Emergency Department Hospitalization Volume and Mortality in the United States

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Study objective: Although numerous studies have demonstrated a relationship between higher volume and improved outcomes in the delivery of health services, it has not been extensively explored in the emergency department (ED) setting. Therefore, we seek to examine the association between ED hospitalization volume and mortality for common high-risk conditions.

Methods: Using data from the Nationwide Inpatient Sample, a national sample of hospital discharges, we evaluated mortality overall and for 8 different diagnoses between 2005 and 2009 (total admissions 17.55 million). These conditions were chosen because they are frequent (in the top 25 of all ED hospitalizations) and high risk (>3% observed mortality). EDs were excluded from analysis if they did not have at least 1,000 total annual admissions and 30 disease-specific cases. EDs were then placed into quintiles based on hospitalized volume. Regression techniques were used to describe the relationship between volume (number of hospitalized ED patients per year) and both subsequent early inpatient mortality (within 2 days of admission) and overall mortality, adjusted for patient and hospital characteristics.

Results: Mortality decreased as volume increased overall and for all diagnoses, but the relative importance of volume varied, depending on the condition. Absolute differences in adjusted mortality rates between very high-volume EDs and very low-volume EDs ranged from −5.6% for sepsis (95% confidence interval [CI] −6.5% to −4.7%) to −0.2% for pneumonia (95% CI −0.6% to 0.1%). Overall, this difference was −0.4% (95% CI −0.6% to −0.3%). A similar pattern was observed when early hospital deaths were evaluated.

Conclusion: Patients have a lower likelihood of inhospital death if admitted through high-volume EDs. [Ann Emerg Med. 2014;64:446-457.]

Please see page 447 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Numerous studies have demonstrated a relationship between higher volume and improved outcomes in the delivery of health services.[1] Previous investigations have examined the association between procedure case volume and mortality at the hospital[2-6] and provider level,[7-9] hospital volume and mortality for common medical conditions,[10] and hospital volume and outcomes for high-risk clinical conditions.[11,12] However, with the exception of a few narrow clinical scenarios,[13-15] a comprehensive evaluation of this relationship in the emergency department (ED) setting has remained unexplored.

Importance

The ED is now the gateway for more than half of all patients admitted to the hospital.[16,17] Many of these admissions are for time-sensitive illnesses such as acute myocardial infarction, sepsis, and stroke that require immediate interventions and specialty care to stabilize a patient's clinical condition. In these situations, care delivered effectively and expeditiously has been shown to improve outcomes.[18-22] Therefore, ED-based care likely affects downstream inhospital death. Similar to other health care environments, higher-volume EDs might deliver more effective care than lower-volume centers, contributing to a relationship between ED case volume and subsequent inpatient survival. For example, a strong association between case-specific ED volume and early mortality has been shown in both sepsis and chronic obstructive pulmonary disease.[14,15] Understanding the effect of ED care

Editor's Capsule Summary

What is already known on this topic

For certain medical procedures and conditions, it has been shown that higher-volume facilities achieve better outcomes.

What question this study addressed

What is the association between emergency department (ED) volume and survival for 8 high-acuity conditions such as congestive heart failure and sepsis?

What this study adds to our knowledge

In this administrative database study, higher volume was associated with lower rates of mortality for all conditions except pneumonia. However, data are insufficient to explain whether the effect is due to ED volume or an associated covariate.

How this is relevant to clinical practice

A better understanding of the meaning of these findings is required before they can be used to model better-performing health care systems.

and mortality risk has implications for policymakers determining appropriate quality metrics for emergency care, regional referral network planning for out-of-hospital and transfer care, and patient and family decisionmaking when faced with a medical emergency.

Goals of This Investigation

In this context, we examined inpatient mortality for patients admitted from the ED, using the Nationwide Inpatient Sample, a large national data set of hospital discharges. We placed EDs into quintiles of hospitalized case volume and assessed risk-adjusted inpatient mortality for early and overall death for all admissions and 8 ED conditions for which patients are commonly hospitalized.

MATERIALS AND METHODS

Study Design, and Setting

There are several causal pathways in which ED volume may affect mortality. First, the fundamental basis motivating emergency care research is that "[r]apid diagnosis and early intervention in acute illness or acutely decompensated chronic illness improves patient outcomes."[2,3] It follows, therefore, that the type, manner, appropriateness, and promptness in which ED-based care is delivered for time-sensitive conditions such as sepsis or acute myocardial infarction also likely affects patient outcomes. In particular, early mortality for time-sensitive conditions may be more reflective of care provided in the ED compared with overall hospital mortality.

Second, because larger hospitals with higher-volume EDs have greater available resources such as consultants, advanced diagnostic capabilities, or emergency procedural interventions, they may be able to deliver higher-intensity care that correlates with lower mortality rates for certain diagnoses compared with smaller hospitals with lower ED volumes. Conversely, there also may be reasons to postulate that lower-volume centers may demonstrate mortality improvements because these tend to be smaller hospitals with, on average, shorter ED wait times, less boarding, and fewer episodes of ED crowding,[24] which may also affect patient mortality.[25,26]

Third, higher-volume EDs likely have a greater exposure to time-sensitive conditions, which may lead to the development of departmental or institutional policies, treatment plans, and streamlined processes that ultimately improve the quality of care for these higher-risk patients.

To investigate the relationship between ED admission volume and hospital mortality, we performed a retrospective analysis of the Nationwide Inpatient Sample, combining 2005 through 2009. The Nationwide Inpatient Sample is administered by the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project and is the largest all-payer inpatient database in the United States. It contains information on approximately 8 million hospitalizations each year. A detailed description of the data collection, abstraction, and cleaning procedures is available from Agency for Healthcare Research and Quality.[27] Additional information about the study methodology can be found in Appendix E1, available online at http://www.annemergmed.com.

Selection of Participants

All patients in the data set who were hospitalized through the ED were initially considered for analysis. The Nationwide Inpatient Sample does not include observation admissions; therefore, these were not included. Figure 1 shows a flow diagram of how the study samples were constructed with 17,554,356 cases contained in the overall analysis. Patients who were transferred from a referral hospital or those who were admitted through the ED and subsequently transferred were excluded from analysis because outcomes could not solely be attributed to care delivered at the index institution. These cases represented a small proportion of ED admissions overall (2.5%). A sensitivity analysis was performed with these patients in the modeling, assigning the cases the average mortality rate for their hospital, and it did not significantly alter the results.

Each year of the Nationwide Inpatient Sample contains an average of 1,050 hospitals, with a total of 5,249 hospitals in the 5-year sample. Hospitals were excluded from the study if overall ED admission volume was fewer than 1,000 patients or fewer than 30 condition-specific admissions because we believed this would not be an adequate representation of care delivered for these patients. For purposes of the analysis, we then sorted hospital ED admission case volume into quintiles, using 2

