may be provided institutional-approved workstations and be allowed to work from home. Other supportive resources could also be offered, such as webcams and headsets for video conferencing. At VMMC, employees, including residents, are provided thermometers free of charge. As long as the pandemic continues, residency and fellowship interviews should be conducted virtually using software such as FaceTime (Apple Inc, Cupertino, California), Skype Business (Microsoft, Seattle, Washington), or Zoom (San Jose, California).

Residents should be empowered by residency leadership to promote the safety and health of others in the department, including technologists, nurses and assistants. Residents should alert involved staff taking care of patient's suspected of COVID-19 infection to take the necessary precautions. If a resident on call identifies findings on a chest CT or radiographic exam suspicious for COVID-19, the resident should (in addition to communication of this to the referring physician) notify the technologist to be on alert for subsequent steps regarding potential exposure.

A live online document of tips related to staying healthy and safe, with contact information and protocols for resident illness, self-quarantine, and procedures for testing may be helpful. Development of back-up call teams (in case the on-call resident falls ill), if not already in place, should be considered. Residency programs should have various ways for residents to call in sick during routine times, but if they do not have a robust system in place already, the pandemic may be an impetus for creating one. Residency programs could develop a standardized sickness notification email template (with information such as resident rotation) that a resident can send for distribution to a group that includes the program director (s), chief residents, relative attendings on the assigned service, and the program coordinator. An app such as Viber (Rakuten Viber, Luxembourg) that the whole program, including program leadership and key faculty, can subscribed

to, can provide centralized communication; care must be made to ensure secure communication and compliance with the Health Insurance Portability and Accountability Act (HIPAA).

Maintaining Protected Teaching Time and Overcoming Physical Barriers to Teaching

While limiting exposure is paramount to ensure the safety and health of patients and residents, and radiology clinical volume is reduced in some areas, there is still opportunity for residents to learn and actively participate on the clinical rotations. Other than skills related to radiological diagnosis and interpretation, active onsite involvement may be an opportunity for residents to learn about organization, leadership, teamwork, and crisis management.

Residency program leadership should work with department leadership and faculty to champion continued quality education during the pandemic crisis. To find the balance of on-site learning versus distance learning, soliciting input from different perspectives can be helpful. For example, at UCSD, a workgroup was formed by faculty and residents to address the educational needs of residents, particularly to those assigned to home distance learning. Considerations such as the flexibility of independent study versus increased structure, adapting conferences to an entirely virtual format, and attendance and/or accountability were made to design a program that would ensure continued resident engagement in learning. Programs may elect to maintain regularly scheduled conferences and lectures by videocast, and supplement education by compiling additional resources for independent study.

A variety of technological aids and tools are available to assist in the transition to teleconferencing. For instance, at UCSD, as all didactics and conferences are now held via Zoom (San Jose, California); faculty teaching didactic and case-based conferences are encouraged to use tools that promote interaction and audience participation, such as Poll Everywhere (San Francisco, California) and RSNA Diagnosis Live. The chief residents are taking initiative to form a supplemental educational plan, with frequent testing through Radprimer (Amirsys, Inc, Salt Lake City, Utah) to follow progress. Suggestions for additional educational materials include the Radiological Society of North America (RSNA) and/or American Association of Physicists online physics modules, RadioGraphics American Board of Radiology Diagnostic Radiology Core Exam Blueprints Article Index, the Society of Thoracic Radiology online course, and the International Skeletal Society, Society of Skeletal Radiology online core lectures (Table 1). The American College of Radiology has recently added new resources to the Residency Training Program Tools to include CPI (Continuous Professional Improvement) electronic books (Table 1). The Association of University Radiologists has recently launched the radiology core curriculum lecture series (Table 1).

Other ideas for off-site education include creating picture archiving and communication system (PACS) teaching folders for remote viewing, and remote one-on-one or group readout sessions using Zoom (San Jose, California) or TeamViewer (TeamViewer AG, Germany) technology; privacy concerns need to be addressed and a HIPAA compliant platform must be used.

