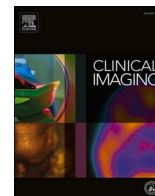




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Musculoskeletal and Emergency Imaging



Increased per-patient imaging utilization in an emergency department setting during COVID-19

Marc D. Succi^{a,b,c,*}, Ken Chang^{a,c}, Thomas An^{a,c}, David A. Rosman^{a,c}, Ali S. Raja^{c,d},
Michael S. Gee^{a,b,c}, Michael H. Lev^{a,c}, Ray Liu^{a,c}, Sanjay Saini^{a,c}, James A. Brink^{a,b,c}

^a Department of Radiology, Massachusetts General Hospital, Boston, MA, United States of America

^b Medically Engineered Solutions in Healthcare Incubator, Innovation in Operations Research Center (MESH IO), Massachusetts General Hospital, Boston, MA, United States of America

^c Harvard Medical School, Boston, MA, United States of America

^d Department of Emergency Medicine, Massachusetts General Hospital, Boston, MA, United States of America

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ABSTRACT

Introduction: COVID-19 has resulted in decreases in absolute imaging volumes, however imaging utilization on a per-patient basis has not been reported. Here we compare per-patient imaging utilization, characterized by imaging studies and work relative value units (wRVUs), in an emergency department (ED) during a COVID-19 surge to the same period in 2019.

Methods: This retrospective study included patients presenting to the ED from April 1–May 1, 2020 and 2019. Patients were stratified into three primary subgroups: all patients ($n = 9580$, $n = 5686$), patients presenting with respiratory complaints ($n = 1373$, $n = 2193$), and patients presenting without respiratory complaints ($n = 8207$, $n = 3493$). The primary outcome was imaging studies/patient and wRVU/patient. Secondary analysis was by disposition and COVID status. Comparisons were via the Wilcoxon rank-sum or Chi-squared tests.

Results: The total patients, imaging exams, and wRVUs during the 2020 and 2019 periods were 5686 and 9580 (−41%), 6624 and 8765 (−24%), and 4988 and 7818 (−36%), respectively, and the percentage patients receiving any imaging was 67% and 51%, respectively ($p < .0001$). In 2020 there was a 170% relative increase in patients presenting with respiratory complaints. In 2020, patients without respiratory complaints generated 24% more wRVU/patient ($p < .0001$) and 33% more studies/patient ($p < .0001$), highlighted by 38% more CTs/patient.

Conclusion: We report increased per-patient imaging utilization in an emergency department during COVID-19, particularly in patients *without* respiratory complaints.

1. Introduction

The disruptive effects of the COVID-19 pandemic have caused significant declines in imaging volume in emergency departments. Absolute decreases in imaging volume have ranged between 28 and 55% across all patient service locations (e.g. inpatient, outpatient, and emergency departments) in recent studies.^{1–3} Emergency department (ED) imaging volume has similarly been affected by the pandemic, with absolute imaging volumes decreasing 42% compared to pre-COVID levels.⁴ While recent studies on imaging volume in the context of the pandemic have highlighted absolute declines in imaging utilization and corresponding work relative value unit (wRVU) data, specific data on

changes in per-patient utilization, including data by modality and corresponding wRVU, have not been reported.^{5–8} Such data may be of benefit to recently published models detailing financial recovery predictions as hospitals aim to resume operations.^{6,9} Lastly, with widespread news of decreased ED imaging volumes and concern that sick patients are avoiding the ED secondary to fear of contracting COVID-19, analyzing imaging utilization on a per-patient basis may support anecdotal reports of the increasing complexity of presenting patients – low-acuity patients who are less likely to be imaged may be avoiding the ED.^{10–15}

This study compares per-patient imaging utilization, characterized by imaging studies and work relative value units, in patients presenting

* Corresponding author at: Massachusetts General Hospital, Department of Radiology, 55 Fruit Street, Boston, MA 02114, United States of America.

E-mail address: msucci@mgh.harvard.edu (M.D. Succi).

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to the ED during a 2020 COVID-19 pandemic surge to the same period in 2019. We hypothesize that there was increased imaging utilization across all patients in the ED, regardless of COVID status or respiratory-related chief complaint.