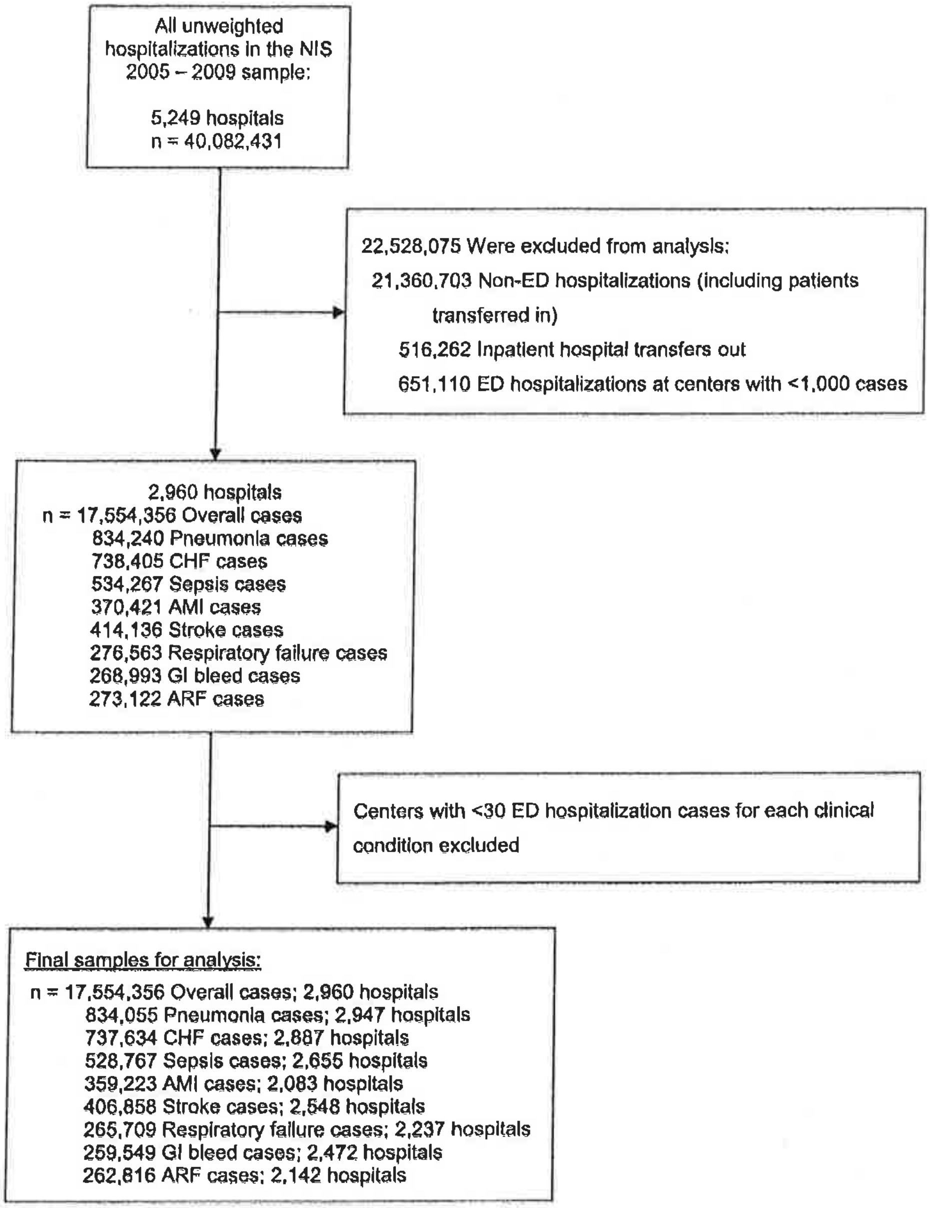

Figure 1. Flow diagram showing derivation of study sample. *NIS*, Nationwide Inpatient Sample; *ED*, emergency department; *n*, number; *CHF*, congestive heart failure; *AMI*, acute myocardial infarction; *GI*, gastrointestinal; *ARF*, acute and unspecified renal failure.

different approaches: based on equal numbers of patients (and varying numbers of hospitals) within each quintile, and based on equal numbers of hospitals (and varying numbers of patients) within each quintile.

Clinical conditions were categorized by using the principal discharge diagnosis associated with the hospitalization and grouped according to Clinical Classifications Software. The software was developed by the Agency for Healthcare Research and Quality to group conditions into clinically meaningful categories based on *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes.[28] References for those *ICD-9* codes corresponding to Clinical Classifications Software categories can be found on the Healthcare Cost and Utilization Project Web site.[29] The 8 clinical conditions chosen for analysis were based on the frequency (all in the top 25 of conditions admitted through the ED) and high-risk nature of the illness (greater than 3% risk of inpatient mortality) (Table E1, available online at http://www.annemergmed.com). They included pneumonia (Clinical Classifications Software category 122), congestive heart failure (category 108), sepsis (category 2), acute myocardial infarction (category 100), acute cerebrovascular disease (stroke) (category 109), respiratory failure (category 131), gastrointestinal hemorrhage (gastrointestinal bleeding) (category 153), and acute and unspecified renal failure (category 157).

To determine ED admission case volume, we created a hospital-level variable that represented the total number of patients within each hospital who had been admitted through the ED. Observations were then ranked by their hospital's case volume (all-cause ED case volume for the overall mortality analysis and condition-specific ED case volumes to assess mortality for each of the 8 clinical conditions studied). For ease of interpretation, observations were placed into quintiles according to their associated hospital's ED case volume rank: very low, low, medium, high, and very high. Quintiles were defined by whole-number cutoff points for ED volume that most closely sorted observations into 5 groups of equal sizes. Although ED case volume is a hospital-level variable and therefore all observations within a given hospital will have the same associated ED volume, we first chose to define quintiles at the patient level to ensure an adequate sample size in each quintile to better test the association between ED volume and mortality. This method has previously been used to assess the relationship between volume and mortality in other health care settings.[2,3,5,7,12,14,30,31]

An alternative methodological approach is to sort at the hospital level according to the facility volume and then divide into quintiles. However, for some conditions with low ED case volumes, this would have resulted in very small patient sample sizes in the lower quintiles, potentially biasing any associations that may have been found toward the higher quintiles. Nevertheless, this alternative approach has also been used in the literature studying volume-outcome relationships in health care.[4,11,15] We therefore performed an additional sensitivity analysis, constructing our quintiles by sorting on hospitals in this fashion. These results are found in Appendix E1, available online at http://www.annemergmed.com. We also checked the assumption that there is a constant inverse relationship between volume and mortality by treating ED case volume as a continuous variable (after logarithmic transformation because of its skewed distribution). These results are reported in the text.

The Nationwide Inpatient Sample includes information on patient demographics, visit characteristics, and hospital factors. Patient demographics that were included in our regression models were age (considered as a categorical variable in 6 groupings), sex, race (white, black, Hispanic, or other), insurance status (categories collapsed to uninsured [self-pay or no charge], Medicaid, Medicare, private, or other insurance), and median household income of patient's zip code by national quartiles. Because there may be differences in mortality related to day of admission (weekday or weekend)[32] or year of admission (considered as a categorical variable, with 2005 as the reference category), these were also included in the modeling. Acuity of presenting illness and underlying comorbidities were accounted for with the All-Patient Refined Diagnosis Related Groups version 20.0 risk of mortality and severity of illness classification[33] and 29 Elixhauser comorbidities,[34] which are all provided by the Nationwide Inpatient Sample data set. Hospital factors included location (urban or rural), hospital region (Northeast, Midwest, South, or West), hospital bed size (small, medium, or large), and hospital type (teaching or nonteaching), which are also all provided by and defined by the Nationwide Inpatient Sample. Further detail about these variables can be found on the Healthcare Cost and Utilization Project Web site[35] and also in Appendix E1, available online at http://www.annemergmed.com.

Outcome Measures

The primary outcome for this study was inhospital death (eg, whether a patient admitted from the ED died during his or her hospital stay). Mortality was further stratified into early death within 2 days of admission and death at any time during the hospitalization. We hypothesized that early death was more likely to be directly attributable to care delivered during the initial presentation to the ED.

Primary Data Analysis

Descriptive statistics of patient and hospital characteristics were generated by quintile of ED case volume and diagnosis. Mixed-effects hierarchic logistic regression was used to evaluate the relationship between ED volume and inhospital mortality to account for clustering within hospitals. We regressed the dichotomous outcome of died inhospital (yes/no) by the categorical variable quintile of ED volume for all admissions and each clinical condition. Early and overall inpatient mortality was investigated in separate modeling. Odds ratios and predicted mortality rates are reported for each quintile of ED case volume. Although the Nationwide Inpatient Sample provides a means to calculate national estimates based on sampling weights, we did not use this function in our study design because we excluded some low-volume hospitals from analysis. Effectively, our study was an analysis of a very large convenience sample of US hospitals, which the Nationwide Inpatient Sample is also frequently used for in the literature.

Variables were selected as covariates in the models according to their a priori hypothesized influence on patient inhospital mortality. *C* statistics for these models were determined to evaluate their potential explanatory power and included 0.924 (95% confidence interval [CI] 0.924 to 0.924) for overall inpatient mortality and 0.901 (95% CI 0.900 to 0.902) for early mortality.

Defining an appropriate cutoff for an adequate ED case volume was arbitrary. Therefore, we performed a sensitivity analysis, using a threshold of 500 ED admissions and 10 clinical cases per ED. The approach to constructing the models was otherwise unchanged. Details of these results are available in Appendix E1, available online at http://www.annemergmed.com.

Data management and analysis were performed with Stata software (version 12.1 MP; StataCorp, College Station, TX). The institutional review board of the University of Michigan evaluated this study and classified it under not-regulated status.

