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RESEARCH ARTICLE

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Association of emergency department crowding with inpatient outcomes

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Abstract

Objective: To examine the association of higher emergency department (ED) census with inpatient outcomes on the day of discharge (inpatient length of stay, in-hospital mortality, ED revisits, and readmissions).

Data Sources and Study Setting: All-payer ED and inpatient discharge data and hospital characteristics data from all non-federal, general, and acute care hospitals in the state of California from October 1, 2015 to December 31, 2017.

Study Design: In retrospective data analysis, we examined whether ED census was associated with inpatient outcomes for all inpatients, including those not admitted through the ED. The main predictor variable was ED census on day of discharge, categorized based on hospital year and day of week. Separate linear regression models with robust SEs and hospital fixed effects examined the association of ED census on inpatient outcomes (length of stay, 3-day ED revisit, 30-day all-cause readmission, in-hospital mortality), controlling for patient and visit-level factors. We stratified analyses by whether admission was elective or unscheduled.

Extraction Methods: Inpatient discharges in non-federal, general medical hospitals with EDs.

Principal Findings: We examined 5,784,253 discharges. The adjusted model showed that, compared to when the ED was below the median, higher ED census on the day of discharge was associated with longer inpatient length of stay, lower readmissions, and higher in-hospital mortality (90th percentile for length of stay: +0.8% [95% confidence interval, CI: +0.6% to +1.1%]; readmissions: −0.59 percentage points [or −5.6%] [95% CI: −0.0071 to −0.0048]; mortality: +0.14 percentage points [or +5.4%] [95% CI: +0.0009 to +0.0018]). [Correction added on 18 November 2022, after first online publication: '[odds rato, OR −5.6%]' and '[OR +5.4%]' of the preceding sentence have been corrected to '[or −5.6%]' and '[or +5.4%]', respectively, in this version.] Results for length of stay were primarily driven by patients with elective admissions, while results for readmissions and in-hospital mortality were primarily driven by patients with unscheduled admissions.

Conclusions: This study suggests that ED crowding may affect inpatients throughout the hospital, even patients who are already admitted to the hospital.

KEYWORDS
California, crowding, emergency department, hospital mortality, hospitals, length of stay, patient readmission

What is known on this topic

- Emergency department (ED) crowding on the day that patients visit the ED is associated with poorer quality of care and outcomes for both ED patients and patients admitted from the ED.

What this study adds

- ED crowding on the day of inpatient discharge is associated with longer length of stay, lower probability of readmission, and higher in-hospital mortality for inpatients, even for already-admitted inpatients.
- ED crowding affects all inpatients in the hospital, including patients who were already admitted to the hospital.

1 | INTRODUCTION

Emergency department (ED) crowding is a significant problem for many hospitals. ED crowding on the day that patients visit the ED is associated with poorer quality of care and outcomes for both ED patients and patients admitted from the ED.[1–10] For instance, ED patients admitted to the inpatient unit on days the ED is crowded have higher morbidity and mortality, although this varies by hospital system.[5,11,12] Yet, it is unknown whether ED crowding and daily surges affect general inpatient care. Specifically, it is unknown whether ED crowding on the day of inpatient discharge influences outcomes for inpatients already in the hospital, including inpatients who were not originally admitted through the ED.

In this study, we focused on whether ED crowding on the day a patient is discharged from the inpatient unit is associated with changes in inpatient length of stay, in-hospital mortality, ED revisits, and 30-day all-cause readmissions. We theorized ED crowding at inpatient discharge might influence inpatient care through two routes (Figure 1).

Direct: Because hospitals may adjust inpatient discharge processes to address ED crowding (e.g., invoking protocols to avoid ambulance diversion or address surge capacity), ED crowding on the day of discharge might directly influence inpatient care. Because a major predictor of ED crowding is a lack of inpatient beds,[13–15] many hospitals employ specific strategies to create inpatient beds when the ED is crowded. Streamlined discharge processes include re-prioritizing processes to enable discharges earlier in the day to increase bed availability,[16–19] active bed management,[20–24] and reverse triage,[25,26] which is when "bed czars" or "patient flow coordinators" more aggressively search for potential disposition options so that stable inpatients can be discharged to make beds available to admit ED patients. These streamlined discharge processes could increase inpatient discharges and shorten inpatient lengths of stay on days when the ED is crowded. This might be particularly true of patients who are elective admissions, as those patients are more likely to be stable.[27–31]

However, because discharge processes in the presence of ED crowding may be different from usual care, it may unintentionally result in sub-optimal discharges. For instance, ED crowding might result in discharging patients who are not completely stable, providing inadequate discharge instructions, or discharging patients to inappropriate facilities that are not suited to care for patients' needs. If improper discharges did take place, then inpatients discharged on days the ED is crowded might be more likely to return to the hospital, either as an ED revisit or as readmission.

