

The “Vertical Response Time”: Barriers to Ambulance Response in an Urban Area

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Abstract

Background: Ambulance response time is typically reported as the time interval from call dispatch to arrival on-scene. However, the often unmeasured “vertical response time” from arrival on-scene to arrival at the patient’s side may be substantial, particularly in urban areas with high-rise buildings or other barriers to access.

Objectives: To measure the time interval from arrival on-scene to the patient in a large metropolitan area and to identify barriers to emergency medical services arrival.

Methods: This was a prospective observational study of response times for high-priority call types in the New York City 9-1-1 emergency medical services system. Research assistants riding with paramedics enrolled a convenience sample of calls between 2001 and 2003.

Results: A total of 449 paramedic calls were included, with a median time from call dispatch to arrival on-scene of 5.2 minutes. The median on-scene to patient arrival interval was 2.1 minutes, leading to an actual response interval (dispatch to patient) of 7.6 minutes. The median on-scene to patient interval was 2.8 minutes for residential buildings, 2.7 minutes for office complexes, 1.3 minutes for private homes (less than four stories), and 0.5 minutes for outdoor calls. Overall, for all calls, the on-scene to patient interval accounted for 28% of the actual response interval. When an on-scene escort provided assistance in locating and reaching the patient, the on-scene to patient interval decreased from 2.3 to 1.9 minutes. The total dispatch to patient arrival interval was less than 4 minutes in 8.7%, less than 6 minutes in 28.5%, and less than 8 minutes in 55.7% of calls.

Conclusions: The time from arrival on-scene to the patient’s side is an important component of overall response time in large urban areas, particularly in multistory buildings.

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Rapid emergency medical services (EMS) response is needed for acute medical events such as respiratory distress, cardiovascular emergencies, and trauma, and response times are an important measure of the effectiveness of EMS systems.

EMS response time is usually reported as the interval from call assignment (by radio dispatch) to arrival of an emergency medical response unit at the scene (street location). This does not, however, include any additional

time that it may take for emergency responders to get from the on-scene location to the patient’s side.

In urban areas, this unreported time interval is sometimes referred to as the “vertical response time” because it reflects the particular challenges associated with reaching patients in multistory residential and office buildings. We postulated that in a large urban area, this on-scene to patient interval might substantially add to the actual time it takes a paramedic unit to reach a patient. If lengthy

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on-scene to patient intervals do indeed exist, then the total time from call assignment to arrival at the patient's side would better indicate actual response times. In addition, identification of factors contributing to prolonged on-scene to patient intervals might point to effective means for remediation.

The objective of this study was to determine the time interval from paramedic arrival at the scene to arrival at the patient's side for high-priority medical emergencies called in to the New York City (NYC) 9-1-1 response system. We evaluated arrival times by patient location, comparing calls from street and public locations with private homes and multistory buildings. We also identified barriers that might have contributed to delays in arrival at the patient's side.

METHODS

Study Design

This was a prospective observational case series representing a convenience sample of EMS call types in NYC that triggered a paramedic response from observation periods July 2001 to December 2003. A three-tiered 9-1-1 EMS response system in NYC consists of firefighter/first responder engine companies, basic life support units, and paramedic units. Paramedic units are preferentially assigned the highest priority calls (1, 2, and 3 out of 9), with basic life support units providing backup when advanced life support (ALS) units are not immediately available. Priority 1 calls include cardiac arrest and choking; priority 2 calls include anaphylaxis, status epilepticus, unconscious, critical asthma exacerbations, difficulty breathing (age older than 40 years), and acute strokes (less than three hours since onset); and priority 3 calls include altered mental status, major trauma/burns/shootings/stabbings, cardiac complaints, gastrointestinal bleeds, and amputations (except digits). The study was performed in collaboration with the Fire Department of New York (FDNY) Office of Medical Affairs and was approved by the Human Subjects Review Committee at Long Island Jewish Medical Center.

Study Setting and Population

The population of NYC was 8,085,742 in 2003, with an overall population density of 26,402.9/sq mi (66,940.1/sq mi in Manhattan).¹ The average annual FDNY EMS volume for the observation period was 1,090,000 calls/year. Trained observers rode along with paramedic units that cover three sections of NYC: midtown Manhattan, uptown Manhattan, and central Queens. These areas represent a mixture of commercial and residential districts and building types. Units may also have covered prisons or institutions housed on smaller islands adjacent to Manhattan or Queens and connected by a bridge.

