

# Characteristics Associated With Out-of-Hospital Cardiac Arrests and Resuscitations During the Novel Coronavirus Disease 2019 Pandemic in New York City

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## Editor's Note

**IMPORTANCE** Risk factors for out-of-hospital death due to novel coronavirus disease 2019 (COVID-19) are poorly defined. From March 1 to April 25, 2020, New York City, New York (NYC), reported 17 118 COVID-19–related deaths. On April 6, 2020, out-of-hospital cardiac arrests peaked at 305 cases, nearly a 10-fold increase from the prior year.

**OBJECTIVE** To describe the characteristics (race/ethnicity, comorbidities, and emergency medical services [EMS] response) associated with outpatient cardiac arrests and death during the COVID-19 pandemic in NYC.

**DESIGN, SETTING, AND PARTICIPANTS** This population-based, cross-sectional study compared patients with out-of-hospital cardiac arrest receiving resuscitation by the NYC 911 EMS system from March 1 to April 25, 2020, compared with March 1 to April 25, 2019. The NYC 911 EMS system serves more than 8.4 million people.

**EXPOSURES** The COVID-19 pandemic.

**MAIN OUTCOMES AND MEASURES** Characteristics associated with out-of-hospital arrests and the outcomes of out-of-hospital cardiac arrests.

**RESULTS** A total of 5325 patients were included in the main analysis (2935 men [56.2%]; mean [SD] age, 71 [18] years), 3989 in the COVID-19 period and 1336 in the comparison period. The incidence of nontraumatic out-of-hospital cardiac arrests in those who underwent EMS resuscitation in 2020 was 3 times the incidence in 2019 (47.5/100 000 vs 15.9/100 000). Patients with out-of-hospital cardiac arrest during 2020 were older (mean [SD] age, 72 [18] vs 68 [19] years), less likely to be white (611 of 2992 [20.4%] vs 382 of 1161 [32.9%]), and more likely to have hypertension (2134 of 3989 [53.5%] vs 611 of 1336 [45.7%]), diabetes (1424 of 3989 [35.7%] vs 348 of 1336 [26.0%]), and physical limitations (2259 of 3989 [56.6%] vs 634 of 1336 [47.5%]). Compared with 2019, the odds of asystole increased in the COVID-19 period (odds ratio [OR], 3.50; 95% CI, 2.53-4.84;  $P < .001$ ), as did the odds of pulseless electrical activity (OR, 1.99; 95% CI, 1.31-3.02;  $P = .001$ ). Compared with 2019, the COVID-19 period had substantial reductions in return of spontaneous circulation (ROSC) (727 of 3989 patients [18.2%] vs 463 of 1336 patients [34.7%],  $P < .001$ ) and sustained ROSC (423 of 3989 patients [10.6%] vs 337 of 1336 patients [25.2%],  $P < .001$ ), with fatality rates exceeding 90%. These associations remained statistically significant after adjustment for potential confounders (OR for ROSC, 0.59 [95% CI, 0.50-0.70;  $P < .001$ ]; OR for sustained ROSC, 0.53 [95% CI, 0.43-0.64;  $P < .001$ ]).

**CONCLUSIONS AND RELEVANCE** In this population-based, cross-sectional study, out-of-hospital cardiac arrests and deaths during the COVID-19 pandemic significantly increased compared with the same period the previous year and were associated with older age, nonwhite race/ethnicity, hypertension, diabetes, physical limitations, and nonshockable presenting rhythms. Identifying patients with the greatest risk for out-of-hospital cardiac arrest and death during the COVID-19 pandemic should allow for early, targeted interventions in the outpatient setting that could lead to reductions in out-of-hospital deaths.

JAMA Cardiol. doi:10.1001/jamacardio.2020.2488  
Published online June 19, 2020.

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**O**n March 1, 2020, the first case of novel coronavirus disease 2019 (COVID-19) was diagnosed in New York City, New York (NYC); by April 25, 2020, 17 118 confirmed and probable deaths due to COVID-19 had already occurred.<sup>1</sup> On April 6, 2020, NYC out-of-hospital cardiac arrests peaked at 305 cases, an increase of almost 10-fold compared with April 6, 2019. In Northern Italy, during the COVID-19 pandemic, out-of-hospital cardiac arrests increased by 58% compared with the same time period in 2019 and were associated with lower rates of sustained return of spontaneous circulation (ROSC).<sup>2</sup> Infectious viral epidemics causing severe respiratory infections have long been associated with an increased risk of death.<sup>3-7</sup> For the COVID-19 pandemic, factors independently associated with in-hospital deaths included being older than 65 years, hypertension, diabetes, cardiovascular disease, and chronic obstructive pulmonary disease (COPD).<sup>8</sup>

To date, factors associated with out-of-hospital cardiac arrests and successful resuscitation during the COVID-19 pandemic have not been defined. Using data from the NYC 911 emergency medical services (EMS) system, our study compared patients with nontraumatic out-of-hospital cardiac arrest who received resuscitation during the COVID-19 period and their outcomes with patients and outcomes during the same period in 2019. Our goal was to identify COVID-19-associated changes in frequency, risk factors, presenting cardiac rhythm, and out-of-hospital death despite EMS resuscitation.

## Methods

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline. The institutional review board of the Montefiore Medical Center, Albert Einstein College of Medicine, Bronx, New York, approved this study and, owing to minimal risk to the participants (ie, no effect on their rights and welfare), waived the need for informed consent.

### Data Sources

The NYC 911 EMS system is the largest in the United States, serving a population of more than 8.4 million and responding to more than 1.5 million medical calls annually. This 3-tiered system consists of firefighter-certified first responders, emergency medical technician basic life support units, and paramedic advanced life support (ALS) units. In the NYC 911 system, cardiac arrests receive the highest response priority and all 3 units (firefighter-certified first responders, basic life support units, and ALS units) are immediately dispatched. Both firefighter-certified first responders and basic life support units are certified in basic cardiac life support and carry automated external defibrillators. Paramedic ALS units can obtain and interpret 12-lead electrocardiograms and are certified in advanced cardiac life support, including advanced airway management and administering cardiac resuscitation medications. Out-of-hospital cardiac arrests are managed by EMS responders using regional prehospital protocols modeled after the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.<sup>9</sup>

## Key Points

**Question** What characteristics are associated with out-of-hospital cardiac arrests and death during the COVID-19 pandemic in New York City?