2. Methods

2.1. Study design and setting

This single-institution, retrospective collection of aggregate data was compliant with the Health Insurance Portability and Accountability Act and approved with exemption by the Institutional Review Board.

All patients who presented to our ED, housed within a large, urban academic medical center, from April 1–May 1, 2020 and April 1–May 1, 2019 were included. In 2020, this time period was largely considered the height of the COVID-19 pandemic in Massachusetts. At the time of this manuscript, Massachusetts had amassed >121,000 cases and >8700 deaths.¹⁶ We retrospectively identified all patients seen in our ED via our built-in electronic health record (EHR, Epic Systems, Verona WI) reporting system during the study periods; there were no exclusions. Imaging utilization included only studies ordered and performed in the Emergency Department and was quantified by calculating 1) imaging studies/patient (including stratification by modality) and 2) imaging wRVUs/patient. We compared 2020 and 2019 cohorts to identify broad differences according to presenting symptoms, and then sub-analyzed the cohorts by disposition and COVID test status.

2.2. Participants

Both the 2020 and 2019 patient cohorts were stratified into three primary subgroups (Figs. 1 and 2): (I) All Patients, (II) Patients presenting with respiratory complaints, (III) Patients presenting without respiratory complaints. Further secondary subgroups included: (IV) Admitted patients (V) Discharged patients, as well as (VI) COVID+ (defined as any positive test in the patient’s three most recent tests) and (VII) non-COVID+.

Subgroups II and III were intended to highlight the primary respiratory-centered presenting complaints of COVID-19 patients, and to quantify this impact by utilization year-over-year. Distinction between subgroups II and III was based on the chief complaint as recorded by the ED clinician. This field allows for both pre-defined text input and manually entered free-text, and is logged in our EHR and typically recorded upon initial patient presentation to the ED. The vast majority entered are pre-defined text, followed by a mix of pre-defined and free text, and finally less than 1% free text only. The criteria terms for inclusion in subgroup II were: “aspiration”, “asphyxia”, “asthma”, “bronchitis”, “chills”, “cough”, “COVID”, “COPD”, “crackles”, “fever”, “hypoxemia” “hypoxia”, “nasal congestion”, “phlegm”, “pleural”,

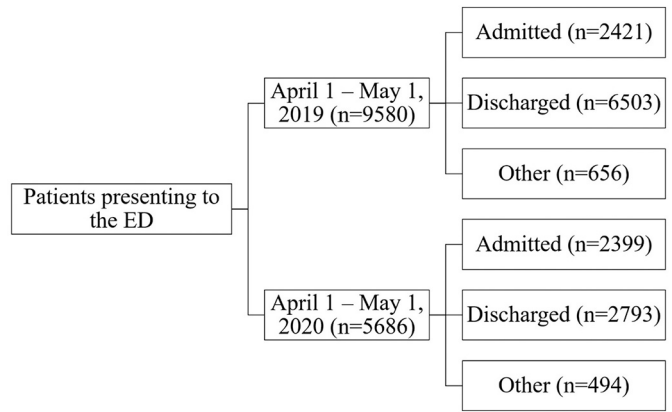


Fig. 2. Flow chart of the study cohort with subgroups by disposition. wRVU = work relative value unit.

“pneumonia”, “pulmonary”, “pulmonary embolism”, “rales”, “shortness of breath”, “sore throat”, “sputum”, “stridor”, and “wheeze”. Upon categorizing the patient in either subgroup II or III or VI and VII, all imaging studies associated with the patient, regardless of body part or modality, were included in the per-patient calculations for these groups.

Patient descriptive data, including age and gender, were collected from the EHR. All corresponding imaging exam codes and classes performed in our ED imaging locations were also collected during the study period. To calculate wRVUs, we obtained a list of all exam classes, and manually correlated these to the 2020 National Physician Fee Schedule Relative Value File July Release.¹⁷

2.3. Variables

The primary study outcome was per-patient imaging utilization, defined as overall/modality-specific studies/patient and wRVUs/patient, among the primary subgroups. Modalities analyzed included computed tomography (CT), ultrasound (US), magnetic resonance imaging (MRI), and conventional radiograph (CR). Per-patient utilization in this context is the number of imaging studies or wRVUs during the study period divided by the total number of presenting patients in each subgroup, regardless of if they received imaging. Using wRVU allows generalizability to practice outside of our geographic location, and further generalizability between facility and non-facility practices. It is understood that using only the wRVU component of reimbursement likely results in more conservative, but also more generalizable, results. Secondary study outcomes included imaging utilization as previously defined in the secondary subgroups - by disposition and COVID test status.

