Original Investigation

Sources of Revenue Loss and Recovery in Radiology Practices During the Coronavirus Disease 2019 (COVID-19) Pandemic

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Rationale and Objectives: This study seeks to quantify the financial impact of COVID-19 on radiology departments, and to describe the structure of both volume and revenue recovery.

Materials and Methods: Radiology studies from a large academic health system were retrospectively studied from the first 33 weeks of 2020. Volume and work relative value unit (wRVU) data were aggregated on a weekly basis for three periods: Presurge (weeks 1−9), surge (10−19), and recovery (20−33), and analyzed compared to the pre-COVID baseline stratified by modality, specialty, patient service location, and facility type. Mean and median wRVU per study were used as a surrogate for case complexity.

Results: During the pandemic surge, case volumes fell 57%, while wRVUs fell by 69% relative to the pre-COVID-19 baseline. Mean wRVU per study was 1.13 in the presurge period, 1.03 during the surge, and 1.19 in the recovery. Categories with the greatest mean complexity declines were radiography (−14.7%), cardiothoracic imaging (−16.2%), and community hospitals overall (−15.9%). Breast imaging (+6.5%), interventional (+5.5%), and outpatient (+12.1%) complexity increased. During the recovery, significant increases in complexity were seen in cardiothoracic (0.46 to 0.49), abdominal (1.80 to 1.91), and neuroradiology (2.46 to 2.56) at stand-alone outpatient centers with similar changes at community hospitals. At academic hospitals, only breast imaging complexity remained elevated (1.32 from 1.17) during the recovery.

Conclusion: Reliance on volume alone underestimates the financial impact of the COVID-19 pandemic as there was a disproportionate loss in high-RVU studies. However, increased complexity of outpatient cases has stabilized overall losses during the recovery.

Key Words: Relative value units; Case complexity; Image volume; COVID-19.

Abbreviations: COVID-19 Coronavirus disease (2019), **CPT** Current procedural technology, **wRVU** Work relative value unit

INTRODUCTION

The coronavirus disease 2019 (COVID-19), originating in Wuhan, China in December of 2019, led to a pandemic resulting in millions of infections and over a million deaths worldwide (1). The outbreak and subsequent containment measures markedly reduced diagnostic and interventional radiology volume around the United States as patients delayed elective studies, health systems reduced non-emergent care, and stay-at-home orders were instituted. At the onset of the pandemic extensive discussion in the literature focused on the expected impact of the pandemic on radiology practices, as well as the steps taken by various practice types to adjust to the changes (2−5).

Prior studies have also quantified the influence of the first wave of the virus and measures taken to contain it on imaging volume (6−9). The decline in volume, however, incompletely characterizes the true financial effect on radiology practices, as the types of imaging studies performed also shifted. For example, in a large New York State health system, inpatient radiography volume actually increased over baseline at the height of the pandemic, driven by the surge in COVID-19 positive inpatients (10).

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The economic impact of the pandemic on radiology practices has also been explored, although less well quantified. Several recent studies have quantified the loss in productivity by exploring changes in work relative value unit (wRVU) output in various settings (11−13).

While imaging volume had begun to recover around the country by the end of May, 2020 (14), it predated the more recent increase in new COVID-19 cases throughout the United States that began in early June and has progressively increased in severity (15). The full effects of this surge have yet to be seen, but new declines in imaging volume are expected. In New York State, however, new hospitalizations and deaths remain well below the local peak, and did not start increasing again until the early winter (16). As the former global epicenter experiencing relatively less severe ongoing outbreaks than many other regions, the New York City area provides a unique opportunity to model both the impact of the first wave virus and the structure of the recovery.

In anticipation of renewed demand for imaging as restrictions are lifted, professional societies in the United States and abroad, have published guidelines for safe resumption of normal services (17−19). However, little data-driven guidance exists on strategies to ensure the financial health of radiology practices. Therefore, this study seeks to more accurately quantify the financial impact of the dramatic case volume losses during the COVID-19 pandemic by concurrently evaluating the loss in wRVUs. Furthermore, as volume recovers, it is important to understand which service lines and facilities have returned to their prepandemic revenue levels or even exceeded them in order to maintain overall revenue while traditionally strong divisions are struggling. These analyses can serve as a reference for radiology departments making budget preparations and decisions in parts of the country actively experiencing outbreaks.

METHODS

A retrospective review of billing data for diagnostic and interventional radiology studies in a large academic health system was performed between December 29, 2019 and August 18, 2020 including the patient service location, performing hospital or imaging center, and submitted current procedural technology (CPT) codes.