RESULTS

Characteristics of Study Subjects

Our study sample included information on 17,554,356 discharges from 2,960 hospitals. In general, higher-volume

Table 1. Characteristics of hospitals according to ED case volume.*

Characteristic	ED Case Volume Quintile, Percentage of Hospitals				
	Very Low	Low	Medium	High	Very High
Overall, n	1,464	625	412	294	165
Avg ED cases/y	1,000–4,382	4,383–7,086	7,087–10,190	10,191–14,535	>14,535
Teaching	9.0	34.6	43.1	59.8	78.2
Large (bed size)	34.2	47.4	70.1	76.6	93.9
Urban	58.0	88.9	96.4	99.0	100.0
Pneumonia, n	1,252	667	471	350	207
Avg ED cases/y	30–201	202–302	303–410	411–575	>575
Teaching	11.5	31.2	41.4	44.0	60.4
Large (bed size)	33.5	46.2	61.4	74.7	90.8
Urban	58.9	83.3	89.8	93.7	98.1
CHF, n	1,399	606	414	295	173
Avg ED cases/y	30–190	191–299	300–419	420–613	>613
Teaching	11.7	31.7	43.0	49.3	65.7
Large (bed size)	35.5	50.1	65.3	75.6	91.3
Urban	59.4	85.1	94.4	97.8	99.4
Sepsis, n	1,330	563	367	251	144
Avg ED cases/y	30–141	142–240	241–346	347–524	>524
Teaching	18.4	36.1	37.8	47.8	58.3
Large (bed size)	38.2	58.4	67.4	71.9	82.6
Urban	66.9	87.4	91.2	97.6	97.9
AMI, n	1,043	426	288	206	120
Avg ED cases/y	30–129	130–209	210–298	299–430	>430
Teaching	22.3	44.9	47.4	50.2	60.0
Large (bed size)	41.9	58.6	70.5	85.4	92.5
Urban	78.4	92.0	95.8	96.1	100.0
Stroke, n	1,262	536	357	253	140
Avg ED cases/y	30–115	116–190	191–270	271–406	>406
Teaching	13.0	34.8	48.0	59.5	69.8
Large (bed size)	39.3	51.7	72.2	79.8	97.1
Urban	63.9	89.7	96.1	98.8	100.0
Respiratory failure, n	1,016	515	354	224	128
Avg ED cases/y	30–80	81–127	128–189	190–290	>290
Teaching	24.1	35.9	41.1	46.0	44.5
Large (bed size)	39.3	57.4	70.0	75.2	88.3
Urban	77.0	88.3	89.5	92.8	96.9
GI bleeding, n	1,056	567	392	284	173
Avg ED cases/y	30–74	75–114	115–152	153–219	>219
Teaching	14.1	35.5	44.6	47.3	65.3
Large (bed size)	39.1	48.9	69.4	76.2	93.1
Urban	64.4	89.0	93.9	99.6	100.0
ARF, n	969	484	331	227	131
Avg ED cases/y	30–85	86–135	136–187	188–287	>287
Teaching	21.7	35.9	43.5	52.9	68.7
Large (bed size)	40.1	53.7	66.5	80.0	90.8
Urban	79.0	90.0	94.9	97.3	99.2

Avg, Average; *y*, year.
*All differences are statistically significant at $P<.001$ because of the large database.

hospitals tended to be predominantly teaching institutions, larger, and located in urban areas regardless of the clinical condition (Table 1). However, depending on the clinical condition, there were important differences between low- and high-volume centers across patient characteristics (Table 2). Lower-volume centers tended to care for an older patient population, whereas higher-volume centers cared for a higher proportion of black and Medicaid patients. These disparities may reflect local and regional differences in the organization and delivery of health care, including the influence of out-of-hospital referral patterns. They may also reflect the underlying distribution of US urban and rural populations. There were some differences between centers related to the proportion of patients with multiple comorbidities; however, there was no consistent pattern found across all clinical conditions.

When assessed as a continuous variable, ED volume was related to adjusted hospital mortality overall and for all 8 clinical conditions ($P<.001$) except pneumonia. When stratified by

Table 2. Characteristics of patients according to ED case volume.*

Characteristic	ED Case Volume Quintile, Percentage of Patients				
	Very Low	Low	Medium	High	Very High
Overall, n	3,514,357	3,513,077	3,518,655	3,503,850	3,504,417
Age ≥65 y	49.6	46.9	45.6	42.6	38.0
Female sex	55.7	54.6	53.9	53.6	53.2
Black race	7.7	10.5	11.4	15.7	16.9
Medicaid	13.0	13.6	13.4	15.5	19.0
Comorbidities ≥2	63.2	62.8	63.6	61.5	57.3
Pneumonia, n	168,629	166,131	165,776	166,955	166,564
Age ≥65 y	60.6	58.1	57.2	56.0	53.6
Female sex	52.0	52.0	52.3	51.6	51.4
Black race	7.0	10.0	9.7	10.4	11.9
Medicaid	12.3	13.0	14.3	14.1	15.1
Comorbidities ≥2	77.0	77.0	76.5	75.1	73.3
CHF, n	148,588	147,137	147,405	147,088	147,416
Age ≥65 y	77.7	73.8	73.3	71.4	71.3
Female sex	54.4	52.4	52.2	51.4	50.5
Black race	9.1	13.0	13.5	18.5	20.8
Medicaid	6.5	7.9	8.3	8.6	8.9
Comorbidities ≥2	82.0	83.2	83.2	83.5	83.6
Sepsis, n	106,103	105,665	105,915	105,455	105,629
Age ≥65 y	66.0	64.8	65.2	66.5	64.7
Female sex	53.5	53.0	53.1	53.2	53.6
Black race	8.2	10.9	11.7	13.4	12.5
Medicaid	9.4	10.1	9.5	9.5	9.2
Comorbidities ≥2	83.2	85.6	86.3	86.8	86.7
AMI, n	73,002	71,522	71,171	72,878	70,650
Age ≥65 y	68.5	58.0	55.0	56.3	57.1
Female sex	47.3	40.9	39.0	39.4	39.4
Black race	7.8	8.9	7.6	6.5	7.3
Medicaid	5.3	5.9	5.5	4.8	5.6
Comorbidities ≥2	70.8	65.6	63.6	64.5	65.6
Stroke, n	81,846	81,077	81,248	82,372	80,315
Age ≥65 y	73.1	69.6	67.6	64.6	63.0
Female sex	55.2	53.6	52.8	52.2	51.1
Black race	8.8	11.3	12.8	13.2	16.3
Medicaid	5.6	6.9	7.0	7.0	7.9
Comorbidities ≥2	72.1	72.9	72.3	72.1	71.2
Respiratory failure, n	53,810	52,815	54,646	51,629	52,809
Age ≥65 y	59.6	58.1	60.2	59.6	59.5
Female sex	54.6	53.6	54.3	54.7	55.0
Black race	9.9	11.8	9.6	12.5	11.2
Medicaid	11.6	12.9	11.3	11.3	10.6
Comorbidities ≥2	91.0	90.9	91.5	92.3	91.3
GI bleeding, n	52,009	52,803	51,739	51,302	51,696
Age ≥65 y	61.6	60.1	58.9	59.4	59.4
Female sex	49.1	49.0	48.2	48.6	48.4
Black race	7.8	10.0	12.6	10.7	12.5
Medicaid	7.6	8.2	8.3	8.3	8.3
Comorbidities ≥2	78.0	78.6	79.6	78.9	78.0
ARF, n	53,089	52,423	52,607	52,379	52,318
Age ≥65 y	68.5	66.7	68.0	65.8	66.3
Female sex	50.4	49.8	49.4	49.7	49.0
Black race	11.9	12.7	14.9	16.7	17.8
Medicaid	8.9	8.5	7.4	8.4	9.0
Comorbidities ≥2	91.0	90.7	91.6	91.3	90.5

Comorbidities, Elixhauser comorbidities.
*All differences are statistically significant at $P<.001$ because of the large database.

