



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.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



# Remote Reading and Teaching of Nuclear Medicine in the Era of COVID-19

Edgar Zamora, MD, Renee M. Moadel, MD, MSc, Na Song, PhD, and  
Lionel S. Zuckier, MD, MBA, FRCPC

Community SARS-CoV-2 has profoundly affected traditional elements of learning and teaching in nuclear medicine and diagnostic radiology departments. The response of the nuclear medicine community to the challenges imposed by the COVID-19 pandemic can be described in 3 phases: accommodation, consolidation and optimization, and a return towards normalcy. Adoption of virtual communication platforms has emerged as the crucial interim tool for preservation of trainee supervision and diagnostic imaging education. Development of supplemental teaching materials, refocusing research interests, and relaxation of requirements have all contributed toward stabilization of the residency programs. As we embark on a gradual return to normalcy, many of the virtual solutions that were employed have gained a degree of enduring popularity and may find a place in the postpandemic period.

Semin Nucl Med 52:71-78 © 2021 Published by Elsevier Inc.

## Introduction

Community transmission of SARS-CoV-2 coronavirus disease 2019 (COVID-19) was first detected in the United States in February of 2020. The spread of this novel and highly transmissible pathogen imposed extraordinary challenges on government and institutions that affected medical care and education worldwide. Nuclear medicine departments implemented changes to protect patients and staff including physical distancing, wearing of facemasks, frequent hand washing, sanitization of surfaces, and deferral of nonacute studies.<sup>1-3</sup> Usual interactive methods of in-person image interpretation were no longer viable while apprentice-level supervision of resident activities, the core paradigm of traditional teaching in medicine, was disrupted. Many trainees in the hospital were urgently redeployed to COVID wards as facilities became overwhelmed with critically ill patients. The usual and diverse volume of patients seen in teaching departments was drastically curtailed and restricted.

As we look back on this period, understanding the impact that COVID-19 related changes had upon academic nuclear medicine practice will allow departments to better prepare for future challenges and possibly identify selected adaptations that merit

continuation. This review will collate observations and best practices from the literature, as well as offer illustrations from our own experience at Montefiore Medical Center in the Bronx, NY, one of the early epicenters of the pandemic in the United States, with over 200,000 positive cases reported in the Bronx during the period of March to May 2020.<sup>4,5</sup>

## Function of a Typical Pre-COVID Academic Department

The paradigm of patient care and education in academic nuclear medicine departments parallels that of other diagnostic imaging specialties and is fairly homogenous across multiple institutions with which we have experience. The majority of staff interactions occur in the reading room, a common space housing the image-display workstations and clinical information systems. As departments of nuclear medicine have expanded and computer-based information systems have proliferated, one of the tangible results has been a steady crowding of this typically space-constrained room. Prior to the pandemic, physical interaction and co-location of the staff in the reading room was central to function of the department as technologists, nurses, administrative staff, and referring providers would visit or call in to review and discuss cases with the attending physicians and residents. In addition to providing value to patient care, these interactions

Division of Nuclear Medicine, Department of Radiology, Montefiore Medical Center and the Albert Einstein College of Medicine, Bronx, NY.

Address reprint requests to Lionel S. Zuckier, MD, MBA, Division of Nuclear Medicine, Department of Radiology, Montefiore Medical Center, Bronx, NY 10467. E-mail: LZuckier@montefiore.org

present valuable learning opportunities for trainees to assimilate clinically relevant knowledge regarding management of patients from the perspective of ancillary staff and referring physicians.

In the realm of diagnostic imaging, trainees generally performed the initial assessment of images, drafting provisional reports, and only subsequently reviewed the cases with the supervising faculty member, typically in-person at the workstation. An important component of teaching occurs during these interactions, as attending physicians guide trainees by requesting additional views from the technical staff when necessary, highlighting important imaging findings, explaining underlying pathophysiology, and developing a differential diagnosis. Even the hectic ambiance of the reading room, with several workstations co-located in a small space, leads to learning opportunities based on shared and overheard conversations.

With respect to therapeutic nuclear medicine, patient care and teaching occur during patient consultations and the actual administration of therapy. In addition to the nuclear medicine attending physician and trainees, these procedures frequently include allied house-staff (diagnostic radiology and radiation oncology residents) and medical students who participate in interview and examination of patients in relatively close quarters. Assay of therapeutic doses takes place in the “hot lab”, a typically confined space, and is witnessed by the attending physician, technologist, and trainees, prior to subsequent administration to the patient.

In the pre-COVID-19 department, divisional meetings, such as Grand Rounds and Journal Club, and didactic lectures for the residents occurred daily and in-person. In spite of the need to assemble in one location, staff benefited by meeting physically, allowing them the opportunity to catch up personally and discuss issues of common interest. Interdisciplinary tumor boards, an important aspect of clinical care and education, typically occurred several times weekly, with domain experts in numerous specialties from across the hospital assembling in person. Trainees and staff in the division also attended professional conclaves and specialty meetings of regional, national, and international scope, bringing together experts from widely distributed geographical locations to share in dissemination of scientific knowledge on at least an annual basis.