Residents may be encouraged to develop research projects or Practice Quality Improvement projects with faculty during this time. For home and/or distancing learning, a key component is a system that ensures accountability of the learners; this can include having each resident regularly log their learning activity which then can be reviewed by the program director at a later date.

For first-year radiology residents preparing to take call, it may be necessary to allot more on-service clinical days in order to allow exposure to more cases, and adequate assessment by faculty for call readiness. Continuation of pre-call teaching sessions, simulations and practical exams may need to be adapted to a virtual format. Administrative support is vital to making these changes to the curriculum in a timely and flexible fashion.

The distance learning time is also a great opportunity for resident-resident mentoring. At VMMC, one of the chief residents volunteered to review all overnight call cases daily, and to send the most high-yield cases with learning points to the junior residents.

Educating Trainees on Disaster Preparedness: Imminent and Future

At Stage 3 pandemic emergency status, all ACGME program requirements can potentially be suspended. Program directors and residents should be aware that trainees can be reassigned to clinical service outside of the radiology department, as long as supervision, PPE, and work hours are maintained (6).

With increasing demands for physician and other healthcare workers, radiology residents may be redeployed to deliver services in the emergency room, inpatient setting, or remotely via telemedicine in order to triage patients. Mental preparedness is the first step, and a review of donning and doffing of PPE is vital. For additional preparation, the Society of Critical Care Medicine is offering online education to healthcare professionals who may benefit from critical care training (7). The Society of IR offers a Critical Care Introductory Course to reinforce clinical knowledge for residents (8). An assessment of resident readiness for deployment can also help in planning. For instance, at UCSD, a survey led by the residents is in progress to collect data on individual clinical skill sets that can be readily available should redeployment to specific clinical areas become necessary. Residency program leadership also need to take an active role in hospital interdepartmental surge planning.

Communication and collaboration within the department and with other sections in the organization are of high importance in disaster preparations; in fact, getting involved with others in this crisis is an opportunity to get involved in health systems (9). With a dispersed team, it may be useful to hold periodic, if not daily, huddles as long as physical distancing is

TABLE 1. On-Line Resources for Radiology Resident Distance Learning Rotations

AUR Radiology Resident Core Curriculum Series	https://radiologyresidentcorelectures.com/
APDR Virtual Noon Conference Series	https://apdr.org/uploadedFiles/Content/Residents_Students/APDR_Noon_Conference_Schedule.pdf
ACR: -Continuous Professional Improvement (CPI) -Case in Point -PFCC Communication Curriculum with simulation videos -ACR-AMSER-APDR Lecture Series -Lung Cancer Screening Education -DXIT Exam Sets	https://www.acr.org/Lifelong-Learning-and-CME/Learning-Activities/Residency-Training-Hub
RSNA: Education Center -RadioGraphics -RSNA Physics Modules Patient Centered Care Curriculum	http://education.rsna.org/diweb/catalog https://www.rsna.org/-/media/Files/RSNA/Education/Educator-resources/Patient-centered-care-learning-set/rsna-pcc-modular-learning-set.ashx
Other Radiological Societies -American Society of Neuroradiology -Society of Thoracic Radiology -International Skeletal Society and Society of Skeletal Radiology -Society of Breast Imaging	https://www.asnr.org/education/neurocurriculum-live/ https://thoracicrad.org/?portfolio=education https://radiologycorelectures.org/msk/ https://www.sbi-online.org/EDUCATION/E-Learning.aspx
Teaching Files and Modules offered by Residency Programs & Hospitals -University of Rochester School of Medicine: Radiology Teaching Files -University of Virginia: Introduction to Radiology Online Tutorials -Cleveland Clinic Pediatric Radiology	https://www.urmc.rochester.edu/imaging/education/educational-resources/radiology-teaching-files.aspx https://www.med-ed.virginia.edu/courses/rad//index.html https://www.cchs.net/onlinelearning/cometvs10/pedrad/default.htm
Other On-Line Resources -Radiology Assistant: Educational Site of the Radiological Society of The Netherlands -Interactive Radiology Physics -Head Neck Brain Spine	https://radiologyassistant.nl/ http://www.xrayphysics.com/ http://headneckbrainspine.com/
Crowd-Sourced #FOAMrad (Free Open Access "Meducation" radiology) resources- compiled by Patricia Balthazar, MD, Radiology Resident, Emory School of Medicine	https://docs.google.com/document/d/15_Bh4fAsbpdrCrYjQvin6w-sZZ0WAwHtBn2w-va_mHQ/mobilebasic?urp=gmail_link

