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# Patterns of Recovery in Cardiovascular Care after the COVID-19 Pandemic Surge

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## ABSTRACT

**Background:** Cardiovascular disease remains the number one cause of death globally. Patients with cardiovascular disease are at risk of poor outcomes from deferral of healthcare during the coronavirus disease 2019 (COVID-19) pandemic. Little is known about recovery of cardiovascular hospitalizations or procedural volume following the COVID-19 surges. We sought to examine the cardiovascular diagnoses requiring healthcare utilization surrounding the first and second COVID-19 waves and characterize trends in return to pre-pandemic levels at a tertiary care center in Massachusetts.

**Materials and Methods:** Using electronic health records and administrative claims data, we performed a retrospective analysis of patients undergoing cardiovascular procedures and admitted to inpatient cardiology services throughout the first two COVID surges. ICD-10 codes were used to categorize admissions.

**Results:** Patients who presented for care during the initial COVID-19 surge were younger, had higher comorbidity burden, and longer length-of-stay compared with pre- and post-surge. Marked declines in admissions in the first wave (to 29% of pre-surge levels) followed eventually by complete recovery were noted across all cardiac diagnoses, with smaller declines seen in the second wave. Cardiac procedural volume declined significantly during the initial surge but quickly rebounded post-surge, eventually eclipsing pre-COVID volume.

**Conclusions:** There was a gradual but initially incomplete recovery to pre-surge levels of hospitalizations and procedures during the reopening phase, which eventually rebounded to meet or exceed pre-COVID-19 levels. To the extent that this reflects deferred or foregone essential care, it may adversely affect long-term cardiovascular outcomes. These results should inform planning for cardiovascular care delivery during future pandemic surges.

**Key Indexing Terms:** Coronavirus disease 2019 (COVID-19); Hospitalizations; Cardiovascular care; Trends. **[Am J Med Sci 2022;363(4):305–310.]**

## INTRODUCTION

The novel coronavirus disease 2019 (COVID-19) pandemic is considered the greatest public health crisis of this century, with both the case rate and death toll continuing to rise worldwide.[1] As a result, healthcare systems have undergone rapid restructuring efforts to accommodate the ebb and flow of patients from acute care in concordance with local COVID-19 conditions.[2,3] With congestive heart failure, acute myocardial infarction and cardiac dysrhythmias making up 3 of the 10 most common diagnoses for inpatient stays, cardiac patients are at particular risk during this pandemic if care is deferred.[4] Thus, practicing cardiovascular medicine amidst the COVID-19 pandemic has presented particular clinical challenges.

During the initial stages of the coronavirus disease 2019 (COVID-19) pandemic in the United States in March 2020, cardiovascular care saw a sudden reduction in inpatient admissions and outpatient procedures because of national stay-at-home orders, enhanced social distancing, reallocation of health resources to COVID-19 care and patient self-isolation due to concern for

infectious spread.[5,6] Though emerging data has demonstrated a globally decreased incidence of acute cardiac hospitalizations concurrent with the onset of COVID-19,[7–10] less is known about the return of patients to cardiovascular care and impact of the COVID-19 waves in the United States. As a result, information regarding the recovery of cardiac hospitalizations and procedures once the initial and second COVID-19 surges eased is lacking. We analyzed trends in cardiology admissions and procedures at a tertiary care academic medical center in Boston, MA to gain a better understanding of practice patterns during this resource-limited period and inform recovery efforts as we continue to face the impacts of COVID-19.

## METHODS

This analysis was performed at Beth Israel Deaconess Medical Center (BIDMC), an academic health system in Boston, MA with more than 5,000 inpatient cardiology admissions, 1,500 electrophysiology (EP) procedures, and 3,700 cardiac catheterization laboratory procedures annually. The BIDMC institutional review board approved this study. Using electronic health records and administrative claims data, we performed a retrospective analysis of all patients undergoing outpatient invasive cardiology procedures and those discharged from the cardiology service from January 1, 2020, through June 28, 2021. Admission date or date of procedure was utilized to account for the earliest date when patients presented to care.

We defined five groups according to admission date (1) pre-surge if on or before the United States National Emergency declaration on March 13, 2020,[11] (2) during initial surge if between March 14, 2020 and May 18, 2020 when Massachusetts declared Phase I of reopening,[12] (3) after initial surge if between May 19, 2020 and November 2, 2020 when Massachusetts Governor Charles Baker issued an order acknowledging rising COVID-19 caseloads and instating a mask mandate in public places,[13] (4) during second surge if between November 3, 2020 and March 22, 2021 when Massachusetts moved into Phase IV ("New Normal") of re-opening,[14] and (5) post-second surge if after March 23, 2021. We used primary diagnosis ICD-10 codes to categorize admissions into nine groups based on pathology (Supplementary Tables 1 and 2).

