


ORIGINAL RESEARCH

Emergency Medical Services

System impacts of the COVID-19 pandemic on New York City's emergency medical services

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Abstract

Objectives: To describe the impact of the COVID-19 pandemic on New York City's (NYC) 9-1-1 emergency medical services (EMS) system and assess the efficacy of pandemic planning to meet increased demands.

Methods: Longitudinal analysis of NYC 9-1-1 EMS system call volumes, call-types, and response times during the COVID-19 peak-period (March 16–April 15, 2020) and post-surge period (April 16–May 31, 2020) compared with the same 2019 periods.

Results: EMS system received 30,469 more calls from March 16–April 15, 2020 compared with March 16–April 15, 2019 (161,815 vs 127,962; $P < 0.001$). On March 30, 2020, call volume increased 60% compared with the same 2019 date. The majority were for respiratory (relative risk [RR] = 2.50; 95% confidence interval [CI] = 2.44–2.56) and cardiovascular (RR = 1.85; 95% CI = 1.82–1.89) call-types. The proportion of high-acuity, life-threatening call-types increased compared with 2019 (42.3% vs 36.4%). Planned interventions to prioritize high-acuity calls resulted in the average response time increasing by 3 minutes compared with an 11-minute increase for low low-acuity calls. Post-surge, EMS system received fewer calls compared with 2019 (154,310 vs 193,786; $P < 0.001$).

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Conclusions: COVID-19-associated NYC 9-1-1 EMS volume surge was primarily due to respiratory and cardiovascular call-types. As the pandemic stabilized, call volume declined to below pre-pandemic levels. Our results highlight the importance of EMS system-wide pandemic crisis planning.

KEYWORDS

COVID-19 pandemic, disaster planning, emergency medical services, pandemic planning

1 | INTRODUCTION

1.1 | Background

The first confirmed case of coronavirus disease 2019 (COVID-19) in New York City (NYC) occurred on March 1, 2020. By May 31, 2020, the crude infection rate as defined by diagnostic testing was 2411 per 100,000.¹ Despite mitigation efforts in NYC, including schools closing on March 16, 2020 and stay-at-home orders implemented on March 20, 2020, COVID-19 continued to alter all aspects of healthcare. By May 31, 2020, 51,212 COVID-19 patients had been hospitalized at 53 acute care hospitals in NYC.¹ This required an immediate and sustained surge in hospital bed capacity, especially ICU beds capable of providing care to intubated patients in respiratory failure.²⁻⁵

NYC's 9-1-1 emergency medical services (EMS) system is the largest in the United States, serving an estimated 8.4 million persons and receiving an average of 4000 calls per day. Response is via a multi-tiered response system consisting of EMS providers (emergency medical technicians and paramedics) and certified first responder firefighters (CFR).

1.2 | Importance

During the COVID-19 pandemic, the NYC 9-1-1 EMS system experienced the largest surge it ever recorded—a surge that was more sustained and involved more critically ill patients than past catastrophic events such as the World Trade Center attacks, the 2003 blackout, and Hurricane Sandy.⁶⁻⁹ A series of pre-planned strategies were implemented to maintain the system's ability to function during a pandemic. These included: (1) a computer-assisted triage system to classify calls on the basis of their acuity, to dispatch response assets accordingly and to identify potential infectious disease calls so that responders could don appropriate personal protective equipment (PPE) that had been stockpiled to minimize infectious exposures and maintain workforce integrity; (2) using additional local and out-of-state ambulances to increase system capacity; and (3) addressing low-acuity call-types by telemedicine referrals that would not necessarily require an ambulance response or by a treat/release/no-transport option after ambulance response. All of the above were initiated to preserve the prioritization of 9-1-1 rapid response to high-acuity, life-threatening call-types during periods of potentially overwhelming increases in call volume demand.

1.3 | Goals of this investigation

To understand the impact of the COVID-19 pandemic on NYC 9-1-1 EMS system, we examined 9-1-1 call volumes, call-types, and response times during the pandemic compared with the same period in 2019.

2 | METHODS

2.1 | Study design and setting

We conducted a population-based, longitudinal study examining NYC 9-1-1 EMS system call volumes, call-types, and system response times during the COVID-19 pandemic compared with the same outcomes 1 year prior. The Montefiore Medical Center/Albert Einstein College of Medicine Institutional Review Board approved this study and waived the need for informed consent based on minimal risk.

