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.

Recover Wisely From COVID-19: Responsible Resumption of Nonurgent Radiology Services

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Rationale and Objectives: Following state and institutional guidelines, our Radiology department launched the "Recover Wisely" for all nonurgent radiology care on May 4, 2020. Our objective is to report our practice implementation and experience of COVID-19 recovery during the resumption of routine imaging at a tertiary academic medical center.

Materials and Methods: We used the SQUIRE 2.0 guidelines for this practice implementation. Recover Wisely focused on a data driven, strategic rescheduling and redesigning patient flow process. We used scheduling simulations and meticulous monitoring and control of outpatient medical imaging volumes to achieve a linear restoration to our pre-COVID imaging studies. We had a tiered plan to address the backlog of rescheduled patients with gradual opening of our imaging facilities, while maintaining broad communication with our patients and referring clinicians.

Results: Recover Wisely followed our anticipated linear modeling. Considering the last 10 weeks in the recovery, outpatient growth was linear with an increase of approximately 172 cases per week, (R^2 =0.97). We achieved an overall recovery of 102% in week 10, as compared to average weekly pre-COVID outpatient volumes. The modalities recovered as follows in outpatient volumes: CT (113%), MRI (101%), nuclear medicine including PET (138%), mammograms (97%), ultrasound (99%) and interventional radiology (106%). When compared to identical 2019 calendar weeks (May 4, 2020−July 10, 2020), the total 2020 radiology volume was 11% reduced from the 2019 volume. The reduction in total weighted relative value units was 8% in this time period, as compared to 2019.

Conclusion: Our department utilized a data-driven, team approach based on our guiding principles to "Recover Wisely." We created and implemented a methodology that achieved a linear increase in outpatient studies over a 10-week recovery period.

Key Words: COVID-19; Recovery; Radiology department.

INTRODUCTION

The COVID-19 pandemic is undoubtedly one of the biggest challenges that the world is facing, particularly in terms of its impact on health care systems. To mitigate the crisis of the COVID-19 pandemic, on March 18, 2020, the Centers for Medicare & Medicaid Services recommended limiting nonessential medical care (1), resulting in deferred health care for a large number of patients.

There was a sharp, 53%−55% decrease in system wide volumes of imaging services in radiology departments in this 7−8-week time span (2,3).We have previously described our rescheduling implementation process for all nonurgent studies during the COVID-19 pandemic, using a tiered priority system to work through the scheduled outpatient radiology examinations that potentially could be delayed with minimal clinical impact (2).

On April 19, 2020, Centers of Disease Control and Prevention (CDC) issued guidance to allow restart of care that was being postponed in regions of relatively low or stable incidence of COVID-19 (4). At a local level, the impact on our health care system was less than predicted, and our capacity of ICU and other hospital resources was not exceeded. On April 30, our state guidelines granted permission to resume nonessential surgeries and procedures that did not require an overnight hospital stay (5). The American College

Acad Radiol 2020; 27:1343–1352

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https://doi.org/10.1016/j.acra.2020.08.002

of Radiology provided further guidelines for safe re-engagement of nonurgent diagnostic and interventional radiology care (6). Although there is no universal strategy applicable to all radiology practices, the American College of Radiology white paper highlighted the need for a comprehensive approach based on the local COVID-19 statistics. The overriding principle was a risk assessment of performing versus postponing radiology exams.

We developed a phased approach to recovery tailored to our department of Radiology—"Recover Wisely." We mapped the restoration of routine radiology care to begin on May 4, 2020 according to the provided state and institutional guidelines. To Recover Wisely, we used a data driven approach to inform our decisions and strategies. Provision of a safe environment for patients and staff remained our top priority. The purpose of this paper is to report our practice implementation and experience of COVID-19 recovery, including lessons learned during the resumption of noncritical imaging tests and procedures.

METHODS

We used the SQUIRE 2.0 guidelines to describe the framework of this practice implementation (7).

Setting and Team

University of Cincinnati is a large, urban, adult tertiary academic medical center with two hospitals and five free standing outpatient imaging centers. We created a COVID-19 Recovery Task Force which included radiologists, administrators, technologists, and schedulers. We prioritized cases based on acuity. The group was invested in working together by sharing best practices to communicate with patients, as well as details about historical trends, including data about volume and prioritization categories. Daily meetings were held virtually, with decreasing frequency as allowed by urgency. Approval of decisions was formalized by departmental leadership after initial vetting by the task force.

Description of the Recovery Process

Guiding Principles and Premises

We used the following guiding principles and premises to help us perform a safe, systematic and data driven approach to recover wisely.

1. We meticulously collected and verified imaging data by date, time of day, site, modality, and individual scanners (e.g. 3T MRI resources), and then used this information to model and subsequently implement the Recover Wisely program.
2. We maintained sufficient imaging capacity for continued, safe outpatient imaging operations during the COVID-19 pandemic, and prioritized patients based on temporal urgency of imaging.
3. Using the electronic medical record (EMR), we continuously monitored the backlog of imaging studies and available imaging resources, as we gradually opened imaging sites. A thorough and real time evaluation of our backlog, vis-a-vis resources, ensured "equity in prioritization" for all referring physicians and specialties.
4. We closely monitored the local pandemic statistics to ensure readiness for any unexpected surge of cases.
5. As an essential element of our recovery process, we carefully and clearly informed patients of our reopening plan, with an emphasis on patient safety and our ability to render care. Our department and institutional message of "Responsible Return"—part of our overall goal to Recover Wisely was simple: We are open. We are safe. We are prepared.

Timelines

We had rescheduled all nonemergent radiology tests and procedures between March 16 and May 3, 2020. Given state guidelines, we chose May 4, 2020 to begin the recovery process and resumption of routine Radiology care. We report our recovery for a 10-week period, from May 4 to July 10, 2020.

