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Emergency Department Closures And Openings: Spillover Effects On Patient Outcomes In Bystander Hospitals

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Emergency departments (EDs) serve as both the first and last resort for patients with acute illness in the health care system, as well as safety-net providers for the uninsured and underinsured.[1,2] ED closures have been on the rise in the United States[3,4] as well as other countries.[5–8] Such closures occur more often in low-income and high-minority areas[9] and can have devastating effects on communities, including decreased likelihood of lifesaving treatment and increased mortality.[10,11] When an ED closes in a community, the next available ED (henceforth, the "bystander ED") becomes the main source of emergency care, and the influx of new patients can contribute to or exacerbate crowding at the bystander ED. Both the anecdotal and academic literature have documented how ED closures and crowding have been associated with poorer outcomes for all patients and for those with time-sensitive illnesses such as acute myocardial infarction (AMI) or unintentional injuries.[12–17]

However, few studies have investigated whether or not ED closures affect all bystander EDs similarly, and even fewer have examined how ED openings affect bystander EDs. We examined whether or not patient outcomes improved at high-occupancy and non-high-occupancy bystander hospitals if an ED opened or closed nearby.

We used nationwide data for the period 2001–13 to develop a conceptual framework that explored the mechanisms by which ED closures and openings can affect patient care at bystander EDs (also known as "bystander hospitals"), and we empirically examined changes in patient outcomes and treatment received at bystander EDs when they were exposed to ED closures or openings nearby. We focused on treatment and patient outcomes for patients with AMI, as the condition typically requires immediate medical attention and would be sensitive to ED availability. Furthermore, we stratified our analysis using baseline hospital occupancy rates to explore potential differential consequences at high-occupancy and non-high-occupancy bystander hospitals when exposed to nearby ED closures and openings. Our study provides critical evidence about whether or not efforts to preserve or enhance access to emergency services should be targeted to certain areas more than others.

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Study Data And Methods

Conceptual Model

When an ED near another currently operating ED (that is, the bystander ED) closes, the bystander ED will gain some patients who would have otherwise received treatment at the closed ED. Similarly, when an ED opens, a bystander ED may lose patients to the newly opened ED.

Online appendix exhibit A1 illustrates three potential mechanisms by which nearby ED closures or openings could affect patient outcomes at bystander EDs.[18] First, ED closures or openings could change the patient volume in the bystander ED, with varying consequences depending on the bystander ED's current patient burden. For a hospital operating under capacity, increased volume might not affect patients negatively and could actually improve patient outcomes, given the well-documented volume-outcome relationship according to which higher volume allows providers to practice their skills more and is associated with better outcomes.[19] If a hospital is operating near capacity, however, increased volume could be harmful due to resource constraints (for example, a fixed number of nurses to administer treatments or competing demands on diagnostic equipment).

Second, ED openings and closures could change the time patients need to travel for care. In particular, patients living near EDs that closed must travel farther to the next closest operating bystander hospital, which could delay treatment and lead to greater severity of illness. Both effects might contribute to detrimental outcomes. Conversely, patients living near EDs that opened could choose to go to the newly opened ED and decrease their travel time, potentially improving their outcomes.

Finally, ED closures and openings could change the underlying health distribution of patients who seek care at the bystander ED. Depending on how the overall health distribution of the affected patients differs from that of the bystander ED's existing patient base, ED closures or openings could result in better or worse observed outcomes.

Hospital Sample And Data

Our hospital universe included all EDs operating in the US in the period 2001–13. We identified ED openings and closures—as well as hospital ownership, inpatient occupancy rate, number of beds, and availability of cardiac care technology (cardiac care units, catheterization laboratories, and coronary artery bypass graft capabilities)—using annual surveys from the American Hospital Association. We obtained additional hospital information, such as the number of patient discharges (total and by payer) and teaching status, from the Healthcare Cost Report Information System.