Data on EMS system call volumes, call-types, and response times were captured in the Fire Department of the City of New York's (FDNY) Computer Aided Dispatch (CAD) system, maintained by FDNY in a secure data warehouse.^{6,10} Phone calls to the NYC 9-1-1 EMS system are processed by specially trained EMS providers using computer-assisted triage algorithms to assign call-types (out-of-hospital "diagnoses") based on patient acuity as assessed by their complaints/history.¹⁰ Not all 9-1-1 calls receive an ambulance response because some are more suitably assisted by other agencies such as police, fire, or poison control. Additional information on the daily number of COVID-19 hospital admissions and intubated patients for all NYC hospitals was obtained from the NYC Department of Health and Mental Hygiene (DOHMH) and the Hospital Emergency Response Data System (HERDS).

2.2 | Interventions—optimization of the disaster management system

Over the prior 10 years, FDNY designed and implemented multiple strategies to optimize management of disasters, including pandemics. For example, in August 2014, during the Ebola crisis, FDNY updated the NYC's 9-1-1 EMS system so that any medical call-type could include a pandemic modifying suffix (Supporting Information Table S1) to alert responders to take appropriate infection-control measures, including

donning PPE, before patient contact.^{11,12} In February 2017, FDNY added computerized call-type triage to NYC's 9-1-1 EMS system to provide more rapid and consistent triaging of patient calls into call-types (Supporting Information Table S1) based on acuity of the presenting complaint.

In anticipation of COVID-19, (1) FDNY activated the "pandemic" call-type modifier ("Fever-Cough") on January 30, 2020 to alert crews that they may be responding to patients returning from CDC-identified countries of concern with suspected COVID-19 disease (flu-like or respiratory symptoms). During the pandemic, COVID-19 criteria were further expanded in a stepwise approach to broaden the identification of potential COVID-19 patients. On March 30, 2020, given increasing community infection, FDNY removed the travel requirement for any caller with COVID-19 symptoms. On April 1, all medically ill patients were classified as potential COVID-19 cases, regardless of symptoms. On April 5, a system-wide order extended PPE precautions to all patients, even trauma patients.

Starting March 1, 2020, CFR firefighter responses were refocused from all high-acuity call-types to primarily cardiac arrest calls. Starting April 1, the number of 9-1-1 EMS system units were augmented by additional units supplied by local mutual aid and out-of-state ambulances through the Federal Emergency Management Agency's (FEMA) National Ambulance Contract. Starting March 31, 2020, low-acuity patients were transferred to telemedicine without an ambulance response. On April 13, 2020, patients who had an ambulance response and were found to be stable were offered a treat/release/no-transport option when their COVID-19-like symptoms were minimal, their temperature did not exceed 100.4°F, and their resting oxygen saturation was $\geq 95\%$.

2.3 | Outcomes

Three outcomes were examined in these analyses: call volumes and associated call-types, system times, and daily counts of hospital admissions and intubated patients. Calls were triaged into 65 distinct diagnostic call-types (Supporting Information Table S1) and then categorized into 8 segments based on response priority. Segments 1–3 were considered high-acuity, life-threatening calls warranting the highest response priority. Segments 4–8 were considered low-acuity calls with corresponding lower response priorities. Call-types were grouped into 10 broad categories based on common medical categories as defined in Munjal et al¹⁰ (Supporting Information Table S1). Respiratory call types included asthma, difficulty breathing, respiratory distress, and choking. Cardiovascular call-types included cardiac arrest, cardiac symptoms, stroke, and hypertension. Each call received by NYC 9-1-1 EMS system was considered a unique incident regardless of the number of units that responded. Call data included those responded to by FDNY and hospital-based ambulances, local mutual aid and out-of-state ambulances, transfers to telemedicine, and the treat/release/no-transport option.⁶

System times were segmented into the following categories: (1) response time, defined as the time from call assignment to time of first unit arriving on-scene; (2) on-scene time, defined as the time from the

The Bottom Line

New York City (NYC) was one the most intense epicenters of COVID-19 in the world. This study describes the impact of the COVID-19 pandemic on the operations of NYC's emergency medical services (EMS), the largest in the United States. The COVID-19 peak of March 16–April 15 2020 resulted in a 60% increase in EMS calls compared with March 16–April 15 2019 (161,815 vs 127,962 calls), primarily comprising respiratory and cardiovascular calls. The proportion of high-acuity call types increased 6%. These results illustrate the results of NYC EMS's systemwide preparation for COVID-19.

first unit arriving on-scene to time first unit leaves the scene (includes donning of PPE, assessment, and treatment); and (3) turnaround time, defined as the time from hospital arrival to time unit is ready for its next call (includes patient handoff to hospital staff and ambulance decontamination).