Table 3. Hospital mortality rates and their association with ED case volume.*

Diagnosis	ED Case Volume Quintile (95% CI)				
	Very Low	Low	Medium	High	Very High
Overall					
Overall mortality rate, %	3.1 (3.1–3.2)	3.1 (3.1–3.1)	3.2 (3.1–3.2)	2.9 (2.9–2.9)	2.7 (2.7–2.7)
Unadjusted OR	Ref	0.99 (0.97–1.01)	1.01 (0.99–1.02)	0.92 (0.90–0.94)	0.85 (0.83–0.87)
Adjusted OR*	Ref	0.92 (0.89–0.95)	0.87 (0.84–0.91)	0.82 (0.78–0.86)	0.83 (0.79–0.88)
Early mortality rate, %	1.2 (1.2–1.2)	1.1 (1.1–1.1)	1.1 (1.1–1.1)	1.0 (1.0–1.0)	0.9 (0.8–0.9)
Unadjusted OR	Ref	0.92 (0.89–0.95)	0.89 (0.85–0.92)	0.81 (0.78–0.84)	0.77 (0.73–0.81)
Adjusted OR*	Ref	0.90 (0.87–0.94)	0.90 (0.86–0.94)	0.84 (0.80–0.89)	0.87 (0.82–0.93)
Pneumonia					
Overall mortality rate, %	3.9 (3.8–4.0)	4.0 (3.9–4.1)	3.9 (3.8–4.0)	3.6 (3.5–3.6)	3.6 (3.5–3.7)
Unadjusted OR	Ref	1.04 (0.99–1.10)	1.01 (0.95–1.07)	0.94 (0.88–1.00)	0.98 (0.91–1.06)
Adjusted OR*	Ref	1.03 (0.96–1.10)	0.98 (0.91–1.06)	0.91 (0.83–0.99)	0.93 (0.83–1.03)
Early mortality rate, %	1.1 (1.1–1.2)	1.0 (1.0–1.1)	1.0 (0.9–1.0)	0.9 (0.8–0.9)	0.8 (0.8–0.9)
Unadjusted OR	Ref	0.93 (0.86–1.00)	0.87 (0.80–0.95)	0.79 (0.72–0.87)	0.76 (0.68–0.84)
Adjusted OR*	Ref	1.02 (0.93–1.13)	0.98 (0.88–1.10)	0.91 (0.81–1.03)	0.89 (0.77–1.02)
CHF					
Overall mortality rate, %	3.8 (3.7–3.9)	3.5 (3.4–3.6)	3.3 (3.3–3.4)	3.2 (3.1–3.3)	3.1 (3.1–3.2)
Unadjusted OR	Ref	0.91 (0.87–0.96)	0.88 (0.83–0.93)	0.84 (0.79–0.89)	0.85 (0.79–0.92)
Adjusted OR*	Ref	0.86 (0.80–0.92)	0.81 (0.74–0.88)	0.79 (0.72–0.87)	0.76 (0.68–0.86)
Early mortality rate, %	1.3 (1.2–1.3)	1.0 (1.0–1.1)	0.9 (0.9–1.0)	0.8 (0.8–0.9)	0.7 (0.7–0.8)
Unadjusted OR	Ref	0.78 (0.72–0.85)	0.73 (0.67–0.79)	0.63 (0.57–0.69)	0.59 (0.53–0.65)
Adjusted OR*	Ref	0.85 (0.77–0.94)	0.81 (0.73–0.91)	0.74 (0.65–0.84)	0.71 (0.61–0.82)
Sepsis					
Overall mortality rate, %	18.0 (17.8–18.2)	18.9 (18.6–19.1)	18.6 (18.4–18.9)	17.7 (17.4–17.9)	15.8 (15.6–16.0)
Unadjusted OR	Ref	1.02 (0.98–1.05)	0.98 (0.94–1.02)	0.89 (0.85–0.93)	0.74 (0.70–0.78)
Adjusted OR*	Ref	0.83 (0.79–0.87)	0.80 (0.76–0.85)	0.74 (0.69–0.78)	0.62 (0.58–0.67)
Early mortality rate, %	7.8 (7.6–8.0)	7.7 (7.5–7.9)	7.2 (7.0–7.3)	6.8 (6.6–6.9)	6.0 (5.8–6.1)
Unadjusted OR	Ref	0.96 (0.92–1.01)	0.89 (0.85–0.94)	0.84 (0.80–0.88)	0.69 (0.65–0.74)
Adjusted OR*	Ref	0.84 (0.80–0.89)	0.80 (0.76–0.86)	0.78 (0.72–0.83)	0.67 (0.62–0.73)
AMI					
Overall mortality rate, %	10.4 (10.1–10.6)	7.3 (7.1–7.5)	6.5 (6.3–6.7)	6.3 (6.1–6.5)	6.3 (6.1–6.5)
Unadjusted OR	Ref	0.70 (0.66–0.74)	0.62 (0.58–0.66)	0.58 (0.54–0.62)	0.57 (0.53–0.62)
Adjusted OR*	Ref	0.79 (0.74–0.84)	0.75 (0.70–0.81)	0.70 (0.64–0.76)	0.67 (0.61–0.73)
Early mortality rate, %	5.3 (5.1–5.4)	3.4 (3.3–3.5)	3.0 (2.9–3.2)	3.0 (2.9–3.1)	2.8 (2.7–2.9)
Unadjusted OR	Ref	0.64 (0.60–0.68)	0.57 (0.53–0.61)	0.54 (0.50–0.58)	0.51 (0.47–0.56)
Adjusted OR*	Ref	0.75 (0.69–0.81)	0.72 (0.66–0.79)	0.68 (0.62–0.75)	0.66 (0.59–0.73)
Stroke					
Overall mortality rate, %	8.4 (8.2–8.6)	8.6 (8.5–8.8)	9.6 (9.4–9.8)	9.7 (9.5–9.9)	10.6 (10.4–10.8)
Unadjusted OR	Ref	1.04 (0.99–1.10)	1.16 (1.09–1.23)	1.18 (1.10–1.25)	1.19 (1.10–1.28)
Adjusted OR*	Ref	0.92 (0.85–0.99)	0.92 (0.85–1.00)	0.89 (0.82–0.98)	0.89 (0.80–0.99)
Early mortality rate, %	3.7 (3.6–3.9)	3.6 (3.5–3.7)	4.2 (4.1–4.3)	4.4 (4.3–4.6)	4.7 (4.5–4.8)
Unadjusted OR	Ref	0.97 (0.90–1.04)	1.12 (1.04–1.20)	1.20 (1.12–1.29)	1.28 (1.17–1.39)
Adjusted OR*	Ref	0.88 (0.81–0.96)	0.95 (0.86–1.04)	0.95 (0.86–1.05)	1.05 (0.93–1.18)
Respiratory failure					
Overall mortality rate, %	20.1 (19.7–20.4)	18.3 (18.0–18.6)	17.9 (17.6–18.3)	16.2 (15.9–16.5)	14.3 (14.0–14.6)
Unadjusted OR	Ref	0.87 (0.82–0.91)	0.81 (0.77–0.86)	0.72 (0.68–0.77)	0.62 (0.57–0.68)
Adjusted OR*	Ref	0.84 (0.79–0.89)	0.85 (0.80–0.91)	0.81 (0.75–0.87)	0.69 (0.63–0.75)
Early mortality rate, %	8.0 (7.8–8.3)	7.1 (6.8–7.3)	6.8 (6.6–7.0)	6.1 (5.9–6.3)	5.5 (5.3–5.7)
Unadjusted OR	Ref	0.87 (0.82–0.93)	0.82 (0.76–0.87)	0.73 (0.68–0.79)	0.64 (0.58–0.70)
Adjusted OR*	Ref	0.86 (0.80–0.93)	0.85 (0.78–0.92)	0.83 (0.76–0.90)	0.73 (0.65–0.81)
GI bleeding					
Overall mortality rate, %	3.4 (3.3–3.6)	3.3 (3.1–3.4)	3.2 (3.0–3.3)	2.9 (2.8–3.1)	2.8 (2.7–3.0)
Unadjusted OR	Ref	0.95 (0.88–1.03)	0.92 (0.85–0.99)	0.86 (0.79–0.93)	0.83 (0.76–0.91)
Adjusted OR*	Ref	0.86 (0.77–0.95)	0.85 (0.76–0.96)	0.79 (0.70–0.90)	0.79 (0.68–0.91)
Early mortality rate, %	1.6 (1.5–1.7)	1.5 (1.4–1.6)	1.3 (1.2–1.4)	1.2 (1.1–1.3)	1.1 (1.0–1.2)
Unadjusted OR	Ref	0.92 (0.83–1.03)	0.85 (0.76–0.94)	0.76 (0.67–0.85)	0.72 (0.64–0.81)
Adjusted OR*	Ref	0.85 (0.74–0.98)	0.82 (0.70–0.96)	0.76 (0.65–0.90)	0.74 (0.62–0.90)
ARF					
Overall mortality rate, %	6.1 (5.9–6.3)	5.5 (5.3–5.7)	5.2 (5.0–5.4)	4.4 (4.2–4.6)	4.1 (4.0–4.3)
Unadjusted OR	Ref	0.88 (0.82–0.94)	0.81 (0.75–0.87)	0.70 (0.65–0.76)	0.64 (0.58–0.70)
Adjusted OR*	Ref	0.93 (0.85–1.01)	0.83 (0.76–0.92)	0.75 (0.68–0.84)	0.72 (0.63–0.82)

Table 3. Continued.