Patient Sample And Data

We extracted the following relevant patient information from the 100 percent Medicare Provider Analysis and Review and Master Beneficiary Summary Files for the period January 2001–December 2013: the admitting hospital's identifier, date of admission, relevant diagnosis, comorbid and procedural information, patient demographic characteristics, and

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location (ZIP code). Following prior work,[20] we included a patient in our sample if the principal diagnosis had the *International Classification of Diseases*, Ninth Revision (ICD-9), codes 410.x0 or 410.x1; the patient had not suffered from AMI in the previous twelve months; and the admitting hospital was within a hundred miles of the patient's mailing ZIP code. In our analysis of thirty-day readmissions, we excluded patients who could not be readmitted for reasons such as having died during the initial hospital visit, according to the Centers for Medicare and Medicaid Services guidelines.[21]

Hospital Measures

To minimize year-to-year fluctuations due to reporting errors in ED openings and closures, we followed previously established imputation rules[10,22,23] to identify EDs in operation for a given year. Using a hospital's physical address or the longitude and latitude of its heliport,[24] we identified actual driving time between pairs of EDs using automated codes based on Google Map queries.[25]

We identified an operating ED as having been exposed to a nearby ED closure if the driving time from the bystander hospital to its closest neighbor ED increased compared to that in the previous year. Thus, we used increased driving time as a proxy for the disappearance (that is, the closure) of an ED that used to be the closest one. Likewise, we considered a bystander ED as having been exposed to a nearby ED opening if the driving time between the bystander ED and the next closest one decreased. Importantly, the innovative aspect of this study is the measurement of distance between two hospitals, rather than between patient and hospital, which has previously been used. We classified each hospital into one of seven categories: no change in driving time from the bystander hospital to the next closest ED (the reference group); increased driving time from the bystander hospital to the closest ED (due to closure of the previously closest ED) by <10 minutes, 10–<30 minutes, or 30 or more minutes; and decreased driving time (due to opening of a nearby ED) of the same increments. Using changes in driving time to identify ED openings and closures also allowed us to capture ED closures and openings near bystander EDs in rural communities that would otherwise not have been captured under alternative approaches (for example, under a fixed-radius approach, a rural ED might not have a hospital within the fixed radius).

To determine whether or not a hospital operated near capacity, we used annual occupancy rate (total inpatient days divided by available hospital beds) from the Healthcare Cost Report Information System as a proxy. We classified a hospital as "high-occupancy" if it had an annual occupancy rate of 0.65 or higher at baseline (that is, in 2001 or the first year that the ED opened, if it opened after 2001). This cutoff is based on an empirical distribution of the baseline occupancy rate—the upper quartile. Because high-occupancy hospitals tend to be larger than non-high-occupancy hospitals (henceforth known as "other hospitals"), they treated 60 percent of the AMI patients in our sample.

Outcome Measures

Our primary outcomes of interest were thirty-day, ninety-day, and one-year mortality rates, as well as thirty-day all-cause readmissions rates. We also examined treatment received—

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specifically, the receipt of fibrinolytic therapy or percutaneous coronary intervention (PCI)—since treatment can also be affected by delayed care or constrained hospital resources.

Statistical Analysis

We estimated all multivariable models separately for high-occupancy and other hospitals, as patient experiences may differ between hospitals operating below and those operating near capacity. The seven categories of driving time changes described above served as our key independent variables. Because all health and treatment outcomes were binary, we used a linear probability model with ED fixed effects. We chose the hospital fixed-effects model over other panel-data models (for example, random-effects models or hierarchical models) because the fixed-effects model took into account correlations among patients within each hospital and, importantly, unobserved heterogeneity across hospitals—such as in terms of culture or managerial styles. This approach is similar to the case-control method in which the ED serves as its own control.

In our first model (model A), we aimed to investigate the overall effects of exposure to nearby ED closures and openings (net of all underlying mechanisms) on a bystander hospital. In addition to the seven indicators that captured various degrees of exposure to nearby ED closures or openings, model A included hospital characteristics (such as ownership; teaching status; case-mix index; total hospital beds; system membership status; Herfindahl-Hirschman Index, which captures the competitiveness of the hospital market; and availability of cardiac care technology), year dummies to capture macro trends in outcomes over the study period, and patient demographic characteristics (such as sex and race) as control variables. In our second model (model B), we augmented model A by adding age and twenty-two Elixhauser patient comorbid indicators to control for underlying patient health factors. In our third model (model C), we augmented model B by adding treatment received variables. We used the comparison between models A and B to explore the extent to which the observed changes in patient outcomes at the exposed bystander ED might be due to differences in the underlying patient comorbidity distribution, and we used the comparison between models B and C to investigate the impact due to differences in treatment received. To further explore how processes of care in the bystander ED might be affected by exposure to an ED opening or closure, we examined treatment outcomes using model B.