## Response to COVID-19

### The Challenge

Patient care and education faced many foundational challenges arising from the pandemic. The sudden necessity of accommodating a surge of critically ill COVID-19 patients stressed availability of personnel, acute-care beds, and supportive equipment such as ventilators and personal protective equipment (PPE). Affected hospital centers moved into crisis mode as many nonessential hospital areas, such as dining halls and conference rooms, were rededicated to accommodating the burgeoning census of severely ill in-patients.

Based on directives of local health and legislative authorities, elective procedures were deferred and delayed, though performance of emergency and critical studies was generally maintained. Many patients adamantly avoided visiting the hospital or imaging centers due to fear of contagion, further leading to a decline in imaging studies. With onset of the pandemic, there was a marked decrease in imaging volumes and the diversity of cases<sup>6,7</sup>, largely limited to emergency studies such as pulmonary perfusion scintigraphy or inpatient studies such as evaluation of fever of unknown origin with <sup>67</sup>Ga-citrate or <sup>111</sup>In-oxine-WBC. Indeed, radiology training programs noted decreased volumes of resident case interpretations which especially affected specialized rotations such as mammography, magnetic resonance imaging, and nuclear medicine.<sup>7</sup>

Formal education was disrupted, as the crowded venues of the reading room and conference room represented an anathema to social distancing. So too, ongoing research, an important element of academic residency programs, was negatively impacted due to profound limitations in patient recruitment, availability of resources, and the reallocation of priorities. Odedra reported that up to 70% of Canadian radiology residents perceived a moderate or higher level of disruption of research activities.<sup>6</sup>

Due to the urgent need for physician staff to care for the influx of seriously ill COVID-19 patients, many residents in specialty disciplines were redeployed to primary or intensive care wards.<sup>6,8</sup> In other cases, trainees were waylaid by illness occasioned by the pandemic. In our institution, nuclear medicine and radiology residents were on stand-by of which only a small group were called to the wards. A cohort of residents volunteered to work on COVID-19 clinical units, an experience many ultimately found fulfilling. Interestingly, clinicians have described the benefits of working with diagnostic imaging trainees, experienced in both clinical care and diagnostic imaging, which included improved communications and consultations with the imaging specialties.<sup>9</sup> The seconding of residents from their diagnostic imaging programs impinged upon their ability to study primary-specialty material for several months of their finite residency period.

In summary, the initial arrival of COVID-19 patients spurred the medical center to adopt a defensive posture designed to maintain a safe working environment. COVID-19 presented many fundamental challenges to training programs: formal education ceased, patient volumes plummeted, and the volume and nature of interactions between attending physicians and trainees was decreased and degraded. Response of the nuclear medicine community can be described in 3 phases: (1) accommodation, (2) consolidation and optimization, and (3) return toward normalcy.

### Accommodation

The initial priority of nuclear medicine departments was for the safety of patients and staff; early institutional directives included physical distancing and the use of PPE, as recommended by the Centers for Disease Control and Prevention (CDC).<sup>10</sup> Disinfectant wipes meeting the Environmental

Protection Agency's criteria for use against SARS-CoV-2 were used to clean workstations daily, and frequent hand washing was encouraged as per the CDC guidelines. Staff was masked and PPE was rationed and made available to healthcare workers at every location. Staff members and patients were requested to fill out daily questionnaires to assess for symptoms of COVID-19 prior to entering the medical center.

Physical workstations were redistributed to unoccupied conference rooms which were converted into fully operational reading rooms and "thin client" workstations were created in physician offices to afford each trainee and faculty member at least 6-foot distance from other workers. A policy of "one physician one workstation" was established such that workstations were no longer shared on a daily basis. Provision was made for each attending physician to have full image-interpreting functionality from home however this in turn raised questions of performance and compliance. Several considerations arise when physicians interpret studies outside of the facility and are discussed in the following section. We mandated daily presence of residents in the reading rooms which were now arranged in a "socially distanced" manner. Some have suggested that senior residents, needing less supervision than junior trainees, could be deployed remotely, an option that would also be useful for immunocompromised or otherwise higher risk trainees, given provision of acceptable workstations.<sup>11</sup> We also maintained at least one nuclear medicine attending physician at each site, for trainee supervision, maintenance of morale, and to fulfill local regulations requiring presence of an Authorized User of radioactive materials where radiopharmaceuticals are administered.

Technologists, nurses, administrative staff and referring providers were asked to communicate with our reading rooms by telephone whenever possible and the physical sharing of paperwork and printed patient charts was minimized with reliance on scanned documents and the electronic record. Review of resident work by attending physicians was typically performed in either a synchronous or asynchronous manner with feedback given via the telephone. To a large degree, patient consultations and therapies were deferred during this period. In the accommodation period, all lectures, conferences, and tumor boards were cancelled due to lack of venue, paucity of clinical material, and frequently, attention being paid to more pressing issues. All travel, including educational meetings, was restricted.