**Findings** In this population-based cross-sectional study of 5325 patients with out-of-hospital cardiac arrests, the number undergoing resuscitation was 3-fold higher during the 2020 COVID-19 period compared with during the comparison period in 2019. Patients with out-of-hospital cardiac arrest during 2020 were older, less likely to be white, and more likely to have specific comorbidities and substantial reductions in return and sustained return of spontaneous circulation.

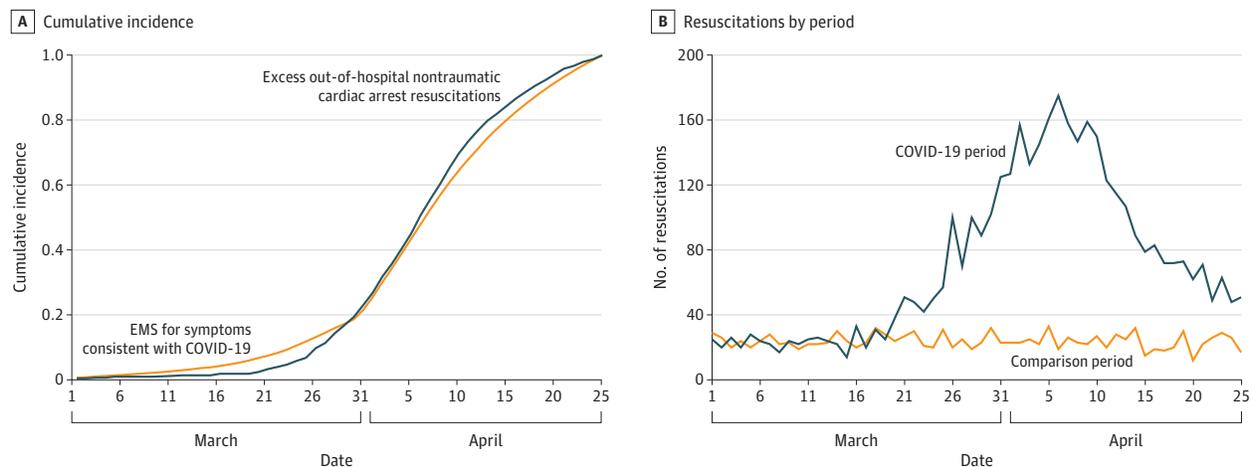
**Meaning** Identifying patients at risk for out-of-hospital cardiac arrest and death during the COVID-19 pandemic should lead to interventions in the outpatient setting to help reduce out-of-hospital deaths.

Data on out-of-hospital cardiac arrests are collected and managed by the Fire Department of NYC Online Medical Control. For cases in which EMS resuscitation is performed, a postresuscitation telephone interview of paramedics and emergency medical technicians is conducted by Online Medical Control staff. The questionnaire collects data in the Utstein style<sup>10</sup> on age, sex, race/ethnicity, preexisting comorbidities, bystander cardiopulmonary resuscitation (CPR), presenting rhythm, and advanced cardiac life support interventions (airway management and medications). The questionnaire was validated in prior cardiac arrest research within our system.<sup>11</sup> Interviews are supplemented with information from electronic prehospital patient care reports completed by EMS responders. Final call-type of cardiac arrest, response time, and ALS first on-scene were obtained from the Fire Department of NYC's 911 computer automated dispatch system. All data are maintained in a secure data warehouse.

### Study Design

This population-based, cross-sectional study included patients 18 years or older with out-of-hospital cardiac arrest who received EMS resuscitation during the COVID-19 period (March 1 to April 25, 2020) or the comparison period (March 1 to April 25, 2019) in NYC. The COVID-19 period was chosen to begin March 1, 2020, the date the first patient was diagnosed with COVID-19 in NYC, and to conclude on April 25, 2020, when EMS call volume approached its pre-COVID-19 baseline. The comparison period was chosen to mirror the COVID-19 dates during the previous year. Patients with out-of-hospital cardiac arrests were excluded if they did not undergo prehospital CPR owing to obvious signs of death or had a valid do-not-resuscitate order present at the time of arrest (n = 3601). The COVID-19 and the 2019 periods had similar proportions of patients dead on arrival (2355 [35.1%] vs 831 [36.1%], respectively) and patients with a do-not-resuscitate order (323 [4.8%] vs 92 [4.0%], respectively). The number of traumatic arrests were similar in the 2 periods (42 vs 43, respectively). Our final population with confirmed, nontraumatic cardiac arrest resuscitations accounted for 60% of total confirmed cardiac arrests during the study period.

Figure. New York City Out-of-Hospital Nontraumatic Cardiac Arrest Resuscitations, March 1 through April 25, 2020



A, Temporal association between the cumulative percentage of emergency medical services (EMS) calls for fever, cough, dyspnea, and viral-like symptoms consistent with coronavirus disease 2019 (COVID-19) and the number of excess out-of-hospital nontraumatic cardiac arrest resuscitations occurring in New York

City in 2020. Excess cases were defined as the daily difference between the number of 2020 and 2019 cases; days with a negative difference were recoded as 0 for graphic presentation. B, The number of daily out-of-hospital nontraumatic cardiac arrest resuscitations.