All CPT codes for each imaging study or procedure were mapped to the associated wRVU. Each code was also mapped to a modality and body region based on the Neiman Imaging Types of Services (NITOS) ontology (11,20). Modalities were classified into six categories: CT, MRI, radiography (including fluoroscopy and mammography), ultrasound, nuclear medicine, and procedures. At exam creation, studies were automatically assigned to subspecialties, which were subsequently condensed into: Abdominal imaging, breast, cardiothoracic, musculoskeletal, neuroradiology, nuclear medicine, and vascular/interventional radiology. Patient age was not evaluated thus pediatric radiology was not considered separately. Subspecialty assignments were based on the interpreting division in this health system. For example, spine imaging was assigned to neuroradiology, and biopsies were assigned to the performing division rather than exclusively to interventional radiology.

Patient service location was classified at the time of study as inpatient, outpatient, or emergency. Within the health system, imaging is performed at each of 7 hospitals (4 academic, 2 community, and 1 specialty), 7 urgent care centers, and 12 stand-alone outpatient sites (primarily located within multispecialty offices), all within the greater New York City area. These were condensed to three facility types: Academic hospital (including the specialty hospital), community hospital, and stand-alone outpatient center.

Using these classifications, four key covariates relevant to departmental accounting were generated for analysis: modality, subspecialty, patient service location, and facility type. Complexity was defined as wRVU per study, and revenue was defined as total wRVUs. Data were aggregated on a weekly basis stratified by each covariate. Volumes and wRVUs are presented as a percentage of the pre-COVID baseline, defined as the mean weekly total during the first 9 weeks of 2020. Cumulative study counts and total wRVUs were plotted over the study period to visualize the trends in volume and revenue. To further elucidate the changes in case complexity over the study period, the mean wRVU per study was plotted separately, stratified by each covariate.

Concurrent analysis of the median wRVU per study was performed to elucidate changes in the skew of the data. As radiography, which uniformly generates less than 1.0 wRVU regardless of specialty, dominates study volume in any large academic practice, median wRVU per study provides a measure of that dominance, as median decreases faster than mean when data become more left-skewed.

For statistical analysis of the effects of the local COVID-19 outbreak, the data was split into three periods: Presurge (weeks 1−9), surge (weeks 10−19), and recovery (weeks 20−33). The surge period was defined as beginning with the first positive case in New York (March 1, 2020) and ending when the average daily new cases crossed below 25% of the peak in the state (May 12, 2020) (16). The overall mean wRVU per study during the surge and recovery periods, as well as the means stratified by subspecialty and facility type, was compared to the presurge baseline using Welch's *t*-test. Statistical analyses were performed using *R* version 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria). As retrospective data were reviewed in aggregate only containing no individually identifying items, this does not qualify as human subjects research and does not meet criteria for institutional review board submission.

RESULTS

More than 500,000 imaging studies were performed in the health system during the study period. The contribution of each modality, subspecialty, patient service location, and facility type to the overall volume and wRVUs are summarized in Table 1.

TABLE 1. Contributions to Overall Imaging Volume and wRVUs Throughout the Health System in 2020 Stratified by Modality, Subspecialty, Facility Type, and Patient Service Location

2020 Contributions	Volume	wRVU
Modality		
CT	20.8%	36.5%
MRI	8.6%	21.7%
Radiography	54.3%	19.3%
Ultrasound	13.4%	12.7%
Nuclear medicine	1.7%	4.6%
Procedure	1.2%	5.3%
Specialty		
Abdominal	20.9%	28.3%
Breast	7.8%	9.7%
Cardiothoracic	32.4%	14.4%
Musculoskeletal	19.3%	7.1%
Neuroradiology	15.4%	26.6%
Nuclear medicine	1.8%	4.6%
Vascular and interventional	2.3%	9.4%
Facility type		
Academic	54.4%	50.9%
Community	15.6%	12.9%
Stand-Alone	30.0%	36.2%
Patient service location		
Inpatient	23.4%	18.9%
Outpatient	40.2%	51.4%
Emergency	36.4%	29.7%

At the height of the pandemic, case volume fell 57%, while wRVUs fell by 69% relative to the pre-COVID-19 baseline. Figure 1 demonstrates the trend in total weekly studies and wRVUs as a percentage of the baseline. The nadir for both measures occurred during week 14 (March 29th to April 4th), but recovery in wRVUs was slightly faster such that by week 19, percentage volume and revenue losses matched, and by week 21 volume loss deviated from baseline more than wRVUs. The nadir corresponds almost precisely to the peak in new daily cases, which occurred on April 4, 2020. A gradual increase was seen in both measures during the recovery period, with volume and wRVUs reaching 90% and 94% of the baseline respectively by the end of week 33.