The average proportion of calls by tour for the entire FDNY EMS system during the study period was as follows: 12 AM to 8 AM, 21%; 8 AM to 4 PM, 40%; 4 PM to 12 AM, 39%. The daily number of weekday calls (3,025) was broadly similar to the daily number of weekend calls (2,891) during the study period. A total of four of the 32 primary stations were sampled, and we estimate that 51 of the 598 FDNY paramedics (8.5%) were observed over the study period.

Calls to the NYC 9-1-1 system for EMS assistance requiring a priority 1, 2, or 3 ALS response in the study areas were eligible for inclusion in the study. Excluded were those cases in which the 9-1-1 ambulance response was cancelled before arrival of the crew on-scene or in which no patient was found. Cases were also excluded if the ambulance crew was "flagged" down for a medical emergency but were not initially received or dispatched through the 9-1-1 system.

Study Protocol

Observers were individually trained using a regimented written protocol and definition set. The observers joined a paramedic unit at the beginning of eight-hour tours. They made the crew aware of the purpose of the study and the type of information being collected and obtained verbal permission from the paramedics to collect data. A standardized data collection instrument was used to record information events, and a stopwatch was used to document all study times to the nearest second. The completed data collection instruments were reviewed with the observers weekly to assure uniformity and compliance. Identifying information was not collected on either the paramedics or patients, and the observer was not permitted to offer medical assistance or otherwise intervene in patient care.

Responding paramedics for midtown and upper Manhattan were municipal-based FDNY EMS units. In the borough of Queens, observers rode on either of two kinds of ALS units: FDNY EMS or 9-1-1 participating ambulances of the North Shore-Long Island Jewish Health System.

Measures

Study time points and intervals were defined as follows: "call assigned" was the time a paramedic unit was assigned a 9-1-1 call by the FDNY EMS dispatcher, "on-scene" was the time the ambulance arrived at the street address or in the general vicinity of the patient, and "patient" was the time the crew reached the patient's side. The standard response time was the interval from call assigned to arrival on-scene. The total response time was the interval from call assigned to arrival at the patient's side. The primary study outcome measure was the interval from arrival on-scene to the patient's side (time of arrival at patient's side – time of arrival on-scene).

Other data collected included the general locations and types of structures where the patients were found. Detailed information was also collected on the presence of an escort and any potential role in facilitating access to the patient. Times related to elevator utilization were documented for relevant calls. Observers identified additional postarrival barriers that delayed arrival by 30 seconds or more and recorded the time necessary to overcome any such delay. This included locked inner or outer doors, incorrect address or locations, difficulty locating the patient, and the presence of crowds, police barricades, or unsafe conditions.

Data Analysis

Data were analyzed with SAS version 8.0 (Research Triangle Institute, Research Triangle Park, NC). In addition to identification of various response times, planned

comparisons included on-scene to patient times for location, elevator utilization, building heights, use of escorts, and other barriers to access greater than 30 seconds. Medians, interquartile ranges (IQRs), means, and ranges were used to describe response times. Response times were compared using two-tailed Wilcoxon rank sum tests and Kruskal-Wallis tests.

For data presented in box-and-whisker plot form, the symbology is as follows. The boxes cover the IQR. The lines within the boxes designate the median values. The whiskers extend to the minimum and maximum values unless there are outliers. Outliers are defined as values that are beyond 1.5 times the IQR away from the upper and lower limits of the IQR. If there are outliers, then the whiskers extend to the most extreme value within a distance of 1.5 times the length of the IQR from the boundary of the IQR. The dots represent the outliers.