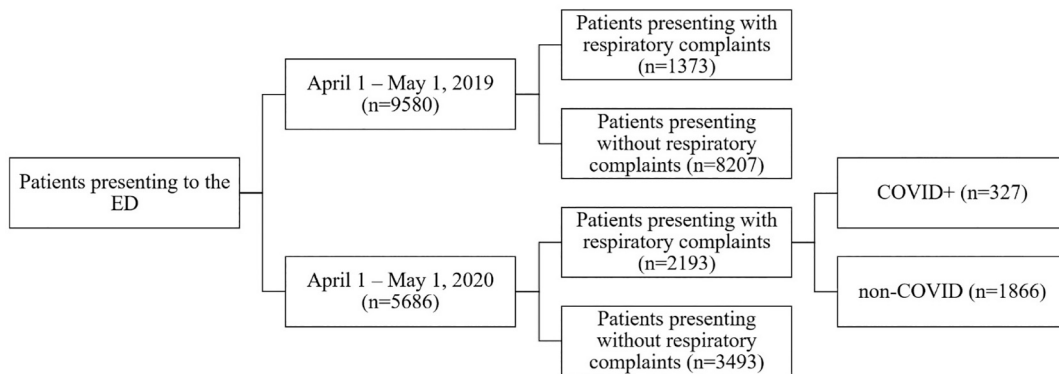


Fig. 1. Flow chart of the study cohort with subgroups by symptom profile and COVID test status. wRVU = work relative value unit.

2.4. Study size

The number of patients presenting to the ED during the 2020 and 2019 study periods determined the sample size.

2.5. Statistical methods and analysis

Patient demographics were reported via descriptive statistics. If a patient presented to the ED for multiple visits during the study period, each visit was treated as a separate patient encounter. Statistical comparison of the subgroups was performed via either the Wilcoxon rank-sum test (for comparison of values) or the Chi-squared test (for comparison of proportions). Comparisons of mean studies per-patient and mean wRVU per-patient and modality subgroups were performed via the Wilcoxon rank-sum test. Confidence intervals (CIs) of the mean studies/patient and mean wRVU/patient were calculated with non-parametric bootstrapping (resampling) to calculate CIs. For all statistical tests, a significance level of $p = .05$ was used.

3. Results

3.1. Participants and descriptive data (Table 1)

The total number of patients presenting to the ED during the 2020 and 2019 study periods was 5686 and 9580 respectively, an approximate 41% decrease for 2020. All patients presenting to the ED were included. The total number of imaging exams during the 2020 and 2019 study periods was 6624 and 8765, an approximate 24% decrease for 2020. The number of patients receiving any imaging during the 2020 and 2019 study periods were and 66.92% (3805/5686) and 50.89% (4875/9580) respectively ($p < .0001$), an approximately 16% relative increase in imaging incidence for 2020. The absolute number of imaging wRVUs in the study period for 2020 and 2019 were 4988 and 7818 respectively, an approximately 36% decrease for 2020. The 2020 cohort had an increased mean age (50.98 [95% CI, 50.47–51.54] vs. 45.50 [95% CI, 45.03–45.93], $p < .0001$) and percentage of patients presenting with respiratory complaints (38.57% [2193/5686] vs. 14.33% [1373/9580], $p < .0001$). The 2020 cohort ED disposition also changed significantly ($p < .0001$) with increased percentage of ED patients admitted (42.19% [2399/5686] vs. 25.27% [2421/9580]), decreased percentage discharged (49.10% [2792/5686] vs. 67.88% [6503/9580])

Table 1

Descriptive characteristics of patients presenting to the ED from April 1–May 1, 2019 and 2020. wRVU = work relative value unit