We, therefore, hypothesized that when an ED is crowded, hospitals would be more likely to discharge inpatients with a shorter length of stay. We additionally hypothesized that ED crowding as measured on the day of inpatient discharge would be associated with higher ED revisits and higher readmissions.

Indirect: ED crowding on the day of discharge might also indirectly influence already-admitted inpatients. ED crowding may increase

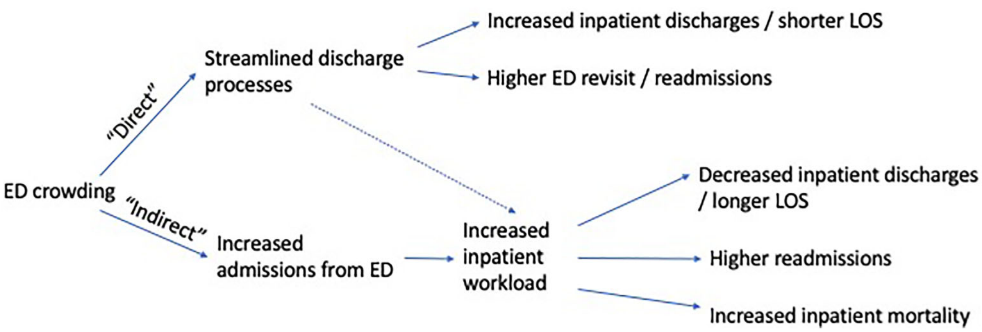

FIGURE 1 Conceptual pathway for understanding how emergency department (ED) crowding may influence inpatient outcomes. LOS, length of stay [Color figure can be viewed at wileyonlinelibrary.com]

workload for inpatient physicians and nurses[32-34] since, for instance, daily inpatient admissions could increase[35,36] or hospitals use full-capacity protocol. Full-capacity protocol is a host of actions that can include transferring ED patients to the "next-appropriate" bed (e.g., inpatient hallways, dialysis rooms),[37,38] and is associated with lower quality,[39–41] perhaps through the influence on workload. Higher workload for inpatient physicians and nurses is associated with increased length of stay,[42,43] higher readmissions,[44,45] and higher mortality and morbidity.[43,46–48] This may occur because higher workload may challenge efficiency and stretch physician and staff capacity and time with each patient, leading to a longer length of stay and higher risk of mortality. In addition, it may reduce time spent on discharge, resulting in higher readmission risk.

ED crowding may therefore indirectly increase inpatient length of stay, readmissions, and inpatient mortality through the mediator of daily inpatient admissions. Increases in mortality and morbidity might be particularly pronounced for inpatients with unscheduled admissions, who are often less stable than inpatients with elective admissions. Thus, we hypothesized that ED crowding as measured on the day of inpatient discharge might be associated with longer length of stay, higher readmissions, and higher in-hospital mortality.

2 | METHODS

2.1 | Data and sample

In this retrospective data analysis, we merged all-payer ED and inpatient hospital discharge data from California, from California's Department of Healthcare Access and Information (HCAI), with hospital characteristics from HCAI. The state of California requires all non-federal hospitals to submit data on all ED and inpatient visits (including information on dates, patient characteristics, and diagnoses). We secured approval for the non-public restricted data. We examined discharges between October 1, 2015 and December 31, 2017 because of the shift from International Classification of Diseases (ICD)-9 to ICD-10 coding in the fourth quarter of 2015.

To identify the sample, we limited the study population to all inpatient discharges in non-federal, acute care, and general hospitals with EDs (Appendix 1). We excluded the smallest hospitals (hospitals with fewer than 50 annual discharges) and hospital years that had no variability in the percentiles of ED census to increase generalizability. We also excluded children because adult ED patients are seldomly admitted to pediatric inpatient beds. Since our data only contained a categorized age variable, this meant that we excluded patients under the age of 20. Finally, we excluded patients who were transferred to another acute care facility and, for outcomes other than in-hospital mortality, patients who died in the hospital.