RESULTS

Data were collected on 487 9-1-1 calls requiring an ALS paramedic response. On 33 occasions, the ambulance was cancelled either before or upon arrival of the unit on-scene; for another five calls, on-scene arrival times were not recorded. These 38 cases were excluded, leaving a total of 449 patient calls for data analysis. The mean (\pm SD) patient age was 52 (\pm 23.2) years (ranging from infancy to 103 years), and 7.6% of calls were for individuals younger than 18 years. A total of 96.5% of calls were represented in the following categories: respiratory distress/critical asthma, chest pain/cardiac, altered mental status/unconscious, seizure, internal bleeding, or trauma. The proportion of cases collected by ambulance tour was as follows: 12 AM to 8 AM, 12.4%; 8 AM to 4 PM, 57.2%; 4 PM to 12 AM, 30.5%. Most (92.3%) of the observations were made on weekdays. A total of 28.9% of calls were from midtown Manhattan, 32.2% from uptown Manhattan, and 35.7% from central Queens. An additional 3.3% were from locations that housed prisons within the units' catchment area.

The standard response interval, defined as the median time from call assignment to arrival on-scene, was 5.2 minutes (IQR, 3.8–7.1; mean, 5.7 [95% confidence interval [CI] = 5.4 to 5.9]). The median interval from arrival on-scene to arrival at the patient's side was 2.1 minutes (IQR, 1.0–3.0; mean, 2.3 [95% CI = 2.1 to 2.4]). Altogether, the median interval from call assignment to arrival at the patient's side was 7.6 minutes (IQR, 5.6–9.9; mean, 8.0 [95% CI = 7.7 to 8.3]).

Location

The differences in response by location were significant ($p < 0.0001$) for each time interval examined (call assign to scene, scene to patient, and call assign to patient; Table 1). As the Table indicates, the median response interval from arrival on-scene to the patient's side was substantially longer in multistory residential buildings (2.8 minutes) compared with private homes or residential structures with three or fewer stories (1.3 minutes). On-scene to patient intervals were shortest for outdoor/street level calls, with a median of 0.5 minutes. A box plot further details the distribution of arrival on-scene to patient intervals by location (Figure 1), highlighting

the more extreme delays sometimes found in reaching patients in multistory buildings.

As Table 1 also indicates, total response times for a given location are a function of the pre-scene and post-scene arrival times. For example, the longer total call assignment to patient interval in private homes compared with street locations is largely attributable to the longer call assignment to on-scene intervals for private homes.

Building Height

For office, apartment, or medical buildings ten stories or higher ($n = 95$), the on-scene to patient interval was 3.2 minutes (IQR, 2.7–4.2 minutes), compared with 2.3 minutes (IQR, 1.6–3.1 minutes) for buildings three to ten stories in height ($n = 159$; $p < 0.0001$). The location of patients in taller buildings had less of an impact on arrival intervals. When the patient was on the first or second story of a building ten stories or taller, the interval from on-scene to patient was 2.8 minutes (IQR, 2.2–4.6 minutes); for the third through ninth floors, the interval was 3.1 minutes (IQR, 2.7–4.1 minutes); and for the tenth floor or higher, the interval was 3.3 minutes (IQR, 3.0–4.2 minutes; $p = 0.3443$).

Elevators

Elevators were used to reach the patient in 37.4% (170) of all calls. For all types of buildings, the median interval from approaching the elevator at ground level to stepping out of the elevator was 51 seconds (IQR, 33–80 seconds). Breaking this down into its individual components, the median time waiting for the elevator to arrive was 18 seconds (IQR, 10–40) and from stepping into the elevator to stepping out at the patient's floor was 29 seconds (IQR, 17–49). Once the crew entered the elevator and it stopped one or more times at nonpatient floors, another 54 seconds was added to the interval from scene to patient. Additional stops happened in 18.6% (21/113) of all elevator calls in high-rise residential apartment buildings and in 17.0% (9/53) of office or medical buildings.

Other Barriers

After arrival on-scene, other nonelevator barriers that caused substantial delays (defined as lasting 30 seconds or more) were recorded in 11.9% (54) of calls (Table 2). When one or more of these barriers was present, the median on-scene to patient interval was 1.6 minutes longer than when none of these barriers were present ($p < 0.0001$).