2.4 | Analysis

Descriptive analyses of counts and means, depending on data type, were conducted for all outcomes from NYC's 9-1-1 EMS system between February 15–May 31, 2020 and February 15–May 31, 2019. Data were further categorized into 3 time periods: pre-surge (February 15–March 15), peak (March 16–April 15), and post-surge (April 16–May 31). Pearson's chi-square and *t*-tests were used to compare categorical and continuous data, respectively, between the COVID-19 time periods and the same periods in 2019. Relative risk (RR) and 95% confidence intervals (CI) were also computed by time period. Analyses were performed using SAS (version 9.4; SAS Institute Inc., Cary, NC).

3 | RESULTS

3.1 | Call volume and types

The first case of COVID-19 in NYC was diagnosed on March 1, 2020. Within 2 weeks, the number of 9-1-1 EMS system calls steadily increased until mid-April (Figure 1). During the pandemic peak, from March 16–April 15, 2020, NYC 9-1-1 EMS system saw an excess of 33,853 calls, averaging an additional 1128 calls per day compared with the same period in 2019 (161,815 vs 127,692; $P < 0.001$). Daily call volume peaked on March 30, 2020 at 6527 calls, a 60% increase from 4077 on March 30, 2019. By April 16, call volumes returned to pre-pandemic levels. Call volumes post-surge, from April 16 through May 31, declined to a level significantly below its 2019 volume (154,310 vs 193,786; $P < 0.001$).

Figure 2 shows that during the peak-period (March 16–April 15, 2020), excess calls occurred only for medical (non-traumatic) call-types

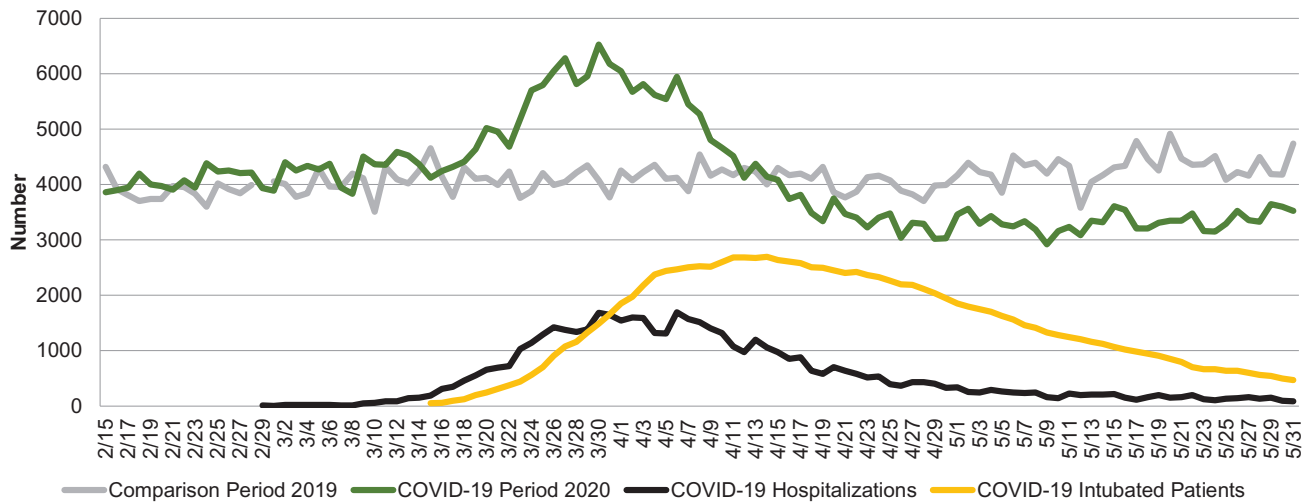


FIGURE 1 Daily number of New York City (NYC) 9-1-1 emergency medical services (EMS) calls, hospitalizations, and intubated patients during the COVID-19 period and 1 year prior. The orange line shows EMS 9-1-1 calls from 2020. The gray line shows comparison EMS 9-1-1 calls from 2019. The black line shows daily COVID-19 related hospital admissions and the yellow line the number of intubated patients in NYC hospitals