The mean wRVU per study was 1.13 in the presurge period, 1.03 during the surge, and 1.19 in the post-surge period. Both the surge and post-surge means were significantly different ($p < 0.001$) from the presurge period. Median was 0.76 during the presurge and recovery periods, and 0.31 during the surge period. Figure 2 demonstrates the trend in weekly median and mean wRVU over time throughout 2020. Drivers of the decline seen during the surge period were explored by independently plotting the mean wRVU per study over time based on modality, subspecialty, patient service location, and facility type as shown in Figure 3.

By modality, the only large changes in complexity during the surge were seen in radiography, which fell by a mean of 14.7% from 0.41 to 0.35 wRVUs per study and nuclear medicine, which fell 7.0% from 3.10 to 2.88 wRVUs per study.

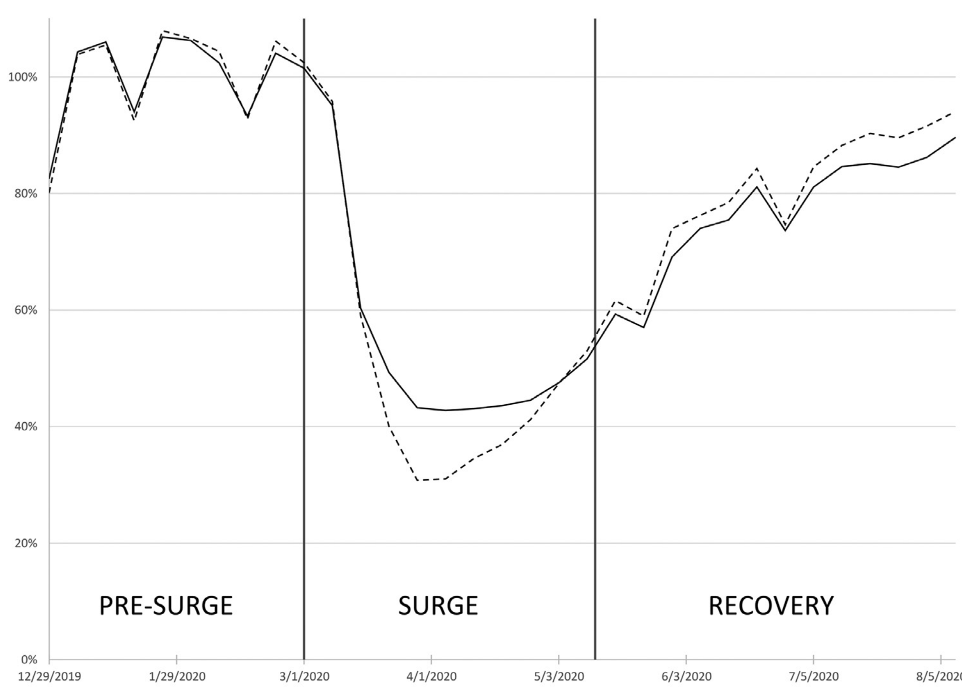

Figure 1. Weekly aggregate radiology case volume and wRVU trend throughout the health system during the first 33 weeks of 2020. Volumes are presented as a percentage of the pre-COVID-19 baseline, which is defined as the mean weekly total during the presurge period. Single week deviations from the overall trend relate to holiday weeks. The vertical black bars separate the presurge (weeks 1–9), surge (weeks 10–19), and recovery (weeks 20–33) periods.