Diagnosis	ED Case Volume Quintile (95% CI)				
	Very Low	Low	Medium	High	Very High
Early mortality rate, %	1.9 (1.8–2.0)	1.6 (1.5–1.8)	1.5 (1.4–1.6)	1.3 (1.2–1.4)	1.1 (1.0–1.2)
Unadjusted OR	Ref	0.86 (0.77–0.95)	0.78 (0.70–0.86)	0.65 (0.58–0.73)	0.58 (0.51–0.66)
Adjusted OR*	Ref	0.93 (0.82–1.05)	0.89 (0.78–1.01)	0.76 (0.66–0.88)	0.74 (0.62–0.88)

OR, Odds ratio.

*Adjusted for year, day of week, age, sex, race, insurance, median household income, Elixhauser comorbidities, All-Patient Refined Diagnosis Related Group (APR-DRG) severity, APR-DRG risk of mortality, hospital location (urban or rural), hospital region, hospital bed size, teaching hospital.

hospital quintile and adjusted for patient and hospital characteristics, ED admission volume had varying effects on overall inpatient mortality (Table 3). Overall mortality was attenuated for clinical conditions such as acute myocardial infarction, respiratory failure, and acute and unspecified renal failure after risk adjustment. In other conditions such as pneumonia, congestive heart failure, sepsis, stroke, and gastrointestinal bleeding, an augmenting effect was observed. The effects of risk adjustment on likelihood of early mortality varied, depending on the clinical condition. However, increasing ED volume was associated with reduced risk of early mortality, similar to the trends observed with overall mortality.

The effect of ED admission volume varied markedly on absolute differences in adjusted mortality rates, depending on the clinical condition (Figure 2*A* and *B*). For example, for sepsis, adjusted rates were 20.8% (95% CI 20.3% to 21.4%) at very low-volume centers compared with 15.2% (95% CI 14.6% to 15.8%) at very high-volume centers, a difference of –5.6% (95% CI –6.5% to –4.7%). The smallest difference was found for pneumonia, at –0.2% (95% CI –0.6% to 0.1%) adjusted mortality. For all comers, admitted ED patients showed a mortality difference of –0.4% (95% CI –0.6% to –0.3%) between the extremes of center volume.

Absolute differences in adjusted mortality declined in various degrees, depending on the clinical condition. For conditions with higher observed mortalities (sepsis, acute myocardial infarction, and acute and unspecified renal failure), mortality declined in a stepwise fashion across hospital quintile case volume, demonstrating a reduction in mortality with each successive increase in strata volume. Those conditions with lower observed inpatient mortalities (pneumonia and gastrointestinal bleeding) showed mortality differences only at the extremes of case volume.

Sensitivity Analyses

We performed 2 sensitivity analyses. We first repeated our analyses, using 500 annual ED admissions and 10 clinical cases per ED as the threshold instead of 1,000 ED admissions and 30 clinical condition cases to detect biased results potentially related to defining very low-volume centers too narrowly. The distribution of patients and hospitals across volume quintiles can be found in Table E2 (available online at http://www.annemergmed.com). The observed and adjusted overall mortality rates and odds ratios are shown in Table E3 (available online at http://www.annemergmed.com). The findings are similar except that stroke patients showed no difference across center case volume.

We also performed a sensitivity analysis in which quintiles were constructed by sorting on equal numbers of hospitals. The distribution of patients and hospitals across volume quintiles can be found in Table E4 (available online at http://www.annemergmed.com). This alternative methodological approach distributes patients in ever-increasing groupings across quintiles. Figure E1*A* and *B* (available online at http://www.annemergmed.com) shows the association between ED admission volume and adjusted inpatient mortality. In general, the relationships across quintiles of volume were not substantively altered, although the baseline adjusted mortality rates differed, depending on the clinical condition. These findings are discussed in greater detail in Appendix E1, available online at http://www.annemergmed.com.

LIMITATIONS

Our study should be interpreted in the context of the following limitations. First, several previous analyses have demonstrated a link between hospital volume and mortality.[3,5,10-12] In our study sample, we found ED volume to be highly correlated with overall hospital volume (Pearson correlation coefficient 0.86 in our sample). As a result, ED case volume may simply be a surrogate for total hospital volume. However, because the ED is increasingly the primary gateway for hospitalization in the United States,[16,17] it is important to understand the relationship between ED admission volume and significant patient outcomes, such as inpatient mortality.

Second, pooling large numbers of hospitals into quintiles of volume implies that mortality outcomes are similar across all of these institutions.[1] We recognize that heterogeneity exists within these hospital quintiles and that some lower-volume centers perform better than higher-volume ones. Therefore, we also assessed mortality as a continuous variable and found that the associations remained. In addition, our focus on mortality, though a critically important outcome measure, does not account for other aspects of quality, such as processes of care and patient experience.

Third, in an effort to provide reliable results, we attempted to avoid outcomes related to care at extremely low frequencies of hospitalization. Therefore, we defined our threshold as 1,000 ED hospitalizations and 30 condition-specific cases for our analysis.

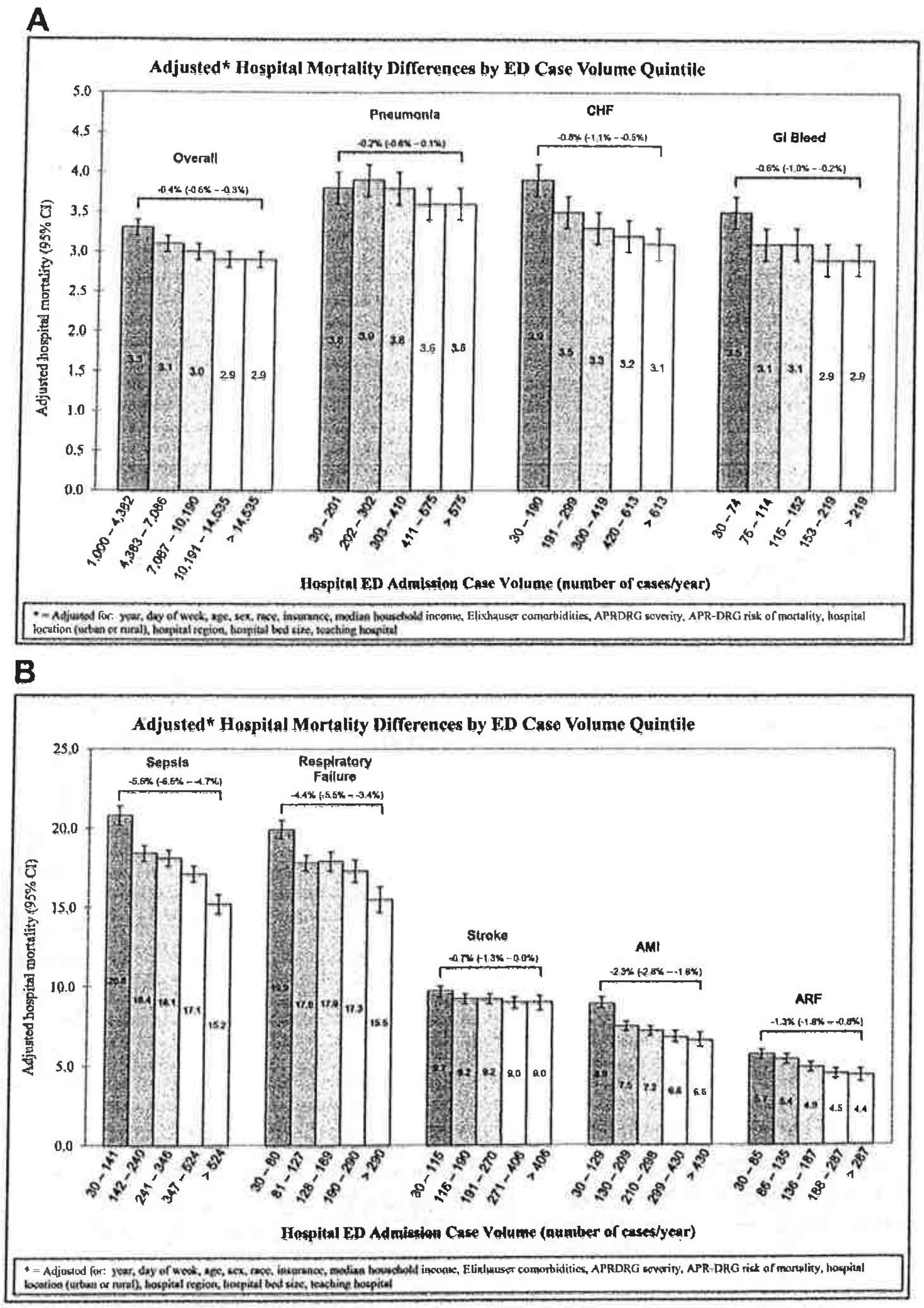

Figure 2. *A*, Adjusted hospital mortality differences by ED case volume quintile.* *B*, Adjusted hospital mortality differences by ED case volume quintile.*