## Considerations for establishing remote reading of nuclear medicine images

### Equipment considerations

When cases are viewed through remote access or screen sharing using communications software, image processing and rendering are performed on a centralized server within the institution, and only the images are sent over the network or internet. The requirements for the remote-reading computers' processing power are therefore lax. Sufficient bandwidth (at least 100 Mbps) and a stable internet connection are required to provide adequate network communications.<sup>31</sup>

Remote monitors must meet basic display requirements to ensure adequate rendering of the diagnostic imaging studies. Early in the pandemic, we noted that published regulations for primary diagnostic monitors (PDM) in nuclear medicine were scarce, posing a limitation for groups wishing to set up ad hoc workstations.<sup>32</sup> The main source of guidance available was published by the American Association of Physicists in Medicine (AAPM), which recommended a white display (maximum luminance)  $>120$  cd/m<sup>2</sup>, minimum luminance for black  $<2$  cd/m<sup>2</sup>, and luminance nonuniformity of  $<20\%$ .<sup>33</sup> The SNMMI and EANM practice guideline for tele-nuclear medicine 2.0, published in 2014, recommended that relatively simple test patterns should be readily displayable on remote monitors to assure quality control.<sup>34</sup> In Jan 2021, SNMMI Physics, Instrumentation, and Data Science Council published a more detailed guideline on remote nuclear medicine viewing, including ambient light, brightness/luminance, display bit depth, grayscale range, resolution, minimum physical size and pixel size, and color calibration, which are definitively discussed.<sup>31</sup>

### Security

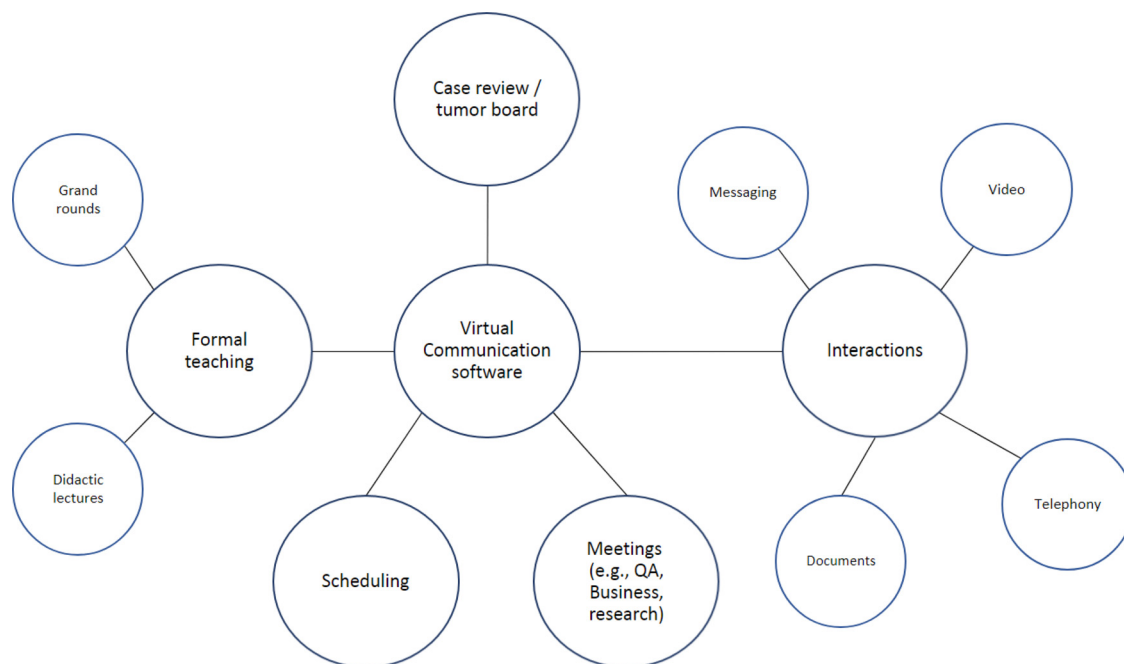
In general, a Health Insurance Portability and Accountability Act (HIPAA) compliant virtual communication platform is necessary to maintain adequate data security when sharing patient data. Due to the lack of supported platforms at the onset of the pandemic, The US Department of Health & Human Services (HHS) announced in March 2020 the waiving of potential HIPAA violations against health care providers who serve patients through virtual communication platforms such as Skype, or FaceTime, when used in good faith.<sup>35</sup> At our institution, patient sensitive data is not stored on off-site computers during remote case reading and teaching. Secure remote server access provided by Citrix is HIPAA compliant and the enterprise virtual communication platform in use at our institution also complies with HIPAA regulations for healthcare providers.