Implementation Workflow

Baseline operations pre-COVID:

Our pre-COVID normal operating hours for CT were 0700-1700, Monday to Friday and 0800−1200 on Saturday. Urgent outpatient CT available appointment times were same day and the routine third next available appointment was within 48 hours. The normal operating hours for MRI were 0700-2100, Monday to Friday and 0800−1500 on Saturday, with urgent outpatient scans available times within 24 hours and the routine third next available appointment within 72 hours. Nuclear medicine, IR, Mammography shared similar operating hours between 0800 and 1700, Monday to Friday, with urgent outpatient appointments available times within 24 hours. The routine third next available appointment for PET and IR was within 72 hours.

Radiology Recovery Preparedness

As part of the pandemic response, we had blocked all open appointment slots starting on March 4 through May 4, 2020. This was the same period where we had rescheduled the nonemergent imaging and procedures in our hospitals and outpatient centers. The team vetted, agreed on, and followed our guiding principles, with preparation and modeling of case recovery for resumption of this nonurgent care.

We redesigned our workflow and pilot tested our plan to minimize uncertainty and errors (Fig 1).

1. *Precertification:* For all rescheduled appointments, our staff contacted insurance companies to confirm that prior authorization was correctly extended and included the expected date of imaging.

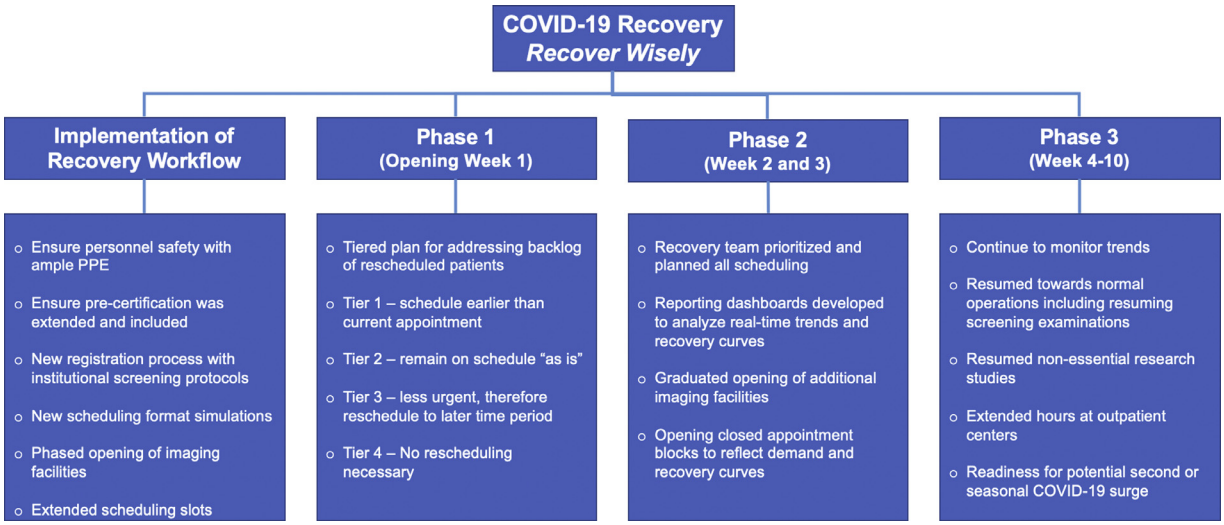
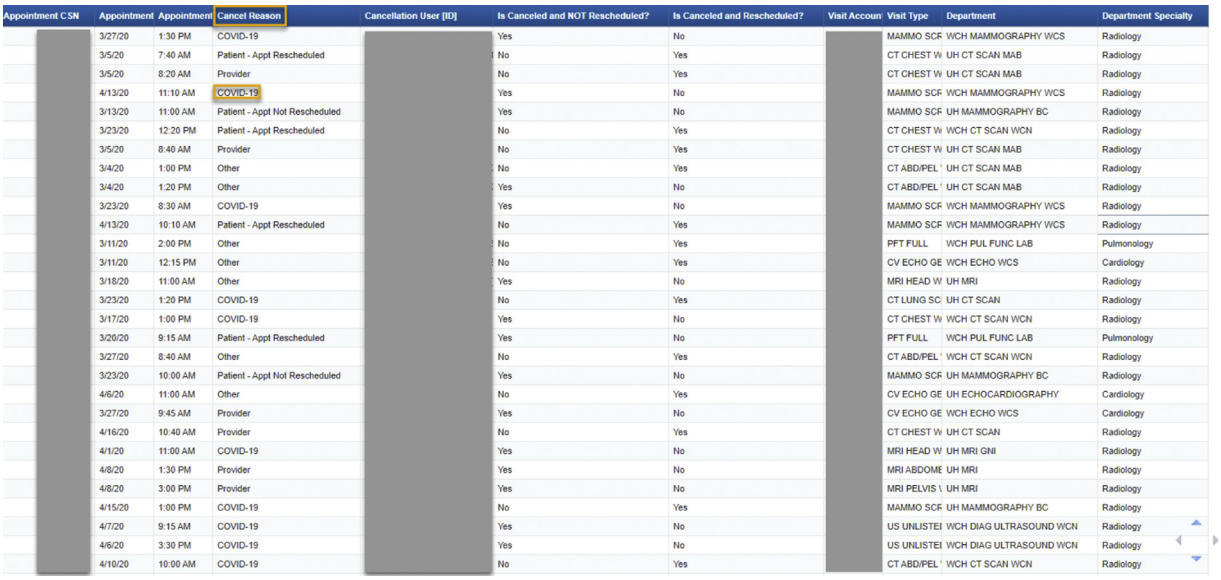


Figure 1. Process map for recover wisely.