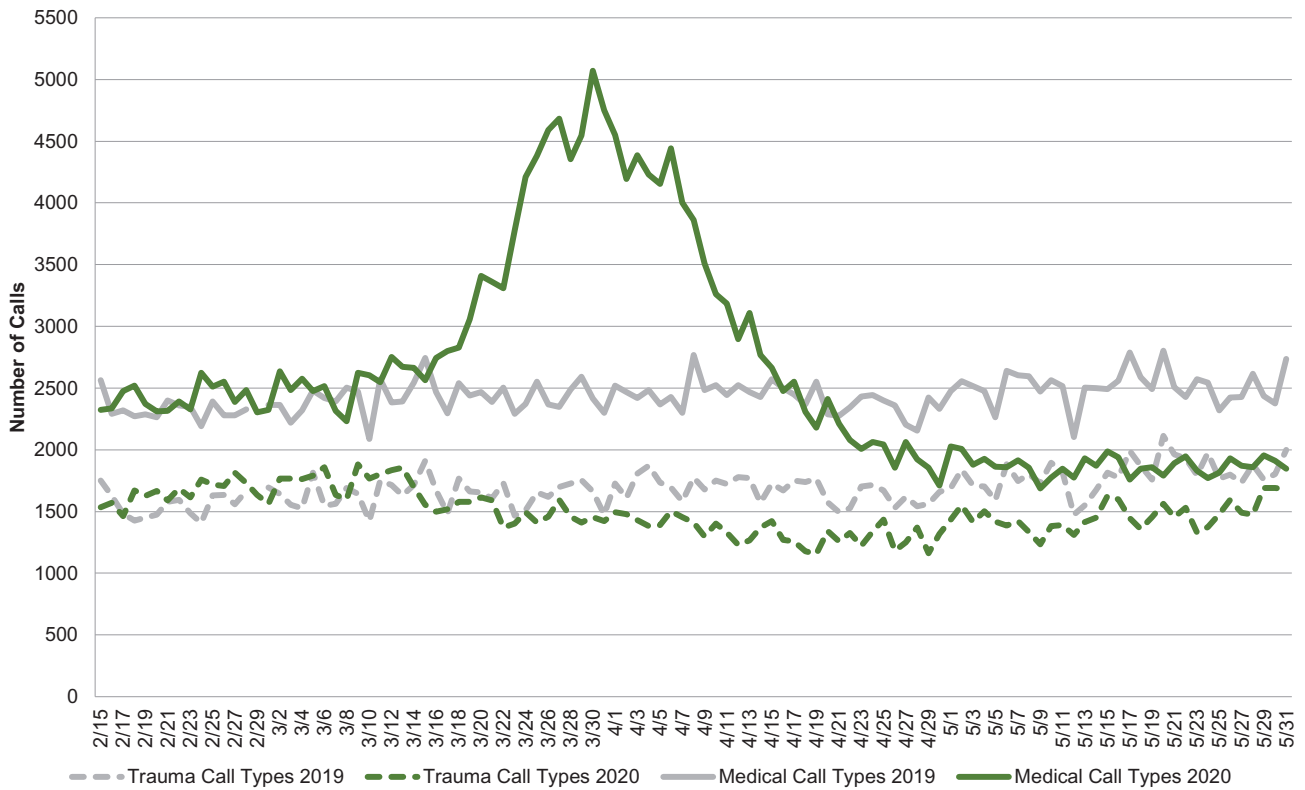


FIGURE 2 Daily number of New York City (NYC) 9-1-1 emergency medical services (EMS) calls by medical versus trauma call-type during the COVID-19 period and 1 year prior. The orange lines show EMS 9-1-1 calls from 2020 (solid line, medical call-types; dashed line, trauma call-types). The gray lines show comparison EMS 9-1-1 calls from 2019 (solid line, medical call-types; dashed line, trauma call-types)

(117,086 vs 76,017; $P < 0.001$). Prior to this, medical call-types were similar to those in 2019. During the post-surge period, both medical and trauma call-types saw significant reductions in the number of calls compared with 2019 (89,765 vs 113,418; $P < 0.001$ and 64,545 vs 80,368; $P < 0.001$, respectively).

Table 1 compares ambulance responses by call-types (out-of-hospital “diagnoses”) seen during the COVID-19 peak-period with the 2019 period. During the peak-period, from March 16–April 15, 2020, the NYC 9-1-1 EMS system responded to 30,469 excess calls, a 24% increase, compared with the same period in 2019 (157,976 vs 127,507

TABLE 1 New York City 9-1-1 emergency medical services responses by call type between March 16 and April 15