	2019	2020	P value
Total patients	9580	5686	–
Patients/day	309.0 (301.7–317.3)	183.4 (176.0–190.4)	<.0001
Patients who received any imaging	4875 (50.89%)	3805 (66.92%)	<.0001
Total imaging studies	8765	6624	–
Imaging studies/day	282.7 (232–324.3)	213.7 (156.3–292.3)	<.0001
Total imaging wRVUs	7818	4988	–
Imaging wRVUs/day	252.2 (242.8–261.5)	160.9 (147.2–174.9)	<.0001
Age (years)	45.50 (45.03–45.93)	50.98 (50.47–51.54)	<.0001
Gender (% M/F/unknown)	48.32/51.67/ 0.01%	44.95/55.05/ 0.00%	.0002
Patients with respiratory complaints (%)	1373 (14.33%)	2193 (38.57%)	<.0001
Respiratory patients who are COVID+ (%)	–	327 (14.91%)	–
ED disposition (%)			
Discharge	67.88%	49.10%	<.0001
Admit	25.27%	42.19%	
Other	6.85%	8.71%	

and decreased percentage other (6.85% [155/5686] vs. 8.71% [292/9580]). The “other” category, again reflecting ED disposition, includes patients transferred, direct-admits, those sent directly to the operating room, patient demise, or for whom the information was not available (failure of documentation).

3.2. Main results

3.2.1. Per-patient imaging utilization

To examine the data in a granular manner beyond absolute volume and wRVU changes, we examined mean per-patient imaging utilization (Table 2 and Figs. 3 and 4). To reduce confounding by COVID-19 presentations, which are primarily pulmonary in nature, analyzing patients presenting without respiratory complaints provides the most direct comparison of 2020 utilization to 2019. In 2020, this group demonstrated a 24% increase wRVU/patient (1.07 [95% CI, 1.01–1.13] vs. 0.86 [95% CI, 0.83–0.90], $p < .0001$), driven increased CT (wRVU/patient 2020 vs. 2019: 0.76 [95% CI, 0.71–0.81] vs. 0.55 [95% CI, 0.53–0.58], $p < .0001$) and CR (wRVU/patient 2020 vs. 2019: 0.12 [95% CI, 0.11–0.13] vs. 0.08 [95% CI, 0.08–0.08], $p < .0001$) wRVU generation. Correspondingly, this group demonstrated a 33% increase in studies/patient (studies/patient 2020 vs. 2019: 1.24 [95% CI] vs. 0.93 [95% CI, 0.90–0.96], $p < .0001$), driven by increased CT (studies/patient 2020 vs. 2019: 0.47 [95% CI, 0.44–0.50] vs. 0.34 [95% CI, 0.33–0.36], $p < .0001$) and CR (studies/patient 2020 vs. 2019: 0.65 [95% CI, 0.62–0.68] vs. 0.44 [95% CI, 0.42–0.56], $p < .0001$).

Among all patient groups, compared to 2019 there was an overall 7% increase in imaging wRVU/patient (overall wRVU/patient 2020 vs. 2019: 0.88 [95% CI, 0.83–0.92] vs. 0.82 [95% CI, 0.7852–0.8474], $p < .0001$), driven by increased CT (wRVU/patient 2020 vs. 2019: 0.62 [95% CI, 0.59–0.66] vs. 0.53 [95% CI, 0.51–0.55], $p = .01$) and CR (wRVU/patient 2020 vs. 2019: 0.13 [95% CI 0.12–0.13] vs. 0.08 [95% CI, 0.08–0.09], $p < .0001$) wRVU generation. Correspondingly, among all patients, compared to 2019 there was a 27% increase in studies/patient (studies/patient 2020 vs. 2019: 1.17 [95% CI, 1.13–1.20] vs. 0.92 [95% CI, 0.89–0.94], $p < .0001$), primarily driven by increased CT (studies/patient 2020 vs. 2019: 0.38 [95% CI, 0.36–0.40] vs. 0.33 [95% CI, 0.31–0.34], $p = .01$) and CR (studies/patient 2020 vs. 2019: 0.70 [95% CI, 0.68–0.72] vs. 0.46 [95% CI, 0.44–0.47], $p < .0001$). Among all patient subgroups, compared to 2019, there was trending towards, but ultimately no significant difference, in MRI or US utilization – this may be in part be due to the relatively low use of these modalities in the ED compared to CT and CR (Supplementary Tables 1 and 2).