All analyses were conducted using Stata Statistical Software: Release 15 (College Station, TX: StataCorp LLC); the unit of analysis was inpatient cardiology admission. Continuous data are represented using mean (± SD) and categorical data presented using proportions. We conducted bivariate analyses evaluating differences in patient and clinical characteristics across COVID-19 time periods using chi-square test for categorical variables and t test for continuous variables. We used Bonferroni test for subgroup comparisons when appropriate. Two-sided p-values <0.05 were considered statistically significant.

## RESULTS

Table 1 demonstrates the clinical and demographic characteristics of the study group. There were 6,148 encounters for admissions and procedures during the study period. Overall, the proportion of inpatient versus outpatient (outpatient procedures and observation) volume increased during the initial COVID-19 peak (64.8% pre-peak to 85.9% during initial peak) and continued to eclipse pre-surge levels both after Phase I of reopening in MA (65.8%) and during the second COVID surge (66.3%). Outpatient volume fell quickly during the initial COVID-19 surge (35.2% pre-peak to 14.1% during-peak) and recovered slowly after the initial surge, though after the second surge outpatient volume surpassed pre-COVID-19 levels (36.6%). This pattern largely reflects the decline in outpatient procedures during COVID-19 surges.

During the initial COVID-19 peak, there was a trend towards increased admissions for younger patients (mean age 67.9 ± 13.9 years) as compared to mean ages ranging from 68.4 to 69.9 years during other time periods. The proportion of White patients fell during the initial surge while the proportion of all other non-Black racial minorities increased, though these patterns did not meet statistical significance ($p$=0.049). During the initial COVID-19 surge there were also a greater proportion of non-English speaking patients and patients from high socioeconomic risk towns (as based on zip code) admitted as compared to other phases. Co-morbidity burden was higher and length of stay longer during the initial surge as compared to all pre- and post-surge phases. These patterns were not observed during the second surge.

Compared to pre-surge levels, during the first surge there was a sharp decline in cardiovascular admissions across almost all diagnostic categories immediately following the National Emergency Declaration to 29% of pre-surge levels. During the second surge there was a less pronounced decline in admissions (to 84% of the preceding period between COVID-19 waves). There was a similar recovery pattern across diagnostic categories during both reopening phases, though when accounting for number of admissions per time period these did not eclipse pre-COVID levels (average 11.4 daily encounters post-surge one and 12.3 daily encounters post-surge two compared to 13.5 daily encounters prior to COVID) (Fig. 1).

Excluding the outpatient procedures for chest pain, there was a nonsignificant increase in the proportion, though not total number, of inpatients treated for acute coronary syndromes (ACS)/chest pain during the initial surge ($n$=85 [33.2%]) versus pre- and immediately post-surge periods ($n$=171 [26.0%] and $n$=344 [26.7%]). During the first surge, the amount of all high-volume