We performed all analyses using Stata software, release 14. We obtained approval for this study through the University of California San Francisco Institutional Review Board.

Limitations

Our study had several limitations. First, our occupancy rate used licensed beds as the denominator, which is often a significant overestimation of the actual number of staffed beds[26,27] and thus suggests that our findings were conservative. While the absolute level of what is considered at or under capacity may change based on the denominator, the magnitude of our findings should not—since a change in the denominator would be applied equally to all quartiles of our hospital capacity measure.

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Second, our driving time computations were based on Google Maps queries and therefore subject to traffic and road conditions at the time of the queries, which might not be consistent across all times of patient admissions in our sample. However, we expect the measurement error to likely bias our estimates toward zero.

Third, we could not identify patients who might have switched EDs in the event of an ED opening or closure nearby and therefore be unaffected. Therefore, our estimates are likely to be more conservative than the true effect, because our sample included patients whose travel time would not be affected. However, we would expect the change in patient burden and resources to affect care for all admitted patients.

Fourth, we did not have information on prehospital care. However, though the quality of that care might vary across communities, such variation would not affect our estimates since our key identification of the estimated effects of ED closure and openings on patients in bystander hospital was from comparing within-ED changes in patient care before and after exposure to ED opening or closure events. However, it is possible that paramedic coverage and therefore response time could change for reasons similar to those for why EDs closed or opened, which could have affected our results.

Study Results

Our study included 1,143,745 patients across 3,720 hospitals, 1,209 of which were high-occupancy hospitals (exhibit 1). The net number of operating EDs decreased from 4,285 in 2001 to 3,881 in 2013 (exhibit 2), representing an annual average decline of 30 EDs. However, the net trend masked the underlying opening and closure activities that happened all over the United States. In the period 2001–13, 898 EDs closed, representing an annual average of 69 closures, while 494 EDs opened, representing an annual average of 38 openings.

Overall, admitted patients at high-occupancy and other bystander hospitals had similar mean travel times (eighteen minutes), with a similar percentage of patients experiencing changes in driving time to the nearest ED (exhibit 1). At high-occupancy bystander hospitals, a larger percentage of patients received catheterization (51 percent versus 35 percent), relative to patients at other bystander hospitals (exhibit 1). A greater percentage of high-occupancy bystander hospitals had cardiac care units (77 percent versus 50 percent), catheterization laboratories (92 percent versus 68 percent), and coronary artery bypass graft capacity (71 percent versus 40 percent), compared to other bystander hospitals (exhibit 1).

Among high-occupancy hospitals, ED closures that led to increased driving times of thirty minutes or more between a high-occupancy bystander hospital and the next closest ED were associated with a 1.33-percentage-point increase (95% confidence interval: 0.50, 2.15), a 1.77-percentage-point increase (95% CI: 0.90, 2.65), and a 3.23 percentage-point (95% CI: 1.80, 4.65) increase in the likelihoods of thirty-day, ninety-day, and one-year mortality rates, respectively, and an increase in the thirty-day readmission rates of 1.52 percentage points (95% CI: 0.33, 2.71) (exhibit 3, which shows the results of model A).

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On the other hand, ED openings that reduced driving time between a high-occupancy bystander hospital and its closest ED by thirty minutes or more were associated with a 3.40-percentage-point (95% CI: −4.75, −2.06), a 3.63-percentage-point (95% CI: −5.18, −2.08), and a 4.42-percentage-point (95% CI: −6.11, −2.73) reductions in thirty-day, ninety-day, and one-year mortality rates, respectively.