2. *Registration:* We performed patient screening, at the time of scheduling, at hospital entrances, and at radiology front desks, using a standardized COVID-19 questionnaire prior to all patient examinations. We also created a process for rapid isolation of patients with COVID-19 suspicion, at screening, consistent with our institution protocol.
3. *Scheduling simulations for forecasting recovery:* We performed scheduling simulations to test the potential of our new schedule to absorb delayed imaging study volumes. In our projections, we also tried to account for patients who might cancel or continue to defer their imaging study out of fear of visiting an academic hospital that cares for known COVID-19 patients. We reviewed our pre-COVID scanner capacities and planned to accommodate for half of daily volume. We also took into account our estimate of 5%–6% "no show" rate. From a resource standpoint, we calculated the number of available staff, abiding by our specific institutional labor reduction plan. We assessed all the rescheduled studies to understand the demand. We also determined how far out we wanted to fill the schedule. These aspects helped us understand the supply in order to service our demand. We then started performing the simulations such that we were filling a few scanners at half capacity to abide the social distancing guidelines. We continuously monitored our access to ensure that the scanners did not reach capacity too far in advance. As we monitored our fill ratios and third next available ratios, we then used these data to determine when to open up the other closed scanners. Once all scanners were opened, we started to open the closed slots on the templates to bring the scanners back to normal schedules and full capacity.
4. *Imaging facilities setup:* In the initial phase, during the first two weeks, three of the outpatient imaging centers were opened. We phased in opening of specific modalities, starting with opening of MRI, CT, and US exams in May as these were the modalities with the greatest number of postponed cases and the most compelling medical need. Screening mammography and DEXA scans were delayed until June. We followed the CDC social distancing guidelines and state regulations to utilize less than 50% of room capacity for social distancing. Detailed workflows were created for each site within the UCH imaging network. We reconfigured our waiting rooms by spacing furniture and placing signs on the floor indicating socially distanced standing locations. Detailed cleaning protocols were instituted. For example, if a patient was required to sit in the waiting room, the chair is cleaned once they leave the area and before the next person arrives. Specific protocols included cleaning all door handles, dressing rooms, lockers, keys, as well as normal cleaning protocol for MRI table and coils. We assigned specific associates to these areas daily to enhance the cleaning process. The enhanced cleaning regime was supported by existing staff. Staff from other support roles were brought into this part of the process. This included PACS assistants, radiation safety assistants, and technologist assistants, as well as the registration staff.
5. *Scheduling slots:* The imaging slots were extended to reduce the number of people in each facility to facilitate social distancing and to allow staff time to properly clean and sanitize spaces and equipment per CDC guidelines. We started with two CT exams scheduled per scanner per hour (as opposed to 3–4/hour pre-COVID) and one MR exam scheduled per hour (as opposed to 1–2/hour pre-COVID).
6. *Personnel safety:* We ensured adequate personal protective equipment (PPE) supply. Each staff member is required to wear a mask and face shield in all patient care areas. All patients are also required to wear a mask in the facilities. If patients do not bring a mask, one is provided to them.



Appointment CSN	Appointment	Appointment	Cancel Reason	Cancellation User [ID]	Is Canceled and NOT Rescheduled?	Is Canceled and Rescheduled?	Visit Accoun	Visit Type	Department	Department Specialty
	3/27/20	1:30 PM	COVID-19		Yes	No		MAMMO SCR	WCH MAMMOGRAPHY WCS	Radiology
	3/5/20	7:40 AM	Patient - Appt Rescheduled		No	Yes		CT CHEST W	UH CT SCAN MAB	Radiology
	3/5/20	8:20 AM	Provider		No	Yes		CT CHEST W	UH CT SCAN MAB	Radiology
	4/13/20	11:10 AM	COVID-19		Yes	No		MAMMO SCR	WCH MAMMOGRAPHY WCS	Radiology
	3/13/20	11:00 AM	Patient - Appt Not Rescheduled		Yes	No		MAMMO SCR	UH MAMMOGRAPHY BC	Radiology
	3/23/20	12:20 PM	Patient - Appt Rescheduled		No	Yes		CT CHEST W	WCH CT SCAN WCN	Radiology
	3/5/20	8:40 AM	Provider		No	Yes		CT CHEST W	UH CT SCAN MAB	Radiology
	3/4/20	1:00 PM	Other		No	Yes		CT ABD/PEL	UH CT SCAN MAB	Radiology
	3/4/20	1:20 PM	Other		Yes	No		CT ABD/PEL	UH CT SCAN MAB	Radiology
	3/23/20	8:30 AM	COVID-19		Yes	No		MAMMO SCR	WCH MAMMOGRAPHY WCS	Radiology
	4/13/20	10:10 AM	Patient - Appt Rescheduled		No	Yes		MAMMO SCR	WCH MAMMOGRAPHY WCS	Radiology
	3/11/20	2:00 PM	Other		No	Yes		PFT FULL	WCH PUL FUNC LAB	Pulmonology
	3/11/20	12:15 PM	Other		No	Yes		CV ECHO GE	WCH ECHO WCS	Cardiology
	3/18/20	11:00 AM	Other		Yes	No		MRI HEAD W	UH MRI	Radiology
	3/23/20	1:20 PM	COVID-19		No	Yes		CT LUNG SC	UH CT SCAN	Radiology
	3/17/20	1:00 PM	COVID-19		Yes	No		CT CHEST W	WCH CT SCAN WCN	Radiology
	3/20/20	9:15 AM	Patient - Appt Rescheduled		Yes	No		PFT FULL	WCH PUL FUNC LAB	Pulmonology
	3/27/20	8:40 AM	Other		No	Yes		CT ABD/PEL	WCH CT SCAN WCN	Radiology
	3/23/20	10:00 AM	Patient - Appt Not Rescheduled		Yes	No		MAMMO SCR	UH MAMMOGRAPHY BC	Radiology
	4/6/20	11:00 AM	Other		No	Yes		CV ECHO GE	UH ECHOCARDIOGRAPHY	Cardiology
	3/27/20	9:45 AM	Provider		Yes	No		CV ECHO GE	WCH ECHO WCS	Cardiology
	4/16/20	10:40 AM	Provider		No	Yes		CT CHEST W	UH CT SCAN	Radiology
	4/1/20	11:00 AM	COVID-19		Yes	No		MRI HEAD W	UH MRI GNI	Radiology
	4/8/20	1:30 PM	Provider		Yes	No		MRI ABDOME	UH MRI	Radiology
	4/8/20	3:00 PM	Provider		Yes	No		MRI PELVIS \	UH MRI	Radiology
	4/15/20	1:00 PM	COVID-19		No	Yes		MAMMO SCR	UH MAMMOGRAPHY BC	Radiology
	4/7/20	9:15 AM	COVID-19		Yes	No		US UNLISTEI	WCH DIAG ULTRASOUND WCN	Radiology
	4/6/20	3:30 PM	COVID-19		Yes	No		US UNLISTEI	WCH DIAG ULTRASOUND WCN	Radiology
	4/10/20	10:00 AM	COVID-19		No	Yes		CT ABD/PEL	WCH CT SCAN WCN	Radiology

Figure 2. Snapshot of query of radiology scheduling database using electronic medical record.

