



# Update on establishing and managing an overnight emergency radiology division

Meir H. Scheinfeld<sup>1</sup> · R. Joshua Dym<sup>2</sup>

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## Abstract

Emergency department (ED) radiology divisions that serve to provide overnight attending coverage have become an increasingly common feature of radiology departments. The purpose of this article is to review the common ED radiology coverage models, describe desirable traits of emergency radiologists, and discuss workflow in the ED radiology setting. ED radiologists may be trained as ED radiologists or may develop the necessary skills and adopt the subspecialty. Choosing radiologists with the correct traits such as being a “night owl” and remaining calm under pressure and implementing an acceptable work schedule such as shift length of 9–10 h and a “one week on, two weeks off” schedule contribute to sustainability of the position. Strategies to address the unique stressors and workflow challenges of overnight emergency radiology coverage are also presented. Workflow facilitators including trainees, PAs, radiology assistants, and clerks all have roles to play in managing high case volumes and in making sure that the service is well staffed. Usage of artificial intelligence software is the latest technique to streamline workflow by identifying cases which should be prioritized on a busy worklist. Implementing such strategies will maintain quality of care for patients regardless of time of day as well as sustainability and quality of life for overnight emergency radiologists.

**Keywords** Emergency radiology · ED radiology · Overnight · Staffing · Burnout

## Introduction

Over the past decade, emergency department (ED) radiology has become an essential component of academic and non-academic radiology practice. The emergency radiology subspecialty has continued to develop in parallel with emergency medicine and has evolved with the increasing complexity of emergency imaging [1]. Some academic ED radiology divisions provide 24/7 coverage; in this model,

dedicated radiologists are completely focused on the ED worklist around the clock, and the ED benefits from having a single point of contact with radiology. Many other ED radiology practices have been born of the necessity to provide overnight attending-level coverage. Whereas in the past, these hours were covered by trainees functioning independently or by commercial teleradiology services, there has been steadily increasing departmental and/or institutional desire to shift toward in-house, attending-level, overnight radiology coverage [2]. Market demand for emergency radiologists and emergency radiology coverage confirms the strong and growing interest in emergency off-hour coverage [3].

In the practice of overnight emergency radiology, there are unique issues which are not found to the same degree in other radiology subspecialties, including an unrelenting desire to decrease reporting turnaround time, high risk of social isolation and burnout, nonstandard work schedules, and balancing the need for generalist and subspecialty skills [4–6]. The purpose of this update is to provide the latest data and ideas regarding ED radiology operational and personnel management, with a focus on the unique aspects of overnight

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✉ Meir H. Scheinfeld  
mscheinf@montefiore.org

R. Joshua Dym  
rjd253@njms.rutgers.edu

<sup>1</sup> Department of Radiology, Division of Emergency Radiology, Montefiore Medical Center, Albert Einstein College of Medicine, 111 East 210 Street, Bronx, NY 10467, USA

<sup>2</sup> Department of Radiology, Division of Emergency Radiology, University Hospital, Rutgers New Jersey Medical School, 185 South Orange Avenue, MSB F508B, Newark, NJ 07103, USA

coverage. It is important to remember that although this update will focus on radiologists, radiologists are only one component of the imaging chain from order to final report. Essential staff including technologists, nurses, physician assistants, radiology assistants, and/or clerks are also necessary to facilitate the smooth functioning of emergency radiology imaging [7].

### Establishing an overnight ED radiology division: pros and cons

There are several advantages to ED radiology overnight coverage. To start, although there have been multiple reports demonstrating a low trainee on-call error rate, it is difficult to rationalize how trainees functioning alone would provide a higher level of care than attending radiologists [8]. Having contemporaneous attending-level interpretations avoids the potential medicolegal liability of not having finalized reports at the time of potential emergency surgical intervention or the decision to defer intervention [9]. Finalized reports at the time of patient discharge decreases the ED call-back rate for missed findings in preliminary reports, and also allows for discharge of patients who would otherwise have been observed in the ED pending the finalized report in the morning, thus preventing unnecessary increases in length of stay [10]. Continuous reading of cases during the overnight period obviously provides a better report turnaround time compared to a model in which all cases would only be finalized in the morning [11]. Aside from its direct impact on patient care and disposition, the turnaround time metric is of special import as some specialty designations require reporting within a certain time frame. (For example, in New York State, a primary stroke center must have “Door to Brain Image Read” time within 45 min 85% of the time [12].) Finally, just as other specialty attendings that frequently consult in the ED (e.g., OB/GYN, surgery, and neurology) are available in-house 24/7, so too there is an increasing expectation from a public relations standpoint for radiologists to also be available.