maintained (10). At Mount Sinai, there has been interdepartmental collaboration with the hospital Mass Casualty Incident team for residents to participate in drills for preparation; the radiology residents also use WhatsApp (Facebook, Menlo Park, California) to quickly assess the status of all the residents and faculty as part of preparedness for disaster response.

Meeting Radiology Resident Requirements for Graduation

The response statement from the ACGME and the Residency Review Committee (RRC) has emphasized that the 80-hour resident work week limit remains in effect for all three stages, as deviation could increase risks for both patients and trainees (4,11). In addition, the ACGME has suspended accreditation activities so that programs can focus on response to the pandemic (11).

Many program directors and residents may have questions regarding maintenance of case logs as the case number for resident participate may decrease. The RRC has reiterated that the goal of establishing the ACGME case logs was for evaluation of residency programs for accreditation, and not for evaluation of individual resident competence. However, the RRC notes that it is up to each program director in conjunction with the Clinical Competency Committee to assess each resident's educational and professional progress regarding

ability to practice autonomously by graduation. The actual numbers in the case log may be informative in this process, but should not hinder the program director or Clinical Competency Committee in this assessment as an absolute barrier. Depending on the length of the pandemic and impact on case volumes, it is possible that certain residents may benefit educationally and professionally from prolonging their tenure to ensure full depth and breadth of case and procedural experience. The ultimate goal is to ensure that safe, competent trainees are graduating as a long-term societal consideration, and adjustments that may be made to resident promotion should keep this goal in mind.

Residency program directors and program coordinators may find it beneficial to document the ways in which their program has been affected by the pandemic, including its effect on case volume, should there be a need for future review. In particular, it is desirable to have notes updated in the program-specific ACGME Web Accreditation Data System "Major Changes and Other Updates" section. This will better enable the RRC to take these factors into account during programmatic evaluation.

In their recent communication, the RRC offers special guidance regarding requirements for mammography, nuclear medicine and interventional procedures. Options for meeting requirements are offered, such as consideration of telemedicine on nuclear medicine and breast imaging rotations. However, it is important to note that federally mandated requirements for mammography (Mammography Quality Standards Act) and nuclear medicine (Nuclear Regulatory Commission) are still in effect as public safety measures. The RRC also offers guidelines for Early Specialization in IR programs, which may prove useful in advising those residents who are anticipated to fall short of completion of the 500 IR cases needed before graduation from DR residency. As long as these residents meet the 1000 IR caseload upon graduation from the independent IR residency, the RRC does not foresee any specific delays in training.

Program directors should support their residents directly impacted by the postponement of the DR and IR/DR Core Exams. The American Board of Radiology announced that those exams have been rescheduled for November 5–6 and 9–10, 2020, and has provided more information on their website, specifically with a statement on the impact of COVID-19 on training (12). Resident schedules will need to be readjusted to ensure appropriate educational experiences before the exam, and to allow for travel to the testing sites at those times. Board review sessions likely will need to be held virtually for a period of time as well.

Addressing Anxiety and Well-being Issues of Trainees and Faculty

Fear and anxiety about the pandemic, as well as adjustments to a change in lifestyle-related physical isolation, can have an adverse effect on well-being for both residents and faculty. Social media, such as Twitter, Instagram, and Slack can help residents and staff stay in communication with each other and form peer support groups. Social media can also be a useful resource for sharing ideas on how to respond creatively to the pandemic (13).