**Table 1.** Patient and primary diagnosis characteristics.

| | Prior to COVID-19 (*N*=1017) | Initial COVID-19 Surge (*N*=298) | After Initial COVID-19 Surge (*N*=1960) | Second COVID-19 Surge (*N*=1647) | After Second COVID-19 Surge (*N*=1226) |
|---|---|---|---|---|---|
| Dates | 01/01/2020 03/13/2020 | 03/14/2020 05/18/2020 | 05/19/2020 11/02/2020 | 11/03/2020 3/22/2021 | 03/23/2021 06/28/2021 |
| Female, *n* (%) | 398 (39.1) | 112 (37.6) | 723 (36.9) | 627 (38.1) | 456 (37.2) |
| Age, mean ± std (years) | 69.2 ± 13.3 | 67.9 ± 13.9 | 68.4 ± 13.7 | 69.9 ± 13.0 | 69.9 ± 13.7 |
| *Race*, *n* (%) | | | | | |
| White | 691 (67.9) | 194 (65.1) | 1394 (71.1) | 1151 (69.9) | 1226 (68.8) |
| Black | 134 (13.2) | 38 (12.8) | 213 (10.9) | 195 (11.8) | 139 (11.3) |
| Asian | 24 (2.4) | 13 (4.4) | 42 (2.1) | 44 (2.7) | 33 (2.7) |
| Latinx | 34 (3.3) | 16 (5.4) | 70 (3.6) | 60 (3.6) | 42 (3.4) |
| Other | 49 (4.8) | 16 (5.4) | 101 (5.2) | 80 (4.9) | 58 (4.7) |
| Unspecified | 85 (8.4) | 21 (7.1) | 140 (7.1) | 117 (7.1) | 111 (9.1) |
| *Language* | | | | | |
| English | 928 (91.3) | 260 (87.3) | 1818 (92.8) | 1522 (92.4) | 1109 (90.5) |
| Other | 89 (8.7) | 38 (12.7) | 142 (7.2) | 125 (7.6) | 116 (9.5) |
| *Admission type, n* (%) | | | | | |
| Inpatient | 659 (64.8) | 256 (85.9) | 1290 (65.8) | 1092 (66.3) | 777 (63.4) |
| Outpatient | 358 (35.2) | 42 (14.1) | 670 (34.2) | 555 (33.7) | 449 (36.6) |
| *Admission Source*, *n* (%) | | | | | |
| Emergency Department | 355 (34.9) | 159 (53.4) | 690 (35.2) | 614 (37.3) | 411 (33.5) |
| Direct Admit/Transfer | 662 (65.1) | 139 (46.6) | 1270 (64.8) | 1033 (62.7) | 815 (66.5) |
| Length of Stay, mean ± std (days) | 4.1 ± 6.7 | 5.2 ± 6.1 | 4.0 ± 5.6 | 4.1 ± 5.5 | 3.5 ± 4.4 |
| Elixhauser Comorbidity Index, mean ± std | 4.2 ± 8.0 | 5.3 ± 9.9 | 4.4 ± 8.5 | 4.0 ± 8.8 | 4.2 ± 8.3 |
| High Socioeconomic Risk Town, *n* (%) | 223 (21.9) | 71 (23.8) | 378 (19.3) | 303 (18.4) | 234 (19.1) |
| *Primary Diagnoses*, *n* (%) | | | | | |
| Arrhythmia or Electrophysiology Disorder | 127 (12.5) | 35 (11.7) | 241 (12.3) | 188 (11.4) | 147 (12.0) |
| Heart Failure/Cardiogenic Shock | 281 (27.6) | 92 (30.9) | 534 (27.5) | 465 (28.2) | 346 (28.2) |
| Acute Coronary Syndrome/Chest Pain | 438 (43.1) | 117 (39.3) | 825 (42.1) | 691 (42.0) | 496 (40.5) |
| ACS/Chest Pain (Inpatient Only) | 171 (26.0) | 85 (33.2) | 344 (26.7) | 279 (25.6) | 193 (24.8) |
| STEMI | 27 (29.7) | 12 (27.3) | 59 (29.1) | 50 (31.8) | 24 (24.2) |
| NSTEMI | 64 (70.3) | 32 (72.7) | 144 (70.9) | 125 (68.2) | 75 (75.8) |
| Valve Disease | 121 (11.9) | 22 (7.4) | 197 (10.1) | 166 (10.1) | 140 (11.4) |
| Pericardial Disease | 15 (1.5) | 8 (2.7) | 32 (1.6) | 34 (2.1) | 23 (1.9) |
| Venous Thromboembolism | 8 (0.8) | 0 | 20 (1.0) | 14 (0.9) | 6 (0.5) |
| Vascular Disease | 8 (0.8) | 1 (0.3) | 35 (1.8) | 30 (1.8) | 25 (2.0) |
| Other Cardiovascular Diagnosis | 0 | 0 | 6 (0.3) | 9 (0.6) | 7 (0.6) |
| Other | 19 (1.9) | 23 (7.7) | 66 (3.4) | 50 (3.0) | 36 (2.9) |

procedures declined with significant rebound post-surge. Both percutaneous coronary interventions (PCI) and right heart catheterizations exceeded pre-COVID levels following the initial surge. There was a smaller decline in all procedural volume observed during the second surge. Total recovery was complete for all procedures at the end of the study period (Fig. 2).

During the surge there was an increase in the proportion of patients admitted from the Emergency Department (ED) (34.9% pre-surge, 53.4% during surge, 35.2% post-surge one and 33.5% post-surge two). Post-surge, direct admit/transfer volume rebounded (64.8% after surge one and 66.5% after surge two as compared to 65.1% prior to COVID).