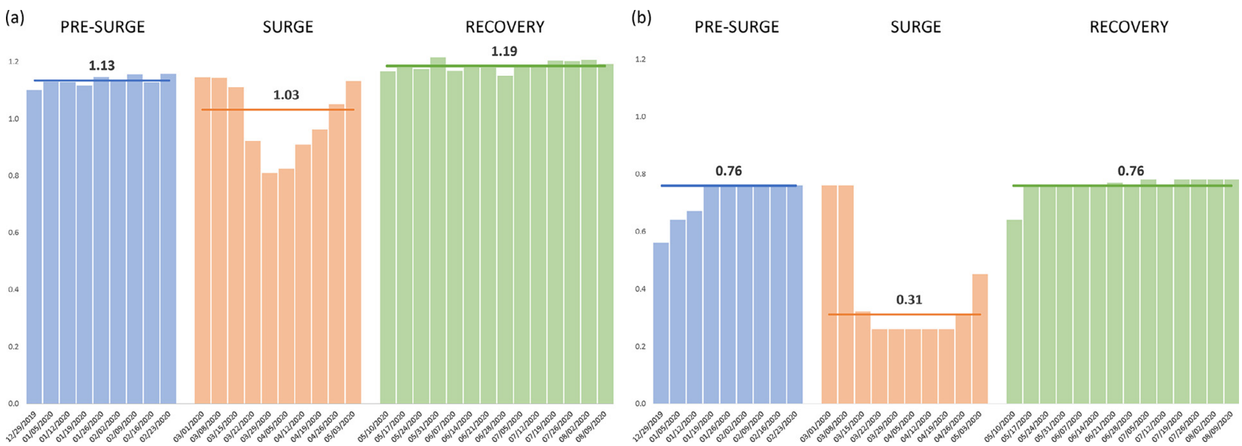

Figure 2. Weekly (a) mean and (b) median wRVU per study during the presurge (weeks 1–9), surge (weeks 10–19), and recovery (weeks 20–33) periods. The surge period began with the first confirmed positive COVID-19 case in New York and ended when daily new cases crossed below 25% of the peak. Horizontal bars indicate the overall mean or median wRVU of each period respectively. At the nadir (week 14: 3/29–4/4), the mean wRVU per study was 0.81, 29% below baseline. (Color version of figure is available online.)

Figure 3. Weekly mean wRVU per study from December 29, 2019 until August 18, 2020 split by (a) modality, (b) subspecialty, (c) patient service location, and (d) facility type. The vertical black bars on each graph separate the presurge, surge, and recovery periods. MSK, musculoskeletal radiology; NM, nuclear medicine; VIR,= vascular and interventional radiology. (Color version of figure is available online.)

Cardiothoracic imaging saw the largest decrease in complexity among specialties, declining as much as 32% to a nadir of 0.36 wRVU per study during week 14. This reflected a marked proportional increase in radiography, reaching a maximum of 95.3% of all cardiovascular studies during that week from an average of 86.1% during the pre-COVID period. The proportion returned to 85% during the recovery, and the change was paralleled primarily by an opposite change in CT. Additionally, specialty cardiothoracic studies such as cardiac MRI fell to near zero. Histograms of the cardiothoracic study wRVUs are shown in Figure 4. With some minor variations, the unique peaks in the histograms correspond (in ascending order of wRVU) to chest radiograph, chest CT, chest/cardiac CT angiogram, chest MRI, and cardiac MRI. The substantial changes in these histograms resulted in a small, but important, decrease in median wRVU per study for cardiothoracic imaging from 0.31 to 0.26, roughly the difference between a one-view and two-view chest radiograph.

More modest maximum mean decreases were seen in neuroradiology (−12%) and nuclear medicine (−20%). The breast imaging and vascular/interventional radiology sections saw maximum weekly complexity increases of 36% and 15% over baseline respectively. Complexity declined at both academic (−12.3%) and community (−15.9%) hospitals but increased by a mean of 11.9% and a maximum of 32% at stand-alone outpatient imaging centers. The most severe decrease in complexity by patient service location was seen in inpatient studies, with wRVUs per study falling a mean of 16.8%. During the recovery, radiograph and CT complexity were slightly above baseline, +2.6% and +3.1% respectively. All three facility types and patient service locations also saw persistent small increases in complexity (2.5%−6% above baseline). A more rapid recovery occurred in inpatient services (84.6% of baseline during the recovery) than outpatient (71.2%) or emergency (74.8%) imaging. Results are summarized in Table 2.

Figure 5 demonstrates the relative contribution of each subspecialty to the overall wRVUs and volume for the system. Cardiothoracic imaging, which typically accounts for 30% of overall volume and 14% of wRVUs, increased to nearly 45% of volume, and 19% of wRVUs during the surge as chest radiography was the only study type without a marked decline in this period. At the peak of the surge period