## Consolidation and Optimization

Components of the consolidation and optimization phase, which began within several weeks of the accommodation phase, include emergence of virtual communication platforms, development of supplemental teaching material, refocusing of research interests, and relaxation of training requirements, which will be discussed in turn below.

### Emergence of Virtual Communication Platforms

Following a period of accommodation to the new situation, efforts were made to reorganize the learning environment under the prevailing constraints in a more optimal manner. Technological solutions were employed as a means of connecting staff virtually, even while physically separated.<sup>12</sup> Nuclear medicine and radiology, which for many years have shifted to interpretation of images presented electronically, were well situated for remote viewing and teaching. In our Division, we initially employed Skype for Business (Microsoft Corporation, Redmond, WA) as a unified communication solution, but migrated shortly thereafter to its replacement,



**Figure 1** Web of applications of HIPAA compliant virtual communications software leveraged in our academic nuclear medicine residency program.

Microsoft Teams (Microsoft Corporation, Redmond, WA), both platforms supported by our Information Technology group throughout the entire medical enterprise. These and several other commercially available software suites facilitate messaging, file sharing, video calls, conferencing, and screen sharing, often including interactive sharing of the desktop, among built-in functions (Fig. 1). As enterprise-wide software, there was no purchase cost to the Division, minimal technical overhead, and preexisting hospital-wide support.

Communication suite software allowed attending physicians and trainees to closely supervise review of cases while maintaining separate and distanced workstations. Residents contacted faculty members via the call or message function in a standard manner, irrespective of their location on any specific day, and were able to share their desktop including mouse and keyboard controls (Fig. 2). On computers used for reporting, the dictation handset doubled as a high-quality microphone and speaker for telephony. Experience using communication software suites was judged by a cohort of radiology and nuclear medicine residents as safer than other methods of case review, including face-to-face review, while generally providing efficient communication (Fig. 3). Multiple users are able to join in in a scalable manner, facilitating interesting case teaching sessions and tumor boards, which were restarted with the resumption of elective procedures.

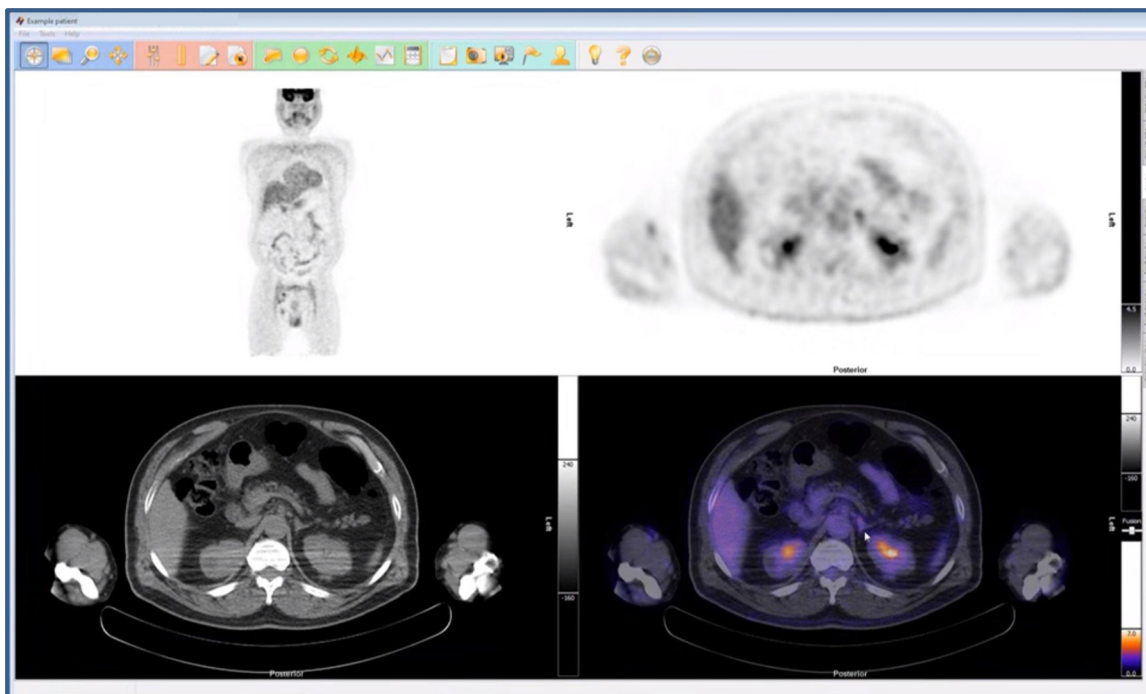
Several radiology groups have also reported use of other similar virtual communication platforms for review of clinical cases and presentation of teaching rounds. Li implemented virtual read-out sessions through Zoom allowing residents to participate in diagnostic imaging interpretation either onsite or through a remote workstation<sup>13</sup> These methodologies also facilitated the restoration of didactic

lecture series. The standard array of daily lectures and rounds was reestablished based on our virtual communication platform. In our experience, there was a paradoxical increase in ease of attendance as need for traveling across the various sites to attend lectures was eliminated. Requirements for hosting high caliber “visiting” speakers was also lowered, in that support for travel and lodging was not needed. So too, there was increased ease of attending national and international conferences which also restarted, based on virtual platforms.

