









BRIEF COMMUNICATION

Emergency Medical Services Responses to Out-of-Hospital Cardiac Arrest and Suspected ST-Segment–Elevation Myocardial Infarction During the COVID-19 Pandemic in Los Angeles County

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BACKGROUND: Public health emergencies may significantly impact emergency medical services responses to cardiovascular emergencies. We compared emergency medical services responses to out-of-hospital cardiac arrest (OHCA) and ST-segment–elevation myocardial infarction (STEMI) during the 2020 COVID-19 pandemic to 2018 to 2019 and evaluated the impact of California’s March 19, 2020 stay-at-home order.

METHODS AND RESULTS: We conducted a population-based cross-sectional study using Los Angeles County emergency medical services registry data for adult patients with paramedic provider impression (PI) of OHCA or STEMI from February through May in 2018 to 2020. After March 19, 2020, weekly counts for PI-OHCA were higher (173 versus 135; incidence rate ratios, 1.28; 95% CI, 1.19–1.37; $P<0.001$) while PI-STEMI were lower (57 versus 65; incidence rate ratios, 0.87; 95% CI, 0.78–0.97; $P=0.02$) compared with 2018 and 2019. After adjusting for seasonal variation in PI-OHCA and decreased PI-STEMI, the increase in PI-OHCA observed after March 19, 2020 remained significant ($P=0.02$). The proportion of PI-OHCA who received defibrillation (16% versus 23%; risk difference [RD], -6.91% ; 95% CI, -9.55% to -4.26% ; $P<0.001$) and had return of spontaneous circulation (17% versus 29%; RD, -11.98% ; 95% CI, -14.76% to -9.18% ; $P<0.001$) were lower after March 19 in 2020 compared with 2018 and 2019. There was also a significant increase in dead on arrival emergency medical services responses in 2020 compared with 2018 and 2019, starting around the time of the stay-at-home order ($P<0.001$).

CONCLUSIONS: Paramedics in Los Angeles County, CA responded to increased PI-OHCA and decreased PI-STEMI following the stay-at-home order. The increased PI-OHCA was not fully explained by the reduction in PI-STEMI. Field defibrillation and return of spontaneous circulation were lower. It is critical that public health messaging stress that emergency care should not be delayed.

Key Words: cardiac arrest ■ COVID-19 ■ emergency medical services ■ myocardial infarction

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On March 4, 2020, California declared a state of emergency, followed by a stay-at-home order on March 19, 2020 to reduce spread of SARS-CoV-2. Nationwide, emergency departments experienced a rapid decline in visits starting in March, with the exception of increased cardiac/respiratory arrest and infectious disease cases.^{1,2} Along with the reduction in emergency departments volume, significant decreases in percutaneous coronary intervention activations for ST-segment-elevation myocardial infarctions (STEMI) throughout the United States began in early March.^{3,4} This drop was seen despite widely-disseminated guidelines that continued to recommend primary percutaneous coronary intervention as the default option in all patients with STEMI.⁵ California healthcare systems noted reductions in pre-hospital transports and emergency departments visits, including acute myocardial infarctions, suggesting that the stay-at-home order may have impacted decisions by the public to activate 9-1-1 for time-sensitive emergencies.^{6,7} Reports from Italy, France, and New York, NY suggested that out-of-hospital cardiac arrest (OHCA) increased but STEMI decreased during the COVID-19 pandemic.⁸⁻¹⁰ Our objective was to assess changes in emergency medical services (EMS) responses for OHCA and STEMI in Los Angeles County (LAC), before and after the stay-at-home order, with comparison with historic values.

METHODS

This was a retrospective study using registry data from LAC-EMS. The study was approved with waiver of informed consent by Medical Institutional Review Board, University of California, Los Angeles. The data that support the findings of this study are available from the corresponding author on request and approval by LAC-EMS Agency.

Study Setting and Population

LAC-EMS serves a diverse population of 10.1 million across 4058 square miles with 29 provider agencies, >4200 paramedics, 70 LAC 911-receiving hospitals and 19 500 licensed beds. LAC-EMS Agency collects data on all field encounters and since April 2020 has conducted a daily census of COVID-19 cases, availability of intensive care unit, and non-intensive care unit beds, and mechanical ventilators. For each encounter, paramedics document up to 2 provider impressions (PI) from a list of 67 potential PIs. A PI of OHCA (PI-OHCA) is defined as non-traumatic cardiac arrest with attempted resuscitation. A PI of obvious death is defined as non-traumatic cardiac arrest found dead on arrival such that no resuscitation is initiated. A PI of STEMI (PI-STEMI) is based on software interpretation of the ECG with further verification by paramedics in context of the patient's clinical presentation and, when necessary, online medical direction.

The documented PI is not a definitive diagnosis, however, each is specifically defined and determined by objective assessment findings in accordance with the LAC treatment protocols. There were no pertinent changes to the PIs and related treatment protocols during the study period. We abstracted volume data for adult patients with PI-OHCA, PI-dead on arrival, and/or PI-STEMI for a period of 17 weeks from February 1 to May 29, 2020 and corresponding weeks from 2018 to 2019; and patient-level data available for 28 of the 29 EMS Provider Agencies, for EMS response times, field defibrillation, return of spontaneous circulation (ROSC), and transports for PI-OHCA. Unlike most other studies that compared 2020 data to 2019 alone, we chose to compare 2020 data to the 2018 and 2019 averages because of potential year-to-year variability.

Outcomes Measures and Statistical Analysis

Using Poisson regression we compared weekly counts of PI-OHCA and PI-STEMI from 2020 to average weekly counts from 2018 to 2019 before and after the March 19, 2020 stay-at-home order. Goodness-of-fit tests were performed to assess the adequacy of the Poisson regression model. The models adjusted for before/after the March 19 inflection point, year, interaction of inflection point and year. Model-based estimates of weekly counts, incidence rate ratios (IRR), 95% CI, and *P* values were determined. Goodness-of-fit tests were evaluated. We compared weekly counts for PI-OHCA before and after March 19, 2020 after adjusting for seasonal variation in PI-OHCA with average counts from 2018 to 2019 and accounting for the decline in PI-STEMI counts. We determined the cumulative change in the incidence of PI-OHCA and PI-STEMI by subtracting 2018 and 2019 averaged daily cases from corresponding daily 2020 cases. These cumulative excess counts were calculated for the March 19 through May 29 period to examine the absolute volume changes following the stay-at-home order. We defined response times as the interval between dispatch and scene arrival of the first EMS unit, defibrillation as at least 1 shock during the EMS encounter, and field ROSC as any occurrence of ROSC documented during the EMS encounter. We evaluated response times with 1-way ANOVA and compared proportions of field defibrillation, ROSC, and transport with risk difference with Chi-square test. Analyses were performed with SAS 9.4 and R 4.0.0.^{11,12}