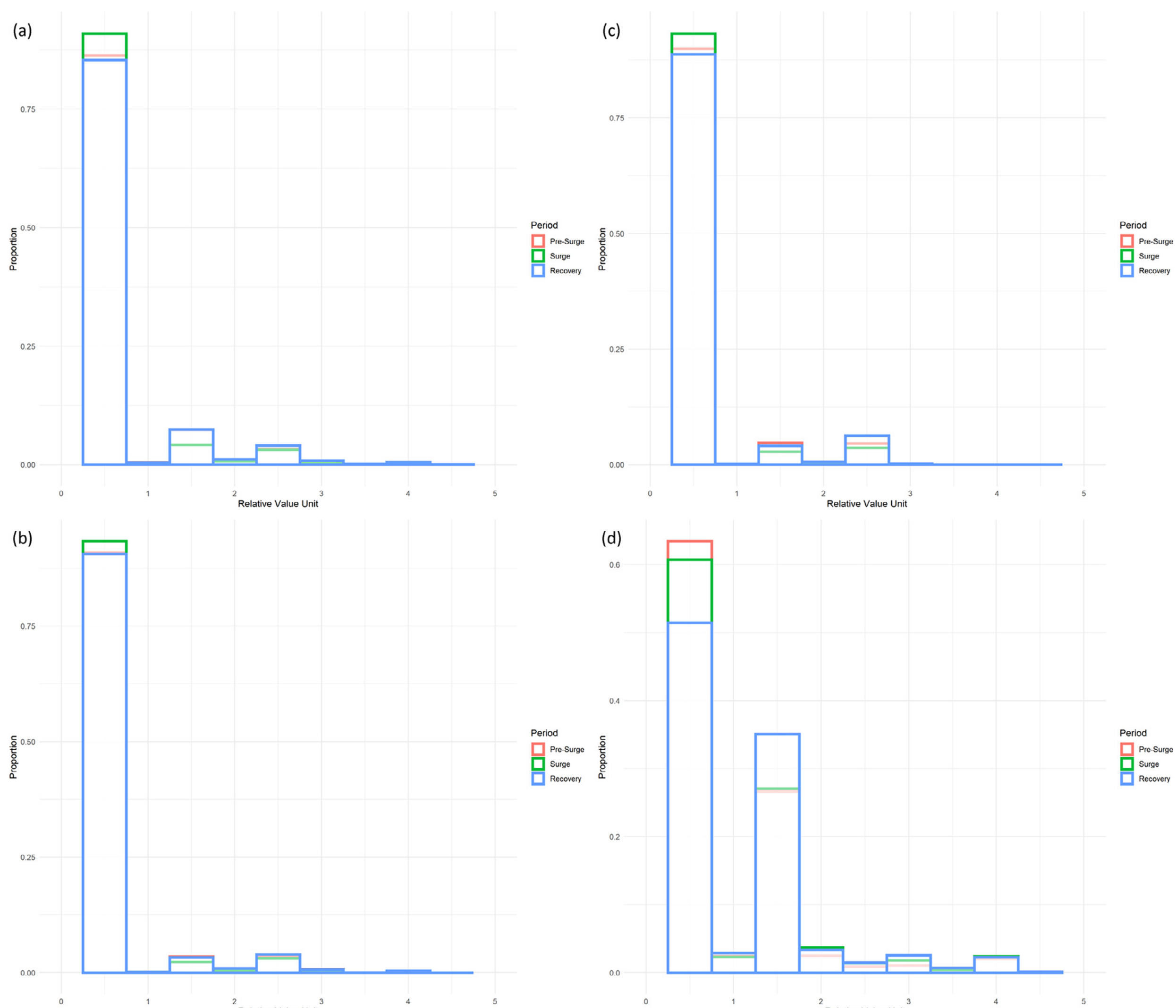

Figure 4. Normalized histograms displaying the relative number of cardiothoracic studies of each wRVU value performed during the study period (a) overall and at each facility type, (b) academic, (c) community, and (d) stand-alone. The graphs are further broken down into the three study periods: presurge (weeks 1−9), surge (weeks 10−19), and recovery (weeks 20−33). (Color version of figure is available online.)

TABLE 2. Mean and Median wRVU per Study During Each Segment of the Study Period Separated by Modality, Subspecialty, Patient Service Location, and Facility Type