Radiology Recovery Phases

Phase 1—Initial Opening Week 1

Backlog patient list prioritization: We queried the radiology scheduling database for all canceled and rescheduled radiology exams, which were prospectively categorized in the EMR system (Epic Systems, Verona, and Wisconsin), between March 16, 2020 and May 3, 2020 (Fig 2). The backlog was evaluated by daily runs from Epic and re-tabulation of the number of patients scheduled, scanned, and those who were scheduled but not scanned.

We developed a tiered plan for addressing the backlog of nonurgent radiology care as detailed in the following.

Tier 1: Patient needs to be scheduled earlier than current appointment. These were moved to the initial opening week (Week of May 4). Examples of Tier 1 cases included a patient with known glioma with increasing seizures or a patient with known gastrointestinal tumor with suspected ascites. Also included in this category were urgent imaging studies requested by the referring clinician.

Tier 2: Patient should be scanned during Phase 1, and ideally would be left on the schedule "as is." An example of a Tier 2 case is a patient with a history of head and neck cancer with recent surgery in last 6 months requiring follow-up.

Tier 3: Less urgent imaging studies. Patients can be rescheduled to a later time period, as defined by recovery plan. Examples of Tier 3 cases included lung and breast cancer screening examinations or follow up of prior surgical intervention with no new symptoms and clinically expected stability.

Tier 4: No rescheduling necessary. Examples include studies cancelled by the patient or referring physician, or scans completed previously within the UC Health imaging network or other facility.

The entire set of outpatients who required rescheduling was downloaded, divided by section, and then each case was reviewed by an attending radiologist using the hospital EMR to determine the priority. Once every case was assigned to a tier by an attending radiologist, the entire set of patients was then rescheduled.

Phase 2—Week 2 and 3

Scheduling prioritization: We locked the scanner schedules and blocked all open appointment slots, allowing control of the scheduling process by the recovery team. We reviewed the schedules daily and rescheduled patients based on tiered priority. Patients were put into the schedule based on the tiers. If a resource (e.g. an MRI unit) had open slots because patients with a specific priority were not imaged, we attempted to manually back-fill that slot with a patient with the same priority.

Reporting dashboard: We developed a reporting dashboard that documented recovery progress trends. The data and figures were reviewed during the daily virtual meetings. We tracked completed, cancelled and rescheduled appointments, and no shows. The recovery trend was analyzed, and we adapted the recovery plan regularly to fit our intended recovery process of a gradual, linear return to pre-COVD imaging volumes by mid-June 2020.

Opening of additional facilities: We initially planned to operate all available imaging facilities with extended hours, including evenings and weekends, in order to accommodate any backlog in a timely manner. However, once all the rescheduled patients were contacted, it became clear that the demand would be less than expected. The reasons for this included a patient scanned in another system, interval resolution of the medical issue without further need for imaging, or patient fear preventing imaging. As a result, outpatient

imaging center hours were extended into the evening at only one facility. We chose the center with the greatest capacity for patient registration personnel and building access. We also regularly reviewed the closed appointment blocks and gradually opened them, to accommodate more patients, while still following the state and institutional guidelines.

Phase 3—Week 4–10

We have now opened all imaging facilities to normal hours, with two outpatient centers continuing to operate with extended hours. We have also resumed screening examinations (including breast and lung cancer screenings). In week 4, we started scheduling nonessential research studies. Critical and essential research (e.g. COVID-19 related research studies) were already being performed.

Monitoring trends: We continue to closely monitor the trends both at a community and hospital level. Our state is using a four-level color-coded system to assess the degree of the COVID-19 spread in every county. The levels are determined by key data indicators that identify the risk level for each county and a corresponding color code to represent that risk level. We track the following information daily within our organization: total number of COVID-19 admitted patients, COVID-19 patients admitted to ICU and on ventilators, OR/procedural cases including number of elective and nonelective cases per day, number of COVID-19 positive employees and employees out of work.

Communication

We recognized that widespread and transparent communication to patients, referring clinicians, radiology workforce, and hospital leadership was critical. We used the following communication strategies to inform internal and external stakeholders of Recover Wisely: sending patient letters (Fig 3), using system wide email communication, and social media. Our chair and enterprise imaging director also created a video message with the institution's marketing team to educate patients and referring clinicians about our radiology workflow redesign to optimize patient and staff safety.

Personnel Workforce

The extension of outpatient imaging hours required physician on-site coverage for intravenous contrast administration. Previously, such evening hour coverage was provided by moonlighting residents. However due to the financial impact of COVID-19 on our department budget, that was no longer an option. Rather than asking faculty radiologists to work extra hours, we chose to maximize the use of faculty already scheduled at the hospital, which included a neuroradiologist working until 9pm and a body/general radiologist working a 5 pm–12 am (midnight) shift. We shifted site coverage for these staff members from the main hospital to the outpatient imaging centers, while on-call residents and other staff provided contrast coverage in the hospitals. We also adjusted technologists' schedules to meet the needs of the patients, including longer shifts. All the staffing decisions were made after active input from radiologists, technologists, chief residents, and departmental leadership.