Escorts

One or more escorts provided assistance to paramedics upon scene arrival in 53.2% (239) of cases, and in some instances more than one escort was present. Escorts most frequently included other emergency personnel (e.g., police, fire units) who arrived on-scene before the paramedics (representing 59% of all calls where an escort was present); building or facility staff such as security personnel, doormen, or patient coworkers (25%); and a family or friend (21%). Types of assistance included (but were not limited to) opening a locked outer building door, securing an elevator, and directing or escorting the paramedics to the patient. When an escort provided

Table 1
Paramedic Response Time Intervals by Location of the Patient

Locale	n	Call Assignment to Scene				Scene to Patient				Call Assignment to Patient			
		IQR				IQR				IQR			
		Median	Lower	Upper	Range	Median	Lower	Upper	Range	Median	Lower	Upper	Range
Multistory residence	162	5.4	3.9	7.0	0.6–13.5	2.8	2.2	3.8	0.5–10.8	8.4	6.9	11.0	3.6–17.6
Private home (less than four stories)	48	6.3	4.3	8.7	1.0–12.5	1.3	1.0	2.0	0.4–7.6	7.8	5.4	10.0	1.4–18.1
Multistory medical facility	61	5.4	4.1	7.0	0.2–12.8	2.5	1.5	3.3	0.7–6.9	7.9	6.4	9.9	3.8–15.9
Multistory office building	32	4.1	3.0	6.0	1.4–15.7	2.7	1.6	3.2	0.9–9.6	6.7	5.7	9.3	2.6–18.9
Street	84	4.3	3.1	5.8	1.3–10.2	0.5	0.3	0.8	0.1–2.2	4.9	3.7	6.3	1.7–11.1
Train station	12	5.8	3.5	7.8	3.1–11.8	1.7	1.4	2.7	0.6–5.4	8.3	6.2	9.1	4.5–14.4
Store/mall	10	5.5	2.2	7.6	1.7–10.7	1.3	0.9	1.8	0.8–3.0	6.3	4.1	8.9	2.5–11.8
Shelter	9	6.3	5.5	8.8	3.3–12.0	1.5	1.3	1.5	0.7–7.5	8.3	6.8	10.3	4.7–17.1
Other public*	29	7.3	4.4	9.3	1.7–26.0	2.1	1.3	2.7	0.4–8.4	9.1	6.6	11.0	4.7–28.0

The sample size was 447 because of missing scene information in two cases.
 Call assignment to scene = time from EMS dispatch to arrival at the address/locale; scene to patient = time from arrival at the address/locale to arrival at the patient’s side; call assignment to patient = total response time (time from EMS dispatch to arrival at the patient’s side).
 IQR = interquartile range.
 * Includes the post office, construction sites, ball parks/stadiums, water treatment facility, and so on.

assistance to the paramedic unit, the mean on-scene to patient interval decreased from 2.3 minutes (no escort) (IQR, 1.0–3.3 minutes) to 1.9 minutes (escort present) (IQR, 1.1–2.9 minutes; $p = 0.0773$).

Call Type

The on-scene to patient response intervals for the most common call types are shown in Figure 2, with median times ranging from 1.3 to 2.9 minutes ($p = 0.0052$). There was a relationship between patient location and call type that influenced these time intervals. For example, of the

91 patients called in as “unconscious,” 39 were located at the street level and had a median on-scene to patient time of 0.41 minutes compared with 3.01 minutes for the 28 “unconscious” patients located in multistory buildings ($p < 0.0001$).

Age

With regard to age, the on-scene to patient interval was similar for those aged 0–17, 18–49, 50–64, and 65 years and older, ranging from a median of 1.9 to 2.2 minutes ($p = 0.2735$).