On the other hand, there are also disadvantages to having a dedicated overnight ED radiology division. Overnight radiologists are hired at a premium due to the undesirable work hours and relative scarcity of these radiologists. In one report, there was an 18% salary premium for overnight radiologists compared to daytime radiologists [13]. ED radiology attendings may encounter cases with new devices, unusual prior surgeries or rare diagnoses which are unfamiliar to emergency radiologists such that their interpretations may be inferior to a subspecialist in that area. Furthermore, some subspecialty-level subtleties may never be detected. Finally, it has been argued that on-hand ED radiologists may result in a loss of trainee independence, possibly impacting

education and development of confidence [14]. However, although there may be some merit to this contention, it is also true that a degree of independence exceeding what is warranted can be counterproductive, and that a lack of real-time attending supervision and feedback can compromise the resident educational experience. In one recent study, a survey of radiology residents following implementation of overnight attending coverage found that 95% felt that they retained adequate independence on-call, with 84% stating that the attending coverage improved their on-call educational experience [15].

Many of the factors listed above do not have data correlated with patient outcomes. Practically speaking, staffing an emergency radiologist or multiple emergency radiologists at night will only be sustainable if there are ample overnight imaging cases to be read and there is financing for the division’s radiologists. A practical target would be an average of 8–10 thousand wRVU per radiologist per year, with adjustments for cFTE (clinical full-time equivalent) for each faculty member. Depending on the exact practice situation, this volume may derive purely from the ED or also from STAT inpatient exams. The exact wRVU target should vary based on case-mix as well as the amount of time spent on non-interpretive tasks and preliminary interpretations, as these efforts are not captured by the radiologist’s wRVU tally.

## Staffing

### What are the staffing options?

A true emergency radiology division requires radiologists that are full-time members of the division. Having overnight coverage provided solely by rotating subspecialists from other radiology specialties and/or by fellows in training does not allow for development, honing and maintenance of ED radiology skills [16]. Aside from the actual reading of cases, dedicated emergency radiologists may participate in administrative duties and engage in research and trainee teaching, depending on the setting. As long-term members of the division, they are committed to covering necessary shifts when there is a need (paid or unpaid depending on the situation) and they are dedicated to the success of the division. Additionally, there may be a need to enlist additional radiologists to help cover the busiest hours of the night, which is generally the first part. This can be accomplished by means of a regular evening swing shift overlapping with the overnight shift hours or with a “short-call” shift during the early overnight hours that may be staffed by moonlighting ED radiologists, subspecialty faculty members from other divisions or per diem radiologists who primarily work at other institutions. Commercial teleradiology providers who read

individual cases or types of cases can also be used to span periods of high volumes on a regular or an as-needed basis.

When subspecialty faculty members from other divisions participate in covering short calls during the later evening, consideration must be made to shift length and ending time. For example, if the short call will be 4 h in duration, then the radiologist covering that shift should be able to arrive at least 4 h later than usual on that day so that their workday does not become too long, which can impact job satisfaction as well as patient safety. Providing extra time off (such as coming 6 to 8 h late when doing a 4-h after-hours shift) would create an added incentive for faculty members taking these calls. Ending time is also an important consideration. If the radiologist is expected to be on duty the next day at 9 AM, then the short call shift cannot end too late. There is no literature addressing a minimum off-time between shifts for radiologists; however, a minimum of 10 h off between shifts seems reasonable. These considerations are less relevant when utilizing moonlighting ED radiologists (during an “off week”) or per diem outside radiologists for whom clinical duties for the next day do not have to be considered.