## DISCUSSION

Using data from a large academic health system, we demonstrate a marked decline in acute care cardiovascular hospitalizations and outpatient procedures at the onset of the initial COVID-19 surge at our facility. This trend is consistent with patterns observed during the initial period of COVID-19 infections nationally and worldwide.[6–10] This is one of the first studies to analyze the trends of cardiac admissions and procedures after both the initial and second COVID-19 surges at a time when patients were returning to cardiovascular care. Our data build on recent studies of admission patterns during the COVID-19 pandemic.

Overall, the patient populations that sought care as well as hospital practice patterns shifted dramatically

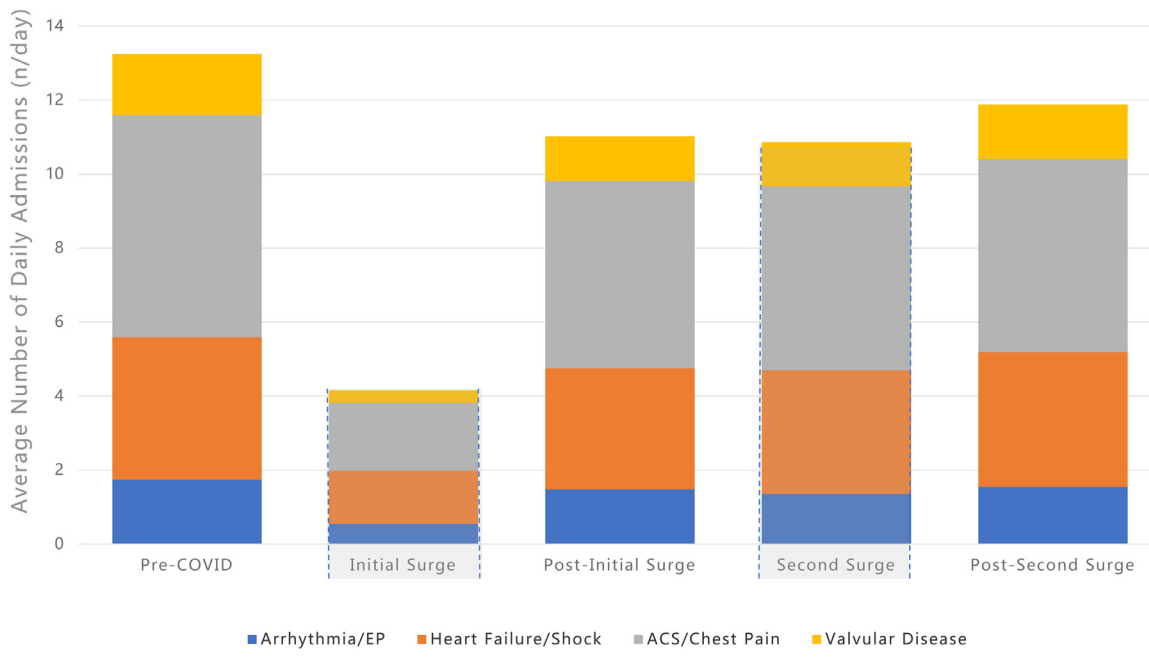


**FIGURE 1.** Average daily cardiology admissions by diagnoses (Top 5). Average daily admissions to cardiology service stratified by primary diagnosis according to time period. The top five categories are displayed. *Abbreviations*: ACS, acute coronary syndrome; EP, electrophysiology.

during the initial COVID-19 surge as compared to the pre-surge and all post-surge time periods. Though absolute numbers of non-White patients were low in our study, there was a trend towards increased proportion of racial and ethnic minorities and patients of lower socioeconomic status presenting for care during the first peak of the COVID pandemic. This finding mirrors other data which suggests disproportionate effect of COVID-19 on persons from racial and ethnic minorities.[15] During the second wave there was significantly less variation in