Utilizing Zoom (Zoom Video Communications, San Jose), Nakaya compared effect of remote versus onsite nuclear medicine technology lectures, assessed by student questionnaire, reporting that virtual sessions were superior with respect to reviewing material (possibly due to recaptured travel time) and presented a superior environment for asking questions (as submitting questions via chat was not intimidating, even for reticent students), but scored significantly lower with respect to student concentration.<sup>14</sup> The authors thought that this could be improved by use of student webcams to facilitate their greater face-to-face participation. Patchoros and Wenzler,<sup>15</sup> in discussing a novel method of nuclear medicine technology education based on student review and presentation of nuclear medicine literature, also noted that presenting and asking questions online lowered students’ level of anxiety, in that “public speaking” had become not quite public.

As a general rule, consultations for radionuclide therapy were resumed over the telephone. Patients came to the hospital for therapy however the amount of face-to-face interaction was minimized based on extensive previsit discussions over the telephone.



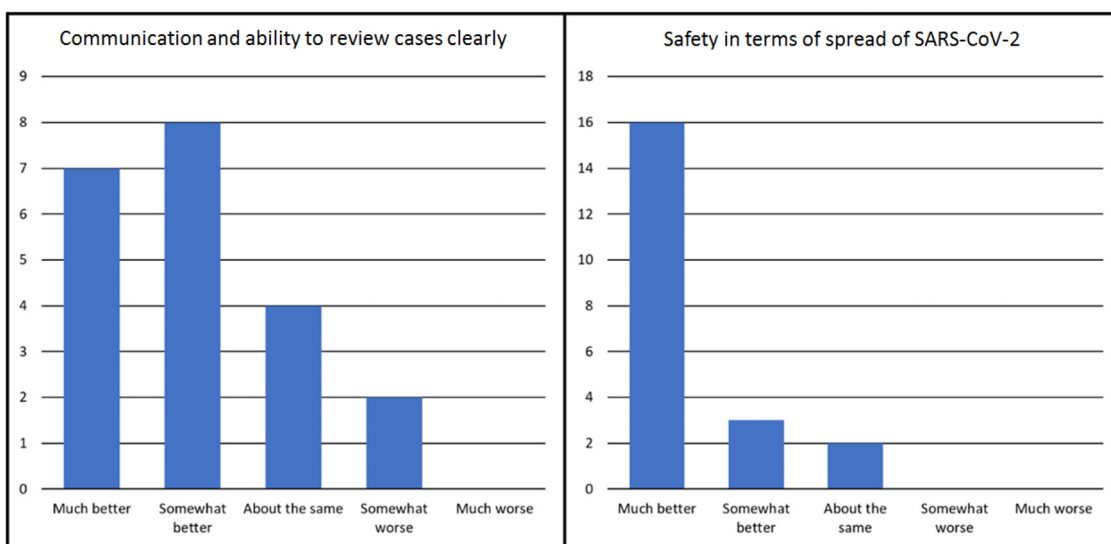


**Figure 2** Screen appearance on attending-physician’s computer monitor during review of a PET/CT case on MS Teams, one of several virtual communication platforms that have been used during the pandemic. Both teacher and trainee can scroll, point, and otherwise control the display while conversing in real time. Note the small arrowhead, directed by the resident in this instance, pointing to the left adrenal gland on the fused panel.

**Development of Supplemental Teaching Material**

In order to compensate for reduced image volumes and diversity of cases, Slanetz et al.<sup>16</sup> suggested that faculty can provide trainees with lists of teaching cases for self-study. Recht et al.<sup>17</sup> employed simulated daily read out sessions where residents would review and dictate generated worklists

comprising of a diverse case mix; this was received with an overall positive reception by residents and attendings. In our division, residents themselves systematically searched local databases to identify interesting cases performed in the department of nuclear medicine in previous years; these were shown during the weekly virtual interesting case conference,



**Figure 3** Resident survey evaluating clarity in communication (left panel) and perceived safety from spread of COVID-19 (right panel) in nuclear medicine case review and learning sessions based on the virtual communication platform illustrated in Figures 1 and 2, as compared to other methodologies, including in-person sessions. The ordinate axis corresponds to number of residents answering each response.