3.3. Other analyses

3.3.1. Per-patient imaging utilization by ED disposition

In 2020 there was a 7% increase in studies/patient (studies/patient 2020 vs. 2019: 1.63 [95% CI, 1.56–1.69] vs. 1.53 [95% CI, 1.47–1.60], $p < .0001$), but no difference in wRVU per-patient (Table 2). For discharged patients, compared to 2019, there was an approximately 20% increase in studies/patient (studies/patient 2020 vs. 2019: 0.89 [95% CI, 0.85–0.93] vs. 0.74 [95% CI, 0.71–0.77], $p < .0001$) with a 3% increase in wRVU/patient (wRVU/patient 2020 vs. 2019: 0.66 [0.61–0.71] vs. 0.64 [0.61–0.67], $p < .0001$, Table 2).

3.3.2. Per-patient imaging utilization by COVID test status

There was no significant difference in imaging utilization when analyzing 2020 COVID+ patients presenting with respiratory complaints and non-COVID+ patients presenting with respiratory complaints, as shown in Table 3 (overall studies/patient COVID+ vs. non-COVID+: 1.07 [95% CI, 0.97–1.177] vs. 1.04 [95% CI, 1.00–1.08], $p = .93$) and (overall wRVU/patient COVID+ vs. non-COVID+: 0.53 [95% CI, 0.42–0.66] vs. 0.58 [95% CI, 0.54–0.63], $p = .55$).

Table 2

Mean imaging utilization of patients presenting to the ED from April 1–May 1, 2019 and 2020, including analysis by respiratory complaint status and ED disposition. wRVU = work relative value unit.

Subgroup	Studies/patient			wRVU/patient		
	2019 (n = 9580)	2020 (n = 5686)	P value	2019	2020	P value
All patients						
Overall	0.92 (0.89–0.94)	1.17 (1.13–1.20)	<.0001	0.82 (0.79–0.85)	0.88 (0.84–0.92)	<.0001
CT	0.33 (0.31–0.34)	0.38 (0.36–0.40)	.01	0.53 (0.51–0.55)	0.62 (0.60–0.66)	.01
MR	0.08 (0.07–0.09)	0.05 (0.05–0.06)	.08	0.17 (0.16–0.19)	0.11 (0.09–0.13)	.08
US	0.05 (0.05–0.06)	0.03 (0.03–0.04)	.05	0.03 (0.03–0.04)	0.02 (0.02–0.02)	.05
CR	0.46 (0.44–0.47)	0.70 (0.68–0.72)	<.0001	0.08 (0.08–0.09)	0.13 (0.12–0.12)	<.0001

Subgroup	Studies/patient			wRVU/patient		
	2019 (n = 1373)	2020 (n = 2193)	P value	2019	2020	P value
Patients presenting with respiratory complaints						
Overall	0.83 (0.78–0.88)	1.05 (1.01–1.09)	<.0001	0.53 (0.48–0.58)	0.57 (0.53–0.52)	<.0001
CT	0.23 (0.20–0.26)	0.25 (0.22–0.27)	.89	0.39 (0.35–0.44)	0.41 (0.37–0.45)	.79
MR	0.01 (0.00–0.01)	0.01 (0.00–0.01)	.93	0.01 (0.01–0.02)	0.02 (0.01–0.03)	.93
US	0.03 (0.02–0.04)	0.01 (0.01–0.02)	.37	0.02 (0.01–0.03)	0.01 (0.01–0.01)	.37
CR	0.57 (0.53–0.60)	0.78 (0.76–0.81)	<.0001	0.10 (0.10–0.11)	0.14 (0.14–0.15)	<.0001

Subgroup	Studies/patient			wRVU/patient		
	2019 (n = 8207)	2020 (n = 3493)	P value	2019	2020	P value
Patients presenting without respiratory complaints						
Overall	0.93 (0.90–0.96)	1.24 (1.19–1.29)	<.0001	0.86 (0.83–0.90)	1.07 (1.01–1.13)	<.0001
CT	0.34 (0.33–0.36)	0.47 (0.44–0.50)	<.0001	0.55 (0.53–0.58)	0.76 (0.71–0.81)	<.0001
MR	0.09 (0.08–0.10)	0.07 (0.06–0.09)	.41	0.20 (0.18–0.22)	0.16 (0.13–0.19)	.41
US	0.05 (0.05–0.06)	0.04 (0.04–0.05)	.37	0.04 (0.03–0.38)	0.03 (0.02–0.03)	.37
CR	0.44 (0.42–0.46)	0.65 (0.62–0.68)	<.0001	0.08 (0.08–0.08)	0.12 (0.11–0.13)	<.0001