Patients in high-occupancy bystander hospitals where the next closest alternative had become an additional thirty or more minutes away had no significant changes in thirty- and ninety-day mortality rates after we controlled for comorbid conditions and age, but they had persistent significant increases of 3.12 (95% CI: 2.18, 4.06) and 1.26 (95% CI: 0.20, 2.32) percentage points in one-year mortality and thirty-day readmission rates, respectively (exhibit 4, which shows the results of model B). On the other hand, ED openings that led to decreases in driving time to the bystander hospital also had smaller improvement in mortality rates after we controlled for patient age and comorbid factors, but the effects remained significant ($p < 0.01$) for all mortality rates. Interestingly, when a non-high-occupancy bystander hospital was exposed to an ED closure that resulted in an increase of thirty minutes or more in driving time, the one-year mortality rate improved by 5.64 percentage points (95% CI: −9.95, −1.33) after we controlled for patient age and comorbidities.

We also controlled for treatment received by patients at high-occupancy hospitals. ED closures that led to increases of thirty minutes or more in driving time to the bystander hospital were not significantly associated with changes in thirty- and ninety-day mortality, but changes in one-year mortality rates and thirty-day readmission rates remained significant (2.39 percentage points [95% CI: 1.46, 3.31] and 2.00 percentage points [95% CI: 0.91, 3.08], respectively) (exhibit 5, which shows the results of model C). The same patients experienced a decrease in the likelihood of receiving PCI by 2.06 percentage points (95% CI: −3.15, −0.97; base rate: 51 percent) and an increase in the likelihood of receiving fibrinolytic therapy by 1.42 percentage points (95% CI: 1.06, 1.77; base rate: 1 percent). In addition, patients at high-occupancy bystander hospitals after ED openings had decreased driving time by thirty minutes or more saw improvements in thirty-day mortality rates, even after we controlled for treatment received (exhibit 5). These same patients saw their probability of receiving PCI improve by 6.21 percentage points (95% CI: 2.41, 10.00) and their probability of receiving fibrinolytic therapy decline by 1.99 percentage points (95% CI: −2.98, −1.00) (exhibit 5).

To provide a more practical interpretation of the coefficient estimates, consider one-year mortality rates from exhibit 5 as an example. The mean rate was 31 percent for high-occupancy bystander hospitals, and therefore a 2.39-percentage-point increase translated to a 7.71 percent (95% CI: 4.71, 10.67) relative increase when an ED closure resulted in increases of thirty or more minutes in driving time to the bystander hospital.

Discussion

Overall, ED openings and closures that led to considerable changes in driving time (those of thirty or more minutes) were associated with significant changes in health outcomes at high-

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occupancy bystander hospitals but not at other bystander hospitals. Specifically, after exposure to ED closures that resulted in considerable increases in driving time to the bystander hospital, compared to patients with AMI whose admission hospital did not experience any closure or opening nearby, those who were admitted to high-occupancy bystander EDs were 4 percent less likely to receive PCI, 6 percent more likely to be readmitted within thirty days, and 8 percent more likely to die within one year. Patients with AMI admitted to non-high-occupancy bystander EDs that experienced a closure of their next closest ED that resulted in at least a thirty-minute increase in driving time were 18 percent less likely to die within one year, compared to patients admitted to hospitals that had not experienced a closure or opening of the next closest ED. On the other hand, after exposure to ED openings that resulted in considerable decreases in driving time to the bystander ED, patients with AMI admitted to high-occupancy bystander EDs had a 12 percent increase in the probability of receiving PCI treatment, as well as a 12 percent improvement in thirty-day mortality rates.