	Presurge Weeks 1−9	Surge - Weeks 10−19 (% Change)		Recovery - Weeks 20−33 (% Change)	
Mean wRVU per Study	1.13	1.03	(−9.0%)	1.19	(+4.5%)
Modality					
CT	1.96	1.96	(−0.3%)	2.02	(+3.1%)
MRI	2.82	2.87	(+1.8%)	2.84	(+1.0%)
Radiography	0.41	0.35	(−14.7%)	0.42	(+2.6%)
Ultrasound	1.07	1.09	(+2.1%)	1.07	(−0.2%)
NM	3.10	2.88	(−7.0%)	3.10	(+0.2%)
Procedure	5.02	5.06	(+0.8%)	5.00	(−0.4%)
Specialty					
Abdomen	1.51	1.54	(+1.8%)	1.55	(+2.4%)
Breast	1.38	1.47	(+6.5%)	1.38	(+0.6%)
Cardiothoracic	0.52	0.44	(−16.2%)	0.54	(+3.0%)
MSK	0.41	0.43	(+2.8%)	0.41	(−0.5%)
Neuroradiology	1.95	1.87	(−4.0%)	2.00	(+2.4%)
NM	2.93	2.71	(−7.7%)	2.94	(+0.1%)
VIR	4.46	4.71	(+5.5%)	4.57	(+2.5%)
Facility type					
Academic	1.07	0.94	(−12.3%)	1.12	(+4.1%)
Community	0.96	0.80	(−15.9%)	1.01	(+5.6%)
Stand-alone	1.30	1.46	(+11.9%)	1.38	(+6.0%)
Patient service location					
Inpatient	0.95	0.79	(−16.8%)	0.98	(+2.6%)
Outpatient	1.38	1.55	(+12.1%)	1.47	(+6.1%)
Emergency	0.92	0.83	(−9.8%)	0.98	(+6.1%)
Median wRVU per Study	0.76	0.31	(−59.2%)	0.76	(0.0%)
Modality					
CT	1.66	1.66	(0.0%)	1.66	(0.0%)
MRI	2.27	2.32	(+2.2%)	2.32	(+2.2%)
Radiography	0.26	0.26	(0.0%)	0.26	(0.0%)
Ultrasound	0.86	0.92	(+7.0%)	0.85	(−1.2%)
NM	3.39	3.48	(+2.7%)	3.48	(+2.7%)
Procedure	3.57	3.66	(+2.5%)	3.57	(0.0%)
Specialty					
Abdomen	1.15	1.15	(0.0%)	1.15	(0.0%)
Breast	1.46	1.46	(0.0%)	1.46	(0.0%)
Cardiothoracic	0.31	0.26	(−16.1%)	0.26	(−16.1%)
MSK	0.26	0.24	(−7.6%)	0.26	(0.0%)
Neuroradiology	1.66	1.65	(−0.6%)	1.66	(0.0%)
NM	2.24	3.32	(+48.2%)	3.48	(+55.4%)
VIR	3.57	3.73	(+4.5%)	3.66	(+2.5%)
Facility type					
Academic	0.31	0.26	(−16.1%)	0.31	(0.0%)
Community	0.32	0.31	(−3.1%)	0.32	(0.0%)
Stand-alone	0.96	1.06	(+10.4%)	1.00	(+4.2%)
Patient service location					
Inpatient	0.26	0.26	(0.0%)	0.26	(0.0%)
Outpatient	0.96	1.15	(+20.0%)	1.06	(+10.4%)
Emergency	0.31	0.31	(0.0%)	0.31	(0.0%)

Percent changes are relative to the presurge value. MSK, musculoskeletal radiology; NM, nuclear medicine; VIR, vascular and interventional radiology.

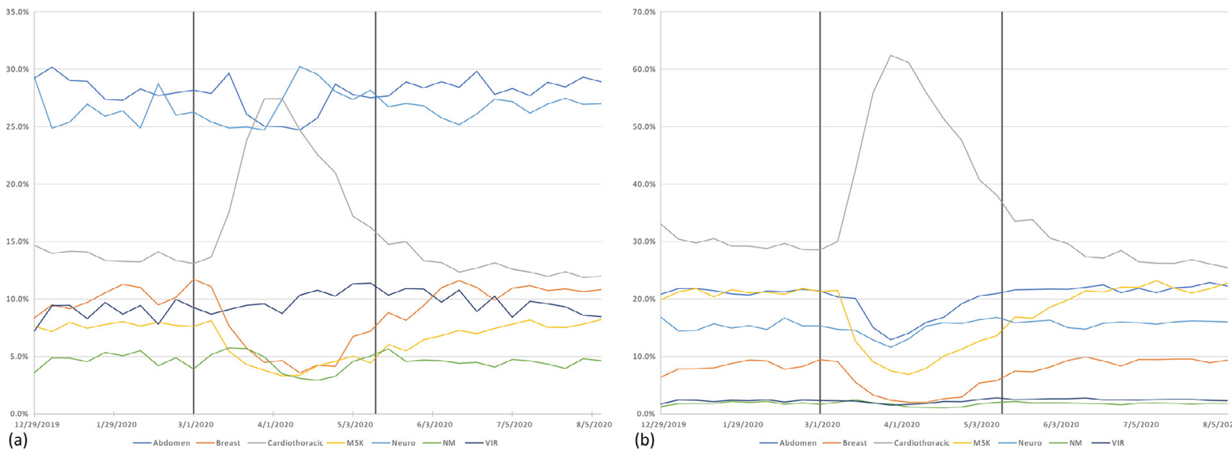

Figure 5. Contribution of each subspecialty to the total wRVUs (a) and overall volume (b) generated by the department during each week of the study period. The vertical black bars on each graph separate the presurge, surge, and recovery periods. MSK, musculoskeletal radiology; NM, nuclear medicine; VIR, vascular and interventional radiology. (Color version of figure is available online.)