**Table 1** Online Educational Resources in Nuclear Medicine and Molecular Imaging

<b>Sponsor</b>	<b>Content</b>	<b>Website</b>
International Atomic Energy Agency (IAEA) #	DATOL: Online training resources for Nuclear Medicine professionals. Teaching cases and lectures. E-learning modules. Guidelines.	<a href="http://www.iaea.org">www.iaea.org</a> <a href="http://humanhealth.iaea.org">humanhealth.iaea.org</a>
Asian Regional Cooperative Council for Nuclear Medicine (ARCCNM) #	E-learning modules.	<a href="http://www.rcaro.org/elearning/">www.rcaro.org/elearning/</a> <a href="http://www.arccnm.org">www.arccnm.org</a> <a href="http://www.aofnmb.org">www.aofnmb.org</a>
Mallinckrodt Institute of Radiology, Washington University School of Medicine #	Online teaching files.	<a href="https://www.mir.wustl.edu/patient-care/clinical-specialties/nuclear-medicine/teaching-file">https://www.mir.wustl.edu/patient-care/clinical-specialties/nuclear-medicine/teaching-file</a>
Society of Nuclear Medicine and Molecular Imaging (SNMMI) *	Technology (JNMT) audio lectures on PowerPoint. Teaching cases. Study guides. Textbooks and online assessment tools.	<a href="http://www.snmmi.org">www.snmmi.org</a>
European Association of Nuclear Medicine (EANM) *	Basic Nuclear Medicine and PET/CT webinars. Guidelines.	<a href="http://www.eanm.org">www.eanm.org</a>
American Society of Nuclear Cardiology (ASNC) *	Guidelines. Online CME and webinars. Board certification educational resources. Nuclear Cardiology self-assessment modules.	<a href="http://www.asnc.org">www.asnc.org</a>
Radiopaedia.org ~	Open-edit radiology resource.	<a href="http://www.radiopaedia.org">www.radiopaedia.org</a>
AuntMinnie.com ~	Comprehensive community internet site for radiologists and related professionals including cases and online textbook.	<a href="http://www.auntminnie.com">www.auntminnie.com</a>
QEVLAR + eScan Academy +	Self-directed board exam preparation. Independent online resource with nuclear medicine lectures and interactive teaching material.	<a href="https://www.imaios.com">https://www.imaios.com</a> <a href="http://www.eScan.com">www.eScan.com</a>

Adapted from Gnanasegaran (20).

#Free content.

\*Content free for members of society or association.

~Free basic and premium paid content.

+Paid content.

resulting in robust didactic discussion identical to that generated by active real-time cases.

Larocque reported upon a virtual learning program where radiology residents alternated tracks between in-hospital subspecialty work and at-home review of a subspecialty based virtual learning curriculum, with the majority of residents reporting high satisfaction. The most frequent barriers to attending this virtual curriculum were technical difficulties (43%) and childcare (36%).<sup>18</sup>

Because students could no longer come in to review teaching cases in the hospital, Biermann implemented a remote yet “hands-on” solution for PET/CT interpretation, through a plugin that connected medical students’ personal computers with a central image database at the university, associated with a high degree of student satisfaction.<sup>19</sup>

Online educational resources which have proliferated in general, gained increasing popularity by providing readily

accessible learning material for physicians challenged by traditional onsite learning limitations and reduced case volumes (Table 1).<sup>20</sup> Many resources are provided at no cost by medical societies (ie, The Society of Nuclear Medicine and Molecular Imaging<sup>21</sup>), international agencies (ie, The International Atomic Energy Agency<sup>22</sup>), or as components of commercial websites (ie, Aunt Minnie<sup>23</sup> and Radiopaedia<sup>24</sup>). Additionally, the Mallinckrodt Institute of Radiology, Washington University School of Medicine provided extensive online nuclear medicine teaching files to compensate for the paucity of cases during this period of time.<sup>25</sup>

Implementation of virtual communication platforms has further facilitated quick sharing and group access of online educational material for cohort learning sessions. These tools provide various advantages over traditional “on-site” learning, such as increased time flexibility, access to large amounts of information, and individualized learning.<sup>20</sup> Nevertheless,

online learning has been associated with limitations such as increased social distancing and distractibility and as such may be best employed as a complement to more traditional learning methodologies.

### Refocusing of Research Interests

While the pandemic had a negative effect on ongoing research endeavors, it did lead to new opportunities as well. Lessons learned early in the diagnosis and management of COVID-19 patients provided an opportunity for residents and faculty to share their knowledge with others in written and oral forums, making productive use of time repurposed from decreased clinical activities. Within our Division of Nuclear Medicine, this prompted multiple research projects and scholarly activities for residents and staff including oral and poster presentations at national meetings and publication of papers advocating best practices in education and clinical care and describing case report findings. We estimated approximately 450 articles regarding nuclear medicine and COVID-19 were published in the peer-reviewed English-language medical literature during 2020 alone, serving the important function of sharing experience and best practices.

