Impact of COVID-19 pandemic on STEMI care: An expanded analysis from the United States

Santiago Garcia MD\(^1\), Larissa Stanberry PhD\(^1\), Christian Schmidt MS\(^1\), Scott Sharkey MD\(^1\), Michael Megaly MD\(^1\), Mazen S. Albaghdadi MD\(^2\), Perwaiz M. Meraj MD\(^3\), Ross Garberich MS, MBA\(^1\), Farouc A. Jaffer MD, PhD\(^2\), Ada C. Stefanescu Schmidt MD MSc\(^2\), Simon R. Dixon MBChB\(^4\), Jeffrey J. Rade MD\(^5\), Timothy Smith MD\(^6\), Mark Tannenbaum MD\(^7\), Jenny Chambers MBA\(^8\), Frank Aguirre MD\(^8\), Paul P. Huang MD, MSc\(^9\), Dharam J. Kumbhani MD, SM, MRCP\(^{10}\), Thomas Koshy MD\(^{10}\), Dmitriy N. Feldman MD\(^{11}\), Jay Giri MD, MPH\(^{12}\), Prashant Kaul MD\(^{13}\), Craig Thompson MD\(^{14}\), Houman Khalili MD\(^{15}\), Brij Maini MD\(^{15}\), Keshav R. Nayak MD\(^{16}\), Mauricio G. Cohen MD\(^{17}\), Sripal Bangalore MD, MHA\(^{14,18}\), Binita Shah MD, MSc\(^{14,18}\), Timothy D. Henry MD\(^6\)

\(^1\)Minneapolis Heart Institute Foundation at Abbott Northwestern Hospital, Minneapolis, Minnesota
\(^2\)Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts
\(^3\)Northwell Health Hospital, Manhasset, New York
\(^4\)Beaumont Hospital Royal Oak, Royal Oak, Michigan
\(^5\)UMass Memorial Medical Center, Worcester, Massachusetts
\(^6\)The Lindner Center for Research and Education at The Christ Hospital, Cincinnati, Ohio
\(^7\)Iowa Heart, Des Moines, Iowa
\(^8\)Prairie Cardiovascular, Springfield, Illinois
\(^9\)Swedish Medical Center, Seattle, Washington
\(^10\)UT Southwestern Medical Center, Dallas, Texas
\(^11\)Weill Cornell Medical College, New York Presbyterian Hospital, New York
\(^12\)Hospital of the University of Pennsylvania and University of Pennsylvania, Perelman School of Medicine, Philadelphia, Pennsylvania
\(^13\)Piedmont Heart Institute, Atlanta, GA
\(^14\)NYU Langone Health System and NYU Grossman School of Medicine, New York
\(^15\)Delray Medical Center and Florida Atlantic University, Delray Beach, Florida
\(^16\)Scripps Mercy Hospital and Cardiac Advisory Committee, County of San Diego Health & Human Services Agency, Emergency Medical Services, San Diego, CA
\(^17\)University of Miami Miller School of Medicine, Miami, Florida
\(^18\)Bellevue Hospital Center and NYU Grossman School of Medicine, New York

Correspondence
Santiago Garcia, MD, Minneapolis Heart Institute at Abbott Northwestern Hospital, Minneapolis, MN.
Email: santiagogarcia@me.com

Abstract
Objective: To evaluate the impact of COVID-19 pandemic mitigation measures on ST-elevation myocardial infarction (STEMI) care.

Received: 18 June 2020 Revised: 5 July 2020 Accepted: 6 July 2020
DOI: 10.1002/ccd.29154
Background: We previously reported a 38% decline in cardiac catheterization activations during the early phase of the COVID-19 pandemic mitigation measures. This study extends our early observations using a larger sample of STEMI programs representative of different US regions with the inclusion of more contemporary data.

Methods: Data from 18 hospitals or healthcare systems in the US from January 2019 to April 2020 were collecting including number activations for STEMI, the number of activations leading to angiography and primary percutaneous coronary intervention (PPCI), and average door to balloon (D2B) times. Two periods, January 2019–February 2020 and March–April 2020, were defined to represent periods before (BC) and after (AC) initiation of pandemic mitigation measures, respectively. A generalized estimating equations approach was used to estimate the change in response variables at AC from BC.

Results: Compared to BC, the AC period was characterized by a marked reduction in the number of activations for STEMI (29%, 95% CI:18–38, p < .001), number of activations leading to angiography (34%, 95% CI: 12–50, p = .005) and number of activations leading to PPCI (20%, 95% CI: 11–27, p < .001). A decline in STEMI activations drove the reductions in angiography and PPCI volumes. Relative to BC, the D2B times in the AC period increased on average by 20%, 95%CI (−0.2 to 44, p = .05).