(week 14), it accounted for over 62% of the total studies and 27% of wRVUs. Neuroradiology and abdominal imaging remained the largest contributors to overall wRVUs throughout 2020 at 26% and 28%, respectively, despite small decreases in volume contribution. Musculoskeletal imaging volume contribution fell by one third, from 21% to 14%, with a corresponding wRVU contribution decrease from 8% to 6%. A similar decline occurred in breast imaging, which normally makes up 10% of both volume and wRVUs. There were essentially no changes in the contributions of nuclear medicine or vascular and interventional radiology. All specialties returned to presurge levels during the recovery period.

The durability of changes in complexity is demonstrated in Table 3. While nearly every subspecialty experienced a significant change in complexity at all sites during the pandemic, increasing at outpatient centers and decreasing at hospitals, few changes persisted during the recovery period. At the stand-alone outpatient centers, significant increases were seen in abdominal, cardiothoracic, and neuroradiology complexity (1.80 to 1.91, 0.87 to 1.06, and 2.46 to 2.56 respectively). These were mirrored to a lesser extent at the community hospitals. However, at the academic centers, complexity remains elevated for breast imaging alone (1.32 from 1.17).

DISCUSSION

Early predictions suggested radiology practices could anticipate 50%−70% losses in imaging volume lasting at least 3 to 4 months, depending on the timing and severity of the outbreak, with outpatient and screening services experiencing the greatest revenue losses (5). Both the volume losses and prolonged recovery seen closely reflect these predictions, and are more severe than those seen by other, similar radiology practices (6,9), possibly due to the geographic position at the early pandemic epicenter. The economic impact was further exacerbated by a disproportionate loss in high-value services during the height of the COVID-19 surge. Fortunately, the overall complexity returned roughly to normal within a month of the peak in new daily cases, which occurred during the second week of April (week 15) (16), and remained consistent throughout the recovery phase. Nonetheless, even 18 weeks after the nadir, the total volume remains about 10% below baseline, and despite increased complexity wRVUs still lag by 6%.

The change in case complexity, defined as mean wRVU per study, for each facility type surrounding the surge period had a surprising resiliency, particularly at nonteaching sites. For example, the significant decrease in complexity seen in inpatient studies at academic centers was expected as sites increased capacity by nearly 50%, dedicating all new beds to COVID-19 positive patients. As minimal imaging is recommended for these patients (21), primarily limited portable radiography and ultrasonography, mean wRVU naturally fell during the surge, and normalized in the recovery. Conversely, stand-alone outpatient centers experienced a durable increase in complexity extending into the recovery period, particularly in cardiothoracic imaging and neuroradiology. While some of this has been driven by follow-up imaging on prior COVID-19 patients, it may also reflect patients' collective persistent reticence to seek all but the most time sensitive imaging, for example procedures and cancer staging studies, which tend to generate higher wRVUs. As a result, complexity remained elevated throughout the system months after the outbreak peak. Similarly asymmetric changes between academic sites and nonacademic imaging centers were also previously reported from a large system in Massachusetts (22).

The drivers of the financial recovery for any given radiology practice are still being revealed. Our experience suggests that after the initial surge, case complexity returns quickly, but diminished volume persists for many months, even in the setting of persistently low COVID-19 cases locally. Based on prior predictive models, these results may reflect a combination of patients' economic concerns and COVID-19-related fears resulting in decreased healthcare utilization (14).

TABLE 3. Mean and median wRVU per study during each phase stratified by facility type and subspecialty. Comparisons of the means were made to the presurge period using a Welch's *t*-test with $p < 0.05$ considered statistically significant