### Updating of Training Requirements

The American Board of Nuclear Medicine recognized the overall decrease in patient volumes nationwide, and issued a statement on March 25, 2020 to downgrade case experience requirements for nuclear medicine residents and fellows completing training in 2020.<sup>26</sup> So too, case minimum requirements for board eligibility were adjusted in other specialties including diagnostic and interventional radiology.<sup>27</sup> The American College of Graduate Medical Education (ACGME) accreditation council allowed virtual conferences to fulfill required hours of didactic education. For radiology residents, telemedicine rotations for senior residents impacted by the COVID-19 pandemic were permitted to count toward the required minimum of 700 hours of training and supervised nuclear medicine experience. The ACGME permitted Diagnostic Radiology program directors with assistance from the Clinical Competency Committee to graduate residents deemed competent even if certain minimum requirements were not met,<sup>27,28</sup> and allowing postgraduate documentation of supervised radioiodine treatment for graduating senior residents. Nuclear medicine trainees were afforded an additional 2 weeks of medical leave if affected by COVID-19.<sup>26</sup>

### Return to Normalcy

Widespread vaccination of healthcare workers at our institution, coupled with a sharp decrease in infection in the community, has brought us back to in-person review with attendings and trainees again co-located at the workstation and participating in consultations and procedures in person. Precautions such as mask wearing, frequent hand washing, surface sanitization, and physical distancing continue as of this writing. More recently, there has been increasing concern over novel SARS-CoV-2 variants with new spike glycoprotein

mutations, and whether these changes lead to vaccination resistance<sup>29,30</sup> making caution prudent until the virus is controlled globally.

## Conclusions

The COVID-19 pandemic has led to a multitude of changes in the operations of nuclear medicine and radiology residency programs. Virtual communications software has been used to maintain daily case review, reintroduce conferences and meetings, and disseminate lectures. Additionally, embrace of technology by medical societies has allowed trainees to attend and present research and scholarly projects at local, national, and international scientific meetings.

Although virtual communication was fundamental to safe operations during the pandemic, this approach is associated with limitations, including a perceived decrease in personalized teaching by some trainees and increased distractibility, yet many residents report a desire to maintain elements of virtual learning post-pandemic.<sup>18</sup> As immunization efforts continue to expand, residency training programs are slowly returning to a more traditional teaching structure. Based on the benefit and reported success of virtual online learning, we should consider which of the new methodologies should continue being employed, and with which modifications. Larger training systems with dispersed campuses may be able to leverage remote communication software to minimize idle travel time for conference attendance. Hybrid systems that include both onsite and online learning, under development, may be helpful in tailoring the learning environment to different styles of the learners. As we return to “normal”, it may be worthwhile to maintain some aspects of virtual communications in resident education.

## ACKNOWLEDGEMENTS

We wish to recognize the dedicated trainees and staff who diligently contributed to patient care and maintained a dynamic learning environment over the challenging period of the COVID-19 pandemic.

## References

1. COVID-19: Executive orders by state on dental, medical, and surgical procedures. Available at: <http://www.facs.org/covid-19/legislative-regulatory/executive-orders>.
2. Paez D, Gnanasegaran G, Fanti S, et al: COVID-19 pandemic: guidance for nuclear medicine departments. *Eur J Nucl Med Mol Imaging* 47:1615-1619, 2020
3. Annunziata S, Bauckneht M, Albano D, et al: Impact of the COVID-19 pandemic in nuclear medicine departments: preliminary report of the first international survey. *Eur J Nucl Med Mol Imaging* 47:2090-2099, 2020
4. Centers for Disease Control and Prevention: Geographic Differences in COVID-19 Cases, Deaths, and Incidence — United States. *MMWR*, 2020 February 12–April 7. Available at: <https://www.cdc.gov/mmwr/volumes/69/wr/mm6915e4.htm>. Accessed May 31, 2021
5. NYC Health. COVID-19: Data. <https://www1.nyc.gov/site/doh/covid/covid-19-data.page>. Accessed May 31, 2021.