2.2 | Variables

Our main outcome variables were: (1) inpatient length of stay; (2) an ED revisit within 3 days of inpatient discharge; (3) readmission within 30 days of inpatient discharge; and (4) in-hospital death. Inpatient length of stay was the number of days in the hospital. We log-transformed the length of stay because of the skewed distribution and to facilitate interpretation as a percentage change. ED revisits and readmissions are all-cause and to any hospital within the dataset.

Our main predictor variable was a categorical variable indicating ED census on the day of inpatient discharge. Previous literature suggests that ED census can proxy for ED crowding.[49,50] We adopt this convention. Although more precise measures of ED crowding exist,[51,52] these measures require the information we lack, such as triage category. However, ED census approximates these more precise measures.[49,53] We were not able to measure ED length of stay, so we assumed that all patients in the ED were discharged, admitted, or transferred on the same day. Supporting this assumption is research suggesting that approximately 3% of ED discharges take longer than 24 h,[54] and our own analyses suggest approximately 93% of ED visits are discharged, admitted, or transferred the same day (Appendix 2).

The specific categorical variable we used for ED census was one that indicated whether for a specific hospital, year, and day of the week (weekend [including holidays] or weekday), the ED census was: below the median, 50th to <75th percentile, 75th to <90th percentile, or ≥90th percentile. First, we calculated the daily ED census for each hospital. We then calculated the percentile distribution of daily ED census for each hospital-year weekend (or weekday). Finally, using this percentile distribution, we defined a specific day as being below the median, 50th to <75th percentile, 75th to <90th percentile, or ≥90th percentile based on a comparison of that day's ED census at a specific hospital to the hospital-specific, year-specific, weekend/weekday distribution of ED census.

We used this categorical variable, rather than the raw ED census number because we theorized the relationship between ED crowding and inpatient outcomes might be non-linear. In addition, the categorical variable controls for potential variability in ED census across hospital-year and day of the week, which is important because analyses at several hospitals (not shown) suggested autocorrelation in ED census disappeared after controlling for the day of the week.

2.3 | Statistical analysis

Descriptive: We compared patient and hospital characteristics for whether patients were discharged from the inpatient unit on days where ED census was below the median, 50th–<75th percentile, 75th–<90th percentile, and ≥90th percentile. The characteristics were: age, sex, primary insurance type (uninsured, Medicare, Medicaid, private, and other/missing), number of comorbidities (Elixhauser comorbidity index[55]), hospital teaching status, size (0–99, 100–299, 300–499, and 500+ beds), urbanicity (using a categorized version of the National Center for Health Statistics urban–rural classification[56]), and ownership (public, non-profit, for-profit). Age was categorized into five-year bands, except for one category for adults older than 85. We tested for differences in inpatients discharged across each ED census category as well as when ED census was below the median versus the 90th percentile, using, as appropriate, chi-squared tests and Kruskal-Wallis rank tests to determine statistical significance.

We also conducted several additional descriptive analyses, described further in Appendix 3. First, we calculated the difference in ED census and percent difference in ED census when the ED census was at the 90th percentile, compared to the median. Second, to examine our assumption that inpatient admission is higher on days when the ED is crowded, we examined the relationship between ED crowding and inpatient admission. Third, we examined the unconditional intraclass correlation for each outcome.

Adjusted: We estimated separate regression models for each outcome—natural log of days in the hospital, ED revisit, readmission, and in-hospital death. We conducted analyses overall and stratified based on whether patients had an elective or unscheduled admission. We estimated a linear probability model for dichotomous outcomes for ease of interpretation, particularly since we used fixed effects and the outcomes are rare.[57,58] For each model, we estimated the relationship between the category of ED crowding and each outcome, while controlling for visit-level covariates (age, sex, comorbidities, weekend [or holiday] discharge; whether the admission was through the ED, Medicare Severity Diagnosis Related Groups) as well as separate quarter, year, and hospital fixed effects. Quarter fixed effects to control for seasonality, year fixed effects captured secular changes affecting all hospitals, and hospital fixed effects control for all time-invariant observed and unobserved hospital characteristics.

We used Stata MP 15.1 for all analyses[59,60] and reported results following the STROBE checklist. This study was approved by the Pennsylvania State University Institutional Review Board.