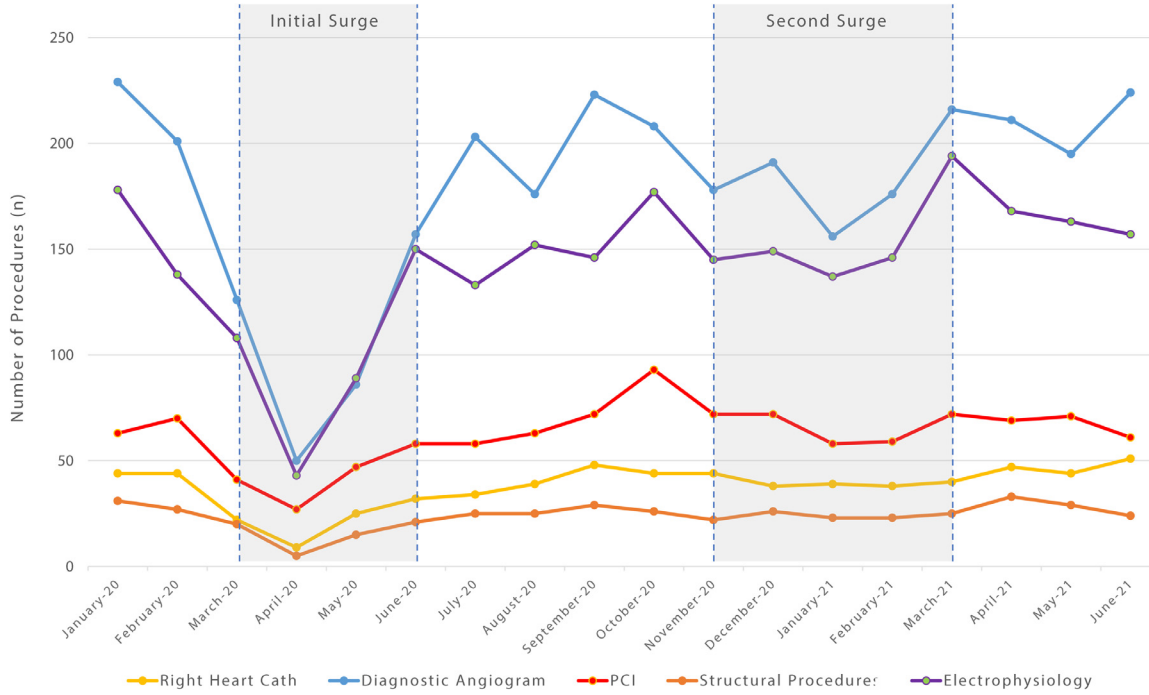


**FIGURE 2.** Monthly procedural burden by type (Top 5). Monthly procedure burden stratified by procedure type. *Abbreviation*: PCI, percutaneous coronary intervention.

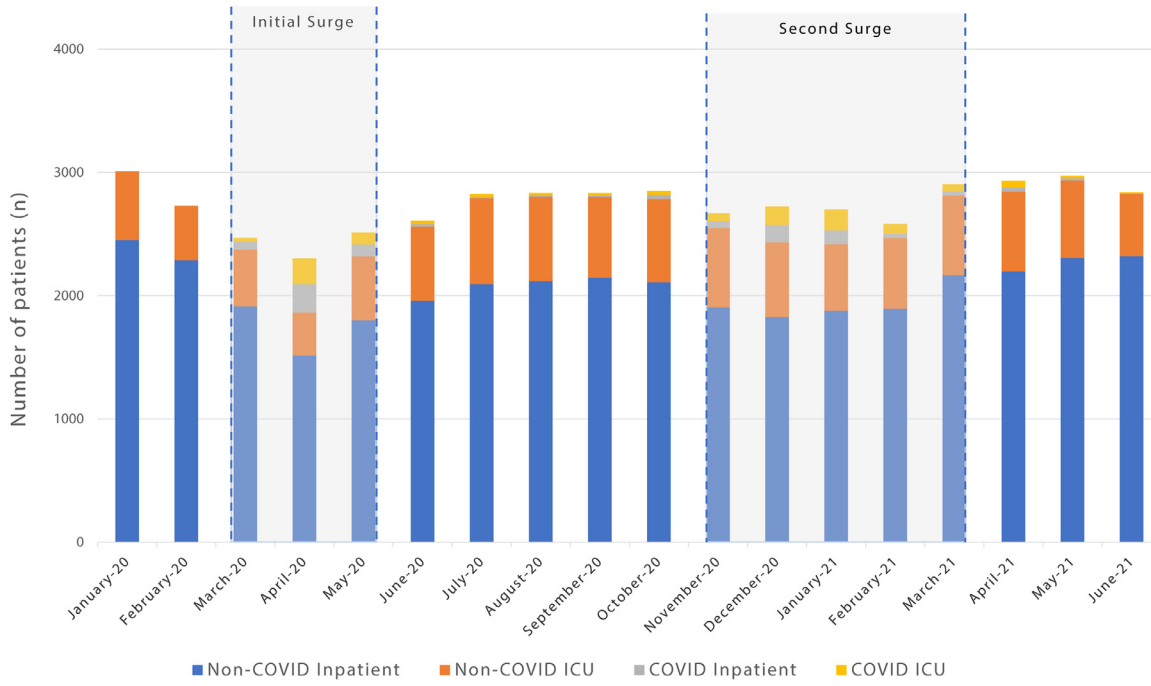


**FIGURE 3.** *Monthly hospital census.* Monthly hospital census at BIDMC stratified by COVID diagnosis and care acuity. *Abbreviation*: ICU, Intensive Care Unit.