RESULTS

There were 2890 PI-OHCA cases from February 1 to May 29, 2020, compared with an average of 2393 PI-OHCA cases during the same 2018 to 2019 time period. Weekly counts for PI-OHCA were 170 during 2020

compared with 141 during 2018 to 2019 (IRR 1.22; 95% CI, 1.16–1.29; $P < 0.001$). For PI-STEMI there were 1087 cases during 2020 compared with an average 1167 cases during 2018 to 2019, with weekly counts of 64 versus 69, respectively (IRR, 0.94; 95% CI, 0.86–1.01; $P = 0.10$). The goodness-of-fit tests (ratio of scaled deviance to degrees of freedom and Pearson Chi-Square to degrees of freedom) verified that the Poisson regression model fit the data and was appropriate for the analyses.

After March 19, weekly counts for PI-OHCA in 2020 were significantly higher than the corresponding average weekly counts from 2018 to 2019 (173 versus 135; IRR, 1.28; 95% CI, 1.19–1.37; $P < 0.001$) (Figure 1A). Weekly counts for PI-STEMI in 2020 after March 19 were significantly lower compared with the corresponding average weekly counts from 2018 to 2019 (57 versus 65; IRR, 0.87; 95% CI, 0.78–0.97; $P = 0.02$) (Figure 1B). Before March 19, weekly counts for PI-OHCA were higher in 2020 than in 2018 to 2019 (166 versus 148; IRR, 1.12; 95% CI, 1.03–1.22; $P = 0.01$), but there was no difference in PI-STEMI before March 19 (74 versus 73; IRR, 1.01; 95% CI, 0.89–1.14; $P = 0.88$).

Significant increase in weekly PI-OHCA counts ($P = 0.02$) and a trend to a decrease in weekly PI-STEMI counts ($P = 0.08$) was observed during 2020 after March 19, 2020 when compared with before, after adjusting for seasonal variation in corresponding counts from the same time periods in 2018 to 2019 (Figure 2A and 2B). After adjusting for the decrease in PI-STEMI and seasonal variation in PI-OHCA counts, the aforementioned increase in weekly PI-OHCA counts after March 19, 2020 remained significant ($P = 0.02$).

There was a cumulative excess of 465 PI-OHCA cases (37%) and decrease of 55 PI-STEMI cases (8%) from March 19 to May 29, 2020 compared with same period in 2018 and 2019 period. (Figure 3) There was also an increase in patients with PI-dead on arrival in 2020 compared with 2018 and 2019, starting around the time of the stay-at-home order (Figure S1).

EMS response times were longer after March 19, 2020 compared with 2018 to 2019 for PI-OHCA (5.13 ± 0.17 versus 4.71 ± 0.40 minutes; difference 0.42; 95% CI, 0.19–0.64; $P = 0.001$) and PI-STEMI (5.08 ± 0.55 versus 4.67 ± 0.44 minutes; difference

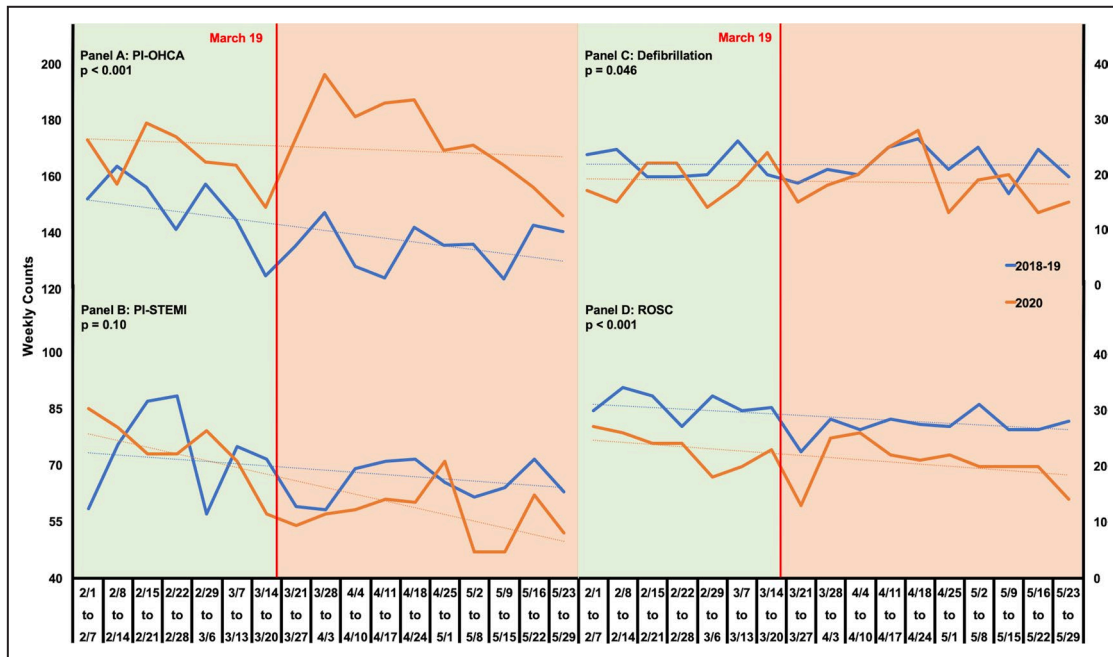


Figure 1. Weekly counts of EMS responses with provider impression of out-of-hospital cardiac arrests (PI-OHCA) and ST-segment-elevation myocardial infarction (PI-STEMI) from February 1 to May 29, 2020.

Field defibrillation and return of spontaneous circulation (ROSC) data were available for 28 of the 29 EMS agencies which represent approximately two thirds of all responses. **A**, Weekly counts of PI-OHCA were significantly higher during 2020 compared with corresponding average weekly counts from 2018 to 2019 ($P < 0.001$). **B**, Weekly counts of PI-STEMI were not significantly different during 2020 compared with corresponding average weekly counts from 2018 to 2019 ($P = 0.1$). **C**, Weekly counts of field defibrillation showed trend towards a significant reduction during 2020 compared with corresponding average weekly counts from 2018 to 2019 ($P = 0.067$). **D**, Weekly counts of field return of spontaneous circulation (ROSC) were significantly lower during 2020 compared with corresponding average weekly counts from 2018 to 2019 ($P < 0.001$). PI-OHCA, provider impression of out-of-hospital cardiac arrests; PI-STEMI, provider impression-ST-segment-elevation myocardial infarction; and ROSC, return of spontaneous circulation.