2.4 | Sensitivity analyses

We conducted several robustness checks, described further in Appendix 4. First, the main analysis excluded children since adults are seldomly admitted to pediatric inpatient beds. However, since different hospitals may have different approaches, we included children to test the robustness of our analysis in a sensitivity analysis. Second, the main analysis used ED census on the day of discharge. However, because our data did not contain hours, we could not determine who might have been discharged at the beginning of the day versus the end of the day. Thus, in the sensitivity analysis, we also examined ED census on the day before discharge. Third, because we did not have a discharge date, in the main analysis, we assumed that ED patients were admitted and discharged on the same day. In sensitivity analysis, we assumed instead that ED patients were discharged or admitted the next day. Fourth, in sensitivity analysis, we controlled for potential confounders (payer and individual day of week [vs. weekend/weekday]). Fifth, in sensitivity analysis, we examined two potential mediators, hospital-specific daily inpatient occupancy, and the hospital-specific daily percent of inpatient admissions from the ED. Sixth, in the sensitivity analysis, we excluded patients who were admitted on the same day. This sub-analysis examined whether ED census on the day of discharge influenced inpatients who were already admitted to the hospital. Seventh, for the length of stay outcome, we also conducted a separate analysis that excluded patients not discharged home.

3 | RESULTS

3.1 | Descriptive statistics

We included 5,784,253 inpatient discharges across 307 hospitals. In our sample, 3,444,238 (59.6%) patients were female, 3,466,701 (59.3%) were between age 20 and 64, and 2,317,562 (40.1%) were age 65+. Because of sample size, most patient and hospital characteristics varied significantly across the categories of ED census, but these differences were not clinically significant (Table 1). Across all hospitals, ED census was from 7% to 132% higher (mean: 18%) at the 90th percentile compared to when ED census was at the 50th percentile (Appendix 3). Inpatient admission was also higher when ED census was higher. For instance, at the largest hospitals (500+ beds), the number of inpatients admitted on days when the ED was at the 90th percentile was 9.5% higher compared to when the ED was below the median (from 74 to 81 inpatients).

3.2 | ED census and length of stay

The unadjusted mean inpatient length of stay was 5.1 days. Adjusted analyses showed that inpatient length of stay was slightly longer when ED census was higher on the day of discharge (Figure 2). Compared to when ED census on the day of inpatient discharge was below the hospital median, mean lengths of stay were 0.3% longer when ED census was in the 50th–<75th percentile (95% confidence interval [CI]: 0.001–0.004, $p < 0.001$), 0.6% longer when it was in the 75th–<90th percentile (95% CI: 0.004–0.008, $p < 0.001$), and 0.8% longer at the 90th percentile (95% CI: 0.006–0.011, $p < 0.001$) (Table A1).

3.3 | ED census and hospital revisits and readmissions

The overall ED revisit rate was 4.5% (not shown). There was no statistically significant relationship between ED occupancy on the day of discharge and ED revisits within 3 days (Table A2).

The overall readmission rate was 10.5% (not shown). In adjusted analyses, a higher ED census on the day of inpatient discharge was associated with a lower probability of readmission (Figure 3). Specifically, compared to when ED census on the day of discharge was below the median, readmissions were 0.10 percentage points (or 0.9%) lower when it was between the 50th–<75th percentiles (95% CI: −0.0017 to −0.0003; $p = 0.004$); 0.25 percentage points (or 2.4%) lower when it was between the 75th–<90th percentiles (95% CI: −0.0034 to −0.0017, $p < 0.001$); and 0.59 percentage points (or 5.6%) lower when it was the 90th percentile (95% CI: −0.0071 to −0.0048; $p < 0.001$)

TABLE 1 Descriptive statistics, by emergency department census on day of inpatient discharge