### What subspecialty training do ED radiologists have?

In a recent paper surveying ED radiology fellowship programs, there were 18 North American emergency radiology fellowships [17]. These do not graduate sufficient ED radiologists to meet current demands [3]. Many ED radiology positions are filled by radiologists with other fellowship training or without fellowship training. In a 2017 survey, abdominal imaging, None, ED radiology, neuroradiology and musculoskeletal radiology were the most common fellowships performed by ED radiologists [18].

More important than training are the skills of the emergency radiologist. For example, if the position is stroke-imaging intensive, it would be prudent for the ED radiologist to be well equipped to read (at minimum as a preliminary interpretation) the full spectrum of stroke imaging efficiently and accurately. If a children’s hospital is being covered, being comfortable interpreting pediatric imaging would be a requirement. Different institutions have different requirements for on-site ED radiologists to perform or supervise minor procedures overnight such as intussusception reductions, pediatric upper GI studies, barium swallows and retrograde urethrograms. If these are required, the ED radiologist must develop proficiency in these procedures.

The same principle would apply to new diagnostic exams or techniques which become adopted into ED radiology practice; the ED radiologist would need to develop the necessary competence in order to provide the required service. Ultimately, the ED radiologist needs to be specialized in the practice of ED radiology rather than a “super-generalist” radiologist who can read every single study. For example,

the general radiologist may need to read a mammogram or bone age study, but this would be unnecessary for an emergency radiologist. Therefore, the ED radiologist must continually evolve with the trend of the subspecialty and the practice at which they are working in order to provide effective and timely service.

### What are the stressors in (overnight) ED radiology practice?

Stress refers to too much physical demand or too much mental demand. Burnout refers to a state of exhaustion where there is a lack of motivation, a sense of detachment, feelings of ineffectiveness and lack of accomplishment, and a perceived lack of control. In a 2011 survey, emergency medicine physicians were found to have the highest burnout rate among physicians [19]. Many of the factors contributing to burnout in ED clinicians are also found in ED radiologists, including high volume, unpredictable volume, and strong turnaround time pressures. A survey by Hanna et al. found that emergency radiologists who do no night shift work had 2.2 times higher odds of enjoying their job compared to those who worked 17 or more weeks of night shifts per year (i.e., the equivalent of a “one week on, 2 weeks off” schedule) [18].

There are many possible causes for the decreased job satisfaction of night shift workers and different lifestyle and job-related factor(s) may be applicable to different ED radiologists. Regarding lifestyle factors, the substantial commitment to night, evening, weekend and holiday coverage may lead to isolation from one’s family, friends and social support system. A poorly developed backup coverage system to enable dealing with potential emergencies outside the workplace (e.g., family emergencies) may lead to radiologists having to choose between work and family obligations. Diurnal rhythms may be disrupted by switching between day and night schedules and insomnia or somnolence may be triggered, particularly at switch-overs. Isolation from departmental functions such as meetings, conferences and research opportunities may lead to lack of opportunity for advancement: “out of sight, out of mind.”

There are many on the job stressors which accompany the actual task of reading cases. Cases may be left over from the prior shift leading to a backlog which must be read prior to beginning the cases from the overnight shift. There is a constant focus on faster turnaround times, with the ED commonly calling the reading room for an interpretation soon after a study is performed. There are commonly high volumes, including spikes in volume that may occur at variable and unpredictable times. Due to thin nighttime ancillary staffing, there are interruptions due to phone calls (which may not be related to actual interpretations) and requirement to perform non-interpretive tasks (e.g., ordering contrast or

managing contrast extravasations and allergic reactions). Indeed, such interruptions have been shown to cause greater error rates for radiology residents [20]. Moreover, high acuity ED cases have a greater potential for medicolegal hazards compared to inpatient and outpatient cases [21].