patient characteristics, admissions and procedural volume, which is consistent with other studies.[16] This difference amongst surges was likely reflective of increased availability of vaccinations and testing for patients and staff, enhanced telehealth infrastructure, and the employment of risk stratification strategies to prioritize procedures.[17]

We demonstrate that into Phase I recovery in Massachusetts, the growth in inpatient cardiovascular care and invasive procedures occurred largely non-selectively across all diagnostic categories. While overall cardiology inpatient volume dropped sharply, the proportions of top 5 diagnoses prompting inpatient cardiology admission remained largely constant before, during, and after the first surge. Despite the trend towards increased ACS and heart failure/cardiogenic shock admissions during the first wave, there were no statistically significant differences. This challenges the notion that patients with certain cardiac conditions withdrew from care during the surge, and/or waited until the surge had subsided to seek care. The trend toward increased comorbidities and higher acuity admissions diagnoses suggests that only patients with true emergencies were likely to present to care during the first COVID surge. This pattern was not observed during the second COVID-19 peak. Additionally, this suggests that outpatient providers did not selectively refer patients with only certain pathologies for inpatient admission during a time when telehealth was the predominant mode of outpatient encounter.[18] Similarly, cardiovascular procedures changed as a function of time, with no particular type of procedure demonstrating a rate of recovery significantly different than that of other procedures after the initial surge.

Despite a significant decrease in admissions and procedures during the initial peak of the pandemic, once reopening was declared the resumption of volume in both arenas swiftly approached but did not initially achieve pre-surge levels. This highlights how local and national declarations of shutdown and reopening have an immediate, nonselective impact on overall volume. The initially attenuated return of hospital and procedural volume likely reflects a combination of staged reintroduction of ambulatory care, reduced hospital capacity from conversion of inpatient beds to surge intensive care unit (ICU) spaces (Fig. 3), and phased scheduling of non-emergent cardiac procedures (including transcatheter aortic valve replacement, planned percutaneous coronary intervention (PCI), and pulmonary vein isolation ablation) based on symptom burden. Late in the recovery phase after the first COVID-19 surge, there was a rebound in the total number of high-volume procedures, particularly PCI, which matched or exceeded pre-surge levels. This anticipated rebound likely reflected deferred health care and caused increase workload on cardiology services.[2] Following the second surge, admissions and procedural volume largely returned to match those in the pre-COVID era. These findings have important implications for the allocation of staff and resources under similar circumstances going forward. Though data suggests increased mortality for ischemic and hypertensive heart disease after the onset of the pandemic in the United States, more data is needed to determine whether long

term outcomes will differ among those patients who sought or were referred for care during the surges compared with those who waited until the COVID waves subsided.[6]

The reliance on single center administrative claims data limits this study's ability to explain the likely multifactorial cause for the evolution in cardiovascular admissions and procedures over the study time period. The data do suggest that the timing of public health emergency measures has a largely nonselective impact on patients seeking emergent cardiovascular care and the reintroduction of outpatient cardiovascular procedures during both the first and second COVID waves. More data on practice patterns as well as outcomes during the second wave are needed to further inform how COVID-19 will continue to affect cardiology care in the United States.

## CONCLUSIONS

The COVID-19 pandemic had an unprecedented effect on cardiac hospitalizations and procedural volume. Overall, the return to care following the initial peak saw a rebound in cardiovascular admissions and procedures however these did not immediately return to pre-surge levels. Given the ongoing COVID-19 pandemic in the United States, understanding the recovery patterns of hospitalizations and procedures as we continue to progress through COVID-19 surges should inform planning for cardiovascular care delivery during future waves. It also highlights the need for clear public health messaging to prevent further unintended consequences of the pandemic[6]. Larger population-based studies are needed to define the impact of care reintroduction on cardiovascular outcomes in the COVID-19 pandemic.

## AUTHOR CONTRIBUTIONS

JED and MG conceived and designed the analysis; JED collected the data; JED, SM, SK, PC, TD and GP contributed data; JED, SK and TD performed the analysis; JED, SM, SK, and PC wrote the manuscript. All authors contributed to editing and revising the manuscript.

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None.

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Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjms.2021.09.005.

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