	Presurge Weeks 1−9	Surge - Weeks 10−19 (*p*-value)		Recovery - Weeks 20−33 (*p*-value)	
Mean wRVU per Study	1.13	1.03	(<0.001)*	1.19	(<0.001)*
Academic					
Abdomen	1.38	1.37	(0.2)	1.40	(0.2)
Breast	1.17	1.31	(<0.001)*	1.32	(<0.001)*
Cardiothoracic	0.46	0.40	(<0.001)*	0.46	(0.8)
VIR	4.77	5.06	(0.04)*	4.85	(0.5)
MSK	0.36	0.37	(0.4)	0.37	(0.2)
Neuroradiology	1.82	1.73	(<0.001)*	1.85	(0.02)*
NM	2.66	2.48	(0.06)	2.74	(0.2)
Community					
Abdomen	1.28	1.33	(0.02)*	1.33	(0.02)*
Breast	1.24	1.40	(0.05)*	1.28	(0.2)
Cardiothoracic	0.46	0.40	(<0.001)*	0.49	(<0.001)*
VIR	3.87	4.32	(0.03)*	3.94	(0.6)
MSK	0.34	0.35	(0.1)	0.33	(0.3)
Neuroradiology	1.61	1.62	(0.5)	1.75	(<0.001)*
NM	3.27	3.12	(0.7)	2.98	(0.2)
Stand-alone					
Abdomen	1.80	1.97	(<0.001)*	1.91	(<0.001)*
Breast	1.42	1.49	(0.002)*	1.40	(0.2)
Cardiothoracic	0.87	0.92	(<0.001)*	1.06	(<0.001)*
VIR	3.52	3.09	(<0.001)*	3.56	(0.8)
MSK	0.47	0.51	(<0.001)*	0.48	(0.7)
Neuroradiology	2.46	2.57	(<0.001)*	2.56	(<0.001)*
NM	4.04	3.57	(0.004)*	3.93	(0.5)
Mean wRVU per study	0.76	0.31		0.76	
Academic					
Abdomen	0.98	0.98		0.98	
Breast	1.06	1.46		1.46	
Cardiothoracic	0.26	0.26		0.26	
VIR	3.57	3.91		3.66	
MSK	0.24	0.24		0.24	
Neuroradiology	1.62	1.22		1.62	
NM	1.67	1.67		2.24	
Community					
Abdomen	0.98	1.38		1.15	
Breast	1.46	1.46		1.46	
Cardiothoracic	0.26	0.26		0.26	
VIR	3.66	3.66		3.66	
MSK	0.24	0.24		0.24	
Neuroradiology	1.22	1.22		1.22	
NM	1.49	1.49		1.49	
Stand-alone					
Abdomen	1.15	1.40		1.15	
Breast	1.46	1.46		1.46	
Cardiothoracic	0.31	0.31		0.31	
VIR	3.57	3.51		3.57	
MSK	0.26	0.26		0.26	
Neuroradiology	2.11	2.11		2.11	
NM	3.48	3.48		3.48	

Mean and median wRVU per study during each phase stratified by facility type and subspecialty. Comparisons of the means were made to the presurge period using a Welch's t-test with $p < 0.05$ (*) considered statistically significant.

Interestingly, there was no slowdown in recovery when new virus outbreaks began outside of the New York area, suggesting that safety-related concerns are either less important or influenced primarily by local disease spread and public health initiatives.

To our knowledge, no prior publications have evaluated the structure of the revenue loss and recovery among radiology practices due to the COVID-19 pandemic by considering the changes in case complexity. While the initial surge of the virus passed in this health system's region, spikes in new COVID-19 cases and deaths continue throughout the United States, and the severity of the local "second wave" is still unclear. Therefore, these results may help inform budgeting and resource allocation decisions in newly affected regions.

For example, breast and cardiac imaging sections both saw increased complexity during the pandemic but lagged in volume recovery, highlighting patient reticence to seek screening services such as mammography, cardiac calcium scoring, and screening chest CTs even after restrictions have been lifted. This is consistent with pooled data from 60 health care systems indicating a delayed recovery in cancer screening procedures around the country (23,24). These indicate important potential patient outreach avenues when working to restore normal services. Additionally, in any future outbreaks, oncology screening will require early focus, as these services are generally high volume and time-sensitive, although nonemergent. Other authors have discussed specific strategies in detail for safely and responsibly clearing study backlogs and recovering volume (2,25).

The primary limitation of this study is the retrospective, single system design, which may limit generalizability of the findings to other healthcare systems and radiology groups. The use of billing data restricted the available information about each study such that potentially important factors, such as patient demographics, were not available. Furthermore, wRVUs were used as a surrogate for revenue, thus additional considerations such as uncaptured charges or changes in payer mix were not included. With the national unemployment rate at historic highs (26), there may also be a shift from employer sponsored private insurance to public insurance, deferred services, or self-pay, which is not captured in this data. Previous studies have seen a payer mix shift with increased Medicaid and decreased commercial insurance coverage during similar surges in other regions (13). Given the lag between billing and payment, any change in charge capture could not be evaluated.

In conclusion, reliance on case volume alone underestimates the financial impact of the COVID-19 pandemic as there was a disproportionate loss in high-RVU procedures. However, increased complexity of outpatient procedures has stabilized overall losses during the recovery.

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