### **What personality traits and temperament are a good fit for ED radiologists?**

Whether one is a “night owl,” i.e., feeling more awake and alert at night, is a meaningful consideration for a radiologist contemplating working all or most of their shifts during the overnight period. Five to 10% of the population is believed to fit into this category and being able to identify these people may not be easy [22]. Having a well-developed social support network or not requiring social support is another important consideration for an overnight job. Regardless of time of day, emergency radiologists should have a broad radiology knowledge base and wide range of radiology interests in order to be prepared for the variety of cases and findings typically encountered in the ED. Additional factors include being able to manage stress and ability to work in a disruptive, noisy and sometimes chaotic environment.

### **What strategies can be used to foster sustainability and quality of life in an ED radiology position?**

Minimizing staff turnover leads to well-trained and experienced ED radiologists who are adapted to the work schedule, understand the institutional workflow and are able to provide excellent service. Addressing stressors makes the overnight ED radiology position sustainable, while failing to address them leads to a “churn and burn” paradigm that is detrimental to adequate staffing and a consistent high level of service. Methods of fostering sustainability fall into three categories: personnel, job satisfaction and operational.

For personnel, identifying radiologists with the correct temperament and traits as described above is essential. A radiologist who is initially attracted to the “one week on, two weeks off” work schedule but is not able to adjust to sleeping during the day and working all night will not last long in an overnight emergency radiology position.

How to foster job satisfaction depends on the individual. Some will appreciate the position more if they remain engaged with other radiologists and functions in the department, while others may prefer to work their overnight shifts and then be uninvolved with other departmental pursuits during their time off. Some overnight radiologists may enjoy the opportunity to work scheduled or moonlighting daytime shifts in order to participate in the daytime activities of the department and to interact with the daytime radiologists. Avoiding working in isolation, by either working with other attendings, trainees or both, can decrease stress by allowing

for sharing of responsibilities and having someone to discuss challenging cases with. Last, engaging in non-radiology interests, maintaining health and wellness and getting adequate exercise are all important to balance a job which involves many uninterrupted sedentary hours of sitting (or standing) at a PACS workstation.

Operational considerations are also important to keep an ED radiology position sustainable. In a survey by Hanna et al., a shift length less than or equal to 9 h was associated with increased job satisfaction [18]. Reasonable case volumes and adding additional radiologists or hours of coverage as needed allows cases to be read efficiently and prevent complaints from the ED of cases not being read quickly enough. Turnaround times are important and should be monitored but should not be overemphasized to the point where it leads to continuous stress and negative feedback, which may be a driver of errors and medicolegal hazards. Limiting non-interpretive and clerical responsibilities by using workflow facilitators (see later) allows radiologists to focus on reading cases rather than the frustrations of the difficulty or inability to reach providers and radiology staff. Having a call-room available for short naps if necessary or to get away from the reading room for a few minutes (e.g., to eat or take a break) is a good way to enable radiologists to recharge when feeling stressed. Finally, constructing a robust backup coverage system allows for an ED radiologist who is ill or has a personal emergency to take the night off rather than working a shift when it would be very difficult to do so or when they would be unable to perform effectively.

## **Scheduling**

### **What are the ideal hours of coverage?**

Exact hour of overnight coverage is institution dependent. The ED radiologist on overnight coverage generally begins their night when the “short-call” or evening shift ends, typically some time between 8 and 11 PM, and will end their night when the day radiologists being arriving in the morning for the new workday. There will naturally be variation if there is the desire to have partial overlap between the evening and overnight shifts because of high evening volumes. Arrangements where ED radiology covers evenings and weekends can also be constructed but the details go beyond the scope of this discussion.

Regarding shift length, as noted above, a shift length less than or equal to 9 h was associated with increased job satisfaction. Also, importantly, using a large teleradiology database of 2.9 million cases, errors were found to peak between 10 and 12 h into a shift [23]. A similar increase in errors was found for residents after working 10 h [24]. These factors suggest that a shift length of 9–10 h would be ideal.

A “one week on, two weeks off” schedule is a common coverage model for academic overnight practice. This amounts to 121 or 122 shifts per year which can either be strictly 7 nights on-duty followed by 14 nights off-duty (with occasional switching if necessary) or can be more flexible and variable with blocks of shorter or longer lengths which sum to a total of 122 shifts over the course of the year. Non-academic practices commonly implement a one week on-duty, one week off-duty arrangement. However, there appears to be increasing recognition, even within non-academic practices, that a “one week on, two weeks off” schedule is a more sustainable model [25].