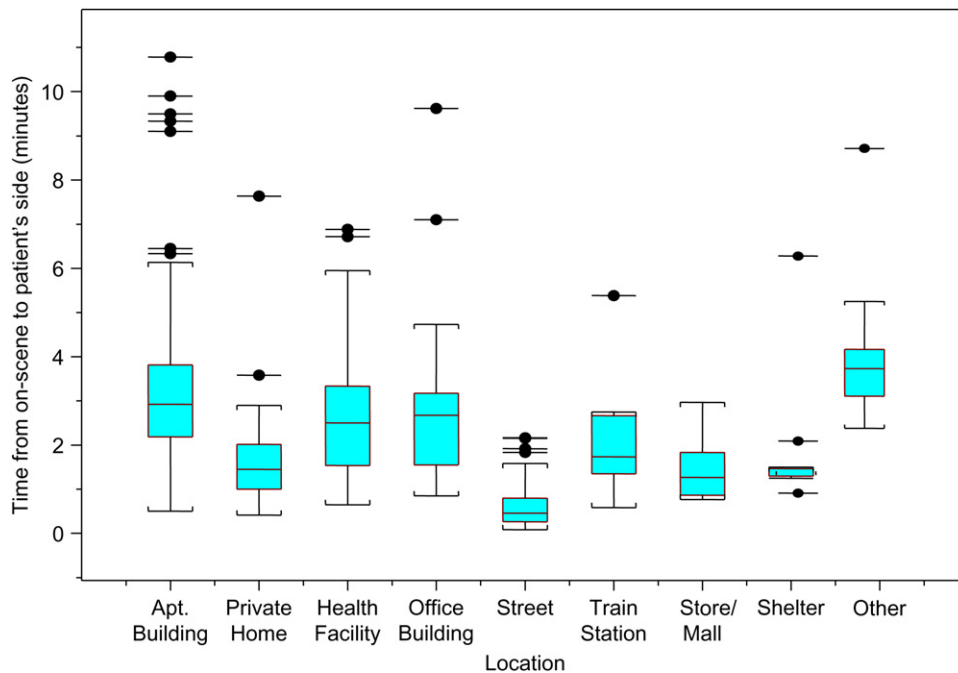


Figure 1. Time from emergency medical services arrival on-scene to patient’s side. (Color version of this figure available online at www.aemj.org.)

Table 2
Types of Barriers Present after Arrival On-scene

Barrier	n
Incorrect address/apartment number	17
Difficulty finding location/address not visible	6
Wrong entrance to building used	6
Locked doors (outer building or immediate to patient)	14
Location blocked by other emergency personnel	5
Difficulty finding patient at scene	8
Other (guard dog, poor building access)	4

Barrier defined as causing delay of 30 seconds or longer.

Critical Response Intervals

Finally, we evaluated how often ALS units arrive within established or accepted critical response times (Table 3). To show how different definitions of response time impact target intervals, we compared standard response times (call assignment to scene) with the total response time (call assignment to patient). The frequency of achieving any given cutoff was substantially higher when the time from call assignment to arrival on-scene is presented (Table 3). For example, the interval from call assignment to on-scene was less than 6 minutes in 61.5% of calls, but when the interval from call assignment to patient (total response time) was calculated, arrival within 6 minutes occurred in only 28.5% of these calls.

DISCUSSION

EMS response time is typically reported as the interval from EMS dispatch to arrival on-scene. This interval ac-

counts, however, for only a portion of the total and therefore clinically relevant response time. In NYC, an extra 2.1 minutes was required for paramedics to actually reach the patient following the arrival of an ambulance on-scene. Not surprisingly, these intervals were related to the location of the patient. For example, an extra 2.8 minutes was needed to reach the patient in an apartment building, adding the equivalent of 52% of the standard EMS arrival to on-scene time. Because the majority of acute serious medical emergencies take place in residential locations, any additional time it takes to reach patients is particularly important in locales with a high concentration of apartment buildings.²⁻⁵

Several other studies have reported on-scene to patient time intervals.⁶⁻⁹ In a study of four EMS regions in Arizona, the on-scene to patient interval was 1.0 minute.⁶ In Kansas City, Missouri, a city of 500,000, the median on-scene to patient time was 1.3 minutes; this time was 0.8 minutes when there were no identifiable barriers and 2.3 minutes when one or more barriers were identified.⁷ The longer on-scene to patient intervals in our study may reflect the greater concentration of multistory buildings encountered in large metropolitan areas and the additional challenges in reaching patients in these buildings. This is supported by our relatively short on-scene times when patients were located in public locations and smaller residences. Further, our multistory response times are similar to other studies. In Toronto, the apartment building on-scene to patient interval was 2.4 minutes,⁸ and in Singapore the interval for high-rise buildings was 2.5 minutes.⁹

On-scene to patient time intervals are of particular concern in larger cities because a large segment of the