Conclusions: The COVID-19 Pandemic has adversely affected many aspects of STEMI care, including timely access to the cardiac catheterization laboratory for PPCI.

Keywords: COVID-19, ST-elevation myocardial infarction, STEMI

1 | INTRODUCTION

The coronavirus 2019 (COVID-19) pandemic has significantly impacted healthcare delivery around the globe.1,2 To preserve hospital beds and intensive care unit capacity, elective cardiovascular procedures have been canceled or postponed, and access to in-person outpatient clinics have been severely restricted.3

An unexpected and troublesome decline in the number of patients seeking medical care for cardiovascular emergencies has been reported during the early phase of the pandemic.4,5 Concomitantly, the number of patients suffering cardiac arrest at home has significantly increased in areas most affected by COVID-19.6,7 Taken together, these observations suggest that many patients with acute cardiovascular conditions may be circumventing needed medical care. We previously reported a 38% decline in cardiac catheterization laboratory activations for ST-segment elevation myocardial infarction (STEMI) in 9 high-volume STEMI centers in the early phase of the Pandemic.8 The purpose of this investigation is to extend and expand on our early observations by (a) including 18 hospitals or healthcare systems representative of different regions of the US with varying COVID-19 incidence rates, (2) analyzing other metrics relevant to STEMI care including the number of cardiac catheterization laboratory activations leading to angiography and primary percutaneous coronary intervention (PPCI), and door to balloon (D2B) times, and (3) continuation of our analysis of STEMI decline into April 2020, including a comparison with March 2020 to assess novel trends.

2 | METHODS

A total of 18 sites representing PPCI hospitals and healthcare systems across the US were included in the study (Table S1 and Figure S1). In this study, March 1, 2020, was identified as the date when US medical operations were significantly affected. It was also the day that New York City, the current epicenter of the US pandemic, reported its first COVID-19 case through social distancing was not recommended by the federal government until March 15th. Therefore, we identified two periods before and after March 1, 2020, and label them as BC and AC, accordingly. The BC period encompasses the 14 months from January 1, 2019, to February 29, 2020. The AC period includes March and April of 2020.

Data on monthly volumes of cardiac catheterization laboratory activations for STEMI, cardiac catheterization laboratory activations leading to angiography, and PPCI were collected. In addition, monthly mean door-to-balloon (D2B) times (in minutes) were collected for each study site. Since COVID-19 cases in the US initially clustered in the Tri-state area in the Northeast of the US, we grouped STEMI programs into four geographic regions (Northeast, South, West, and Midwest) to account for potential differential effects according to COVID-19 disease burden and testing (Table S2).

Continuous study variables were summarized using median and interquartile ranges (median Q1, Q3). For each response variable, the change in volumes at AC from BC were estimated using a generalized estimating equations approach to account for within-site
dependencies. Poisson models were used for variables reflecting procedural volumes (STEMI, angiography, and PCI), and a Gaussian distribution was used to estimate changes in the door to balloon times (log scale). The covariates in each model included a natural cubic spline to adjust for seasonal trends, an indicator variable for the year, categorical variable for the region, and an indicator variable for influenza epidemics (October–April). The COVID pandemic period was either coded as an indicator for BC/AC or a three-level categorical variable (BC, March 2020, April 2020). The estimates are reported either as percent change from baseline or incidence rate ratios (IRR) together with the 95% confidence intervals (CI) and p-values. The analysis was conducted using R v4.0 in the Rstudio environment (Rstudio Inc.). No Institutional review board (IRB) approval was required to conduct this survey of the cardiac catheterization laboratory during the COVID-19 Pandemic.

### Table 1

| Variable                  | Before COVID | March 20 | April 20 |
|---------------------------|--------------|----------|----------|
| STEMI activations, n = 18 | 22 (14, 28)  | 13 (7, 26) | 17 (6, 24) |
| STEMI angiography, n = 12 | 12 (7, 17)   | 8 (4, 11) | 8 (1, 14) |
| Primary PCI, n = 13       | 8 (9, 15)    | 6 (4, 10) | 7 (4, 11) |
| Median D2B, min, n = 12   | 70 (61, 75)  | 70 (66, 95) | 87 (57, 99) |

Abbreviations: D2B, door to balloon time; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

### Figure 1

Changes in cardiac catheterization laboratory ST-elevation myocardial infarction activations for each program (gray lines) relative to their respective mean BC volumes (Panel A) and Changes in cardiac catheterization laboratory ST-elevation myocardial infarction activations according to geographic regions (gray lines) relative to their respective BC volumes (Panel B). The purple line represents the overall median. The band represents interquartile ranges [Color figure can be viewed at wileyonlinelibrary.com]
Our expanded analysis of the impact of COVID-19 Pandemic on STEMI care has several key findings. First, the decline in cardiac catheterization laboratory activations for STEMI has persisted into April 2020, with some programs showing signs of recovery while others remain significantly below their 2019 averages. Second, the number of cardiac catheterization laboratory activations leading to coronary angiography and PPCI has also declined during the Pandemic by 31% and 18%, respectively. Third, the decline in STEMI metrics was seen in all geographic areas included in our analysis, irrespective of COVID-19 incidence, implementation of lockdown orders, and levels of testing. Finally, among patients who received PPCI, delays in reperfusion were noted in March 2020 with improvements in April 2020.