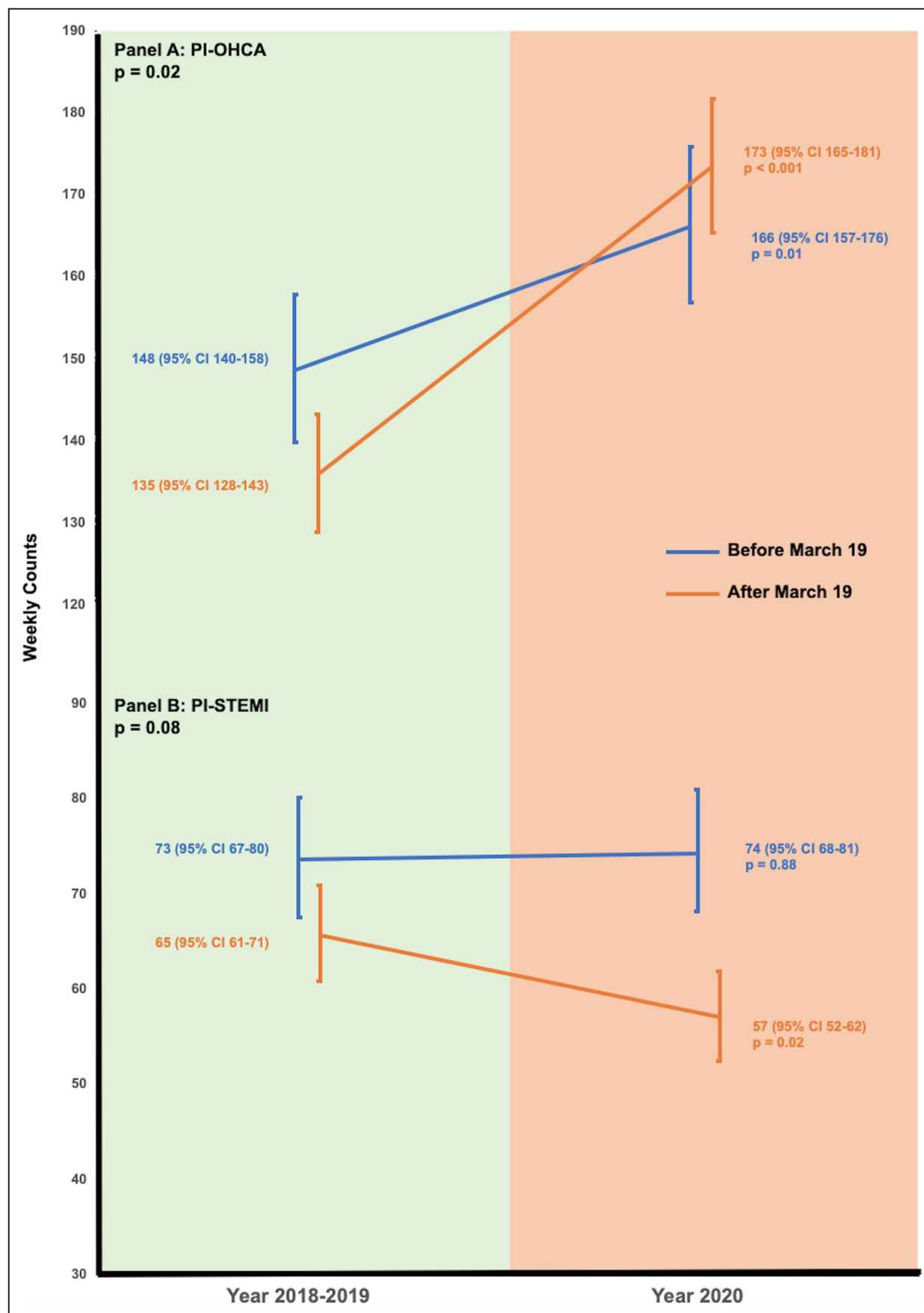


Figure 2. The average weekly counts for emergency medical services responses with provider impression of out-of-hospital cardiac arrests (PI-OHCA) and ST-segment-elevation myocardial infarction (PI-STEMI) before and after March 19 in 2020 compared with 2018 and 2019.

A, The increase in weekly counts of PI-OHCA in 2020 after March 19 was statistically significant compared with counts before March 19, after adjusting for the seasonal variation noted in 2018–2019 ($P=0.02$). **B,** The decrease in weekly counts of PI-STEMI in 2020 after March 19 trended towards a significant change compared with counts before March 19, after adjusting for the seasonal variation noted in 2018–2019 ($P=0.08$). PI-OHCA, provider impression of out-of-hospital cardiac arrests; and PI-STEMI, provider impression-ST-segment-elevation myocardial infarction.

0.41; 95% CI, 0.09–0.73; $P=0.015$). The proportion of PI-OHCA who received defibrillation (16% versus 23%; risk difference, -6.91% ; 95% CI, -9.55% to -4.26% ; $P<0.001$), had ROSC (17% versus 29%; risk difference, -11.98% ; 95% CI, -14.76% to -9.18% ; $P<0.001$) and were transported (26% versus 47%; risk difference, -20.99% ; 95% CI, -24.12% to -17.76% ; $P<0.001$) were all lower after March 19, 2020 compared with 2018 and 2019 (Table S1). The decrease in weekly counts of defibrillation and ROSC was noted during 2020 both before and after March 19 compared with 2018 and 2019 (Figure 1C and 1D). A detailed comparison of EMS response times and proportion of patients getting field defibrillation, ROSC, and those transported is provided in Table S1 and Figure S2.

Throughout the COVID-19 pandemic, LAC maintained daily availability of staffed intensive care unit (228 ± 36) and non-intensive care unit (1043 ± 210) beds as well as mechanical ventilators (1145 ± 110) (Figure S3).

Though 2018 and 2019 PI-OHCA weekly counts were similar, 2018 PI-STEMI weekly counts were lower than 2019 PI-STEMI weekly counts (Figure S4).

DISCUSSION

In LAC we found a 37% increase in EMS responses for OHCA and 8% decrease in EMS responses for STEMI from the March 19, 2020 stay-at-home order through May 2020 compared with 2018 and 2019. After adjusting for seasonal variation in PI-OHCA and decline in PI-STEMI, the observed increase in PI-OHCA remained significant following the stay-at-home order. We found slightly longer EMS response times, and a significant decline in the proportion of PI-OHCA with field defibrillation, ROSC, and transport to the hospital after March 19, 2020 compared with 2018 to 2019.