### Data Analysis

First, we examined characteristics (demographic and other) of individuals with confirmed, nontraumatic out-of-hospital cardiac arrests who underwent resuscitation during the 2 study periods. The assumption was that excess cases of out-of-hospital cardiac arrests in the COVID-19 period were likely associated with the COVID-19 pandemic, either directly or indirectly. Excess cases of out-of-hospital cardiac arrest resuscitations were calculated by taking the daily difference between the number of calls in 2020 and 2019. The cumulative percentage of EMS calls for fever, cough, dyspnea, and viral-like symptoms consistent with COVID-19 and the cumulative percentage of excess out-of-hospital cardiac arrest resuscitations were calculated, and the temporal relationship graphed. Second, we compared the association of COVID-19 with out-of-hospital ROSC and ROSC that was sustained until emergency department arrival (hereinafter referred to as sustained ROSC), adjusted for known covariates of ROSC and sustained ROSC. These covariates included age (in 10-year increments), race/ethnicity, sex, medical history, EMS response time, bystander CPR, ALS first on-scene, ALS interventions, and presenting rhythm. For the models, first-unit response time was recoded from a continuous time variable to a binary variable of less than 6 minutes (yes or no). A response time of less than 6 minutes has been shown in multiple studies and national registries<sup>12</sup> to provide the most benefit to out-of-hospital cardiac arrest outcomes.<sup>5,13</sup> Last, presenting rhythm was only captured for cases in which ALS personnel were the first arriving units, because basic life support units or firefighter-certified first responders cannot confirm presenting rhythm when first on the scene. Because this reduced the sample available for our multivariate models, the variable was recoded to include an unclassified category to encompass cases in which presenting rhythm was missing.

### Statistical Analysis

Unadjusted outcomes were compared using descriptive statistics. Categorical data were compared using Pearson  $\chi^2$ , whereas continuous data were compared using 2-tailed *t* tests or medians and interquartile ranges. Multivariable logistic regression analyses were performed to identify characteristics of patients with out-of-hospital cardiac arrest in the COVID-19 period as well as to assess the association of the COVID-19 period with ROSC and sustained ROSC, controlling for the above covariates. A 2-sided *P* < .05 was considered statistically significant for both unadjusted and adjusted analyses.

Two sensitivity analyses using these same outcomes were conducted. The first compared the peak 2-week period of out-of-hospital cardiac arrests during the COVID-19 period (March 29 to April 11, 2020) with the same 2-week period in 2019. The second compared the peak 2-week COVID-19 period with that of the 2 weeks just before (March 16-28, 2020) and after (April 12-25, 2020) that peak. Analyses were conducted in SAS, version 9.4 (SAS Institute Inc).

### Results

A total of 5325 patients were included in the main analysis (2935 men [56.2%] and 2292 women [43.9%]; mean [SD] age, 71 [18] years). Compared with 2019, 2020 had an excess of 2653 patients with out-of-hospital cardiac arrest who underwent EMS resuscitation (3989 in 2020 vs 1336 in 2019, *P* < .001), an incidence rate triple that of 2019 (47.5/100 000 vs 15.9/100 000). No time lag was observed between the proportion of daily NYC 911 EMS calls for fever, cough, dyspnea, and viral-like symptoms consistent with COVID-19 and excess out-of-hospital cardiac arrest resuscitations, defined as the difference between 2020 and 2019 counts each day (Figure, A).

Table 1. Patient Characteristics of Out-of-Hospital Nontraumatic Cardiac Arrests During COVID-19 and 1 Year Before<sup>a</sup>

Characteristic	Cardiac arrest resuscitations			
	Main analysis (n = 5325) <sup>b</sup>		Sensitivity analysis peak period (n = 2292) <sup>c</sup>	
	Comparison period (n = 1336)	COVID-19 period (n = 3989)	Comparison period (n = 341)	COVID-19 period (n = 1951)
Age, mean (SD), y	68 (19)	72 (18)	69 (18)	72 (15)
Male <sup>d</sup>	752 (57.1)	2183 (55.8)	200 (59.9)	1085 (57.0)
Race <sup>e</sup>				
White	382 (32.9)	611 (20.4)	87 (30.3)	244 (17.6)
Asian	88 (7.6)	218 (7.3)	19 (6.6)	96 (6.9)
Black	332 (28.6)	1025 (34.3)	89 (31.0)	486 (35.0)
Hispanic	239 (20.6)	763 (25.5)	64 (22.3)	391 (28.1)
Mixed	120 (10.3)	375 (12.5)	28 (9.8)	172 (12.4)
Medical history				
Cardiac disease	397 (29.7)	1008 (25.3)	105 (30.8)	465 (23.8)
Hypertension	611 (45.7)	2134 (53.5)	157 (46.0)	1039 (53.3)
Diabetes	348 (26.0)	1424 (35.7)	81 (23.8)	708 (36.3)
Renal disease	105 (7.9)	313 (7.8)	28 (8.2)	137 (7.0)
Asthma/COPD	214 (16.0)	509 (12.8)	57 (16.7)	227 (11.6)
Cancer	125 (9.4)	282 (7.1)	39 (11.4)	114 (5.8)
CVA	90 (6.7)	228 (5.7)	20 (5.9)	114 (5.8)
Physical limitations	634 (47.5)	2259 (56.6)	164 (48.1)	1128 (57.8)
Bystander witnessed	404 (30.2)	1080 (27.1)	106 (31.1)	516 (26.4)
Bystander CPR	441 (33.0)	1359 (34.1)	109 (32.0)	657 (33.7)
Presenting rhythm <sup>f</sup>				
Ventricular rhythms <sup>g</sup>	38 (11.0)	45 (3.6)	13 (13.8)	17 (2.9)
Asystole	209 (60.6)	973 (77.6)	53 (56.4)	475 (80.7)
PEA	72 (20.9)	177 (14.1)	21 (22.3)	64 (10.9)

Abbreviations: COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; CPR, cardiopulmonary resuscitation; CVA, cerebrovascular accident; PEA, pulseless electrical activity.

<sup>a</sup> Study population used for these estimates includes only patients who received resuscitation by emergency medical services. Unless otherwise indicated, data are expressed as number (percentage) of patients.

<sup>b</sup> Covers March 1 to April 25, 2019 (comparison period) and 2020 (COVID-19 period).

<sup>c</sup> Covers March 29 to April 11, 2019 (comparison period) and 2020 (COVID-19 period).

<sup>d</sup> Owing to missing data, includes 1316 for the main analysis comparison period, 3915 for the main analysis COVID-19 period, 334 for the sensitivity analysis comparison period, and 1902 for the sensitivity analysis COVID-19 period.