Call type categories	Comparison period: March 16–April 15, 2019		COVID-19 period: March 16–April 15, 2020		Relative risk (95% CI) ^c
	N	% ^a	N	% ^b	
Total	127,507	100	157,976	100	1.24 (1.23–1.25)
Respiratory	10,480	8.2	26,192	16.6	2.50 (2.44–2.56)
Asthma ^d	1159	11.1	1731	6.6	1.49 (1.39–1.61)
Cardiovascular	16,146	12.7	29,881	18.9	1.85 (1.82–1.89)
Cardiopulmonary arrest ^e	1989	12.3	6416	21.5	3.23 (3.07–3.39)
Other cardiac ^e	14,157	87.6	23,465	78.5	1.66 (1.62–1.69)
General illness	22,637	17.8	35,859	22.7	1.58 (1.56–1.61)
Miscellaneous	9552	7.5	12,002	7.6	1.26 (1.22–1.29)
Other medical	18,509	14.5	18,497	11.7	1.00 (0.98–1.02)
Other trauma	538	0.4	445	0.3	0.83 (0.73–0.94)
OBGYN	1763	1.4	1422	0.9	0.81 (0.75–0.87)
Violence ^f	4898	3.8	3805	2.4	0.78 (0.74–0.81)
Environmental	179	0.1	124	0.08	0.69 (0.55–0.87)
Psych/drug	21,522	16.9	15,145	9.6	0.70 (0.69–0.72)
Blunt trauma	21,190	16.6	14,555	9.2	0.69 (0.67–0.70)
Mass casualty incident	93	0.07	49	0.03	0.53 (0.37–0.74)

^aPercent of total assignments between March 16–April 15, 2019.

^bPercent of total assignments between March 16–April 15, 2020.

^cRelative risk and 95% confidence intervals (CI) comparing the proportion of 9-1-1 calls in New York City for 2020 compared to 2019, assuming the population of NYC did not change between the 2 years.

^dSubset of respiratory call numbers.

^eSubset of cardiovascular call numbers.

^fViolence calls are considered a type of trauma call but are separated in FDNY EMS documentation as they also receive a NYPD response.

calls; RR = 1.24, 95% CI = 1.23–1.25). Most of the increase was from additional respiratory (RR = 2.50; 95% CI = 2.44–2.56) and cardiovascular call-types (RR = 1.85; 95% CI = 1.82–1.89).

Within the broader cardiovascular category, there were 4427 excess cardiac arrests during the COVID-19 peak-period (RR = 3.23; 95% CI = 3.07–3.39). Even after accounting for cardiac arrests (21.5% of cardiovascular calls), the “other” cardiovascular calls remained elevated (RR = 1.66; 95% CI = 1.62–1.69). General illness call-types including fever-cough-viral-like symptoms, but without significant dyspnea also received an excess of 13,222 calls. In contrast, blunt trauma, psychiatric/drug and violence-related call-types declined by 6635, 6377, and 1093 calls, respectively.

3.2 | System response times

During the COVID-19 peak-period, the average ambulance response time increased from 10 minutes on March 16, 2020 to a peak of 45 minutes on March 30, 2020, 36 minutes slower than 1 year prior on March 30, 2019 (Figure 3A). Overall, daily mean ambulance response times during the peak-period (March 16–April 15) averaged >7 minutes slower than in 2019 (17.8 vs 10.4; $P < 0.001$). By April 16, 2020, ambulance response times declined. During the post-surge period (April 16–

May 31), daily mean ambulance response time averaged 4 minutes faster in 2020 compared to 2019 (7.2 vs 11.2; $P < 0.001$).

3.2.1 | High-acuity calls

During the peak-period (March 16–April 15), average response times to high-acuity calls increased by only 3 minutes, whereas average response times to low-acuity calls increased by 11 minutes (Figure 4). The proportion of high-acuity calls during the peak COVID-19 period increased to 42.3% compared with 36.4% 1 year prior. CFR firefighters continued to respond to high-acuity calls, but focused their efforts on responding to cardiac arrests. During the pandemic peak, CFR firefighters responded to 14,032 high-acuity calls of which 44% ($n = 6227$) were cardiac arrests; in 2019, only 8.6% of CFR responses (1946 of 22,510) were for cardiac arrests. During the pandemic peak, CFR firefighters arrived, on average, 2.6 minutes faster than EMS ambulances.