Special Considerations

1. *Interventional radiology (IR) procedures:*

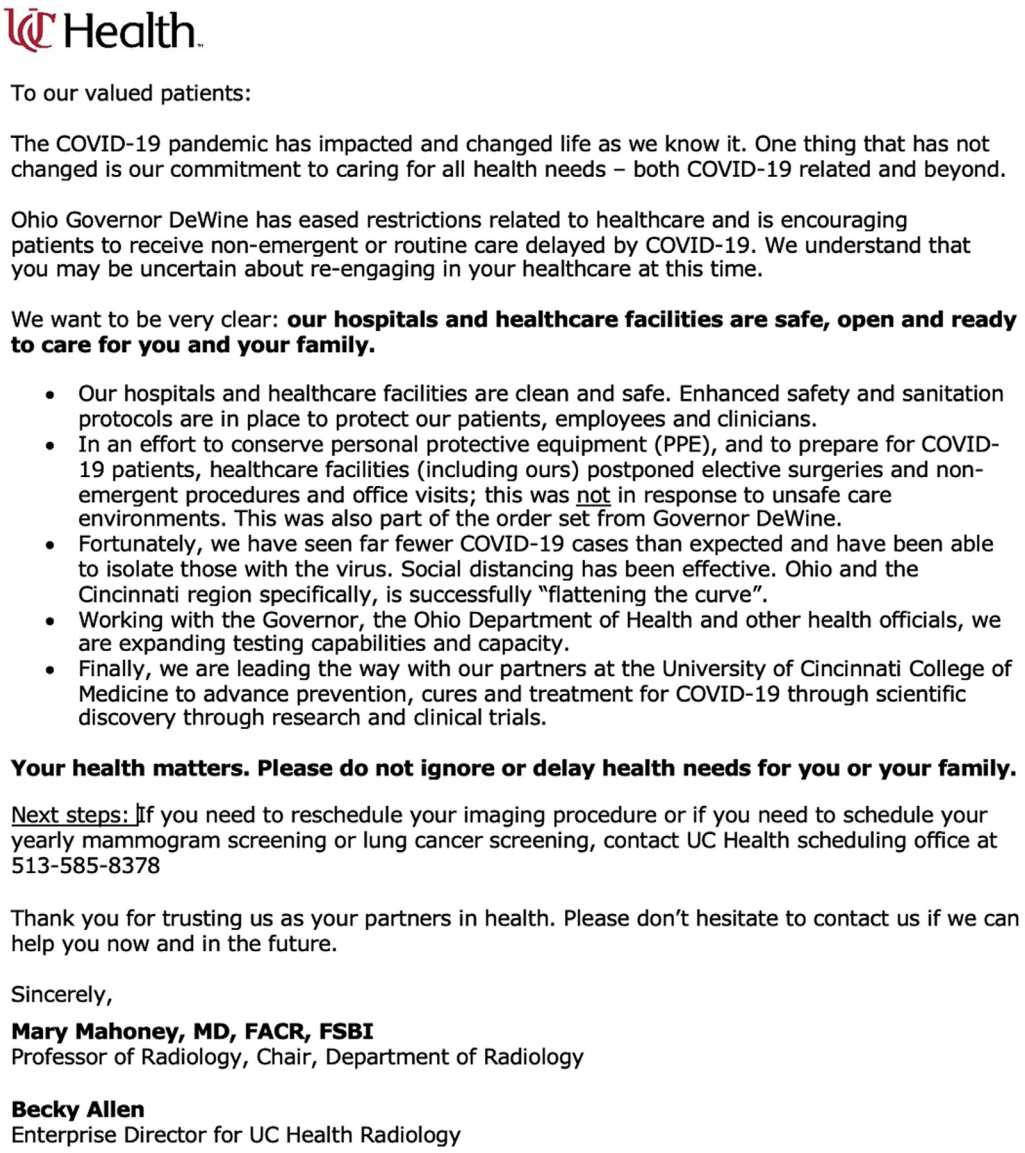
IR rescheduling did not directly mirror other radiology studies because the specialty is procedural based. Our IR recovery plan consisted of three phases based on Society of Interventional Radiology (SIR guidelines):

Phase 1: Rescheduling all patients overdue for their procedure. This phase included oncology patients who were initially deemed appropriate to postpone treatment for 3 months.

Phase 2: Rescheduling all elective nontime sensitive procedures in which it been previously determined that delay in care would not affect outcomes, but that the procedure could provide symptomatic relief or Quality of Life improvement.

Phase 3: Resumption of all elective procedures regardless of the type and return to normal pre-COVID operations.

We created priority lists to schedule IR procedures based on the type of procedure, diagnosis, urgency, and considered if the procedure has been postponed during the initial COVID phase (Details in Supplemental material). We created a site-specific IR plan in cooperation with the hospital COVID-19 team to coordinate a safe and responsible return. All outpatients or same-day admission procedures received preprocedural COVID-19 testing to evaluate asymptomatic patients. In the scenario of a positive test result, the IR team considered delaying the procedure, based on patient factors such as diagnosis, active symptoms, and clinical urgency. These precautionary measures were implemented to minimize risks to our healthcare team members and other vulnerable patients. Preprocedural COVID-19 testing was coordinated through drive-thru clinics two days prior to the procedure. If the patient resided in a skilled nursing facility, COVID-19 tests were performed within the respective facility. If the patient resided a significant distance from our testing center, tests were coordinated by the patient at a local facility, with results available prior to the procedure date. Exceptions to COVID-19 testing was made for patients undergoing recurrent and frequent IR procedures such as paracentesis and PICCs, given the limited number of test kits available. In the situation where a patient was not tested, our workflow was adjusted to having a limited number of IR staff interact with the patient. The patient was accompanied directly to the IR procedure room with immediate discharge from the procedure room following the procedure. Attention to our resources, in particular to appropriate use of PPE, for patient care remains a priority. At the time of writing, our protocol is now to allow one family member to accompany the patient for the IR procedure. We have also modified our clinic operations physically and added appropriate inter-visit



UC Health

To our valued patients:

The COVID-19 pandemic has impacted and changed life as we know it. One thing that has not changed is our commitment to caring for all health needs – both COVID-19 related and beyond.