Subgroup	Studies/patient			wRVU/patient		
	2019 (n = 2421)	2020 (n = 2399)	P value	2019	2020	P value
Admitted patients						
Overall	1.53 (1.47–1.60)	1.63 (1.56–1.69)	.0001	1.42 (1.35–1.51)	1.25 (1.18–1.33)	.44
CT	0.60 (0.56–0.64)	0.59 (0.55–0.63)	.09	0.97 (0.91–1.03)	0.94 (0.89–1.01)	.05
MR	0.12 (0.11–0.14)	0.05 (0.04–0.07)	.01	0.28 (0.23–0.32)	0.12 (0.09–0.15)	.01
US	0.07 (0.06–0.08)	0.03 (0.02–0.03)	.02	0.04 (0.04–0.05)	0.02 (0.01–0.02)	.02
CR	0.75 (0.71–0.78)	0.96 (0.92–1.00)	<.0001	0.14 (0.13–0.14)	0.17 (0.17–0.18)	<.0001

Subgroup	Studies/patient			wRVU/patient		
	2019 (n = 6503)	2020 (n = 2793)	P value	2019	2020	P value
Discharged patients						
Overall	0.74 (0.71–0.76)	0.89 (0.85–0.93)	<.0001	0.64 (0.61–0.67)	0.66 (0.61–0.71)	<.0001
CT	0.25 (0.23–0.26)	0.25 (0.23–0.28)	.67	0.39 (0.37–0.42)	0.42 (0.38–0.46)	.64
MR	0.07 (0.06–0.08)	0.05 (0.04–0.07)	.57	0.15 (0.13–0.17)	0.11 (0.09–0.14)	.57
US	0.05 (0.04–0.05)	0.04 (0.03–0.05)	.40	0.03 (0.03–0.04)	0.03 (0.02–0.03)	.41
CR	0.37 (0.26–0.39)	0.55 (0.52–0.58)	<.0001	0.07 (0.06–0.07)	0.10 (0.09–0.10)	<.0001

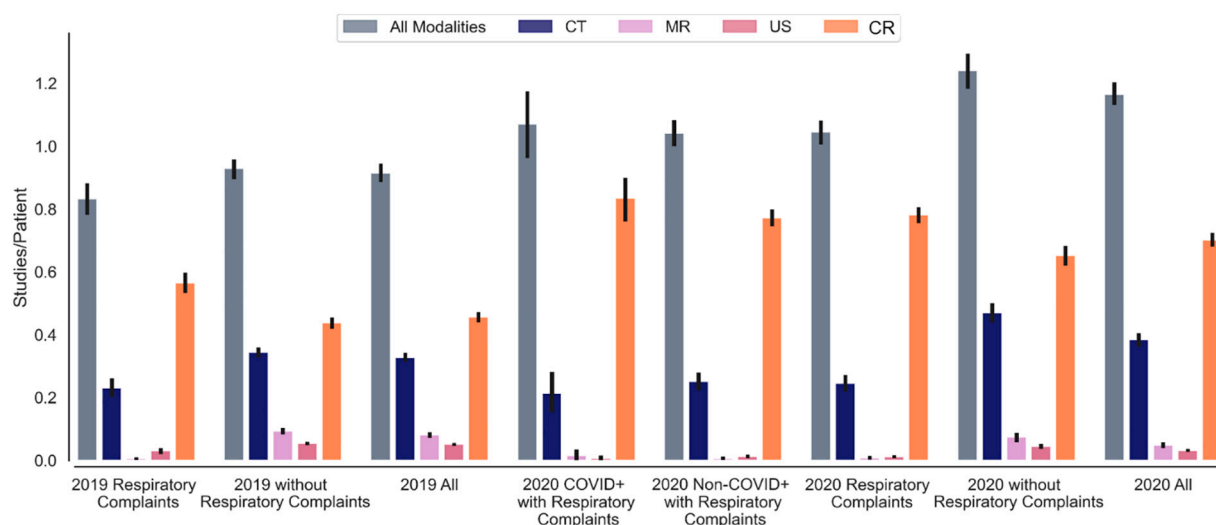


Fig. 3. Bar plot of subgroup exams by year, modality, and respiratory status. Data shown as mean (95% of mean).