3.2.2 | Low-acuity calls

On March 30, 2020, the average response time for low-acuity calls was 65 minutes. With the deployment of ambulances from the FEMA

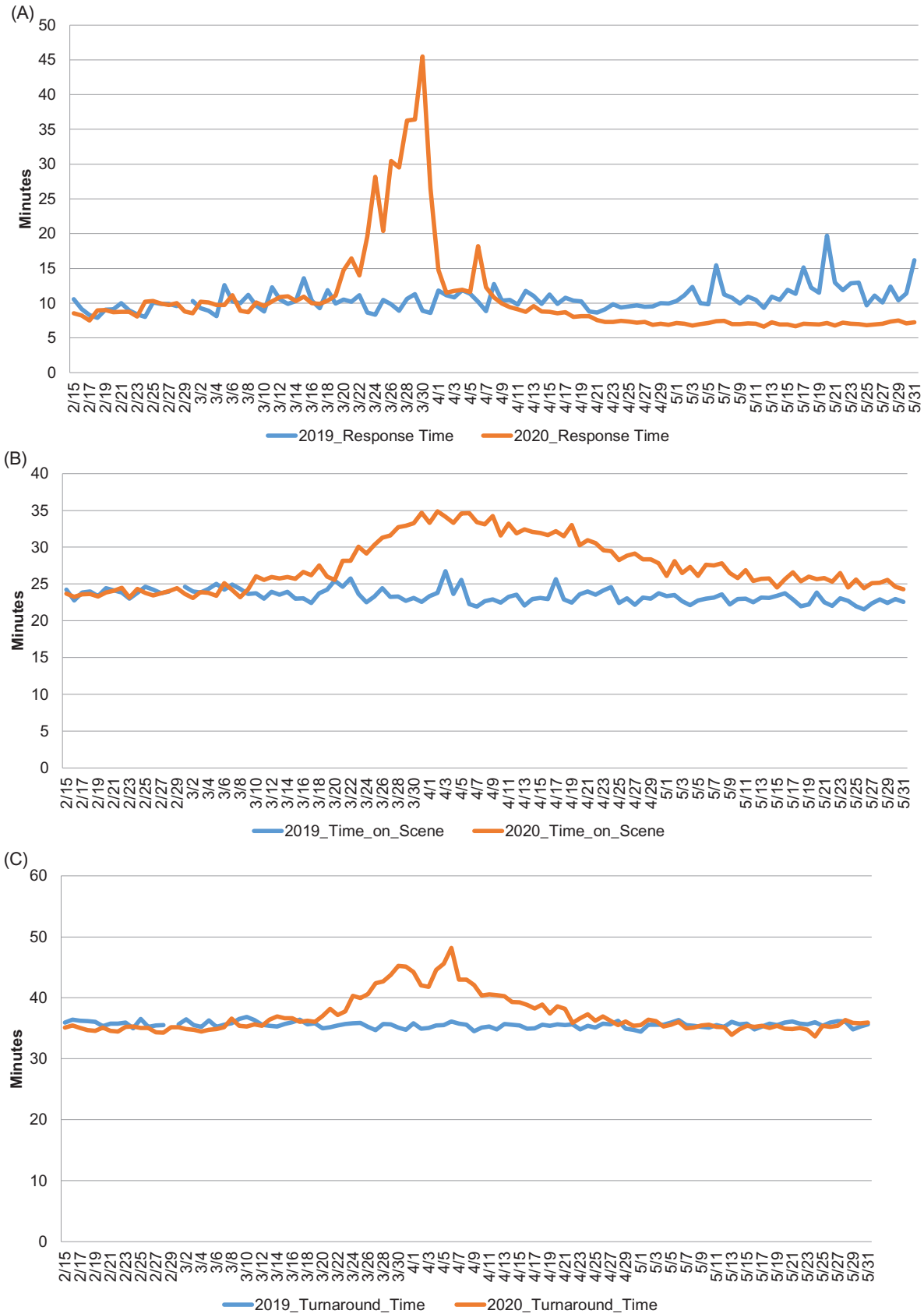


FIGURE 3 Average New York City (NYC) 9-1-1 emergency medical services (EMS) system times for each day February 15–May 31 (COVID-19 vs 1 year prior). The red line shows response time from 2020. The blue line shows comparison from 2019. Three components of system times in minutes are shown (A) response time, (B) on-scene time, and (C) hospital turnaround time at the ED