## Workflow

### What are the unique workflow challenges in overnight ED radiology?

Unlike outpatient imaging, for which patients have ordering clinicians who will receive the results and are responsible for following up, in ED imaging, the care team is more fluid due to shift changes and the movement of patients between different testing and acuity areas in the ED. Completion of exams by technologists, particularly portable exams, may be performed in batches, presenting a problem for radiologists who would prefer to interpret exams at a steady pace. Imaging volumes are variable and unpredictable, and there are few validated parameters which can be used to reliably predict volumes [26]. Overnights present a greater challenge than daytimes regarding variability in volumes because while during the day there is the possibility of receiving help from subspecialist radiologists to assist with ED cases, this assistance is not readily available overnight.

### Where should the ED radiologist(s) be located?

The ED radiologist can be on-site or remote (either at home or at one hospital covering multiple hospitals in the network). Being on site at the hospital that is being covered allows for face-to-face consultations. This is enhanced when the reading room is co-localized with the ED, allowing for more convenient direct interaction between the ED healthcare providers and the ED radiologist. The remote radiologist model has the advantages of eliminating travel time (with benefits for radiologist wellness) and resilience to challenges such as adverse travel conditions or the need for physical distancing during a pandemic [27]. This model also allows for recruitment of out-of-area radiologists to increase the candidate pool during a tight job market. When the radiologist is off-site, trainees may experience a greater sense of independence. On the other hand, being at different sites makes consultation between radiologist and trainee

or between two attending radiologists more cumbersome. Additionally, having multiple radiologists working from a single location fosters informal learning from colleagues through discussions and by “looking over the shoulder” at interesting cases.

### How has the COVID-19 pandemic influenced the localization of ED divisions?

The broad effects of the COVID-19 pandemic on radiology have been discussed elsewhere in the radiology literature [28–30]. In regards to emergency radiologists’ reading areas, various infection control methods may be employed, including separating teams of emergency radiologists to work in different reading rooms or from home, social distancing and mask wearing when sharing a reading room, and performing consultations with clinicians using the phone or videoconferencing platforms such as Zoom (Zoom Video Communications, San Jose, CA) or Teams (Microsoft Corporation, Redmond, WA) [31]. An important lesson taught by the pandemic is that even divisions which generally work on-site should have the capability for at least some of their radiologists to work off-site as needed. This entails developing the necessary IT infrastructure and having the hardware (including high-resolution monitors) to accomplish this goal. The capacity for remote reading can enable an emergency radiology division to remain fully operational during an unexpected crisis, such as the most uncertain early days of the a pandemic, and can prevent a division from becoming short-staffed if there is a prolonged disruptive situation during which many radiologists may be compelled or have a strong preference to remain at home. Of course, during non-disaster situations, the advantages of working remotely must be balanced with the benefits of an on-site presence of radiologists in achieving the division’s mission.

### How can non-attending radiologists be used to streamline ED radiology workflow?

Residents and fellows at academic medical centers play a crucial role in pre-dictating cases from the ED, providing preliminary interpretations for inpatients, and performing emergency procedures such as ultrasound (if there is no technologist) or fluoroscopy. Still, educational goals must be balanced with service responsibilities. Radiology assistants (RAs) and physician assistants (PAs) may play a role in performing or arranging procedures, obtaining informed consent, communicating results, or preparing preliminary reports for uncomplicated cases [32]. Reading room coordinators are clerical staff who are trained to facilitate radiologist workflow. These coordinators can track down providers to obtain additional information if required, communicate findings, or coordinate patient imaging in the ED setting

[33]. Medical students have been used as ED radiology “triage assistants,” in which their role may include answering phone calls, facilitating ordering and protocoling of studies, and communicating results to clinicians [34].