<sup>e</sup> Owing to missing data, includes 1161 for the main analysis comparison period, 2992 for the main analysis COVID-19 period, 287 for the sensitivity analysis comparison period, and 1389 for the sensitivity analysis COVID-19 period.

<sup>f</sup> Owing to missing data, includes 345 for the main analysis comparison period, 1254 for the main analysis COVID-19 period, 94 for the sensitivity analysis comparison period, and 589 for the sensitivity analysis COVID-19 period. Presenting rhythm data were only collected for those out-of-hospital cardiac arrests in which an advanced life support unit was first on the scene.

<sup>g</sup> Ventricular rhythms include ventricular fibrillation and ventricular tachycardia.

Figure, B shows the number of resuscitations in the population, as described herein, by period.

Table 1 displays the characteristics of patients with out-of-hospital nontraumatic cardiac arrests who underwent EMS resuscitation during each period. The patients with out-of-hospital cardiac arrest in 2020 were older (mean [SD] age, 72 [18] vs 68 [19] years); less likely to be white (611 of 2992 [20.4%] vs 382 of 1161 [32.9%]); and more likely to have hypertension (2134 of 3989 [53.5%] vs 611 of 1336 [45.7%]), diabetes (1424 of 3989 [35.7%] vs 348 of 1336 [26.0%]), and physical limitations (2259 of 3989 [56.6%] vs 634 of 1336 [47.5%]). Alternately, 2020 patients with out-of-hospital cardiac arrest did not have higher proportions of prior cardiac disease, asthma/COPD, cerebrovascular accidents, or cancer. The proportions of bystander-witnessed arrests and bystander CPR were similar in both periods.

In our multivariate model of patient characteristics, we found that compared with 2019, out-of-hospital cardiac arrest resuscitations during the COVID-19 period were associated with increasing age (odds ratio [OR], 1.12; 95% CI, 1.07-1.18;  $P < .001$ ), nonwhite race/ethnicity (eg, OR for Hispanic, 2.06 [95% CI, 1.68-2.52;  $P < .001$ ]; OR for black, 1.90 [95% CI, 1.57-2.29;  $P < .001$ ]), a history of diabetes (OR, 1.45; 95% CI, 1.23-1.71;  $P < .001$ ) or hypertension (OR, 1.28; 95% CI, 1.09-1.50;  $P = .002$ ), and physical limitations (OR, 1.27; 95% CI, 1.09-1.49;  $P = .002$ ) (Table 2). By contrast, the odds of cardiac disease, asthma/COPD, cancer, and cerebrovascular accidents were not increased in 2020 relative to 2019. During the COVID-19 period, out-of-hospital cardiac arrests were 3.5 times more likely to present in asystole (OR, 3.50; 95% CI, 2.53-4.84;  $P < .001$ ) and twice as likely to present in pulseless electrical activity (OR, 1.99; 95% CI, 1.31-3.02;  $P = .001$ ) than

**Table 2. Association of Risk Factors With Out-of-Hospital Nontraumatic Cardiac Arrests in the COVID-19 Period vs 1 Year Before<sup>a</sup>**

Risk factor	Main analysis <sup>b</sup>		Sensitivity analysis peak period <sup>c</sup>	
	OR (95% CI)	P value	OR (95% CI)	P value
Age (per 10 y)	1.12 (1.07-1.18)	<.001	1.16 (1.05-1.27)	.003
Sex				
Female	1 [Reference]		1 [Reference]	
Male	0.92 (0.79-1.06)	.25	1.05 (0.79-1.39)	.74
Race/ethnicity				
White	1 [Reference]		1 [Reference]	
Asian	1.43 (1.08-1.91)	.01	1.82 (1.01-3.28)	.05
Black	1.90 (1.57-2.29)	<.001	1.91 (1.33-2.74)	<.001
Hispanic	2.06 (1.68-2.52)	<.001	2.28 (1.54-3.37)	<.001
Mixed	1.96 (1.52-2.53)	<.001	1.99 (1.21-3.28)	.007
Medical history				
Cardiac disease	0.72 (0.61-0.86)	<.001	0.67 (0.49-0.93)	.02
Hypertension	1.28 (1.09-1.50)	.002	1.27 (0.94-1.73)	.12
Diabetes	1.45 (1.23-1.71)	<.001	1.81 (1.31-2.51)	<.001
Renal disease	0.79 (0.60-1.03)	.08	0.64 (0.39-1.06)	.09
Asthma/COPD	0.78 (0.64-0.95)	.02	0.67 (0.45-0.99)	.05
Cancer	0.72 (0.56-0.92)	.009	0.59 (0.37-0.94)	.03
CVA	0.70 (0.52-0.94)	.02	0.74 (0.41-1.32)	.30
Physical limitations	1.27 (1.09-1.49)	.002	1.38 (1.03-1.86)	.04
Presenting rhythm <sup>d</sup>				
Ventricular rhythms <sup>e</sup>	1 [Reference]		1 [Reference]	
Asystole	3.50 (2.53-4.84)	<.001	5.37 (3.01-9.58)	<.001
PEA	1.99 (1.31-3.02)	.001	2.77 (1.29-5.91)	.009

Abbreviations: COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; CVA, cerebrovascular accident; OR, odds ratio; PEA, pulseless electrical activity.

<sup>a</sup> Study population used for these estimates includes only those out-of-hospital cardiac arrests who received resuscitation by emergency medical services.

<sup>b</sup> Covers March 1 to April 25, 2019 (comparison period) and 2020 (COVID-19 period).

<sup>c</sup> Covers March 29 to April 11, 2019 (comparison period) and 2020 (COVID-19 period).

<sup>d</sup> Presenting rhythm data were only collected for those out-of-hospital cardiac arrests in which an advanced life support unit was first on the scene; however, an unclassified category was added for missing data to bolster model observations.

<sup>e</sup> Ventricular rhythms include ventricular fibrillation and ventricular tachycardia.

in ventricular rhythms (ventricular fibrillation or ventricular tachycardia).