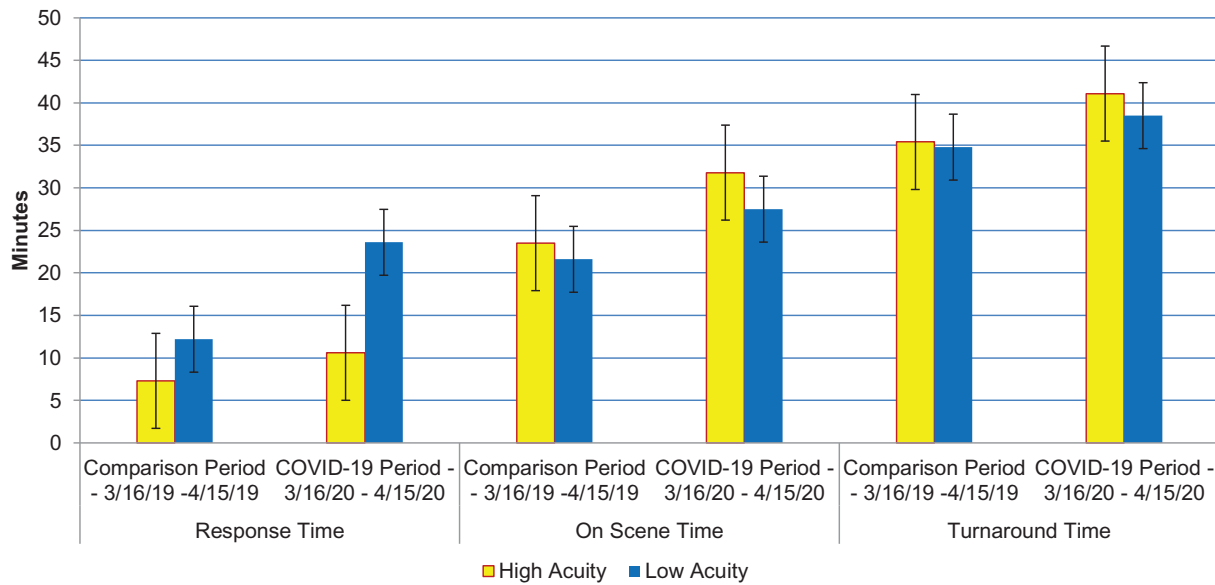


FIGURE 4 Average New York City (NYC) 9-1-1 emergency medical services (EMS) system times for low and high acuity assignments during the COVID-19 epidemic peak versus 1 year prior. The yellow bar represents high acuity call-types and the blue bar represents low acuity call-types during the COVID-19 peak period (March 16–April 15, 2020) and the comparison period (March 16–April 15, 2019). System time is divided into 3 components—response time (call assignment to being on-scene), on-scene time, and hospital turnaround time at the ED

National Ambulance Contract, the number of ambulances in service during peak hours of April 1–April 15 averaged 556 as compared with 468 during 2019. These additional ambulances were deployed primarily to low-acuity calls. Furthermore, the introduction of telemedicine reduced the number of low-acuity calls responded to by an average of 166 calls per day between March 31 and April 15. Last, the treat/release/no-transport option started on April 13 and resulted in an average of 15 patients per day not transported to a hospital. By April 15, 2020, average response times for low-acuity calls returned to pre-pandemic levels (10 min), a 55-min decrease in response time.

3.2.3 | 9-1-1 EMS system on-scene and hospital turnaround times

Average on-scene (Figure 3B) and hospital turnaround (Figure 3C) times also increased during the COVID-19 peak-period. In contrast to response times, recovery of on-scene and hospital turnaround times to pre-2019 levels took longer to occur. For time on-scene, average times did not become similar to 2019 levels until May 10. For hospital turnaround time, average times did not become similar to 2019 levels until April 24.

3.3 | Hospital admissions and intubations

Daily numbers of hospitalizations and intubated patients followed patterns similar to those of the NYC 9-1-1 EMS system, peaking at 1,694 on April 6, 2020 and 2,695 on April 14, 2020, respectively (Figure 1).

4 | LIMITATIONS

First, as with other health crises that NYC has faced (ie, the World Trade Center attacks, H1N1, Ebola, and Hurricane Sandy), response to the surge associated with the COVID-19 pandemic required multiple simultaneous mitigation strategies.^{7-9,13,14} Therefore, it is impossible to determine the relative contribution of any individual component of the overall strategy to maintaining the integrity of the NYC 9-1-1 EMS system. However, that does not diminish the overall impact, in that the sum of our mitigation strategies allowed the NYC 9-1-1 EMS system to remain effective by maintaining prioritization of high-acuity calls during an unprecedented health crisis.