An alternative explanation for the increase in PI-OHCA could be that paramedics were more likely to

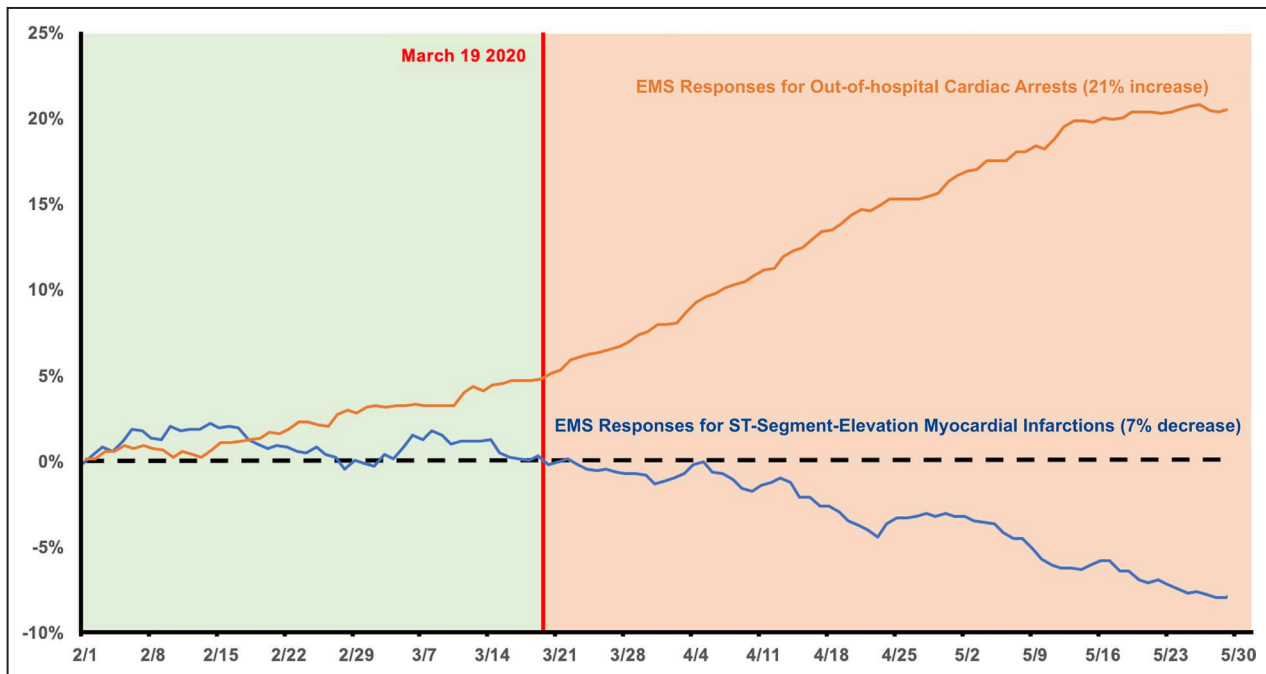


Figure 3. Percentage cumulative change in the daily counts for emergency medical services responses with provider impression of out-of-hospital cardiac arrests (PI-OHCA) and ST-segment-elevation myocardial infarction (PI-STEMI) in 2020 compared with 2018 and 2019 plotted over time.

From March 19 to May 29, 2020 there was a cumulative excess of 465 PI-OHCA cases (37%) and a cumulative decrease of 55 (PI-STEMI) cases (8%). EMS indicates emergency medical services.

resuscitate patients and were less likely to determine a patient as dead on arrival. However, we found an increase in patients with PI-dead on arrival in 2020 compared with 2018 and 2019, starting around the time of the stay-at-home order (Figure S1). Therefore, the increase in PI-OHCA cannot be explained by changes in resuscitation patterns and, in fact, underestimates the increase in OHCA. This finding is consistent with other studies that also established an increase in field patients dead on arrival^{13,14} and suggests that paramedics may have attempted resuscitation less often during the height of the pandemic.

The increase of 37% in PI-OHCA cases in LAC is substantial, but considerably less than the observed 199% increase in OHCA New York, NY, and the 52% increase in Lombardy, Italy.^{10,15} A recent study found that only 45% of excess California deaths in March and April, 2020 could be directly attributed to COVID-19. However, official COVID-19 death tallies underestimate full impact of COVID-19-related mortality.^{16,17} Previous work found >30% higher death rates during winter months compared with summer months, suggesting that OHCA would be expected to decline as the year progresses rather than plateau as occurred in 2020.^{18,19} Thus, the increase in PI-OHCA during 2020 is out of proportion and noted before reduction in PI-STEMI occurred; this in conjunction with a lower proportion of field defibrillation may be associated with prevalent but undiagnosed COVID-19. Early descriptive studies in the Seattle metropolitan area and Australia's Victoria state identified low prevalence of COVID-19 (0%–10%) among patients with OHCA, but these studies also did not find any increase in OHCA responses during their study periods.^{13,14} Throughout our study period, LAC had ample availability of beds and mechanical ventilators, possibly because of early implementation of the stay-at-home order and a less dense population compared with New York, NY and Italy, where a sudden surge in COVID-19 incidence overwhelmed local health systems.

Our investigation adds to prior publications and demonstrates that, in a different geographic area impacted by COVID-19, OHCA increased while field ROSC and STEMI responses decreased. Our findings of decreased PI-STEMI beginning after the March 19 stay-at-home order also align with hospital data showing declines in cardiac catheterization STEMI activations beginning in early March.^{3,4} Furthermore, the 2018 to 2019 variability in PI-STEMI likely diluted the potential stay-at-home order effect and led to a smaller decrease in PI-STEMI than would have been found had 2020 been compared with 2019 alone. To our knowledge, this study is the first to evaluate simultaneous trends in EMS responses for both OHCA and STEMI and to show that the increase in OHCA was not fully explained by the reduction in responses for STEMI or lack of healthcare availability.

Limitations

Given retrospective analysis we cannot determine causality. The data set excludes OHCA and STEMI not treated by EMS. Diagnosis of PI-STEMI was based upon field ECG interpretation, and does not represent those subsequently undergoing coronary angiography or percutaneous coronary intervention. Patient-level data to determine response times, field defibrillation and ROSC, and transport were not available in 2020 for one of the 29 EMS Agencies, representing approximately one third of EMS responses. Comparing prior years response times and demographics for this agency yielded similar results to the overall system. We could not determine initial rhythm in database but only if patient was defibrillated in field. Finally, we cannot ascertain which cases of OHCA directly resulted from COVID-19 infection.