### **What is the role for artificial intelligence (AI) in ED radiology workflow?**

Interest in radiology applications for AI has skyrocketed over the past few years [35]. Although emergency radiology may benefit from other types of AI such as automatic segmentation of structures [36], ventricular volume measurements for hydrocephalus [37], predicting ED patient volume—which is a driver of ED imaging volume [26, 38]—or for protocoling studies [39], the main applications for the ED are for diagnosis [40]. This currently takes the form of flagging studies for worklist prioritization or as a double-check to catch radiologist errors (i.e., “misses”) rather than as a radiologist replacement [41]. Current applications include pulmonary embolism detection [42], lung nodule detection, pneumothorax detection [43], and intracranial hemorrhage detection [44]. Applications are available from multiple vendors including AIDoc (Tel Aviv, Israel), Zebra Medical Vision (Shefayim, Israel), Arterys Inc. (San Francisco, CA), and Viz.ai (San Francisco, CA). Additional applications are continuously being added and can be found in an online database [45].

### **How can a real-time data dashboard improve workflow?**

A real-time dashboard provides up-to-the-minute information on studies awaiting performance by technologists and awaiting interpretation by ED radiologists. This can be in the form of a dashboard built into the electronic medical record/radiology information system (EMR/RIS) or may be a standalone custom or commercial application. Data can be organized by site (at multi-site practices), by modality, or by specialty, depending on how the information will be used to optimize workflow. At minimum, the dashboard should include data of cases ordered but not performed and cases which were performed but not read. ED census data gives a somewhat longer horizon for anticipated imaging orders [46, 47].

Specific examples of workflow benefits include the following: Having a firm grasp on current and immediate future volumes facilitates radiologist scheduling. Additional radiologists can be mobilized or one of the on-duty radiologists can be released early depending on current and anticipated studies. Regarding trainee education, when the dashboard indicates that there are many cases on deck and the resident(s) is busy with other responsibilities, the attendings can read cases quickly without prior resident review.

When there are few anticipated cases, a larger fraction of cases can be left for the resident(s) to pre-dictate.

### **How should cases which will not receive a final report overnight be handled in the overnight ED setting?**

There are several reasons why a study may not receive a final report overnight. ED radiologists are specialists in ED radiology and cannot possess the subspecialty expertise of all the radiology subspecialties. There will inevitably be times when cases are encountered for which the ED radiologist can report the acute findings, but other aspects of the case require subspecialty input. Alternatively, there may be an institutional practice for certain cases to only be read by certain subspecialists (e.g., nuclear medicine or pediatric studies). Another scenario is where the study is performed in the ED for convenience, but it is not really an emergency study (e.g., metastatic workup, preoperative lower extremity CTA for chronic peripheral vascular disease, or body MR exam for lesion characterization or follow-up). Such studies commonly require subspecialty expertise. More importantly, reading these studies emergently would delay reporting of true emergency studies.

Depending on the exact situation, there are various ways in which this can be handled. For large institutions which have multiple ED radiologists on duty per shift, there can be a mix of radiologists with training and/or skill-sets encompassing the various subspecialties. In this scenario, it is advantageous for all radiologists to also be able to read routine ED studies rather than being fully subspecialized such that cases outside that area cannot be read. In this way, if there is a skew in cases to one subspecialty area, the other radiologists can assist. With a large enough group of ED radiologists, even non-emergency studies can be read contemporaneously.

For studies which cannot be read, a preliminary interpretation can be provided until the next daytime shift. For example, if an abdominal MRI is done, the ED radiologist can assess common duct size and the presence of cholelithiasis but would not typically provide a full characterization of a pancreatic lesion. The rationale for this is similar to other medical specialties which do not provide many non-emergent services overnight. For example, Whipple procedures are not done overnight but a temporizing measure such as stenting may be done if necessary. Subspecialty reads may also add value for more complex cases such as where unusual surgeries are being followed up. Regardless of the strategy being used, having subspecialty backup is a good idea for those rare cases where a subspecialty interpretation is required immediately and where such a reading will impact immediate patient care.