Second, testing was not available to confirm that increased calls (respiratory, cardiac, and general illness) were solely due to COVID-19. However, comparison with the same time 1 year prior supports our conclusions. We acknowledge that NYC 9-1-1 EMS calls for respiratory or cardiovascular illnesses including cardiac arrests¹⁵ could have been directly due to COVID-19 infection or indirectly related due to delays in seeking or receiving healthcare for COVID-19 infections or for pre-existing conditions (eg, cardiopulmonary diseases or cancer). This possibility is supported by a decline in call volumes to below 2019 levels starting April 16, 2020 and by recent studies demonstrating decreases in hospital admissions for cardiovascular diseases and diabetes during the COVID-19 pandemic.^{13,14,16-18}

Third, we cannot determine how many patients who accepted NYC 9-1-1 EMS call transfers to telemedicine or on-scene treat/release/no-transport option called the system back at a later time. A major strength of our study is the longitudinal system-wide ascertainment of NYC 9-1-1 EMS system responses in a city of 8.4 million people facing the largest pandemic since the 1918 influenza pandemic.¹⁹ By includ-

ing data from the entire NYC 9-1-1 EMS system and comparing findings to the same time period 1 year prior, the potential for ascertainment and selection biases were minimal.

5 | DISCUSSION

During the COVID-19 peak-period, sustained increases in daily EMS call volume have been reported.²⁰ In this description from NYC, we observed that increased 9-1-1 call volume resulted mostly from respiratory and cardiovascular call-types, consistent with symptoms of COVID-19 infection. In NYC, the sustained increase in daily call volume demand averaged an additional 1128 calls versus slightly over 4000 in 2019.

Several pre-planned targeted interventions assisted in dealing with surge demand. Computerized triage was essential, because it allowed efficient classification of high versus low-acuity call-types during the peak of the pandemic when call volumes placed huge demands on EMS system phone call receivers. Complementing increased ambulance availability was our strategy to reduce the number of low-acuity calls requiring an ambulance response or transport. 9-1-1 EMS phone call receivers, using computerized triage algorithms, transferred low-acuity calls directly to telemedicine nurses and physicians. For calls that could not be triaged to telemedicine, an on-scene treat/release/no-transport option was begun. These initiatives not only increased ambulance availability, but also reduced the impact of additional patients on already strained resources at crowded emergency departments (EDs), potentially reducing the spread of COVID-19 infection. The capability to use telemedicine and on-scene treat/release was limited by patient acceptance and by our capacity to make such referrals. Starting in 2021, the 9-1-1 EMS capacity for referring to telemedicine and alternative destinations other than emergency departments should increase with the nationwide implementation of the Centers for Medicare and Medicaid Innovation's Emergency Triage, Treat and Transport "ET3" program that incentivizes such strategies even during normal operation.²¹

FEMA provided fully staffed ambulances that focused on low-acuity calls, thereby allowing NYC 9-1-1 EMS ambulances and CFR firefighters to focus on high-acuity calls. These additional FEMA ambulances, when in sufficient number, had the greatest impact on lowering response times. However, outside resources should not be the centerpiece of a 9-1-1 EMS system pandemic plan because, in a prolonged surge affecting many areas of the country simultaneously, their availability cannot be guaranteed.

Our planned strategies had limited, if any, impact on prolonged ambulance on-scene and turnaround times, a critical component of ambulance availability. Likely, increased times for on-scene and hospital turnaround resulted from complex out-of-hospital medical care and lengthy hand-offs to hospital staff already dealing with high numbers of critically ill patients, evident by the dramatic increase in hospital admissions and numbers of intubated patients. Hospital turnaround times were also prolonged by the added time needed for ambulance decontamination.

After the peak COVID-19 period, NYC 9-1-1 EMS system call volume decreased substantially to below baseline levels. Significant decreases in ED visits and hospital admissions for non-COVID-19 diagnoses occurred during the pandemic, suggesting avoidance of, or limited access to, healthcare.^{2,16,18,22-24} The lesson learned is that public health messaging, during and after a pandemic, must strike a careful balance between encouraging use of the 9-1-1 EMS system only for high-acuity emergencies (COVID-19-related or -unrelated) and the use of alternative resources (primary care physicians, other healthcare clinicians, telemedicine, and home monitoring) for low-acuity conditions.²⁵ This can occur if patients and their healthcare providers have confidence that sufficient emergency and non-emergency supplies/services exist,²⁶ infection controls are observed, and the costs for these services are not overwhelming.

In conclusion, our study demonstrates that increased ambulance responses starting mid-March 2020 were due to respiratory and cardiovascular call-types consistent with COVID-19 infection. FDNY's pandemic planning was essential to meet the enormous, immediate, and sustained surge demands that COVID-19 placed on the largest 9-1-1 EMS system in the United States.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

David J. Prezant, MD, Elizabeth A. Lancet, Rachel Zeig-Owens, and Michael D. Weiden contributed equally to this study. David J. Prezant takes the final responsibility of the article.

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SUPPORTING INFORMATION

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

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