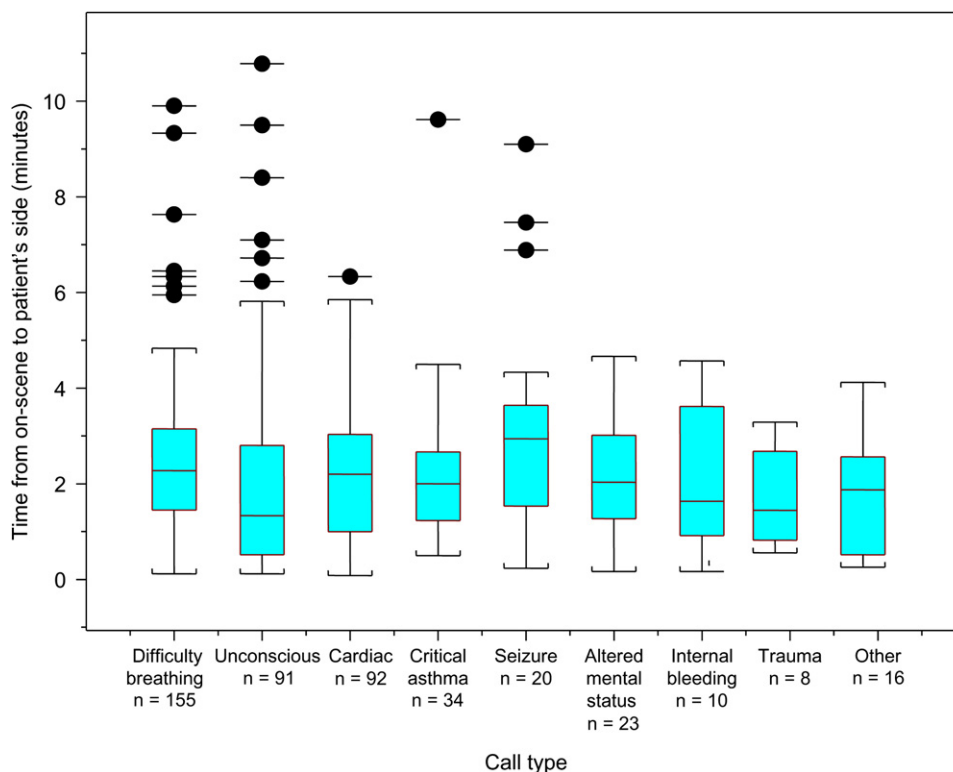


Figure 2. Time from on-scene to patient's side by emergency medical services call type. (Color version of this figure available online at www.aemj.org.)

Table 3
Frequency with Which EMS Response Met Selected Benchmarks When Reported as Standard Response versus Total Response Intervals

Response Time Cutoffs	Standard Response (%) (95% CI)	Total Response (%) (95% CI)
Less than 4 minutes	27.9 (22.3, 32.3)	8.7 (6.2, 11.7)
Less than 6 minutes	61.5 (56.8, 66.0)	28.5 (24.4, 32.9)
Less than 8 minutes	82.3 (78.5, 85.7)	55.7 (50.9, 60.3)

Standard response = call assignment to on-scene interval; total response = call assignment to patient arrival.

population may live or work in multistory buildings. Among Toronto's population of more than two million, 31.3% live in apartment buildings.⁸ In NYC, 74% of all residential units are found in structures three or more stories high.¹⁰ This concern also extends beyond large metropolitan regions; in a sampling of U.S. "central cities" (which include populations >250,000 or of at least 100,000 people working within its corporate limits), 38% of residential units are three or more stories in height.¹¹ With increasing urbanization, longer overall scene to patient intervals can be anticipated, with the impact of multistory buildings on response times likely to become even more important.

Among multistory structures, the actual height of the building is an important factor in patient access. We found that calls from taller multistory buildings had longer scene to patient intervals than smaller multistory buildings. Of note, the height of the building appeared more important than the location of the patient within the building. This suggests that factors such as the overall footprint and infrastructure of taller buildings need to be considered in assessing emergency response intervals.

Identifying barriers in advance of EMS arrival for any given system or region is an important step for improving response times. Paper or electronic maps with detailed layouts of building entrances and structure could be made available to emergency personnel. In special instances, detailed premise histories might conceivably be entered into 9-1-1 computer-aided dispatch systems to be communicated to ambulance crews at the time of dispatch. Ready access (and egress) needs to strongly factor into building design, especially when taller structures are involved. Means of entry that are relatively continuous and unobstructed are needed through courtyards, doorways, corridors, stairways, and other passageways. Along with adequate numbers of elevators, EMS personnel might be allowed to operate standard elevators in certain emergencies through the use of a special key, as is often the case in incidents involving fire suppression. In addition, apartment or office locations should be clearly marked at key entry points throughout the building.