### **Should the radiology department perform and interpret cases after-hours, which are generally performed by other departments during the daytime?**

Careful consideration must be given to exams that are part of inter-departmental “turf-battles” during the day (e.g., vascular ultrasound or obstetric ultrasound). From a political standpoint, it may be undesirable to “cover” the other department that has the primary responsibility for the examination during the day. Furthermore, the technologists and radiologists may not have enough experience performing and reading these exams and having radiology cover only during off-hours may therefore provide suboptimal patient care. On the other hand, performing and reading these exams may allow for more complete usage of imaging equipment and staff and may provide trainee exposure to certain exams which they do not see during normal business hours. Furthermore, providing the service well during off-hours provides a foothold into expanding the department’s role in the exam, which may ultimately extend into normal business hours. Each department must take these factors into consideration when deciding whether to provide these services to the ED during off-hours.

### **How should system downtimes be approached by ED radiology?**

Scheduled downtimes are most commonly performed during off-hours, making these the domain of emergency radiologists. In some ways, ED radiologists are also de facto downtime specialists in that they are generally the most experienced in implementing various workaround systems and workflows to ensure that cases are read efficiently during and following downtimes. Various systems may be impacted, either enterprise systems such as the EMR, which would also directly affect the ED physicians, or applications localized to radiology such as the dictation software or PACS. Procedures must be in place to deal with these downtimes. Adequate personnel must be available, such as radiologists (including residents at academic institutions), technologists, clerks, and IT staff, in order to prepare for the downtime, manage the downtime, and recover from the downtime.

Radiologists may need to provide preliminary interpretations by reading directly from the displays of the CT/MR/US/X-ray units during the downtime; this would require on-site radiologists at each impacted site. Alternatively, redundancy of systems can be indispensable in minimizing the impact of the downtime. For example, when the main PACS is down, a separate system such as a DICOM viewer that is usually used for 3D rendering and advanced visualization can be used as a temporary viewer. As another example, when an EMR downtime results in imaging studies not being

assigned to their usual worklists, alternate worklists must be identified or developed which will capture all recently performed studies to aid in identifying the cases that will require urgent interpretation.

### **What metrics can be used to monitor ED radiology performance?**

Metrics are important in ED radiology, as they are in other areas of medicine and radiology. Although accuracy is viewed as the more important metric in the eyes of most radiologists, there is generally a low reporting rate and heterogeneity of reporting of errors [48]. Turnaround times, on the other hand, although important for rapidly deteriorating patients, generally have less long-term implications. Still, as they are easily quantified and stratified using data from the RIS, and as imaging delays are believed to be a driver of increased ED length of stay [49], they are commonly used as a primary service indicator. Various intervals along the imaging timeline can be measured; the ED is ultimately interested in the interval between the time the study is ordered and the time the report is finalized.

Different turnaround time metrics can be measured: The mean is an easy metric to use but is subject to skewing by outlier exams; an exam which slips through the cracks and is only dictated 3 weeks later will have a large impact on the mean turnaround time. The median is less sensitive to outliers and tends to provide a lower turnaround time. Percent of exams within a certain time window (e.g., a goal of 90% of CT exams finalized within 2 h) is the most useful in measuring conformity to a certain service level. It is hard to reach 100% compliance with time window metrics as there will always be “problem studies” or studies which cannot be completed within the usually narrow time window due to complexity of the exam or a spike of volume of cases during busy time periods. Residents preliminarily dictating reports may cause an additional built-in delay in attendings finalizing cases; this needs to be considered in setting turnaround time expectations in the academic setting.

### **Conclusion**

ED radiology divisions are rapidly becoming a common addition to US radiology departments, particularly for overnight coverage. Forming such a division presents unique challenges as the practice functions differently than most other radiology divisions. In order to attract and retain quality emergency radiologists, it is important that these divisions devise a structure and schedule that will be sustainable for their radiologists in the long term and will not increase the chances of “burnout” and resultant high radiologist turnover. Factors such as number of shifts and time

frame of shifts are key variables to consider, and it is also critical to staff divisions such that the volume of imaging is manageable for radiologists and will allow for expeditious turnaround times.

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