CONCLUSIONS

Paramedics in LAC responded to a significant increased number of PI-OHCA and a decreased number of PI-STEMI following the stay-at-home order issued in response to COVID-19. The increase in OHCA was not fully explained by the reduction in responses for STEMI. Field defibrillation and ROSC were significantly lower following the stay-at-home order. Our findings indicate that public health messaging, such as stay-at-home orders, may be associated with adverse changes in out-of-hospital cardiovascular emergency volumes. It is critical that public health messaging stress that care should not be delayed for emergency medical conditions.

ARTICLE INFORMATION

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Author Contributions: All authors contributed to the study design with data available for full access. The article was drafted by Rollman, Rafique, and Tan with further contributions by other authors. Critical review and edits to the article were done by Kloner, Bosson, Niemann, Gausche-Hill, and Shavelle. Data and project coordination were completed by Williams and Clare. Statistical analysis was done by Wang. Proposal and Institutional Review Board submission was completed by Tan.

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Disclosures

No disclosures or conflict of interest for authors.

Supplementary Material

Table S1

Figures S1–S4

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SUPPLEMENTAL MATERIAL

Table S1. Comparison of EMS response times and proportion of patients getting field defibrillation, return of spontaneous circulation and those transported to the hospital.

	2020	2018-19	Difference	95% CI	p-value
	Feb 1 to May 29 (17 weeks)				
OHCA Response times, mean (SD), min	4.99±0.25	4.77±0.36	0.22	0.02, 0.42	0.031
STEMI Response times, mean (SD), min	4.90±0.55	4.73±0.42	0.17	-0.10, 0.45	0.213
Field Defibrillation, N (%)	318/2017 (15.77%)	741/3386 (21.88%)	-6.12%	-8.20, -3.97	<0.001
Field ROSC, N (%)	365/2017 (18.10%)	978/3386 (28.88%)	-10.79%	-13.02, -8.48	<0.001
Transported, N (%)	591/2017 (29.30%)	1582/3386 (46.72%)	-17.42%	-19.99, -14.79	<0.001
	After March 19 (11 weeks)				
OHCA Response times, mean (SD), min	5.13±0.17	4.71±0.40	0.42	0.19, 0.64	0.001
STEMI Response times, mean (SD), min	5.08±0.55	4.67±0.44	0.41	0.09, 0.73	0.015
Field Defibrillation, N (%)	210/1326 (15.84%)	475/2088 (22.75%)	-6.91%	-9.55%, -4.26%	<0.001
Field ROSC, N (%)	226/1326 (17.04%)	606/2088 (29.02%)	-11.98%	-14.76%, -9.18%	<0.001
Transported, N (%)	344/1326 (25.94%)	980/2088 (46.93%)	-20.99%	-24.12%, -17.76%	<0.001
	Before March 19 (6 weeks)				
OHCA Response times, mean (SD), min	4.75±0.19	4.89±0.27	-0.14	-0.45, 0.17	0.372
STEMI Response times, mean (SD), min	4.56±0.35	4.83±0.36	-0.27	-0.70, 0.16	0.229
Field Defibrillation, N (%)	108/691 (15.63%)	266/1298 (20.49%)	-4.86%	-8.36%, -1.37%	20
Field ROSC, N (%)	139/691 (20.12%)	372/1298 (28.66%)	-8.54%	-12.37%, -4.68%	<0.001
Transported, N (%)	247/691 (35.75%)	602/1298 (46.38%)	-10.63%	-15.05%, -6.19%	<0.001
	After March 19	Before March 19	Difference	95% CI	p-value

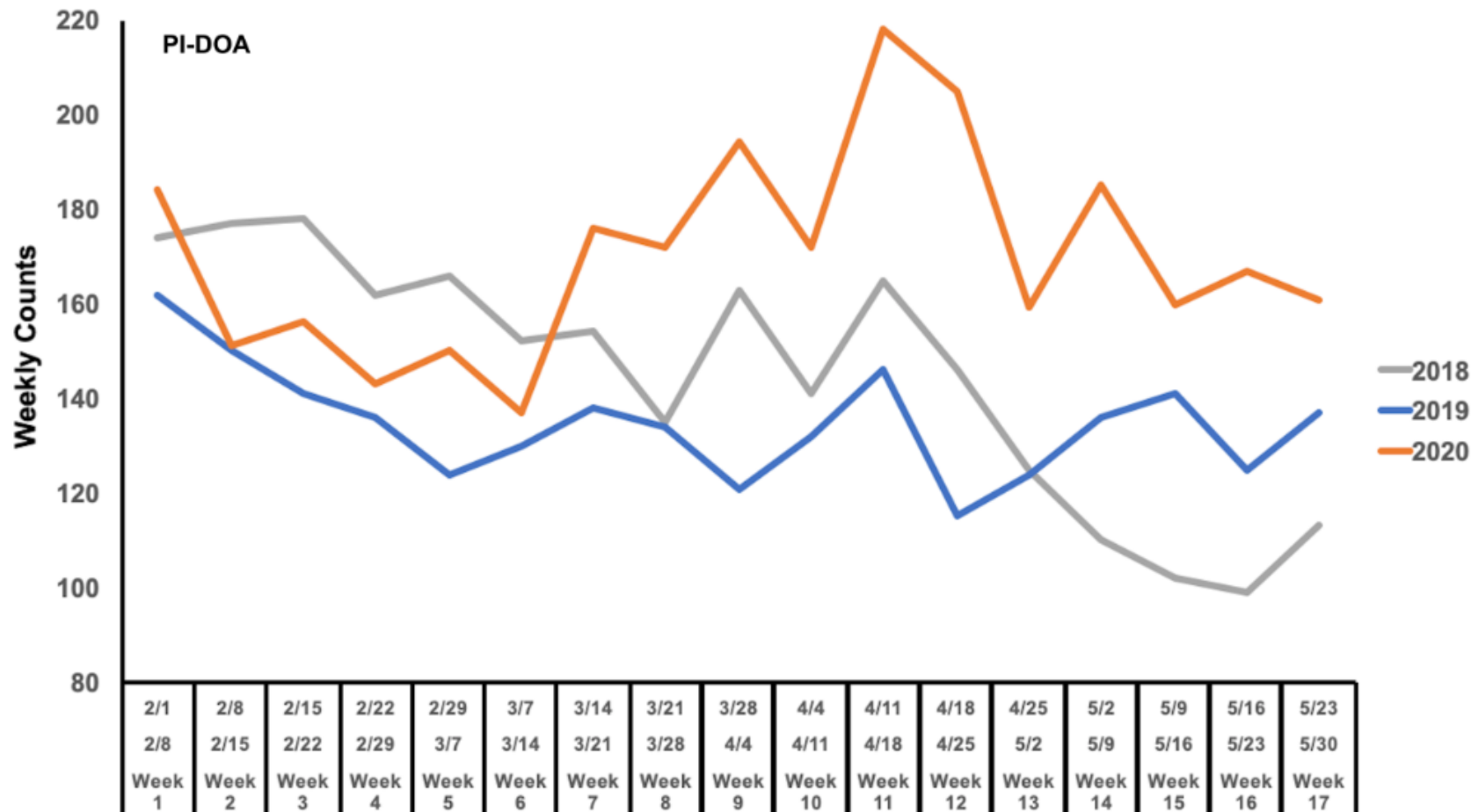
	2020 Only (17 weeks)				
OHCA Response times, mean (SD), min	5.13±0.17	4.75±0.19	0.38	0.07, 0.69	0.021
STEMI Response times, mean (SD), min	5.08±0.55	4.56±0.35	0.52	0.08, 0.96	0.024
Field Defibrillation, N (%)	210/1326 (15.84%)	108/691 (15.63%)	-0.21	-3.14%, 3.55%	0.903
Field ROSC, N (%)	226/1326 (17.04%)	139/691 (20.12%)	-3.08%	-6.74%, 0.51%	0.089
Transported, N (%)	344/1326 (25.94%)	247/691 (35.75%)	-9.81%	-14.11%, -5.54%	<0.001
	2018-19 Only (17 weeks)				
OHCA Response times, mean (SD), min	4.71±0.40	4.89±0.27	-0.18	-0.44, 0.08	0.175
STEMI Response times, mean (SD), min	4.67±0.44	4.83±0.36	-0.16	-0.46, 0.14	0.287
Field Defibrillation, N (%)	475/2088 (22.75%)	266/1298 (20.49%)	2.26%	-0.61%, 5.06%	0.123
Field ROSC, N (%)	606/2088 (29.02%)	372/1298 (28.66%)	0.36%	-2.80%, 3.47%	0.821
Transported, N (%)	980/2088 (46.93%)	602/1298 (46.38%)	0.55%	-2.91%, 4.01%	0.753