This resulted in a moderate proportion of hospitals being excluded from our study sample. However, many of the excluded hospitals likely represented specialty institutions without an affiliated ED (15% of exclusions experienced no ED admissions) or small hospitals with very low ED admission volume (80% of exclusions were small-bed-size institutions). We adapted our exclusion criteria according to the Centers for Medicare & Medicaid Services, which uses a similar minimum threshold before publicly reporting quality data on the Hospital Compare Web site.[36] Also, we performed a sensitivity analysis to assess the validity of our findings and arrived at similar results.

Fourth, using administrative data has important drawbacks, including the lack of clinical granularity and inability to adjust for potential confounders that are not directly measured in the Nationwide Inpatient Sample data set. For example, patient and family wishes on aggressiveness of care (do not resuscitate status or withdrawal of care) or differences in coding practices for billing across hospitals may systematically vary across the patient populations in the volume quintiles, although there is also little evidence to suggest that these would be biased in any particularly direction as a function of hospitalized volume. However, as a result, there may be some unmeasured severity from confounders not included in the regression models that contributed to the observed association between ED admission volume and mortality. Nevertheless, we used established rigorous multivariable techniques and accounted for relevant patient and hospital characteristics to produce valid mortality estimates from these administrative data.

Fifth, we used hospital discharge diagnoses, which may be different from the diagnoses at admission from the ED. We also did not account for mortality outcomes related to any patients discharged from the ED with these diagnoses because overall admission practices can vary substantially between hospitals.[37]

DISCUSSION

Our analysis demonstrated a positive correlation between higher-volume EDs and improved patient outcomes for early 2-day and for overall inpatient mortality. To our knowledge, this is the first comprehensive analysis describing the overall trend linking higher ED volume to better outcomes among hospitalized patients. This relationship persisted for all patients admitted through the ED, as well as for those with 8 higher-risk clinical conditions commonly observed in the ED. We found that the overall adjusted relative risk of hospital death improved by more than 10% (from 3.3% to 2.9%) across the extremes of case volume, with the largest mortality improvement of more than 25% found specifically for sepsis (from 20.8% to 15.2%). To provide a rough gauge of the potential clinical effect of these findings, we calculated the effect of the 4 poorest-performing quintiles improving their blended adjusted mortality rates to the best-performing quintile. This change would have prevented a projected 24,000 deaths among the 17.2 million estimated ED admission patients in 2010.[38]

The finding of improved outcomes for patients admitted through higher-volume EDs is significant for beginning to understand and explain differences in the quality of emergency care. Our results showing disparities in patient mortality likely reflect underlying variation in processes, delivery, and safety of ED- and hospital-based care. It is beyond the scope of our analysis to determine whether the mortality differences noted in this study were related primarily to optimal ED care, high-quality inpatient care, or a combination of both at high-performing hospitals. However, it is likely that some of the mortality benefit observed at hospitals with high ED volume is attributable to the quality of ED care, particularly for time-sensitive conditions such as sepsis, respiratory failure, and acute myocardial infarction, in which early intervention has the greatest ability to influence the clinical course. Furthermore, the improved difference in early mortality between the volume quintiles is also likely a signal that the quality of ED care is contributing to some of the observed mortality differences.

We do recognize, however, that quality of care may not be the only explanation for the differences in mortality. For certain conditions such as stroke, congestive heart failure, and gastrointestinal bleeding, the observed differences in mortality seem to be driven by a relatively higher mortality rate in the lowest quintile of ED volume, with the other quintiles having non–statistically significant differences in mortality rates when compared with one another. Given that visits to hospitals in the lowest quintile of ED volume are also much more likely to be to rural hospitals, it is possible that the higher mortality rates for these patients were due to delays in presentation or greater distances to receive appropriate care. However, other conditions, such as sepsis, respiratory failure, acute myocardial infarction, and acute and unspecified renal failure, showed stepwise declines in mortality for each increase in ED volume.

If emergency care plays a role in outcome differences between hospitals, then it is important to identify to what extent and in what manner. This information may help disentangle which aspects of care contribute most to the improved outcomes noted at high-volume centers. Significant attention has been given to explaining and understanding the volume-outcome relationship in other health care arenas. Two leading hypotheses, "practice makes perfect" and "selective referral pattern," attempt to explain the mechanisms at work in this volume-outcome relationship.[39] The "practice makes perfect" explanation proposes that the increased frequency of encounters allows higher-volume centers to develop more experience and streamlined processes of care, which result in improved outcomes. This argument may be supported by the large difference in outcomes we found in our sepsis subgroups. Evidence-guided therapy for sepsis is time and resource intensive; therefore, differences in outcome may be related to inefficiencies in treatment at lower-volume centers. Patient mortality has been shown to be linked to initiation of early goal-directed bundles, timing of antibiotics, and use of additional therapies.[40] For conditions requiring this type of critical care in the ED, higher-volume centers may have more efficient and effective processes of care. Examining differences in the delivery of ED-based care for these patients may be an important means of understanding the causes for these differences in mortality risk across hospitals.

The other competing theory to consider is selective referral.[39] Higher-volume centers developed a reputation as a center of excellence, thereby benefiting from a strong referral base as a consequence of their good standing. For example, during the last decade many advocacy and accreditation organizations, such as the Leapfrog Group, a large coalition of private and public purchasers of health care, have endorsed minimum-volume standards at hospitals for a variety of surgeries.[30,41] If selection bias dominates the explanatory mechanism, then high-volume hospitals are not truly outperforming low-volume facilities, but only benefiting from unmeasured confounding as a result of their referral base.

Caution must be used in translating these findings too broadly when considering their implications for the organization and delivery of emergency care. For example, policies that regionalize specialized care for patients must take into account that many high-risk emergency conditions are not readily identified in the out-of-hospital setting by patients, outpatient providers, or emergency medical services. Also, the acuity of these conditions often does not provide enough lead time to allow transport to higher-volume centers of ED care, particularly in rural areas. As a result, emergency care may not have the same underlying dynamics driving selection bias as in other clinical circumstances, such as with elective surgery or extended cancer treatment, in which patients have the opportunity to investigate alternative institutions.

Deciding how best to make operational the volume-outcome relationship to emergency care delivery will be determined by identifying the underlying mechanisms for variation in patient outcomes. For example, in surgical patients it has been found that pre- and perioperative interventions explain some of the variation in patient outcomes related to volume.[42] Therefore, future research to understand differences or similarities between care processes and implementation of best practices at high- versus low-volume EDs will better identify how to intervene to optimize outcomes across all EDs. This calculus will likely vary by clinical condition, in which some acute illnesses depend on specialized emergency interventions for their outcomes, such as percutaneous coronary intervention for ST-elevation myocardial infarction or goal-directed therapy for severe sepsis. These conditions are in distinction to other common illnesses, such as pneumonia or congestive heart failure, which generally do not require procedurally based early interventions. There could also be thresholds of ED case volume over which performance is maximized, as has been explored in other care settings.[10] Finally, there may be a tradeoff between operational efficiency, which is typically found at lower-volume EDs, where wait times and boarding times are shorter on average compared with those of higher-volume EDs,[24] and other aspects of care quality such as mortality among hospitalized patients as found in this study. This relationship is particularly relevant because the Centers for Medicare & Medicaid Services is poised to reward hospitals for efficient ED throughput measures.[43]

The relationship between ED case volume and mortality has implications for defining essential factors that optimize the delivery of quality ED-based care. Although the link between high volume and improved outcomes is recognized in other practice environments, our study has comprehensively established this association in the ED setting as well. Most observers consider volume to be a crude proxy for quality of care and not the final determinant,[1,44] and caution should be used when performance is pooled across groups of EDs. Individual EDs may vary widely in their outcomes, and likely some low-volume centers outperform some high-volume ones. In addition, EDs may not perform equally well across all clinical conditions, with some institutions performing better with only particular types of patients. Therefore, future application of these findings to the delivery and regionalization of emergency care within the health system must be conducted judiciously. However, teasing apart the causes of this relationship will be critical to informing how best to drive and make operational quality improvement efforts to enhance outcomes across hospitals for all ED patients.