**Table 3** displays ALS interventions and outcomes for patients with out-of-hospital cardiac arrest who underwent EMS resuscitation during each period. Rates of ROSC (727 of 3989 patients [18.2%] vs 463 of 1336 patients [34.7%];  $P < .001$ ) and sustained ROSC (423 of 3989 patients [10.6%] vs 337 of 1336 patients [25.2%];  $P < .001$ ) were significantly lower during the COVID-19 period than in 2019. Furthermore, patients during the COVID-19 period were significantly more likely to have resuscitation terminated in the field compared with patients from the 2019 period (3566 of 3989 [89.4%] vs 999 of 1336 [74.8%];  $P < .001$ ), reflecting the inability to obtain ROSC or sustained ROSC after at least 20 minutes of resuscitation. When examining only excess cases, resuscitation terminated in 2020 increased to 2567 of 2653 patients (96.8%). Despite marked differences in outcome, bystander-witnessed arrests, bystander CPR, time to first unit on the scene, time to ALS on the scene, and duration of resuscitation were similar in both time periods.

To assess for potential confounding, multivariate logistic regression (**Table 4**) confirmed that compared with 2019, patients with out-of-hospital cardiac arrest in 2020 were 41% less likely to attain ROSC (OR, 0.59; 95% CI, 0.50-0.70;  $P < .001$ ) and 47% less likely to attain sustained ROSC (OR, 0.53; 95% CI, 0.43-0.64;  $P < .001$ ). Additional risk factors for failure to achieve ROSC or sustained ROSC include female sex, black race/ethnicity, ALS not being the first unit on the scene, receiving

airway management other than endotracheal intubation, and receiving no advanced cardiac life support medications. Response time of at least 6 minutes was associated with a lower likelihood of sustained ROSC (OR, 1.38; 95% CI, 1.13-1.69;  $P = .002$ ). Compared with ventricular rhythms, presenting rhythms of asystole and pulseless electrical activity were significantly associated with lower likelihood of achieving ROSC (OR for asystole, 0.26 [95% CI, 0.17-0.41;  $P < .001$ ]; OR for pulseless electrical activity, 0.56 [95% CI, 0.33-0.95;  $P = .03$ ]) or sustained ROSC (OR for asystole, 0.25 [95% CI, 0.15-0.41;  $P < .001$ ]; OR for pulseless electrical activity, 0.50 [95% CI, 0.29-0.89;  $P = .02$ ]).

Our 2 sensitivity analyses revealed the same associations as did our main model (Table 2). For ROSC and sustained ROSC, results from our sensitivity analysis were nearly identical to those in Table 4 in the direction of associations, although some factors lost statistical significance for ROSC (being black and having a presenting rhythm of pulseless electrical activity) or for sustained ROSC (history of asthma/COPD, physical activity limitations, and a response time of  $\geq 6$  minutes). Return of spontaneous circulation and sustained ROSC were both significantly lower during the 2-week COVID-19 peak period in both sensitivity analyses. For example, when compared with the same 2 weeks in 2019, ROSC occurred in 297 of 1951 patients with out-of-hospital nontraumatic cardiac arrest (15.2%) vs 133 of 341 patients (39.0%) ( $P < .001$ ) and sustained ROSC was attained in 153 of 1951 patients (7.8%) vs 96 of 341 patients (28.2%) ( $P < .001$ ). Similarly, when compared with the

**Table 3. Outcomes of Patients With Out-of-Hospital Nontraumatic Cardiac Arrest Resuscitations in the COVID-19 Period vs 1 Year Before<sup>a</sup>**

Variable	Cardiac arrest resuscitations			
	Main analysis (n = 5325) <sup>b</sup>		Sensitivity analysis peak period (n = 2292) <sup>c</sup>	
	Comparison period (n = 1336)	COVID-19 period (n = 3989)	Comparison period (n = 341)	COVID-19 period (n = 1951)
ROSC, No. (%) <sup>d</sup>	463 (34.7)	727 (18.2)	133 (39.0)	297 (15.2)
Sustained ROSC, No. (%)	337 (25.2)	423 (10.6)	96 (28.2)	153 (7.8)
Resuscitation terminated in field	999 (74.8)	3566 (89.4)	245 (71.9)	1798 (92.2)
Time to first unit on scene, median (IQR), min:s	5:05 (2:17-7:13)	5:56 (2:14-9:38)	5:03 (2:36-7:30)	6:38 (2:08-10:28)
Time to ALS unit on scene, median (IQR), min:s	7:32 (2:27-13:17)	9:60 (0:43-19:17)	7:22 (2:24-12:20)	11:17 (1:07-22:07)
Total resuscitation time, median (IQR), min:s	34:58 (20:15-49:01)	32:18 (16:33-48:03)	35:17 (21:14-49:20)	30:55 (16:18-45:32)
ALS unit first on scene, No. (%)	345 (25.8)	1254 (31.4)	94 (27.6)	589 (30.2)
Shock delivered prior to ALS unit arrival, No. (%)	79 (5.9)	109 (2.7)	20 (5.9)	43 (2.2)
Airway, No. (%)				
Endotracheal intubation	1011 (75.7)	1915 (48.0)	245 (71.8)	825 (42.3)
Supraglottic airway	193 (14.4)	1385 (34.7)	59 (17.3)	706 (36.2)
Bag valve mask	132 (9.9)	689 (17.3)	37 (10.9)	420 (21.5)
Medications administered, No. (%)				
None	75 (5.6)	455 (11.4)	27 (7.9)	312 (16.0)
Epinephrine	1238 (92.7)	3516 (88.1)	310 (90.9)	1633 (83.7)
Amiodarone	143 (10.7)	231 (5.8)	33 (9.7)	77 (3.9)
Dextrose	193 (14.4)	328 (8.2)	40 (11.7)	132 (6.8)
Sodium bicarbonate	598 (44.8)	909 (22.8)	164 (48.1)	302 (15.5)
Naloxone	89 (6.7)	67 (1.7)	19 (5.6)	17 (0.9)
Magnesium	43 (3.2)	38 (1.0)	4 (1.2)	9 (0.5)

Abbreviations: ALS, advanced life support; COVID-19, coronavirus disease 2019; IQR, interquartile range; ROSC, return of spontaneous circulation.