CI – Confidence intervals, SD – Standard deviation, OHCA – out of hospital cardiac arrest, STEMI – ST elevation myocardial infarction, ROSC – Return of spontaneous circulation

Figure S1. Weekly counts for Primary Impression – Dead on Arrival (PI-DOA) during 2020 compared to 2018-19.

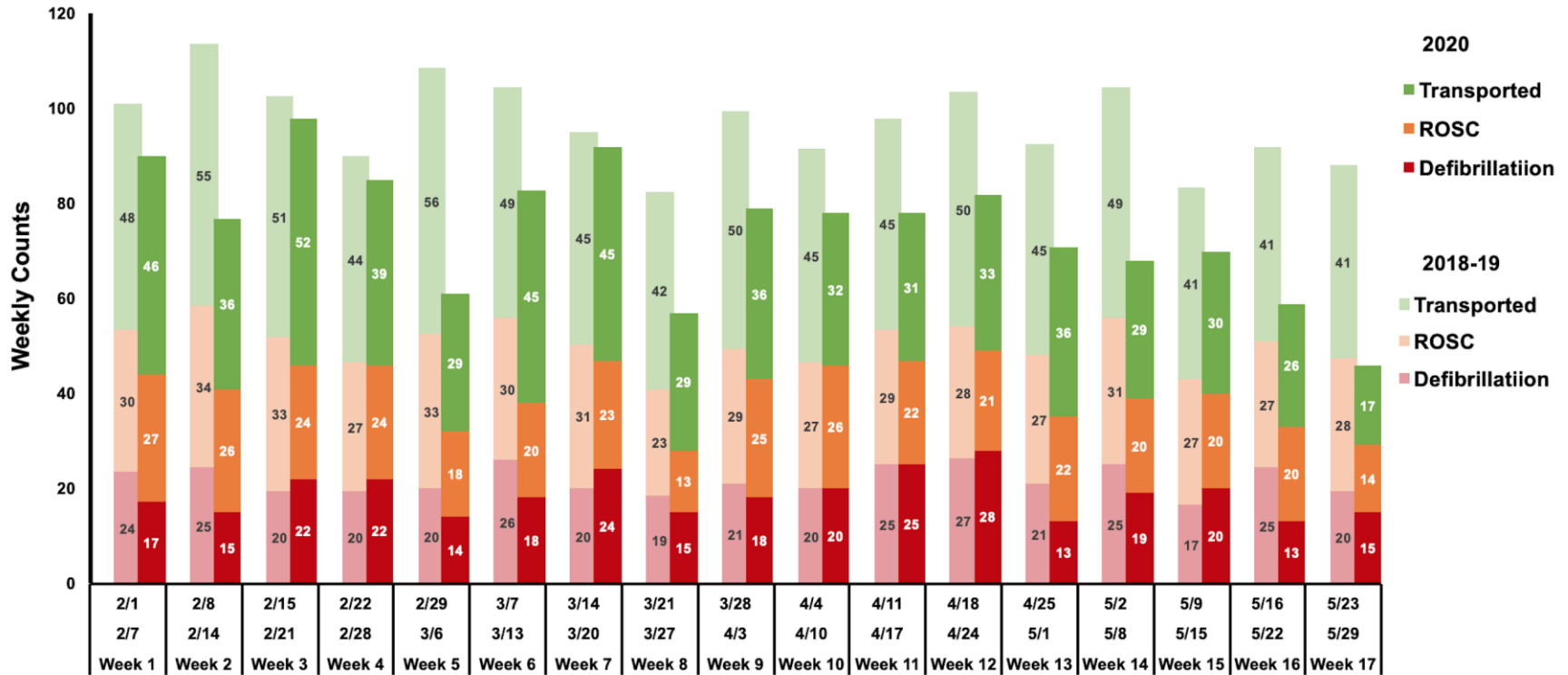


Weekly counts of PI-DOA were significantly greater in 2020 (21% increase during the study period, as compared to 2018-19), with the increase largely beginning around the time of the March 19 stay-at-home order.