COVID-19 has significantly impacted healthcare delivery in the US and around the world. As hospital systems prepared to receive COVID-19 patients, several measures were implemented that restricted access to outpatient care, emergency room evaluations, and diagnostic and therapeutic cardiac procedures deemed elective. Unintended consequences of these directives have been documented.4-6,9,10 We have previously reported a 38% decline in cardiac catheterization laboratory activations for STEMI during the early phase of the COVID-19 Pandemic and highlighted the importance of continuous monitoring of this trend and need to investigate its causes as the pandemic effects are likely to be felt for most of 2020. To that end, we expanded our initial analysis from 9–18 STEMI programs (or healthcare systems) representative of the US, added more granular information regarding important metrics of STEMI care including utilization of coronary angiography, PPCI and D2B times, performed a detailed geographic analysis in areas with different levels of COVID testing and disease burden, and conducted a hospital-or healthcare system-level analysis of trends during the Pandemic. Taken together, these observations suggest a negative, widespread, and persistent impact on STEMI care during the COVID 19 pandemic in the US.

The reduction in utilization of coronary angiography, PPCI, and delays in mechanical reperfusion suggest that even for patients who

by a decline in STEMI activations; when adjusted for the latter, the estimated IRR = 0.07, 95%CI (−0.28, 0.41), p = .693.

Information on cardiac catheterization laboratory STEMI activations leading to PPCI was available from 12 sites. The median volume of PPCI fell from 8 procedures in the BC period to 6 and 7 in March and April 2020, respectively (Table 1 and Figure 3). The estimated reduction in PPCI volumes in the AC period from BC was 20%, 95% CI: (11, 27), p < .001. When controlled for STEMI activations, the estimated incidence ratio relative to the BC period was IRR = 0.21 (0.06, 0.48), p = .123.

Information on D2B times was available from 12 sites. The data indicated an increase in D2B (Table 1, Figure 4). The increase in D2B times in AC relative to BC was 20%, 95% CI: (−0.2, 44), p = .052. On average, D2B times in March 2020 relative to BC increased by 27%, 95% CI: (6, 52), p = .011 with no apparent change in D2B in April 2020; −11%, 95% CI: (−31, 13), p = .314.


delays in mechanical reperfusion suggest that even for patients who

4 | DISCUSSION

FIGURE 2 A dumbbell plot of Z-scores showing changes in cardiac catheterization laboratory ST-elevation myocardial infarction activations for each program. Units are standard deviations from their cardiac catheterization laboratory ST-elevation myocardial infarction Z-score indicates a decline in units of standard deviations from their BC, before COVID-19 [Color figure can be viewed at wileyonlinelibrary.com]
present to the healthcare system, processes of care might have changed during the Pandemic. Although some have advocated for increased use of pharmacological (thrombolytic) reperfusion or pharmacoinvasive strategies, the American College of Cardiology (ACC) and Society for Cardiovascular Angiography and Interventions (SCAI) continue to recommend PPCI for STEMI patients. In fact, of the programs surveyed for this analysis, only three reported using fibrinolytic therapy with very few patients treated (<5 per year). None of them reported using them preferentially during the COVID-19 Pandemic. The reasons for these reductions and treatment delays remain speculative and may include (a) overwhelmed emergency medical systems (EMS), (b) changes in STEMI pathways to facilitate testing in the emergency department with cancellations of direct transfers to the cardiac catheterization laboratory, (c) increased used of imaging, including cardiac CT and echocardiography, to triage STEMI patients suspected of having COVID, (d) late presentations, outside the therapeutic window for mechanical reperfusion, and (e) insufficient access to personnel protective equipment.

The finding of similar reductions in STEMI activations in various geographic areas within the US with different COVID-19 disease...
burden suggests that overwhelmed EMS systems alone are unlikely to explain these declines. Avoidance of the medical system due to fear of contracting COVID-19, restricted access to primary care physicians and emergency departments, and STEMI misdiagnosis are likely to play a role. Of note, some healthcare systems seem to be rebounding from their March 2020 declines faster than others and may provide some clues as to what is needed to revert these trends. For example, Christ Hospital in Cincinnati, OH, conducted an extensive media and public relations campaign in late March to alert patients about the importance of timely medical care. In April 2020, their number of STEMI activations was back to 2019 levels. More information is needed to understand the drivers of and potential solutions to these negative trends in STEMI care.