6. Odedra D, Chahal BS, Patlas MN: Impact of COVID-19 on Canadian radiology residency training programs. *Can Assoc Radiol J* 71:482-489, 2020
7. Poyiadji N, Klochko C, LaForce J, et al: COVID-19 and radiology resident imaging volumes-differential impact by resident training year and imaging modality. *Acad Radiol* 28:106-111, 2021
8. Ramjit A, Gokli A: Brief communication: A radiology resident's experience with COVID-19 in New York City. *Clin Imaging* 71:178-179, 2021
9. Atallah J, Shah S, Toy D, Dodelzon K, Schweitzer AD: The importance of imaging - Perspectives from redeployment. *Clin Imaging* 69:380-383, 2021
10. Centers for Disease Control and Prevention. Public health guidance for community-related exposure. 2021-03-01T04:24:03Z. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/php/public-health-recommendations.html>.
11. Chong A, Gagetsu NJ, Yen A, et al: Radiology residency preparedness and response to the COVID-19 pandemic. *Acad Radiol* 27:856-861, 2020
12. Moadel RM, Zamora E, Burns JG, et al: Remaining academically connected while socially distant: Leveraging technology to support dispersed radiology and nuclear medicine training programs in the era of COVID-19. *Acad Radiol* 27:898-899, 2020
13. Li CH, Rajamohan AG, Acharya PT, et al: Virtual read-out: Radiology education for the 21st century during the COVID-19 pandemic. *Acad Radiol* 27:872-881, 2020
14. Nakaya K, Yasuda E, Muto H, et al: Educational effect of remote lessons. *J Nucl Med Technol* 2020
15. Patchoros GP, Wenzler G: Satisfying program level outcomes by integrating primary literature into the "online" classroom. *J Nucl Med Technol* 2021
16. Slanetz PJ, Parikh U, Chapman T, Motuzas CL: Coronavirus disease 2019 (COVID-19) and radiology education-strategies for survival. *J Am Coll Radiol* 17:743-745, 2020
17. Recht MP, Fefferman NR, Bittman ME, et al: Preserving radiology resident education during the COVID-19 pandemic: The simulated daily readout. *Acad Radiol* 27:1154-1161, 2020
18. Larocque N, Shenoy-Bhangle A, Brook A, et al: Resident experiences with virtual radiology learning during the COVID-19 pandemic. *Acad Radiol* 28:704-710, 2021
19. Biermann M, Kanoun S, Davidsen T, et al: An open source solution for "Hands-on" teaching of PET/CT to medical students under the COVID-19 pandemic. *Nuklearmedizin* 60:10-15, 2021
20. Gnanasegaran G, Paez D, Satheke M, et al: Coronavirus (COVID-19) pandemic mediated changing trends in nuclear medicine education and training: time to change and scintillate. *Eur J Nucl Med Mol Imaging* 2021
21. Society of Nuclear Medicine and Molecular Imaging. SNMMI learning center. Available at: <https://www.snmmilearningcenter.org/lms/home>. Accessed May 31, 2021.
22. International Atomic Energy Agency. Training material. May 31, 2021; Available at: <https://www.iaea.org/resources/rpop/resources/training-material#7>.
23. Nuclear Medicine Case Library. <https://www.auntminnie.com/index.aspx?sec=olce&sub=cotx&pag=archive&categories=72>. Accessed May 31, 2021.
24. Radiopedia.org. Radiology courses. Available at: <https://radiopaedia.org/courses?lang=us>. Accessed May 31, 2021.
25. Mallinckrodt Institute of Radiology. MIR nuclear medicine teaching files. Available at: <https://www.mir.wustl.edu/patient-care/clinical-specialties/nuclear-medicine/teaching-file>. Accessed May 31, 2021.
26. Gordon L: ABNM: Helping diplomates and trainees during the COVID-19 Pandemic. *J Nucl Med* 61:13N, 2020
27. Accreditation Council for Graduate Medical Education. Special communication to diagnostic radiology residents, interventional radiology residents, subspecialty radiology fellows, and program directors. Available at: <https://www.acgme.org/Portals/0/Documents/COVID-19/RadCOVID19LTC.pdf>. Accessed May 31, 2021.
28. Warhadpande S, Khaja MS, Sabri SS: The impact of COVID-19 on interventional radiology training programs: What you need to know. *Acad Radiol* 27:868-871, 2020
29. Korber B, Fischer WM, Gnanakaran S, et al: Tracking changes in SARS-CoV-2 spike: Evidence that D614G increases infectivity of the COVID-19 Virus. *Cell* 182:812-827, 2020, e819
30. Conti P, Caraffa A, Gallenga CE, et al: The British variant of the new coronavirus-19 (Sars-Cov-2) should not create a vaccine problem. *J Biol Regul Homeost Agents* 35:1-4, 2021
31. Wallis JW, Klein R, Bradshaw TJ, et al: Guidelines on setting up stations for remote viewing of nuclear medicine and molecular imaging studies during COVID-19. *J Nucl Med Technol* 49:2-6, 2021
32. Song N, Zuckier LS: A dearth of specifications regarding primary diagnostic monitors (PDMs) for nuclear medicine leaves us with little guidance during the COVID-19 pandemic. *J Appl Clin Med Phys* 21:321-322, 2020
33. Halama JR, Graham D, Harkness BA, et al: Acceptance Testing and Annual Physics Survey Recommendations for Gamma Camera, SPECT, and SPECT/CT CT Systems. The Report of AAPM Task Group 177. American Association of Physicists in Medicine, 2019
34. Parker JA, Christian P, Jadvar H, Sattler B, Wallis JW: The SNMMI and EANM practice guideline for tele-nuclear medicine 2.0. *J Nucl Med Technol* 42:15-19, 2014
35. U.S. Department of Health & Human Services. Notification of enforcement discretion for telehealth remote communications during the COVID-19 nationwide public health emergency. <https://www.hhs.gov/hipaa/for-professionals/special-topics/emergency-preparedness/notification-enforcement-discretion-telehealth/index.html>. Accessed May 31, 2021.