Ohio Governor DeWine has eased restrictions related to healthcare and is encouraging patients to receive non-emergent or routine care delayed by COVID-19. We understand that you may be uncertain about re-engaging in your healthcare at this time.

We want to be very clear: **our hospitals and healthcare facilities are safe, open and ready to care for you and your family.**

- Our hospitals and healthcare facilities are clean and safe. Enhanced safety and sanitation protocols are in place to protect our patients, employees and clinicians.
- In an effort to conserve personal protective equipment (PPE), and to prepare for COVID-19 patients, healthcare facilities (including ours) postponed elective surgeries and non-emergent procedures and office visits; this was not in response to unsafe care environments. This was also part of the order set from Governor DeWine.
- Fortunately, we have seen far fewer COVID-19 cases than expected and have been able to isolate those with the virus. Social distancing has been effective. Ohio and the Cincinnati region specifically, is successfully "flattening the curve".
- Working with the Governor, the Ohio Department of Health and other health officials, we are expanding testing capabilities and capacity.
- Finally, we are leading the way with our partners at the University of Cincinnati College of Medicine to advance prevention, cures and treatment for COVID-19 through scientific discovery through research and clinical trials.

Your health matters. Please do not ignore or delay health needs for you or your family.

Next steps: If you need to reschedule your imaging procedure or if you need to schedule your yearly mammogram screening or lung cancer screening, contact UC Health scheduling office at 513-585-8378

Thank you for trusting us as your partners in health. Please don't hesitate to contact us if we can help you now and in the future.

Sincerely,

Mary Mahoney, MD, FACR, FSBI
Professor of Radiology, Chair, Department of Radiology

Becky Allen
Enterprise Director for UC Health Radiology

Figure 3. Patient communication letter.

intervals to avoid overcrowding or overlap of patient visits. We continue to provide IR clinic services via telemedicine.

2. *Breast imaging:*

Rescheduling of breast imaging studies was prioritized based on medical needs. Since oncology workups including diagnostic imaging and image-guided biopsies and preoperative localizations continued during the pandemic for BI-RADS 4−6, the backlog existed primarily for patients needing (i) screening or (ii) follow-up of probably benign (BI-RADS 3) imaging findings. Patients previously assigned BI-RADS 3 were placed in Tier 2 and left on the schedule with no further delay. Baseline and routine (annual or biennial) screenings were placed in Tier 3 and given the next available appointment. Every patient past due for breast cancer screening (mammography and MRI) or follow-up imaging was called to reschedule their appointment, sent reminders in the mail or the electronic patient portal, and called again the day prior to their scheduled appointment. No-shows are sent missed appointment letters requesting them to reschedule and patients with overdue breast imaging are automatically sent reminder letters every 6 months. To accommodate the anticipated influx of patients for screening, we released vacant diagnostic imaging timeslots to allow booking of screening exams within 24 hours. Additionally, to minimize the number of face-to-face discussions between patients and healthcare providers, patients with normal or stable diagnostic breast imaging receive results from their technologist. Previously, this information was delivered in person by a radiologist or trainee.

3. *Lung cancer screening:*

At the time of phased reopening, the baseline and 12-month screen studies (Lung-RADS 1 or 2) were placed in Tier 3 and rescheduled to the next available appointment. Patients with prior Lung-RADS 3 and 4 (8) category scans

were placed in Tier 2 and were left on the schedule and not further delayed. To accommodate large numbers of pending scans in Tier 1, we held lung-screening days on certain outpatient scanners. We ensured that none of the Lung-RADS 3 and 4 suffered a delay longer than 6 weeks past their scheduled exam date. We contacted every lung cancer screening patient to reschedule, sent a reminder letter in the mail or electronic chart, and made another call the week before their appointment. If the patient was a no show, a missed appointment letter was mailed requesting they call to reschedule the missed appointment. If still no contact is received, they are placed on the long-term overdue list and will be contacted by staff in six months. If any patient reports a history of having contracted COVID-19, the scan will be delayed for four weeks from start of illness to allow for complete recovery and stabilization of residual lung abnormality (9).

4. *Research studies:*

As per the university guidelines, all nonessential research labs were allowed to open starting June 1, after approval of a research reentry process from every department. We implemented a tracking system in conjunction with the clinical trials office to identify research studies throughout the institution that are ready to resume enrollment and that require imaging, in order to accommodate them in the appointment schedules.

RESULTS

We mapped our system wide imaging volumes in the year, starting from January 1 to July 10, 2020. The early decrease in total radiology volumes (March 8–April 18) corresponds to the rescheduling of all nonemergent care and precedes the current phase of recovery under analysis. (Figs 4 and 5). Considering the last 10 weeks in the recovery and normalizing for May 24 and July 4 holidays, our outpatient recovery was linear with an increase of approximately 172 cases per week, ($R^2 = 0.97$; Fig 6). The intended linear recovery corresponded with increased confidence and communication among patients, staff, and senior administration. Considering emergency imaging alone, volumes not driven by Recover Wisely, the increase was more gradual (roughly 100 cases per week).

Considering overall recovery, at week 10, we had a recovery of 102% as compared to average weekly pre-COVID outpatient volumes. The modalities recovered as follows in outpatient volumes: CT (113%), MRI (101%), nuclear medicine including PET (138%), mammography (97%), ultrasound (99%) and interventional radiology (106%).

When compared to identical 2019 calendar weeks (May 4, 2020–July 10, 2020), the total 2020 radiology volume (n = 75,779) was 11% reduced from the 2019 volume (n = 84,903). Modality-wise, total CT volumes were almost similar in 2020 as compared to 2019 in this time period, MRI volumes reduced by 8%, radiography reduced by 13%, US reduced by 12%, and mammography reduced by 21%. The reduction in total weighted relative value units was 8% in this time period, as compared to 2019.

DISCUSSION

Our department launched the "Recover Wisely" for all nonurgent radiology care on May 4, 2020, as part of our COVID-19 pandemic response for medical imaging. Recover Wisely focused on a data driven approach, strategic rescheduling, and redesigning patient flow. It was harmonized with our institutional and departmental overall recovery preparedness, including efforts to ensure appropriate PPE for staff and patients and appropriate cleaning of spaces and equipment.