Weekly counts of PI-DOA were significantly greater in 2020, as compared to 2018 and 2019 individually, with the increase largely beginning around the time of the March 19 stay-at-home order.

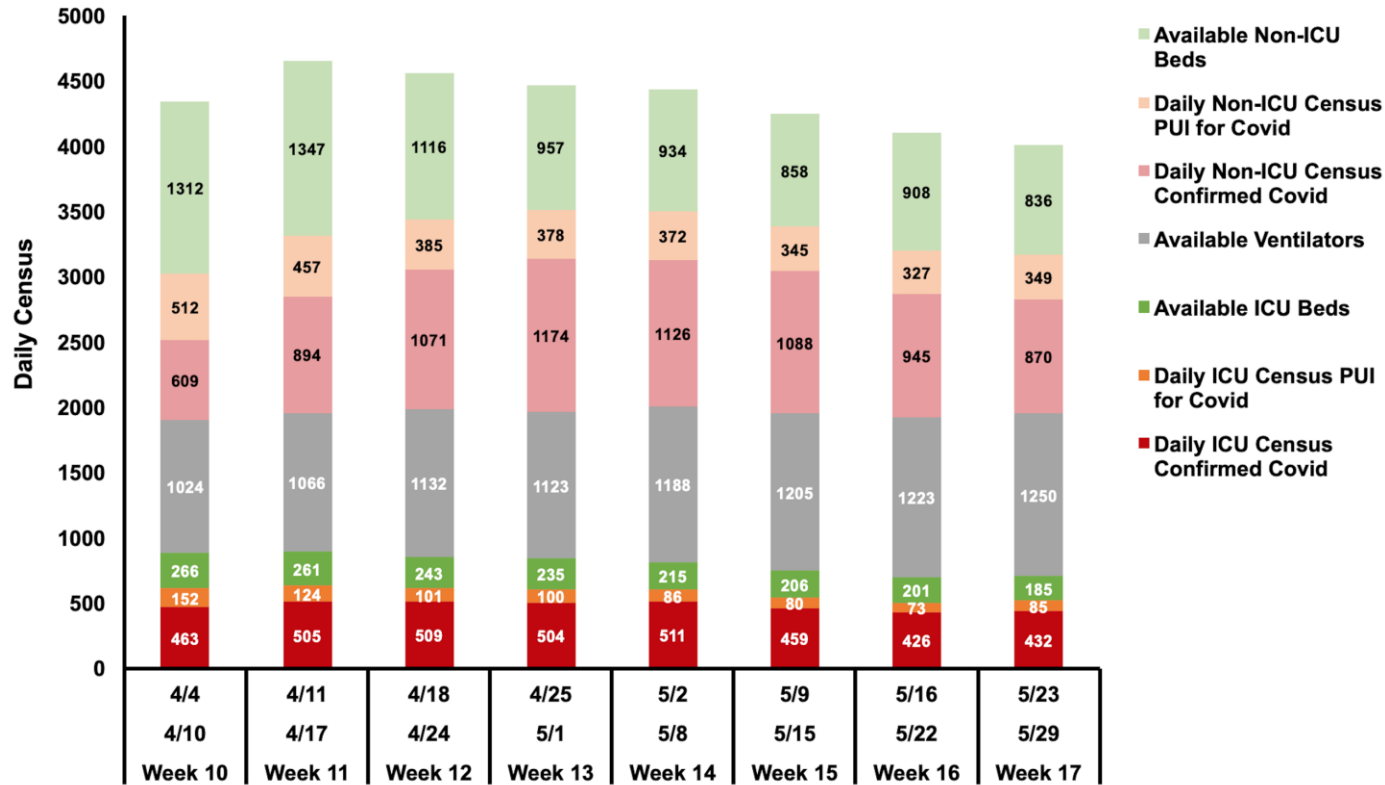
Figure S2. The average weekly counts for patients receiving field defibrillation, return of spontaneous circulation (ROSC) and those transported to the hospital.



A decrease in weekly counts was noted for field defibrillation, ROSC and transport during 2020 compared with 2018-19.

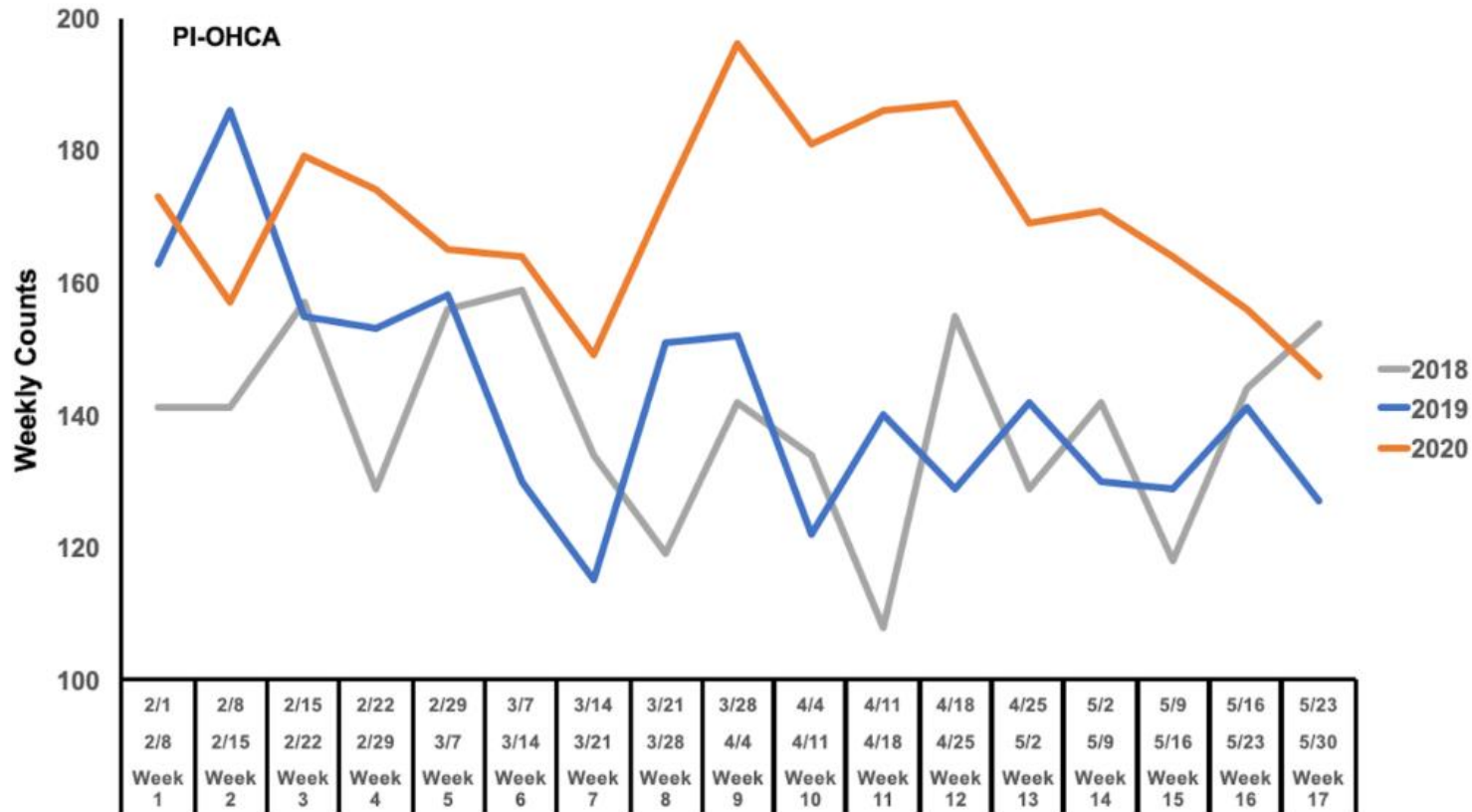
This data includes 2/3 of the EMS responses as patient level data was not available for one of the 29 EMS agencies.