The high sensitivity to ED closures at high-occupancy bystander hospitals is especially concerning, as our data also show that high-occupancy hospitals are disproportionately treating large shares of black patients (35 percent of the hospitals were in the top decile in terms of number of black patients treated, versus 10 percent of other hospitals). The negative effect found in our study can be partially explained by changes in underlying patient comorbidities (comparison of models A and B), where bystander EDs end up receiving sicker patients when there is a closure that results in considerable increases in driving time. The negative effect also appears to be driven by the decreased probability of PCI treatment (from model B to C), which is especially concerning given that PCI has been generally shown to have more favorable outcomes in AMI patients.[28] The reduction in the probability of PCI treatment at high-occupancy bystander hospitals can be due to various factors, such as time delay (with fibrinolytic therapy as an alternative) and resource constraints (not enough resources to provide PCI treatment in a timely manner, even when the hospital is capable of providing it). However, the worsening of one-year mortality rates and thirty-day readmission rates persisted in all model specifications for high-occupancy bystander hospitals. This suggests that even when patients do receive the same treatment, there are significant long-term consequences for patient health when ED closures result in considerable increases in driving time. Our findings suggest that these negative effects may worsen, as recent health care reforms have been associated with changing risks for the survival of EDs: EDs in states that expanded eligibility for Medicaid closed at a higher rate than EDs in nonexpansion states.[3]

On the flip side of ED closures, we found that nearby ED openings may benefit high-occupancy bystander hospitals by relieving their patient burden. Our findings show consistent evidence that ED openings that led to considerable decreases in driving time were associated with reductions in thirty- and ninety-day mortality rates, which suggests that communities with high-occupancy hospitals may benefit at least in the short to medium term from ED openings. The imprecise estimates of changes in one-year mortality rates could reflect uncaptured disparities and require further investigation to more fully determine the benefits of ED openings.

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While previous studies have examined ED closures and their effects,[10,11,29] to our knowledge none has also examined the effects of ED openings and made the distinction between high-occupancy and other bystander hospitals. Our two-tailed approach offers a more complete picture through the examination of various levels of emergency care availability. Importantly, because of our study design, we were able to detect a significantly decreased likelihood of receiving PCI treatment despite controlling for cardiac technology access, which was not detected in a previous study[10] and could point to hospital capacity as an important factor in treatment disparities.