<sup>a</sup> Study population used for these estimates includes only those with out-of-hospital cardiac arrests who received resuscitation by emergency medical services.

<sup>b</sup> Covers March 1 to April 25, 2019 (comparison period) and 2020 (COVID-19 period).

<sup>c</sup> Covers March 29 to April 11, 2019 (comparison period) and 2020 (COVID-19 period).

<sup>d</sup> ROSC and sustained ROSC are not mutually exclusive, but patients must be either in sustained ROSC or have resuscitation terminated.

2 weeks before plus the 2 weeks after the peak 2020 period, ROSC occurred in 297 of 1951 patients (15.2%) vs 430 of 2038 patients (21.1%) ( $P < .001$ ), and sustained ROSC occurred in 153 of 1951 patients (7.8%) vs 270 of 2038 patients (13.3%) ( $P < .001$ ).

## Discussion

Using data from the NYC 911 EMS system during the COVID-19 pandemic, we report 2653 excess out-of-hospital cardiac arrests, a number that, by itself, represents double the number of patients with out-of-hospital cardiac arrests who underwent EMS resuscitation during the comparable 2019 period. More than 90% of these excess cases resulted in out-of-hospital deaths, some of which likely contributed to the 17 118 confirmed and suspected COVID-19-related deaths that occurred in NYC during the first 8 weeks of the pandemic. Risk factors for excess COVID-19-related out-of-hospital cardiac arrests included older age and minority race/ethnicity, after adjustment for comorbidities. Importantly, nonshockable presenting rhythms of asystole and pulseless electrical activity were more commonly documented in 2020 compared with 2019 and likely account for

the substantial increase in out-of-hospital cardiac arrest mortality.

Conditions associated with COVID-19, including hypoxic respiratory failure, massive myocardial infarction, and pulmonary emboli, can lead to rapid decompensation and result in cardiac arrest with initial nonshockable rhythms.<sup>14-16</sup> Our results were similar to those observed in Northern Italy, where out-of-hospital cardiac arrests increased by 58% from the same time period in 2019.<sup>2</sup> Italy had an increase in out-of-hospital mortality from 67.3% to 82.2% and an increase of initial nonshockable rhythms from 83% to 90%.<sup>2</sup> In Wuhan, China, unsuccessful resuscitation for in-hospital cardiac arrests occurred 86.8% of the time, with 89.7% of patients having asystole as the initial presenting rhythm.<sup>17</sup>

Increased out-of-hospital cardiac arrests during influenza are thought to be due to the body's systemic inflammatory response, which destabilizes atherosclerotic plaques that, in turn, produce myocardial infarctions and cardiovascular deaths.<sup>5,7,18</sup> In addition to overwhelming pneumonia, viral sepsis, and acute respiratory failure,<sup>19</sup> COVID-19 causes endothelial injury predisposing to thrombosis in the arterial and venous system with myocardial infarction in the absence of atherosclerosis and increased risk of venous thromboembolism.<sup>20-23</sup> Declining

**Table 4. Association of COVID-19 With ROSC and Sustained ROSC Adjusted for Demographics, Interventions, and Response Time<sup>a</sup>**

Intervention or risk factor	ROSC				Sustained ROSC			
	Main analysis		Sensitivity analysis peak period		Main analysis		Sensitivity analysis peak period	
	OR (95% CI)	P value <sup>b</sup>	OR (95% CI)	P value <sup>b</sup>	OR (95% CI)	P value <sup>b</sup>	OR (95% CI)	P value <sup>b</sup>
Study period								
Comparison	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
COVID-19	0.59 (0.50-0.70)	<.001	0.44 (0.32-0.60)	<.001	0.53 (0.43-0.64)	<.001	0.38 (0.26-0.56)	<.001
Age (per 10 y)	1.00 (0.96-1.05)	.97	0.92 (0.84-1.01)	.07	0.97 (0.91-1.02)	.25	0.90 (0.81-1.01)	.07
Sex								
Female	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Male	1.53 (1.31-1.79)	<.001	1.55 (1.18-2.04)	.002	1.59 (1.32-1.93)	<.001	1.60 (1.13-2.25)	.007
Race/ethnicity								
White	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Asian	1.11 (0.81-1.52)	.52	1.09 (0.62-1.91)	.76	1.16 (0.80-1.68)	.44	0.77 (0.37-1.61)	.49
Black	0.79 (0.64-0.98)	.03	0.73 (0.50-1.06)	.10	0.68 (0.53-0.87)	.002	0.60 (0.38-0.95)	.03
Hispanic	0.89 (0.72-1.12)	.33	0.94 (0.64-1.39)	.77	0.86 (0.66-1.11)	.25	0.78 (0.48-1.25)	.30
Mixed	1.12 (0.85-1.48)	.41	1.10 (0.67-1.80)	.70	1.21 (0.89-1.65)	.23	1.19 (0.66-2.12)	.56
Medical history								
Cardiac disease	1.13 (0.94-1.36)	.18	0.93 (0.67-1.28)	.65	1.30 (1.05-1.61)	.02	1.16 (0.78-1.72)	.47
Hypertension	0.98 (0.83-1.17)	.84	1.09 (0.81-1.46)	.59	1.00 (0.82-1.23)	.98	1.12 (0.77-1.63)	.56
Diabetes	0.93 (0.77-1.11)	.39	0.78 (0.58-1.06)	.11	0.85 (0.68-1.05)	.14	0.83 (0.56-1.23)	.35
Renal disease	1.22 (0.92-1.62)	.17	1.29 (0.79-2.12)	.31	1.28 (0.92-1.79)	.15	0.95 (0.49-1.82)	.87
Asthma/COPD	1.30 (1.05-1.61)	.02	1.20 (0.82-1.76)	.35	1.32 (1.03-1.70)	.03	1.27 (0.80-2.03)	.31
Cancer	1.11 (0.83-1.47)	.48	0.98 (0.60-1.63)	.95	0.98 (0.70-1.39)	.93	0.81 (0.42-1.56)	.52
CVA	0.75 (0.52-1.06)	.11	1.01 (0.56-1.81)	.97	0.83 (0.55-1.25)	.36	1.33 (0.67-2.63)	.41
Physical limitations	0.56 (0.47-0.67)	<.001	0.74 (0.55-1.00)	.05	0.59 (0.47-0.73)	<.001	0.73 (0.50-1.07)	.10
Bystander CPR								
No	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Yes	1.18 (0.99-1.40)	.06	1.27 (0.95-1.71)	.11	1.31 (1.07-1.60)	.009	1.52 (1.06-2.19)	.02
Response time, min								
≥6	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
<6	1.09 (0.93-1.28)	.30	1.06 (0.81-1.40)	.66	1.38 (1.13-1.69)	.002	1.32 (0.93-1.88)	.12
ALS unit first on scene								
No	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Yes	2.44 (1.60-3.73)	<.001	2.70 (1.31-5.58)	.007	2.84 (1.81-4.45)	<.001	3.29 (1.49-7.22)	.003
ALS medication administration								
No	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Yes	1.65 (1.08-2.52)	.02	2.46 (1.24-4.89)	.01	1.25 (0.78-1.99)	.36	1.81 (0.80-4.07)	.15
Airway maintenance								
Endotracheal intubation	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Supraglottic airway	0.48 (0.40-0.58)	<.001	0.52 (0.39-0.71)	<.001	0.41 (0.32-0.52)	<.001	0.50 (0.33-0.74)	<.001
Bag valve mask	0.50 (0.37-0.68)	<.001	0.50 (0.29-0.85)	.01	0.60 (0.42-0.86)	.005	0.57 (0.29-1.09)	.09
Presenting rhythm <sup>c</sup>								
Ventricular rhythms <sup>d</sup>	1 [Reference]		1 [Reference]		1 [Reference]		1 [Reference]	
Asystole	0.26 (0.17-0.41)	<.001	0.21 (0.10-0.44)	<.001	0.25 (0.15-0.41)	<.001	0.16 (0.07-0.36)	<.001
PEA	0.56 (0.33-0.95)	.03	0.60 (0.25-1.47)	.27	0.50 (0.29-0.89)	.02	0.36 (0.13-0.98)	.05