Figure S3. Daily census for 70 Los Angeles County (LAC) 911-receiving hospitals with 19,500 licensed beds since April 2020 for confirmed COVID-19 cases, patients under investigation (PUI) for COVID-19, available staffed intensive care unit (ICU) and non-ICU beds, and mechanical ventilators.

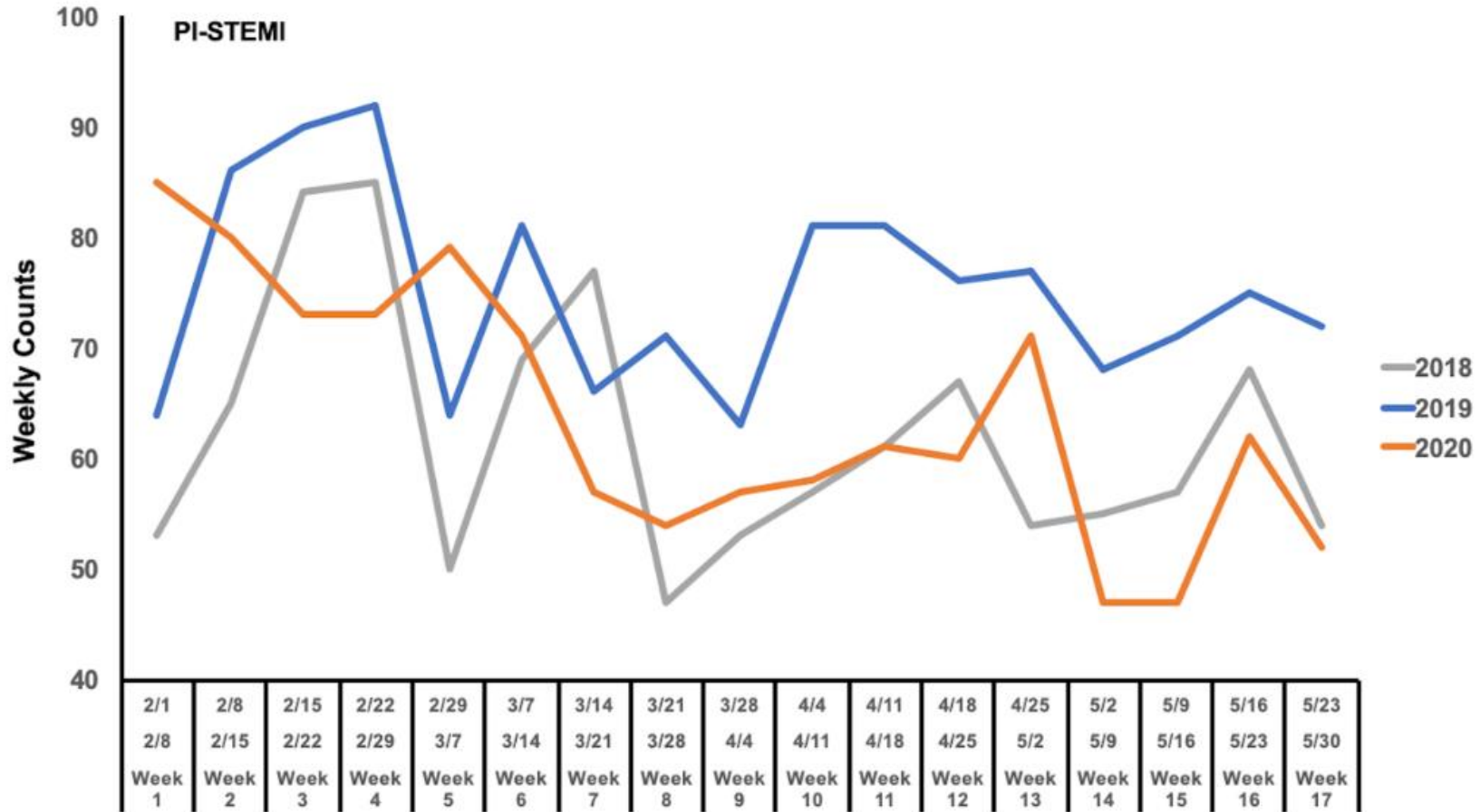


Throughout the COVID-19 pandemic, LAC maintained daily availability of staffed ICU (228 ± 36) and non-ICU (1043 ± 210) beds and mechanical ventilators (1145 ± 110).

Figure S4. Weekly counts of Primary Impression – Out-Of-Hospital Cardiac Arrest (PI-OHCA) and Primary Impression – STEMI (PI-STEMI) in 2018, 2019, and 2020.



Weekly counts of PI-OHCA were substantially similar in 2018 and 2019 and both were significantly less than 2020 counts starting around the time of the March 19 stay-at-home order.



Though weekly counts of PI-STEMI beginning around the time of the March 19 stay-at-home order were significantly less in 2020 compared to 2019, weekly PI-STEMI counts in 2018 are not significantly different. We chose to compare 2020 to 2018-19 averages to better account for the apparent annual variability between 2018 and 2019.