Conclusion

Overall, our findings suggest that high-occupancy hospitals are the most sensitive to nearby ED closures and would benefit from ED openings, while other hospitals may actually absorb extra demand for emergency care after ED closures without significant negative impact on patient outcomes or treatment. Furthermore, significant effects appear only when driving times change by thirty or more minutes, which suggesting that utilization as well as distance from neighboring EDs should be taken into account when deciding to open or close an ED. Our study identifies an inefficient use of resources in the distribution of emergency services and suggests that patient outcomes and care might be improved if utilization and distance between hospitals were carefully considered when allocating or redistributing health care services.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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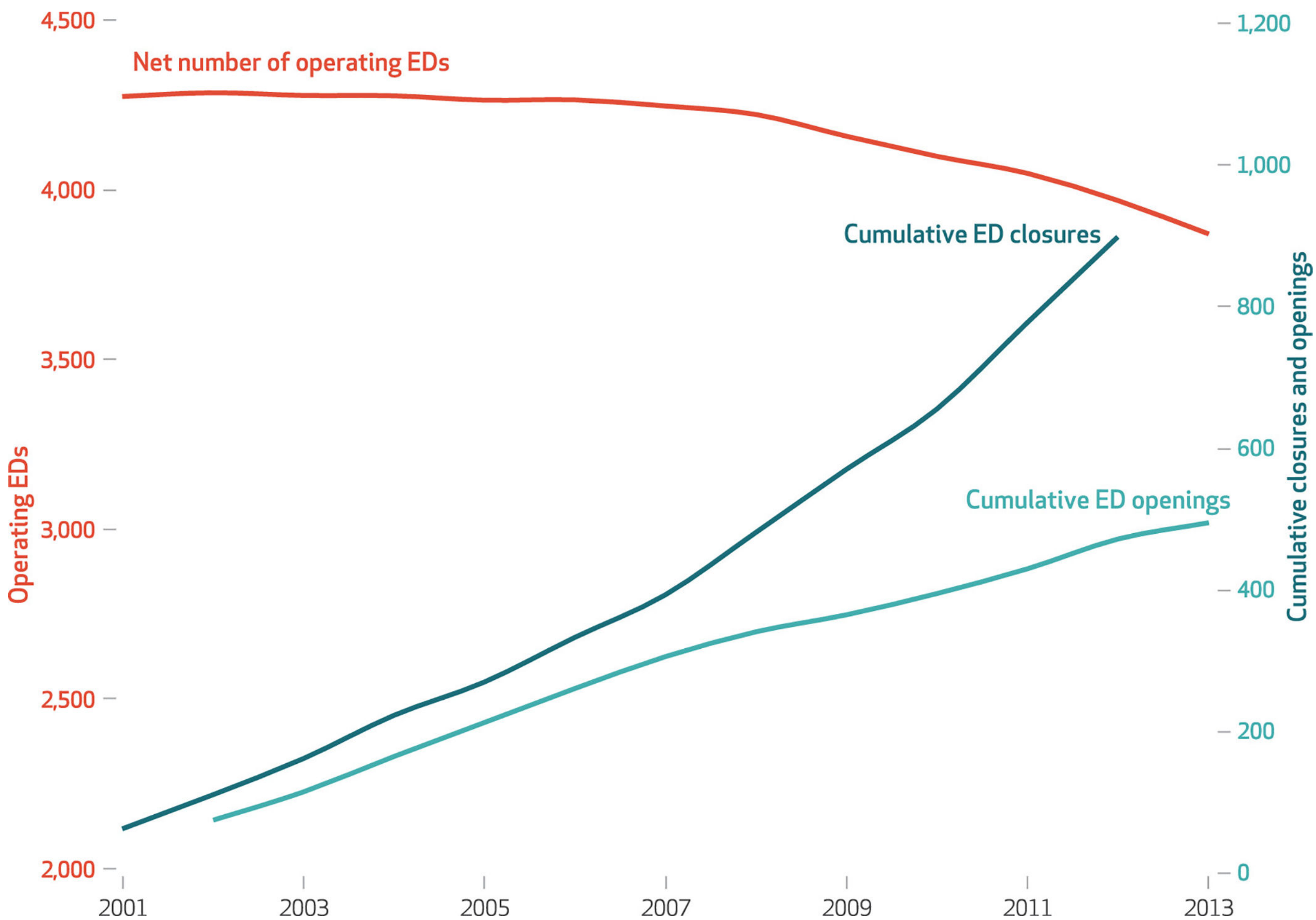

Exhibit 2.

Trends in emergency department (ED) openings and closures and net number of operating EDs in the US, 2001–13

SOURCE Authors' analysis of data for 2001–13 from the American Heart Association and of data for 2001–11 from the Medicare Provider Analysis and Review and Master Beneficiary Summary Files. NOTE The number of operating EDs in any year is equal to the baseline number in 2001, minus the cumulative number of closures and plus the cumulative number of entries in the previous year.

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Exhibit 1:

Hospital and patient characteristics, by hospital high-occupancy status, 2001–13

	Whole sample		High-occupancy hospitals		Other hospitals	
	No.	**% or SD**	**No.**	**% or SD**	**No.**	**% or SD**
Mean driving time of admitted patients (minutes)	17.81	13.38	17.69	13.03	17.96	13.86
Changes in driving time between bystander ED and the next closest ED						
No change	866,405	76%	508,456	76%	357,949	76%
<10 minute increase	101,153	8.8	62,665	9.3	38,488	8.1
10–<30 minute increase	41,482	3.6	20,288	3.0	21,194	4.5
≥30 minute increase	1,205	0.1	565	0.1	640	0.1
<10 minute decrease	99,163	8.7	57,356	8.6	41,807	8.8
10–<30 minute decrease	30,420	2.7	19,062	2.8	11,358	2.4
≥30 minute decrease	3,917	0.3	2,238	0.3	1,679	0.4
Patient outcome						
Treatment received						
Catheterization	508,165	44%	344,014	51%	164,151	35%
Fibrinolytic therapy	17,761	2	8,339	1	9,422	2
Health outcome						
30-day mortality	184,720	16%	102,552	15%	82,168	17%
90-day mortality	253,168	22	141,636	21	111,532	24
1-year mortality	365,587	32	206,064	31	159,523	34
30-day all-cause readmission	305,673	36	185,641	35	120,032	38
Hospital characteristics						
Has cardiac care unit	751,304	66%	515,164	77%	236,140	50%
Has catheterization lab	939,790	82	617,465	92	322,325	68
Has CABG capacity	66,8178	58	479,337	71	188,841	40
Member of a system	733,515	64	459,221	68	274,294	58
For profit	148,488	13	63,220	9	85,268	18
Government owned	124,102	11	58,702	9	65,400	14
Teaching hospital	141,010	12	127,193	19	13,817	3