Abbreviations: ALS, advanced life support; COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; CPR, cardiopulmonary resuscitation; CVAs, cerebrovascular accidents; NA, not applicable; OR, odds ratio; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation.

<sup>a</sup> Study population used for these estimates includes only those with out-of-hospital cardiac arrests who received resuscitation by emergency medical services. Main study period covered March 1 to April 25, 2019 (comparison period) and 2020 (COVID-19 period); sensitivity time period,

March 29 to April 11, 2019 (comparison period) and 2020 (COVID-19 period).

<sup>b</sup> Calculated using logistic regression.

<sup>c</sup> Presenting rhythm data were only collected for those out-of-hospital cardiac arrests in which an ALS unit was first on the scene; however, an unclassified category was added for missing data to bolster model observations.

<sup>d</sup> Ventricular rhythm includes ventricular fibrillation and ventricular tachycardia.

oxygenation and biomarkers of tissue injury (elevated levels of cardiac troponins, cytokines, D-dimer, and lactate) are risk factors for death in hospitalized patients with COVID-19.<sup>24,25</sup>

Similar to risk factors for death in hospitalized patients, we found that increasing age, hypertension, and diabetes were independent risk factors for patients with out-of-hospital cardiac arrest during 2020. We also observed that patients reported to have physical activity limitations, such as being bed or wheelchair bound, were at increased risk for COVID-19-related out-of-hospital cardiac arrests. Immobility may be a marker for frailty and is a risk factor for thromboembolic disease. Although sex, asthma/COPD, prior cardiac disease, and cerebrovascular accidents are known risk factors for in-hospital cardiac deaths,<sup>26-29</sup> they were not risk factors in our study of excess out-of-hospital cardiac arrests in 2020. This may be because these comorbidities were risks for out-of-hospital cardiac arrests<sup>30</sup> in the comparison 2019 period and therefore did not contribute significantly to excess out-of-hospital cardiac arrest cases in 2020.

In our study, minority race/ethnicity was a risk factor for COVID-19-related out-of-hospital cardiac arrests even after adjusting for comorbidities that disproportionately affect minority populations. Black, Hispanic, and Asian patients were at increased risk for COVID-19-associated out-of-hospital cardiac arrests and death. Explanations for these disparities are multifactorial, difficult to disaggregate, and range from individual vulnerabilities to social/environmental factors. The disparate burden of out-of-hospital cardiac arrests in minority populations may be a consequence of underlying comorbidities, genetic-environmental interactions, socioeconomic conditions that include increased viral exposure due to crowding and reduced opportunity to work from home, as well as reduced access to health care.<sup>31</sup>

Although we observed a temporal association (without time lag) between NYC 911 EMS calls for fever, cough, dyspnea, and viral-like symptoms and out-of-hospital cardiac arrests, that in itself is insufficient to demonstrate that excess out-of-hospital cardiac arrests and deaths after attempted resuscitation were solely owing to sudden cardiopulmonary decompensation from COVID-19 infection. The observed temporal relationship does not preclude other explanations, such as the possibility that delays in seeking or receiving health care may have negatively affected slowly progressive COVID-19 infections or preexisting conditions (eg, cardiopulmonary diseases or cancer), resulting in out-of-hospital cardiac arrests and deaths. During this period, hospitals reported few admissions for other conditions,<sup>32</sup> and in Italy, admission rates for acute coronary syndrome significantly declined.<sup>33</sup> Reasons for such delays may include not only lack of health care access but also purposeful avoidance due to fears of contracting COVID-19. In addition, pandemic-related environmental, emotional, and economic stressors could have indirectly contributed to excess out-of-hospital cardiac arrests and deaths. Because our data cannot address the proportion of out-of-hospital cardiac arrests that was directly or indirectly due to COVID-19, further research is needed. Even before the results of further research are available, the increased COVID-19-related out-of-hospital cardiac arrest rates in our study rein-

force the need for improved health care outreach during pandemics, especially for vulnerable populations.