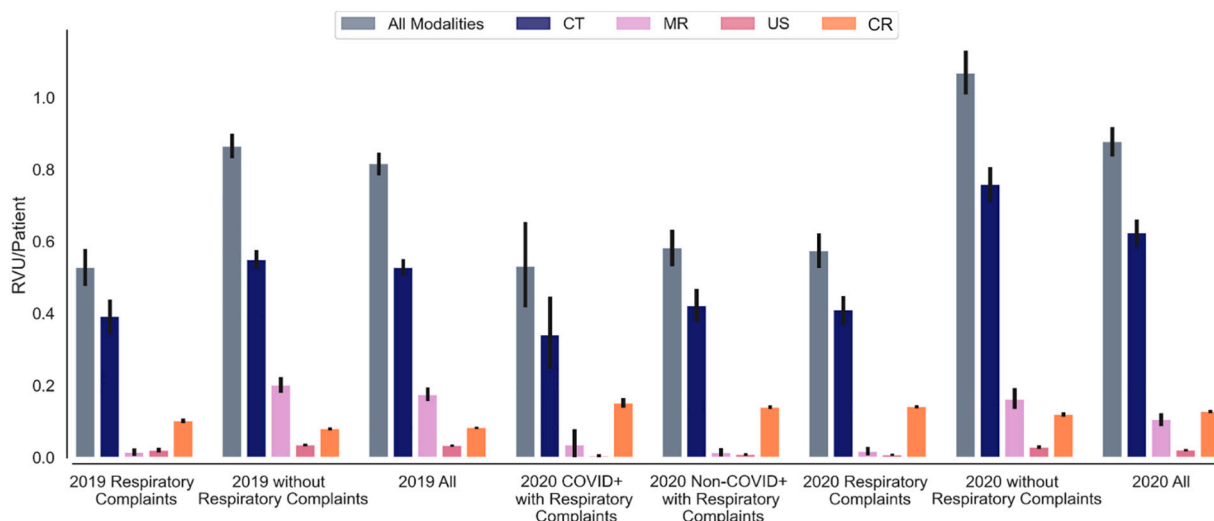


Fig. 4. Bar plot of subgroup wRVUs by year, modality, and respiratory status. Data shown as mean (95% of mean). wRVU = work relative value unit.

Table 3

Mean imaging utilization of patients presenting to the ED with respiratory complaints from April 1–May 1, 2019 and 2020, by COVID test status.

wRVU = work relative value unit.

	Studies/patient			wRVU/patient		
	COVID+ (n = 327)	Non-COVID+ (n = 1866)	P value	COVID+	Non-COVID+	P value
Overall	1.07 (0.97–1.17)	1.04 (1.00–1.09)	.93	0.53 (0.43–0.65)	0.58 (0.53–0.63)	.55
CT	0.21 (0.15–0.29)	0.25 (0.23–0.28)	.22	0.34 (0.24–0.45)	0.42 (0.38–0.47)	.22
MR	0.02 (0.00–0.04)	0.01 (0.00–0.01)	.86	0.04 (0.00–0.09)	0.01 (0.00–0.03)	.86
US	0.01 (0.00–0.02)	0.01 (0.01–0.02)	.86	0.00 (0.00–0.01)	0.01 (0.01–0.01)	.86
CR	0.83 (0.77–0.91)	0.77 (0.75–0.80)	.34	0.15 (0.14–0.16)	0.14 (0.14–0.14)	.34

4. Discussion

To our knowledge this is the first report of increased per-patient imaging utilization during the COVID-19 pandemic. Analyzing emergency department patients presenting without respiratory complaints minimizes confounding by pulmonary-centric COVID-19 presentations: in this subgroup we observed a significant 33% increase in imaging studies/patient and 24% increase in wRVU/patient, compared to 2019, including a 38% increase in CTs/patient. Notably, we observed a significant 170% relative increase in patients presenting with respiratory complaints, accounting for 38.6% of all patients in 2020, compared to 14.9% in 2019. As respiratory patients carry just 53% of the average wRVU/patient of a non-respiratory patient, this engenders a double-financial hit to emergency departments and associated imaging operations - absolute volume contraction and increased lower-wRVU patient profiles.