	Whole sample		High-occupancy hospitals		Other hospitals	
	No.	% or SD	No.	% or SD	No.	% or SD
Mean percent serving large share (top 10 percentile) of black patients	18%	39	35%	48	10%	30
Mean beds	304	441	373	245	207	607
Mean occupancy rate	0.66	0.16	0.76	0.10	0.53	0.12

SOURCE Authors' analysis of data for 2001–13 from the American Heart Association and of data for 2001–11 from the Medicare Provider Analysis and Review and Master Beneficiary Summary Files.

NOTES High-occupancy hospitals are those with annual occupancy rates of at least 0.65 at baseline (in 2001 or in the first year that the emergency department [ED] opened, if it opened after 2001). There were 3,720 hospitals (and 1,143,745 patients) in the whole sample, 1,209 hospitals (and 670,630 patients) in the high-occupancy hospital subsample, and 2,511 hospitals (and 473,115 patients) in the other hospital subsample. A bystander ED is the next available ED to an ED that has closed. Percentages may not sum to 100 due to rounding. Appendix exhibit A2 provides full results (see note 18 in text). SD is standard deviation. CABG is coronary artery bypass graft.

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Exhibit 3:

Overall effect of emergency department (ED) closures and openings on patient health outcomes at bystander EDs, by hospital high-occupancy status, without controlling for age, comorbidities, or treatment received (model A), 2001–13

	High-occupancy hospitals				Other hospitals			
	30-day mortality	**90-day mortality**	**1-year mortality**	**30-day readmission**	**30-day mortality**	**90-day mortality**	**1-year mortality**	**30-day readmission**
Base rate	15%	21%	31%	35%	17%	24%	34%	38%
Percentage-point change during and after the year in driving time to the neighboring ED								
Increased by <10 minutes	0.37	0.53	0.35	−0.40	−0.59	−0.05	−0.61	−0.93
Increased by 10–<30 minutes	−0.82	−0.38	−0.04	−0.36	−0.69	−1.09	−1.60	−0.74
Increased by ≥30 minutes	1.33***	1.77***	3.23***	1.52**	−1.26	−5.12*	−6.63	0.63
Decreased by <10 minutes	0.16	0.52	0.68	0.51	−0.45	−0.03	0.78	−0.89
Decreased by 10–<30 minutes	−0.80	−0.84	−0.88	−1.64	0.08	−0.73	−0.26	−0.57
Decreased by ≥30 minutes	−3.40***	−3.63***	−4.42***	−0.16	2.55	2.60	3.84	−1.10
Number of patients	637,025	637,025	637,025	504,374	449,666	449,666	449,666	302,973

SOURCE Authors’ analysis of data for 2001–13 data from the American Heart Association and of data for 2001–11 from the Medicare Provider Analysis and Review and Master Beneficiary Summary Files. NOTES High-occupancy hospitals are explained in the notes to exhibit 1. The reference group is no change in driving time between the bystander ED (explained in the notes to exhibit 1) and the next closest ED. None of the outcomes was risk-adjusted for age, comorbid conditions, or controlled for treatment received. Appendix exhibit A3 provides complete regression results (see note 18 in text).