One premise for Recover Wisely was meticulous monitoring and control of outpatient medical imaging volumes to achieve a linear restoration to our pre-COVID advanced imaging studies between May 4 and July 10, 2020. Dashboards were created and reviewed, and imaging slots available for outpatient studies were adjusted daily for roughly the first 5 weeks of recovery, and then every other day for several weeks. Currently the outpatient and total volume run-rates in the department are done weekly. The 10-week linear recovery model target model was chosen because a more rapid planned ascent was considered unwise and difficult from the perspective of technologist staffing, and a slower phase would not meet our patients' needs, particularly for advanced imaging studies. The baseline (starting point) for the recovery was our baseline outpatient volumes defined as

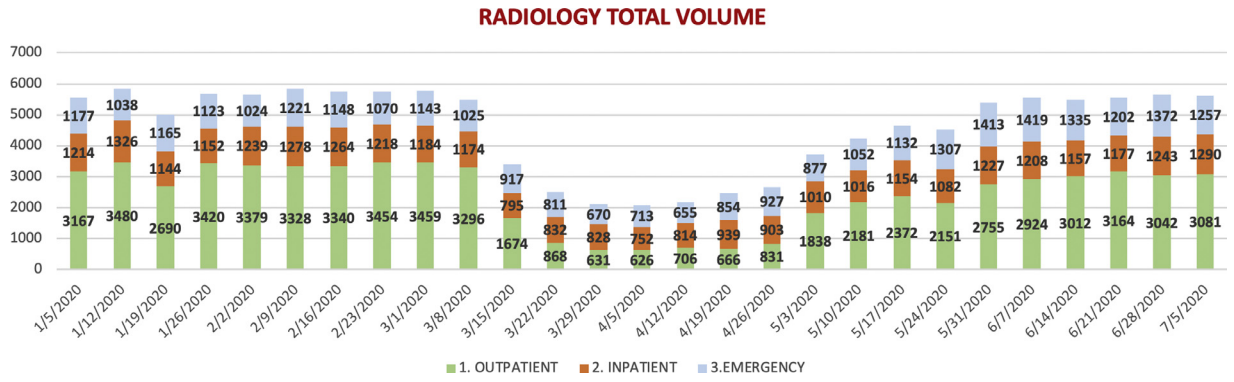


Figure. 4. Total radiology volumes in different settings of outpatient, inpatient and emergency department.

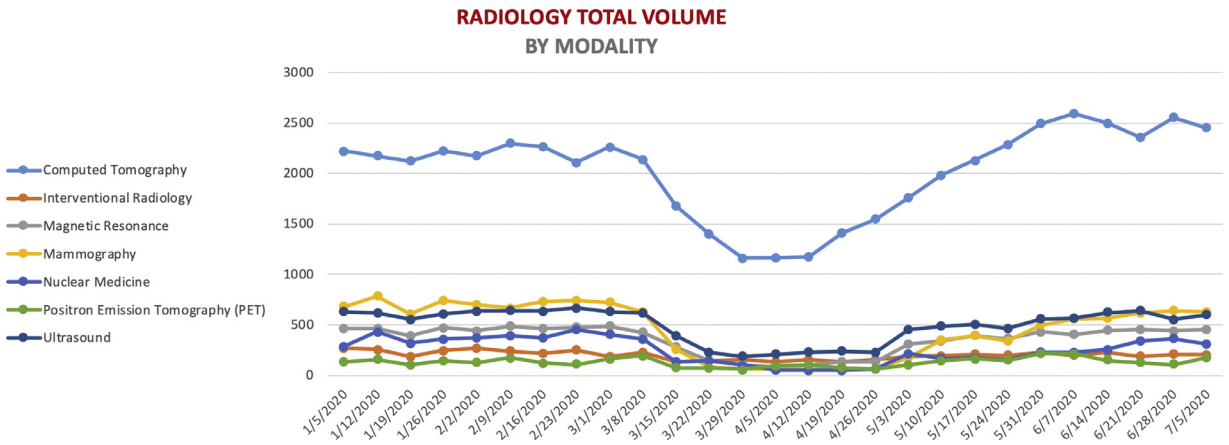


Figure 5. Total radiology volumes in different modalities.

daily imaging just before May 4th, 2020, and the endpoint was an outpatient volume to fully accommodate the clinical demand. When we compared our endpoint to our outpatient volumes at the similar time of the year in 2019, we found the outpatient volumes to be roughly the same. Our linear recovery plan balanced safety, enabled social distancing and room cleaning, and it was one that could be adequately staffed by our technologist workforce. Our actual outpatient volumes matched the intended, progressive, linear recovery. We also carefully followed outpatient clinic openings and the rescheduling of outpatient elective surgeries, assuming that to Recover Wisely our modeling would require us to integrate available imaging spots into the overall hospital goals.

A second premise for Recover Wisely was flexibility. Part of the outpatient imaging demand was unknown, as patient sentiments were difficult to estimate. To manage the former, we reviewed and prioritized every EMR request into a 4-tier system, and to improve the latter, we expanded our marketing strategies. New patient communication considered COVID-19 anxieties and focused on building and maintaining trust in our ability to provide a safe environment for all patients and visitors. Communication was also critical within the workforce and involved all levels—similar to our preparation during the acute pandemic crisis.