While physical distancing is important, so is maintaining social connection via other means. The department and residency community can stay connected through phone calls, video chats, and social media. Chief residents can set up a daily resident chat to review cases, discuss educational topics, and connect socially. There are a variety of on-line resources that can aid in wellness (Table 2). Moreover, institutions may offer specific wellness activities that can be accessed by residents. For instance, at Mount Sinai, in-person meditation sessions have been converted to a virtual format that all are welcome to join. Residents and faculty also benefit highly from practicing self-care such as sound sleep and exercise habits during these times of increased stress. If there are institutional funds normally used to support wellness activities, these funds could be offered to residents for use during the pandemic to sponsor virtual wellness gatherings, or to provide small gift cards for food or snacks. Other accommodations can be made to diminish resident stress and support well-being. For example, to prevent contamination and to ease laundering of clothes, trainees have been approved to wear scrubs during the pandemic in all sections at UCSD. Accommodations should also be made for residents with additional childcare or family needs.

TABLE 2. Wellness Resources for Residents and Program Directors

ACGME	
Links to many offerings by institutions and organizations for all residents	https://www.acgme.org/What-We-Do/Initiatives/Physician-Well-Being/Resources
ACR	
Radiology Well-Being Curriculum	https://www.acr.org/Member-Resources/rfs/learning/Well-Being-for-Residencies
Other	
List of Wellness Resources: Compiled by Rebecca Seidel MD, Breast Imaging Radiologist, Emory School of Medicine	https://docs.google.com/document/d/1KnK0dOacKEUNJIluV0x4UF3NMChbwtsc5P-GYTJinr0/edit?fbclid=IwAR3hsPzJG7z2AJMhOz9D2o1rsjfl_RqOBoMoGm7KpwSuU4aycWpL7Mb4tQc

Close communication with each resident is important to identify those facing stresses such as childcare, potential exposure to family members at high risk, effect on future job availability, and any other financial issues; additional resources should be readily available and provided as needed. With uncertainty regarding the length and course of the pandemic, reaching out to the group of future residents should also be considered, to provide reassurance and information about institutional and residency program status. In reality, however, some medical schools in the center of the pandemic just recently decided to graduate students early as a means to rapidly increase the workforce. In these states, licensing and credentialing of this new workforce accordingly has been expedited.

Communications likely will continue to be plentiful during the crisis. The frequency, volume, complexity and uncertainty in communication can contribute to stress. Given the explosion of COVID-19 related emails, news, messages, and information obtained through other sources, clarification of the chain of communication during these times is important to address feelings of uncertainty and anxiety. Communication expectations should be clear for residents. Program directors should state how often residents should be checking their work email given the rapidity of changes in staffing and protocols in response to the evolving crisis. It may be prudent to update resident contact information in case backup coverage is needed. To manage the volume of emails, resident communication can be included as part of the daily department e-huddle.

Many trainees have also dedicated time and energy to research and educational presentations at national conferences that have been cancelled. "Cancelled due to COVID-19" is a suggested phrase to use on the curriculum vitae to capture an invited lecture, abstract presentation or educational exhibit at a cancelled meeting. Some national societies, such as the ACR, have restructured their annual meeting into a virtual meeting to continue academic endeavors, and have converted all poster presentations into an electronic format. Residents should be encouraged to seek out virtual meetings and conferences, not only to supplement education, but also to foster connection and networking during these times of physical isolation.

CONCLUSION

Radiology training programs and program directors need to develop a specific plan in response to the COVID-19 pandemic to ensure the safety and wellness of their trainees and preserve a healthy workforce with increasing demands, while also maintaining the educational needs of their trainees as much as possible.

While some of the changes in educational format and structure have been implemented as temporary measures, they may result in permanent improvements that can support diverse learning styles and add flexibility. Radiology program directors and faculty should advocate for education on proper PPE in their work environments, as well as preparedness for possible redeployment. In the time of social distancing, self-isolation, and postponement of in-person conferences, the use of teleconferencing and social media to stay connected with the radiology community can be helpful to maintain ongoing networking and collaboration.

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