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APPENDIX E1.

Technical Notes

We performed a retrospective analysis of the Nationwide Inpatient Sample (NIS), combining years 2005 through 2009. The NIS is administered by the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project and is the largest all-payer inpatient database in the United States.[1] It includes information on about 8 million hospitalizations each year and is designed to approximate a 20% sample of US hospitals when used as a complex survey design to produce nationally representative estimates. The NIS draws its sample from Healthcare Cost and Utilization Project's State Inpatient Databases (SID). There are about 40 states that are contained in the SID, but this varies from year to year. Hospitals are chosen according to 5 strata (geographic region, location, teaching status, ownership, and bed size).[2]

All patients in the data set who were hospitalized through the ED were initially considered for analysis. The NIS does not include observation admissions; therefore, these were not included. Figure 1 shows a flow diagram of how the study samples were constructed. Patients who were transferred from a referral hospital or those who were admitted through the ED and subsequently transferred were excluded from analysis because outcomes could not solely be attributed to care delivered at the index institution. These cases represented a small proportion of ED admissions overall (2.5%), although they were disproportionately noted in the lower-volume centers (4.3 times as common in the lowest-volume center compared with the highest-volume center). Presumably, these cases consisted of a sicker cohort of patients with higher mortality risk, likely prompting the need for transfer to a referral hospital. As a result, this potential bias would favor finding an improved mortality rate at lower-volume centers at the expense of higher-volume centers.[3] A sensitivity analysis was performed with these patients in the modeling, assigning the cases the average mortality rate for their hospital, and it did not significantly alter the results.

The American Hospital Association hospital identifier is not available for almost half of the facilities in the NIS data set because many states do not release this information.[2] In addition, some hospitals merge, split, or close, so many facilities may appear on the sample for only a few years. We are therefore unable to uniquely identify all the hospitals across years of the NIS. As a result, we acknowledge that the same hospitals may be sampled from year to year and therefore introduce some degree of autocorrelation in the results. Overall, we believe that the small amount of bias introduced by this concern is balanced by the increased precision obtained by combining years and larger sample sizes for the clinical conditions studied.

Although the NIS provides a means to calculate national estimates, we did not use this function in our study design. This was intentional because as a result of constructing the sample, we eliminated hospitals with very low volumes of ED admissions. Because some hospitals were excluded in this fashion, we were not able to produce national estimates. Effectively, our study was an analysis of a very large convenience sample of US hospitals, which the NIS is also frequently used for in the literature.

Many of the covariates used in the regression models were provided and predefined by the NIS. For patient-level variables, these included demographic and disease information. The median household income of a patient's zip code by national quartiles varies from year to year in the NIS but in 2009 consisted of $1 to $38,999, $39,000 to $47,999, $48,000 to 62,999, and $63,000 or more.[2] APR-DRGs version 20.0 risk of mortality and severity of illness classification[4] and Elixhauser comorbidities[5] are validated and commonly used techniques to control for differences in patient illness when using claims-based analyses. For the modeling, we considered age as a categorical variable in 6 groupings (≤18, 19 to 34, 35 to 49, 50 to 64, 65 to 79, and ≥80 years).

Hospital-level variables were also provided by the NIS. Hospital location was defined as urban or rural setting according to Core Based Statistical Area codes, which come from the US Census Bureau.[6] Hospital region (Northeast, Midwest, West, and South) was also based on US Census Bureau designations. Hospital bed size (small, medium, and large) was predefined by the NIS and specific to the facility's region, location, and teaching status. The NIS designates the bed size cutoff points so that approximately one third of the hospitals in a given region, location, and teaching status combination would fall within each bed size category.[2] Similarly, teaching status was a variable predefined in the NIS. The NIS denotes a teaching hospital if it meets any one of the following 3 criteria: (1) residency training approval by the Accreditation Council for Graduate Medical Education, (2) membership in the Council of Teaching Hospitals, or (3) a ratio of full-time equivalent interns and residents to beds of 0.25 or higher.[2]

When reporting the results, we performed a sensitivity analysis in which quintiles were constructed by sorting on equal numbers of hospitals. The distribution of patients and hospitals across volume quintiles can be found in Table E4 (available online at http://www.annemergmed.com). This alternative methodological approach distributes patients in ever-increasing groupings across quintiles. Figure E1*A* and *B* (available online at http://www.annemergmed.com) shows the association between ED admission volume and adjusted inpatient mortality. In general, the relationships are similar across the conditions to those found in the main results, in which quintiles are sorted at the patient level, particularly when comparing the absolute risk reductions from the lowest- to highest-volume centers. However, the baseline adjusted mortality rates changed, depending on the condition. For example, in sepsis, the lowest-volume group experienced a higher adjusted rate of 22.7% (95% CI 21.8% to 23.6%) and, similarly, the highest-volume group had a rate of 16.9% (95% CI 16.5% to 17.4%), but with a comparable difference of –5.8% (95% CI –6.8% to –4.7%). The smallest difference for all the conditions also remained with pneumonia, at –0.2% (95% CI –0.5% to 0.1%) adjusted mortality. Inpatient mortality for all comers admitted from the ED was also substantively unchanged, demonstrating a difference of –0.4% (95% CI –0.6% to –0.3%) between the extremes of center volume.

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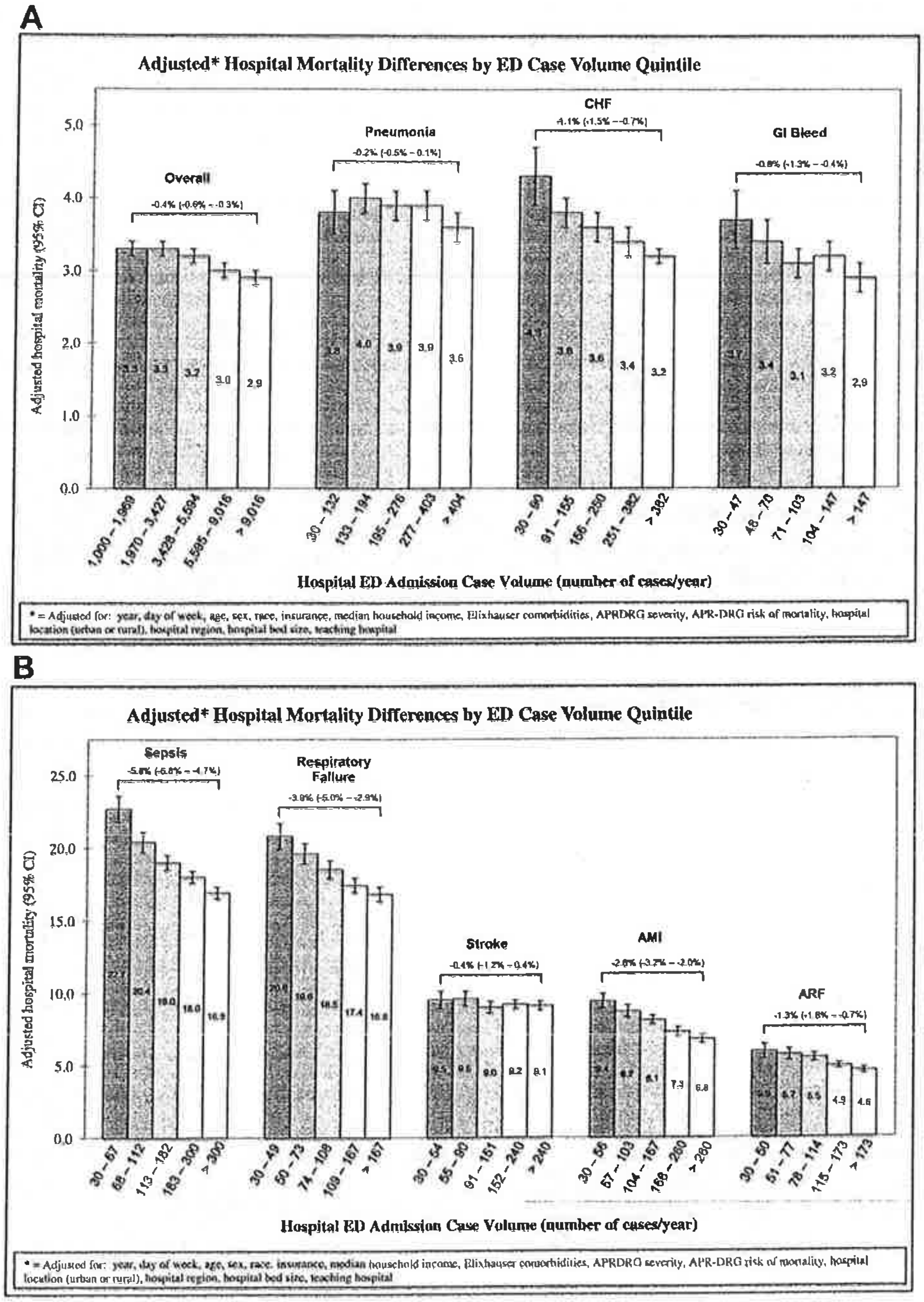