4.1 Limitations

Our study has important strengths, including 16 months of continuous STEMI metrics in 18 large hospitals or healthcare systems representative of diverse areas of the US, but also important limitations. First, given the observational study design, our results are hypothesis-generating regarding the potential mechanisms leading to a reduction in STEMI metrics. Second, we were unable to provide individual-patient data, including demographic, angiographic, and treatment data. Third, we included STEMI hospitals and healthcare systems that may have different configurations (spoke and hub), transfer, and time to treatment protocols. We provided aggregate data for some STEMI metrics but lack granular information on transfer times and other aspects of STEMI care.

5 CONCLUSIONS

The COVID-19 Pandemic has had a negative, widespread, and persistent impact on STEMI care in the US. Efforts to educate the public on the importance of timely care and to maintain unrestricted access to emergency medical care are needed to overcome these trends.

ACKNOWLEDGMENT

The regional STEMI program at Abbott Northwestern Hospital is supported by the Minneapolis Heart Institute Foundation and Allina Health.

CONFLICT OF INTEREST

All authors have no conflict of interest related to this project.

ORCID

Santiago Garcia https://orcid.org/0000-0003-3715-8082
Scott Sharkey https://orcid.org/0000-0002-7678-1742
Michael Megaly https://orcid.org/0000-0003-3176-6677
Perwaiz M. Meraj https://orcid.org/0000-0002-6350-4666
Ada C. Stefanescu Schmidt https://orcid.org/0000-0002-5692-2616

How to cite this article: Garcia S, Stanberry L, Schmidt C, et al. Impact of COVID-19 pandemic on STEMI care: An expanded analysis from the United States. Catheter Cardiovasc Interv. 2021;98:217–222. https://doi.org/10.1002/ccd.29154

REFERENCES

1. http://www.euro.who.int/__data/assets/pdf_file/0007/436354/strengthening-health-systems-response-COVID-19-technical-guidance-1.pdf. Accessed May 21, 2020.
2. Szerlip M, Anwaruddin S, Aronow HD, et al. Considerations for cardiac catheterization laboratory procedures during the COVID-19 pandemic. Catheter Cardiovasc Interv. 2020;96(3):586-597. https://doi.org/10.1002/ccl.28887.
3. https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-hcf.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2FHealthcare-facilities%2Fguidance-hcf.html. Accessed May 21, 2020.
4. Kansagra AP, Goyal MS, Hamilton S, Albers GW. Collateral effect of Covid-19 on stroke evaluation in the United States. New Engl J Med. 2020;383:400-401. https://doi.org/10.1056/NEJMct2014816.
5. De Filippo O, D'Ascanzo F, Angelini F, et al. Reduced rate of hospital admissions for ACS during Covid-19 outbreak in Northern Italy. New Engl J Med. 2020;383:88–89.
6. Marjoni E, Karam N, Jost D, et al. Out-of-hospital cardiac arrest during the COVID-19 pandemic in Paris, France: a population-based, observational study. Lancet Public Health. 2020;5(8):E437-E443. https://doi.org/10.1016/S2468-2667(20)30117-1.
7. https://www.propublica.org/article/theres-been-a-spike-in-people-dying-at-home-in-several-cities-that-suggests-coronavirus-deaths-are-higher-than-reported. Accessed May 21, 2020.
8. Garcia S, Albaghdadi MS, Meraj PM, et al. Reduction in ST-segment elevation cardiac catheterization laboratory activations in the United States during COVID-19 pandemic. J Am Coll Cardiol. 2020;75:2871-2872.
9. De Rosa S, Spaccarotella C, Basso C, et al. Reduction of hospitalizations for myocardial infarction in Italy in the COVID-19 era. Eur Heart J. 2020;41:2083–2088.
10. Pramesh C, Badwe RA. Cancer management in India during Covid-19. New Engl J Med. 2020;382(20):e61.
11. Daniels MJ, Cohen MG, Bavry AA, Kumbhani DJ. Reperfusion of STEMI in the COVID-19 era—business as usual? Circulation. 2020;141:1948–1950.
12. Mahmud E, Dauerman HL, Welt FG, et al. Management of acute myocardial infarction during the COVID-19 pandemic. J Am Coll Cardiol. 2020;76(11):1375-1384. https://doi.org/10.1016/j.jacc.2020.04.039.
13. Bangalore S, Sharma A, Slotwiner A, et al. ST-segment elevation in patients with Covid-19—a case series. New Engl J Med. 2020;382:2478-2480.
14. Stefani GG, Montorfanio M, Trabattoni D, et al. ST-elevation myocardial infarction in patients with COVID-19: clinical and angiographic outcomes. Circulation. 2020;141:2113-2116.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.