Recover Wisely followed our anticipated linear modeling, although we mathematically modeled and prepared for surges. We maintained readiness for both emergency and inpatient volumes to increase dramatically, although neither spiked during the study period. We monitored our volumes on a daily basis to determine if we were seeing an increase in emergency or inpatient volumes, since with a linear recovery of outpatients, our total capacity for delivering radiology services could be compromised. This was especially true for CT, MRI, and ultrasound where our capacity was limited

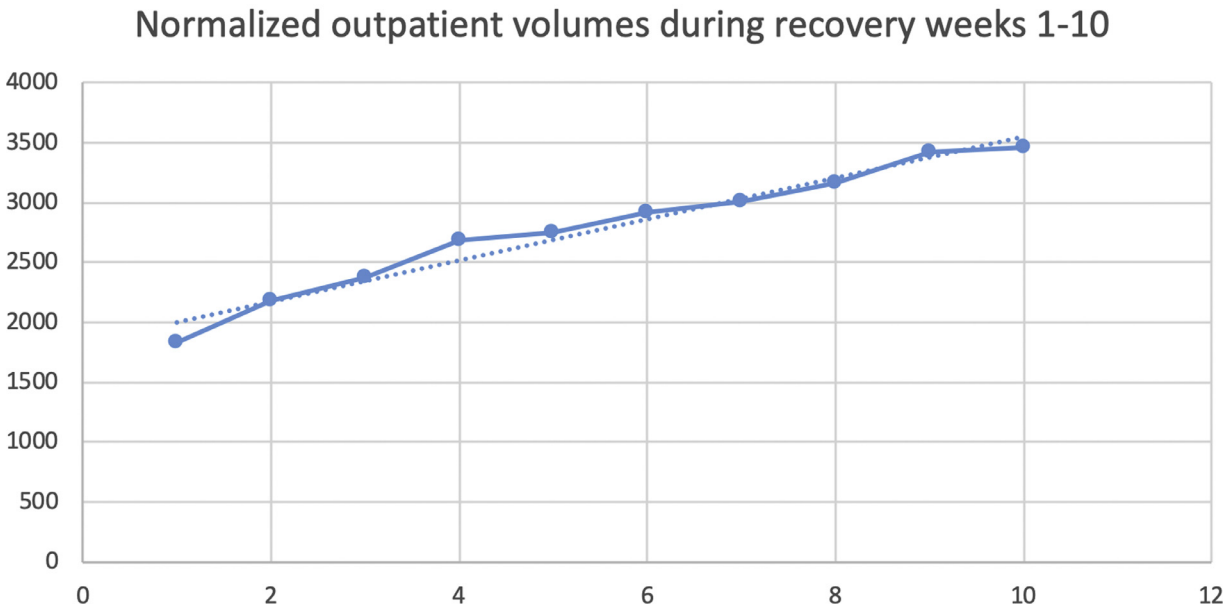


Figure 6. Linear recovery for outpatient volumes in recovery weeks. Weekly volumes were normalized to account for holidays where outpatients were not scheduled.

not only by the number of machines, but also number of technologists. We reviewed the daily technologist worklist for each modality and if we saw a spike, we rearranged the schedule immediately following the daily morning conferences. Our readiness plan included performing inpatients at night with the on-call staff if required, which would help reduce the burden during outpatient operating hours. The backlog was smaller than expected at the beginning of the recovery, if one assumes that we would have had the volumes anticipated based on 2019 data provided, plus all of the cases we rescheduled. Potential reasons for averting imaging volume surges included psychological (fear of academic hospitals with a large number of COVID-19 cases) and economic (unemployment, business closures, and loss of medical insurance) factors.

At the time of writing, our region and state report increased COVID-19 positive rates, similar to many other states in the country. We closely monitor state-wide data, regional cases, and out institutional COVID-19 daily census to maintain readiness. Longer term recovery planning needs to include the possibility of a second or seasonal surge of COVID-19 (10). However, the principles of Recovery Wisely should apply to any rescheduling and recovery strategy; practical implementation of imaging supply and demand and supply can be modified by changing available resources. Our program remains sensitive to the mindset and wellness of the radiology workforce—the uncertainty and anxiety amongst staff, technologists, trainees, radiologists, and senior administration. Our hospital has implemented reduced technologist staffing and hiring freezes as part of the overall pandemic response. The methodology and dashboards created and implemented for Recover Wisely provide evidence that balanced and restored human resources are needed to achieve and maintain pre-COVID imaging volumes. In the dire situation, if a large-scale shutdown occurs again, other departments will find our experience and resumption strategies helpful.

The COVID-19 crisis has called for a reimagination of places, people, and strategies for healthcare organizations to prepare for the postpandemic phase (11–13). In this recovery process, we learned important lessons of effective, tailored communications, cross disciplinary teamwork, and innovative solutions. The main limitation in our recovery was the inherent uncertainty in patient volumes, safety considerations, and the desires to maintain business models. Pre-COVID, we followed patient data on a monthly or quarterly basis and saw limited variations, and relatively small modifications could be made with expected results. The COVID era obligates radiology departmental leadership to make decisions with markedly limited data (14,15). From a practical standpoint, Recover Wisely was driven by all the available data that could be gathered, and then used a clinical priority tiering to plan and execute a linear increase in outpatient imaging that balanced our need to deliver radiology services. Once the studies were ranked, we formulated scheduling and communication templates to maximize safety, while ensuring that the patients in need of outpatient imaging received their exams.

Long-term COVID-19 recovery will require resilience and strategic planning. The post-COVID care will be different and will include a remote workforce, abbreviated imaging protocols, online registrations, and virtual waiting rooms. Although the pandemic is an unprecedented crisis, it provides a unique opportunity for us to rethink our health care operations and create radically different care models for the "new normal."

In conclusion, our department utilized a data-driven, team approach based on our guiding principles to "Recover Wisely." We created and implemented a methodology that achieved a linear increase in outpatient studies over a 10-week recovery period.

FUNDING

No funding received for this manuscript.

CONFLICTS OF INTERESTS

AV: R01 NIH/NINDS NS103824-01; R01 NIH/NINDS NS100417; NIH/NINDS 1U01NS100699; NIH/NINDS U01NS110772; Imaging Core Lab, ENDOLOW Trial, Cerenovus, Johnson & Johnson; Human centered design grant, ACR Innovation Fund.

FR: Director of Medical Affairs at Imagia.

MM: RSNA BOD, ACR BOC, Nonfinancial support from GE research agreement, Personal fees from Elsevier.

JA, BA, JH, SC, KC, SK, MG, AM, AB, SB, EE, JS, GU: No conflicts to disclose

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.acra.2020.08.002.