Figure E1. *A*, Adjusted hospital mortality differences by ED case volume quintile.* *B*, Adjusted hospital mortality differences by ED case volume quintile.*

Table E1. Top 25 clinical conditions resulting in hospitalization through the ED, and associated inpatient mortality.*

Clinical Condition (Clinical Classifications Software Category Number)	Average Annual Hospitalizations Through the ED in Sample	Inpatient Mortality (%)
1. Pneumonia (except that caused by tuberculosis or sexually transmitted disease) (122)†	823,178	3.8
2. Congestive heart failure; nonhypertensive (108)†	728,969	3.4
3. Nonspecific chest pain (102)	627,591	0.1
4. Septicemia (except in labor) (2)†	526,850	17.8
5. Cardiac dysrhythmias (106)	459,411	1.2
6. Chronic obstructive pulmonary disease and bronchiectasis (127)	457,781	1.7
7. Urinary tract infections (159)	409,746	1.0
8. Acute cerebrovascular disease (109)†	408,049	9.4
9. Skin and subcutaneous tissue infections (197)	393,141	0.3
10. Acute myocardial infarction (100)†	366,286	7.7
11. Diabetes mellitus with complications (50)	358,182	0.8
12. Fluid and electrolyte disorders (55)	346,079	1.7
13. Coronary atherosclerosis and other heart disease (101)	340,905	0.5
14. Asthma (128)	310,137	0.3
15. Biliary tract disease (149)	296,683	0.6
16. Respiratory failure; insufficiency; arrest (adult) (131)†	273,064	17.5
17. Acute and unspecified renal failure (157)†	271,182	5.2
18. Mood disorders (657)	268,847	0
19. Gastrointestinal hemorrhage (153)†	265,330	3.1
20. Appendicitis and other appendiceal conditions (142)	248,052	0.1
21. Complication of device; implant or graft (237)	246,237	2.6
22. Complications of surgical procedures or medical care (238)	246,132	1.3
23. Fracture of neck of femur (hip) (226)	245,698	2.7
24. Intestinal obstruction without hernia (145)	243,548	2.5
25. Pancreatic disorders (not diabetes) (152)	224,351	1.0

*Patients transferred to another short-term hospital after admission were excluded. Data presented are weighted with the variables provided in the Nationwide Inpatient Sample to generate national estimates.

†Clinical conditions representing common ED admissions and greater than 3% observed hospital mortality.

Table E2. Distribution of patients and hospitals among quintiles of ED case volume overall and by clinical condition for sensitivity analysis.*

Diagnosis	ED Case Volume Quintile				
	Very Low	Low	Medium	High	Very High
Overall					
No. of patients	3,597,556	3,589,328	3,594,006	3,594,009	3,576,801
No. of hospitals	1,941	665	430	305	170
Avg no. ED cases/y	500–4,115	4,116–6,872	6,873–10,084	10,085–14,423	>14,423
Pneumonia					
No. of patients	176,284	173,554	176,552	174,760	173,404
No. of hospitals	1,639	751	521	374	219
Avg no. ED cases/y	10–183	184–287	288–402	403–565	>565
CHF					
No. of patients	152,174	153,405	150,840	152,390	151,662
No. of hospitals	1,873	668	435	311	180
Avg no. ED cases/y	10–173	174–290	291–411	412–599	>599
Sepsis					
No. of patients	109,256	109,119	107,754	109,384	107,199
No. of hospitals	1,861	611	382	264	147
Avg no. ED cases/y	10–131	132–231	232–340	341–522	>522
AMI					
No. of patients	75,802	74,131	74,315	74,766	74,075
No. of hospitals	1,690	474	311	216	128
Avg no. ED cases/y	10–118	119–202	203–291	292–423	>423
Stroke					
No. of patients	84,389	84,728	84,991	83,595	83,937
No. of hospitals	1,915	602	385	262	149
Avg no. ED cases/y	10–102	103–183	184–267	268–397	>397
Respiratory failure					
No. of patients	56,148	55,495	56,176	55,748	55,392
No. of hospitals	1,566	591	385	251	137
Avg no. ED cases/y	10–72	73–119	120–181	182–283	>283
GI bleeding					
No. of patients	56,041	54,488	54,300	55,326	54,531
No. of hospitals	1,671	642	431	317	186
Avg no. ED cases/y	10–64	65–107	108–146	147–215	>215
ARF					
No. of patients	55,490	56,002	54,288	55,112	54,030
No. of hospitals	1,508	558	353	245	137
Avg no. ED cases/y	10–76	77–130	131–182	183–281	>281

*For this analysis, ED case volume is defined as a minimum of 500 hospitalizations and 10 cases for each diagnosis.

Table E4. Distribution of patients and hospitals among quintiles of ED case volume overall and by clinical condition for sensitivity analysis.*

Diagnosis	ED Case Volume Quintile				
	Very Low	Low	Medium	High	Very High
Overall					
No. of hospitals	592	593	591	592	592
No. of patients	849,037	1,578,218	2,637,087	4,209,937	8,280,077
Avg no. ED cases/y	1,000–1,969	1,970–3,427	3,428–5,594	5,595–9,016	>9,016
Pneumonia					
No. of hospitals	591	592	586	589	589
No. of patients	58,869	96,095	136,315	196,224	346,552
Avg no. ED cases/y	30–132	133–194	195–276	277–403	>403
CHF					
No. of hospitals	578	579	582	575	573
No. of patients	37,818	69,166	115,948	178,164	336,538
Avg no. ED cases/y	30–90	91–155	156–250	251–382	>382
Sepsis					
No. of hospitals	540	525	528	531	531
No. of patients	25,906	46,665	76,087	124,995	255,114
Avg no. ED cases/y	30–67	68–112	113–182	183–300	>300
AMI					
No. of hospitals	429	411	412	416	415
No. of patients	17,440	31,793	54,251	87,349	168,390
Avg no. ED cases/y	30–56	57–103	104–167	168–260	>260
Stroke					
No. of hospitals	522	504	510	507	505
No. of patients	22,002	35,663	60,435	97,448	191,310
Avg no. ED cases/y	30–54	55–90	91–151	152–240	>240
Respiratory failure					
No. of hospitals	460	435	453	445	444
No. of patients	17,911	26,607	40,713	59,550	120,928
Avg no. ED cases/y	30–49	50–73	74–108	109–167	>167
GI bleeding					
No. of hospitals	511	480	500	487	494
No. of patients	19,478	27,821	43,143	60,573	108,534
Avg no. ED cases/y	30–47	48–70	71–103	104–147	>147
ARF					
No. of hospitals	452	414	427	421	428
No. of patients	18,122	26,571	40,695	60,088	117,340
Avg no. ED cases/y	30–50	51–77	78–114	115–173	>173

*For this analysis, quintiles are based on hospitals. ED case volume is defined as a minimum of 1,000 hospitalizations and 30 cases for each diagnosis.