* $p < 0.10$

** $p < 0.05$

*** $p < 0.01$

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Exhibit 4:

Effect of emergency department (ED) closures and openings on patient health outcomes at bystander EDs, by high-occupancy status, controlling for patient age and comorbidities but not treatment received (model B), 2001–13

	High-occupancy hospitals				Other hospitals			
	30-day mortality	**90-day mortality**	**1-year mortality**	**30-day readmission**	**30-day mortality**	**90-day mortality**	**1-year mortality**	**30-day readmission**
Base rate	15%	21%	31%	35%	17%	24%	34%	38%
Percentage-point change during and after the year in driving time to the neighboring ED								
Increased by <10 minutes	0.33	0.51	0.37	−0.51	−0.37	0.30	−0.11	−0.78
Increased by 10–<30 minutes	−0.77	−0.40	−0.18	−0.17	−0.57	−0.89	−1.30	−0.52
Increased by ≥30 minutes	0.71	1.34*	3.12***	1.26**	−0.67	−4.37	−5.64**	−0.47
Decreased by <10 minutes	0.04	0.37	0.51	0.35	−0.53	−0.08	0.73	−0.90
Decreased by 10–<30 minutes	−0.51	−0.38	−0.16	−1.42	0.25	−0.53	−0.15	−0.58
Decreased by ≥30 minutes	−2.93***	−2.83***	−3.22***	−0.58	1.87	1.79	2.86	−1.61
Number of patients	637,025	637,025	637,025	504,374	449,666	449,666	449,666	302,973

SOURCE Authors' analysis of data for 2001–13 from the American Heart Association and of data for 2001–11 data from the Medicare Provider Analysis and Review and Master Beneficiary Summary Files. NOTES High-occupancy hospitals are explained in the notes to exhibit 1. The reference group is no change in driving time between the bystander ED (explained in the notes to exhibit 1) and the next closest ED. All of the outcomes were risk-adjusted for age and comorbid conditions, but none of the outcomes was controlled for treatment received.

* $p < 0.10$

** $p < 0.05$

*** $p < 0.01$

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Exhibit 5:

Effect of emergency department (ED) closures and openings on patient health outcomes and treatment received at bystander EDs, by high-occupancy status, controlling for patient age, comorbidities, and treatment received (model C), 2001–13

	High-occupancy hospitals				Other hospitals			
	Treatments received		**Health outcomes**		**Treatments received**		**Health outcomes**	
	PCI	**Fibrinolytic therapy**	**1-year mortality**	**30-day readmission**	**PCI**	**Fibrinolytic therapy**	**1-year mortality**	**30-day readmission**
Base rate	51%	1%	31%	35%	35%	2%	34%	38%
Percentage-point change during and after the year in driving time to the neighboring ED								
Increased by <10 minutes	−0.69 → 0.69	−0.26	0.48	−0.37	−0.24	0.23	−0.17	−0.74
Increased by 10–<30 minutes	2.54	−0.78	0.43	−0.20	2.55	−0.74*	−0.76	−0.22
Increased by ≥30 minutes	−2.06***	1.42***	2.39***	2.00***	−1.58	−3.02**	−6.15**	−0.32
Decreased by <10 minutes	−0.04	0.62***	0.53	0.25	0.67	−0.33	0.87	−0.85
Decreased by 10–<30 minutes	−0.23	0.35	−0.14	−1.19	1.84	−0.06	0.22	−0.24
Decreased by ≥30 minutes	6.21***	−1.99***	−1.41*	−0.97	4.29	−0.49	3.72	−1.03
Controlled for treatment received	—[a]	—[a]	Yes	Yes	—[a]	—[a]	Yes	Yes
Number of patients	637,025	637,025	637,025	504,374	449,666	449,666	449,666	302,973

SOURCE Authors' analysis of data for 2001–13 the American Heart Association and of data for 2001–11 data from the Medicare Provider Analysis and Review and Master Beneficiary Summary Files. NOTES High-occupancy hospitals are explained in the notes to exhibit 1. The reference group is no change in driving time between the bystander ED (explained in the notes to exhibit 1) and the next closest ED. All of the outcomes and treatments were risk-adjusted for age, comorbid conditions, and treatment received. Regression results of all outcomes (including thirty- and ninety-day mortality) are available in appendix exhibit A4 (see note 18 in text). PCI is percutaneous coronary intervention.

[a] [Please provide].

* $p < 0.10$

** $p < 0.05$

*** $p < 0.01$