In our study, delays in reaching the patient trended to reduction by the presence of an escort on-scene. Escorts helped overcome barriers by opening locked outer doors, securing elevators, and providing directions to the patient's location. Approximately half of all such calls involved emergency personnel escorts (e.g., police or

fire), who often arrived on-scene before paramedics. In only 21% of calls did a concerned bystander or member of the family serve as an escort. This occurred even though EMS dispatchers routinely instructed 9-1-1 callers to send a family member or other bystander to assist emergency crews in locating the patient. More public awareness of the role escorts serve might lead to greater citizen involvement and shorter total response times.

The importance of EMS response time is most critical in out-of-hospital cardiac arrests, where survival is dependent on rapid delivery of cardiopulmonary resuscitation and defibrillation.¹²⁻¹⁵ For out-of-hospital cardiac arrests, mortality substantially increases for each minute delay in initiating resuscitation, with the lowest chances of survival found when response intervals go beyond several minutes after collapse.¹³ In another study, cardiac arrest survival was more closely related to the vertical response time than the standard call-assigned to on-scene time.¹⁶ The Utstein cardiac arrest reporting guidelines indicate the call receipt to arrival at patient's side interval is essential to quality assurance plans and system evaluation.¹⁷ Although we did not specifically study cardiac arrests, another high-acuity call type, "unconscious," had a much shorter scene-patient interval when at street level compared with the same call type from a multistory building (0.41 vs. 3.01 minutes). Knowing that it takes substantially longer to reach a patient in an apartment building than a public location may help to explain the poor survival reported in large urban areas such as NYC and Chicago.^{18,19} The same concerns extend to patients with other conditions, including life-threatening asthma, pulmonary edema, stroke, and overdoses, where delays in EMS arrival could potentially lead to poorer outcome; this needs to be studied.

A major disadvantage of using call assignment to scene as a measure of system performance is the potential for erroneous benchmarking of critical response intervals. Systems might appear to meet a given goal or standard when call assignment to scene intervals are evaluated but frequently fail to meet the same goals when actual call assignment to patient times are determined (Table 3). While the use of spot observers to document the more complete intervals is feasible for research purposes, continuous monitoring of these time intervals within a given EMS system would be more useful for guiding strategic resource deployment. Successful crew reporting of scene to patient intervals through radio entries to dispatch and thereby to computer-aided dispatch has been reported²⁰ and can be attempted through system mandates. The use of wireless electronic handheld data collection technology that is linked to computer-aided dispatch is another reporting option that needs to be explored.

LIMITATIONS

Because paramedics were aware of the study purpose, response times might have been influenced by the presence of observers; this bias could extend in either direction. In addition, some barriers to patient access may have been removed when paramedics were not the first on-scene responders, for example, location of patient pinpointed or elevator secured. This suggests that our

results may underestimate the vertical response times relative to first responder only times.

Our data do not necessarily reflect all EMS call types. We studied the highest-level system emergencies that trigger a rapid paramedic response, which include call types such as stroke, acute chest pain, and loss of consciousness. Still, the knowledge that a patient is reported in cardiac arrest as opposed to reported as "unconscious" may potentially influence response time; there were too few cardiac arrests in our study to determine this. In addition, our sampling methods do not ensure a representative sample of calls in NYC.

Finally, there may have been additional barriers to reaching patients in multistory buildings that we did not capture because of our study design. We captured certain predictable barriers such as locked doors and elevator delays but did not detail the layout and footprints of buildings and building complexes; these can vary considerably and influence rescuer access. A more detailed study would be needed to better define the long scene to patient delays that we found in multistory buildings.

CONCLUSIONS

The vertical response time interval accounts for a substantial portion of the overall EMS response time in a large metropolitan area, particularly for those patients located in multistory buildings. Compared with call assignment to scene intervals, the interval from call assignment to arrival at the patient's side provides a more meaningful representation of EMS response, because it measures the actual time it takes for medical rescue units to reach a patient.

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