Our results agree with established findings of higher rates of sustained ROSC with shorter EMS response time.<sup>12,13,30</sup> With the increased number of patients presenting with COVID-19-like symptoms, the median response time of available EMS units to out-of-hospital cardiac arrests was increased by approximately 1 minute; however, this difference was not statistically significant when compared with the same period in 2019. Although the time range was variable, the median response time was less than the 3-minute increase reported in Italy.<sup>2</sup> In contrast, if ALS units arrived first on the scene, we observed significantly higher rates of ROSC and sustained ROSC compared with other units, even during the COVID-19 period. Studies characterizing the association of prehospital ALS management with out-of-hospital cardiac arrest in the pre-COVID-19 era report conflicting results.<sup>34-37</sup> In our study, ALS interventions (ACLS medications and endotracheal intubation) were associated with significant increases in both ROSC and sustained ROSC (Table 4) in all analyses. We speculate that these ALS interventions were more likely to occur and to be successful when ALS units were first on the scene. In addition, paramedics' higher training and medical knowledge provide critical skills in patient assessment that lead to effective treatment decisions and team-based leadership<sup>35</sup> during resuscitations.

During the COVID-19 study period, less invasive airway management (supraglottic airway or bag-valve-mask ventilation) was associated with lower rates of ROSC and sustained ROSC. Several studies, including a meta-analysis, have shown increased ROSC rates and overall survival to hospital discharge with endotracheal intubation,<sup>38,39</sup> although the mechanism for this improvement has not yet been elucidated. The significant decrease in the use of more invasive procedures, such as endotracheal intubation, in favor of less invasive procedures (supraglottic airways and bag-valve-mask ventilation) may be due to EMS responders wanting to reduce exposure to the patient during the COVID-19 pandemic. This may have been a concern despite the availability of personal protective equipment, including fresh N95 masks, eye protection, gowns, and gloves that were supplied to and required of all personnel during resuscitations. This finding was similarly observed in the management of out-of-hospital cardiac arrests in Italy at the height of their response to COVID-19.<sup>2</sup>

### Limitations

Our study shares several limitations found in recently published COVID-19 in-hospital mortality studies. First, our study population was limited to those who received care, in this case, EMS resuscitation. Second, because postmortem testing to confirm COVID-19 was rarely performed, we cannot distinguish between increased cardiopulmonary arrests directly due to COVID-19 or indirectly due to unattended comorbid diseases during this pandemic. Support for the increase in out-of-hospital cardiac arrests being directly COVID-19 related in our study and for a similar trend in the study from Italy is based on comparisons with the prior year. We acknowledge that

although cardiovascular disease, asthma/COPD, cerebrovascular accidents, and cancer were not risk factors for out-of-hospital cardiac arrests during the COVID-19 pandemic in our study, patient lack of access to or avoidance of health care leading to acute decompensation of comorbid illnesses may have played a role. We do not believe that reliance on prehospital patient information for comorbid history resulted in differential misclassification, because the same method was used in both periods (2019 and 2020), and the percentage of bystander-witnessed events was similar. Ultimately, corroboration by death certificates, along with autopsy studies, is required to determine the proportion of out-of-hospital cardiac arrests and deaths that were related to COVID-19. A strength of the current investigation is the longitudinal, system-wide ascertainment of out-of-hospital cardiac arrests and resuscitations in the largest US 911 system during the largest pandemic since the 1918 influenza pandemic.<sup>40</sup> By including data from the entire 911 system and comparing it with the same time period 1 year prior, the potential for differential ascertainment biases was minimized. By choosing the longer period as our main analysis rather than the 2-week COVID-19 peak period, we purposely biased our results toward the null.

## Conclusions

The tragedy of the COVID-19 pandemic is not just the number of patients infected, but the large increase in out-of-hospital cardiac arrests and deaths. This catastrophe transpired despite similar rates of bystander CPR, similar EMS response times, and similar durations of resuscitation efforts, compared with 2019. The findings of this cross-sectional study emphasize the importance of intervening early in the course of COVID-19 infection, before acute decompensation. They also speak to the critical need to design better systems for providing health care access to vulnerable, at-risk patients with acute and chronic conditions during a pandemic. Aggressive efforts for identifying outpatient risk factors for out-of-hospital cardiac arrests and death, such as hypoxia and hypercoagulability, especially in minority populations, should be instituted. Further research is needed to determine if early, targeted interventions in the outpatient setting for those at risk, such as regular telemedicine visits and home-based monitoring of vital signs, oxygen saturation, and biomarkers of tissue injury in those that test positive could lead to reductions in out-of-hospital fatalities.

### ARTICLE INFORMATION

**Accepted for Publication:** May 20, 2020.

**Published Online:** June 19, 2020.  
doi:10.1001/jamacardio.2020.2488

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**Author Contributions:** Drs Lai and Lancet contributed equally to the study. Drs Lai and Prezant had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Concept and design:* Lai, Webber, Hall, Prezant. *Acquisition, analysis, or interpretation of data:* All authors. *Drafting of the manuscript:* Lai, Weiden, Webber, Zeig-Owens, Prezant. *Critical revision of the manuscript for important intellectual content:* Lai, Lancet, Webber, Zeig-Owens, Hall, Prezant. *Statistical analysis:* Lancet, Weiden, Zeig-Owens, Hall.

*Obtained funding:* Prezant.

*Administrative, technical, or material support:* Lai, Hall, Prezant.

*Supervision:* Lai, Webber, Prezant.

**Conflict of Interest Disclosures:** None reported.

**Funding/Support:** This study was supported by the City of New York and the Fire Department of the City of New York.

**Role of the Funder/Sponsor:** The funders provided data management and access but had no role in the design and conduct of the study; collection, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

**Additional Contributions:** Gretchen Van Wye, PhD, MA; Mary Huynh, PhD; Joseph Kennedy, MPH; and Hiu Tai Chan, MS from the New York City Bureau of Vital Statistics assisted with this study. No compensation was provided to them. Most importantly, we thank the prehospital health care workers throughout New York City and this nation for their dedication and sacrifice.

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