The absolute decline (–24%) in total imaging exams during the 2020 study period compared to 2019 echoes recently published literature.^{3,18} Parikh et al. demonstrated a decline in ED imaging volume of 38–58% in the Cleveland metropolitan area.² Naidich et al. demonstrated a decrease in ED imaging volume of approximately 27% over a seven-week period amidst the COVID-19 pandemic in New York City.¹ Our prior research demonstrated hospital-wide overall volume decreases of 54–64%.⁵ The authors speculate that the magnitude of decline in imaging volume is multifactorial - population density, patient catchment area, severity of COVID-19 outbreaks, and social distancing policies are a few of many possible factors.

4.1. Looking beyond absolute volume contraction

Despite absolute imaging volume contraction, in the 2020 study

period there was, across the board, a 7% increase in wRVU/patient and corresponding 27% increase in studies/patient, compared to the same period in 2019. When analyzing non-respiratory presenting patients, these numbers are even more pronounced – 24% and 33% increases in wRVU/patient and studies/patient, respectively. The overall tempered wRVU increase in the context of the 27% overall imaging utilization increase for all patients in 2020 is consistent with the lower average wRVU for respiratory patients (53% of the average wRVU for non-respiratory patients in 2020, and 62% in 2019), which accounted for a 170% relative increase (60% absolute) in ED visits compared to 2019 (38.6% vs. 14.3%). This double financial hit, comprised of (I) absolute volume contraction and (II) increased proportion of lower-value wRVU volume, is significant and can be taken into account by financial managers at all practices – for forecasting quarterly revenue or preparing for additional surges of this or other pandemics.

In general, causes for the observed increase in per-patient imaging utilization are likely multifactorial. Clinical uncertainty in the diagnosis and management of COVID-19 may have spurred increased diagnostic testing by clinicians regardless of presenting complaint, thereby leading to increased imaging. Further, as many patients began to avoid the healthcare system to reduce risk of exposure to COVID-19, the average acuity of patients presenting to the ED may have increased.^{10,19} This difference in acuity is suggested by the significant increase in the proportion of patients in the ED that were admitted in 2020 compared to 2019 (42% vs. 25%, respectively), and may be proxied by increased imaging – we observed a significant increase in patients receiving any imaging (67% vs. 51%, respectively).

4.2. Limitations

Regarding imaging utilization in the ED of COVID+ compared to

non-COVID+ patients presenting with respiratory complaints, we found no difference in imaging studies/patient or wRVU/patient. However this secondary analysis has significant limitations as (I) our data was ED-specific, excluding inpatient imaging and (II) our data was collected in aggregate, therefore the COVID+ group could theoretically have included patients with a positive test prior to the ED, patients tested and resulted while in the ED, and patients tested and resulted after ED discharge.

Among all data, the retrospective and aggregate data collection limited assessment for the precise causes for the changes in imaging volume. Geographic and temporal variability in the effects of COVID-19 throughout the United States may limit the ability to extrapolate the results of this study to other radiology practices. Our study period is one-month during the first-wave of COVID, and therefore does not assess longitudinal practice patterns during subsequent waves of the pandemic. Lastly, our study is at a large academic center, and primarily generalizable to similar practices reading ED imaging.

In conclusion, this study is the first to report increased per-patient imaging utilization during COVID-19, characterized by significantly increased studies and wRVUs. We also identified a significantly increased proportion of patients receiving imaging as well as increased admitted patients, suggesting that less-acute patients are avoiding care. As the effects of COVID-19 on radiology practices continue to evolve, knowledge of individualized utilization growth metrics may help departments understand and plan for imaging trends.

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Ethics approval

Approved with exemption by the Institutional Review Board with waiver of consent and assent.

Declaration of competing interest

The authors declare no relevant conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.clinimag.2021.06.003>.

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