	Below median	50th–<75th percentile	75th–<90th percentile	≥90th percentile	*p*-Value across all	*p*-Value below median versus ≥ 90th percentile
N	2,888,835	1,447,668	849,792	597,958		
Mean number of days in hospital (SD)	5.08 (5.67)	5.12 (5.66)	5.15 (5.70)	5.21 (5.62)	0.0001	0.0001
Mean deaths	74,258 (2.5%)	38,995 (2.6%)	23,573 (2.7%)	17,515 (2.9%)	<0.001	<0.001
Mean ED revisits	128,312 (4.4%)	64,536 (4.5%)	37,884 (4.5%)	26,833 (4.5%)	0.445	0.118
Mean readmissions	363,802 (12.6%)	182,496 (12.6%)	107,070 (12.6%)	74,271 (12.4%)	0.001	<0.001
Patient						
Female	1,723,133 (59.7%)	1,447,668 (59.5%)	504,907 (59.4%)	354,768 (57.3%)	<0.001	<0.001
Age					<0.001	<0.001
20–39	787,203 (27.3%)	393,393 (27.2%)	228,053 (26.8%)	159,404 (26.7%)		
40–54	466,468 (16.2%)	232,133 (16.9%)	136,345 (16.0%)	94,003 (15.7%)		
55–64	487,127 (16.9%)	241,655 (16.7%)	141,903 (13.7%)	99,003 (15.7%)		
65–74	252,523 (8.7%)	125,520 (8.7%)	73,669 (8.7%)	51,607 (8.6%)		
75+	859,514 (31.0%)	454,967 (31.4%)	269,822 (31.8%)	193,940 (32.4%)		
Comorbidities					<0.001	<0.001
0	624,074 (21.6%)	309,953 (21.4%)	179,404 (21.1%)	124,108 (20.8%)		
1	426,341 (14.8%)	211,505 (14.6%)	123,334 (14.5%)	85,119 (14.2%)		
2	413,424 (14.3%)	207,452 (14.3%)	121,316 (14.3%)	85,315 (14.3%)		
3+	1,424,996 (49.3%)	718,758 (49.7%)	425,738 (50.1%)	303,416 (50.7%)		
Payer					<0.001	<0.001
Private	769,777 (26.7%)	382,555 (26.4%)	222,539 (26.2%)	153,570 (25.7%)		
Medicare	1,188,388 (41.4%)	600,709 (41.5%)	355,538 (41.8%)	254,492 (42.6%)		
Medicaid	803,955 (27.8%)	401,592 (27.7%)	234,769 (27.6%)	164,237 (27.5%)		
Uninsured	56,051 (1.9%)	27,767 (1.9%)	16,501 (1.9%)	11,638 (2.0%)		
Other/missing	70,664 (2.4%)	35,045 (2.4%)	20,445 (2.4%)	13,931 (2.3%)		
Hospital characteristics						
Teaching	546,170 (18.9%)	269,612 (18.6%)	157,636 (18.6%)	110,235 (18.4%)	<0.001	0.001
Size					<0.001	<0.001
500+ beds	433,186 (15.0%)	210,652 (14.6%)	123,545 (14.5%)	85,962 (14.4%)		
300–499 beds	1,464,170 (50.7%)	736,374 (50.9%)	429,898 (50.6%)	303,087 (50.7%)		
100–299 beds	887,738 (30.7%)	446,999 (30.9%)	264,173 (31.1%)	185,783 (31.1%)		
0–99 beds	103,741 (3.6%)	53,643 (3.7%)	32,176 (3.8%)	23,126 (3.9%)		
Urbanicity/rurality					<0.001	<0.001
Large central metro	1,892,499 (65.5%)	951,111 (65.7%)	561,925 (66.1%)	394,524 (66.0%)		
Large fringe metro	345,709 (12.0%)	173,648 (12.0%)	101,096 (11.9%)	71,654 (12.0%)		
Medium metro	509,759 (17.7%)	250,346 (17.3%)	145,309 (17.1%)	102,661 (17.2%)		
Small metro, micropolitan, non-core	140,868 (4.9%)	72,563 (5.0%)	41,462 (4.9%)	29,119 (4.9%)		
Ownership					<0.001	<0.001
Public	462,900 (16.0%)	229,930 (15.9%)	234,159 (15.8%)	94,610 (15.8%)		
Not-for-profit	1,983,769 (68.7%)	992,380 (68.6%)	581,199 (68.4%)	406,907 (68.1%)		
For profit	442,166 (15.3%)	225,358 (15.6%)	134,434 (15.8%)	96,441 (16.1%)		

Note: The percentile for the ED census on day of discharge was calculated for each hospital year and day of a week (weekend/weekday).
Abbreviation: ED, emergency department.
Source: Authors' analyses of data from California's Department of Healthcare Access and Information (October 1, 2015 to December 31, 2017).

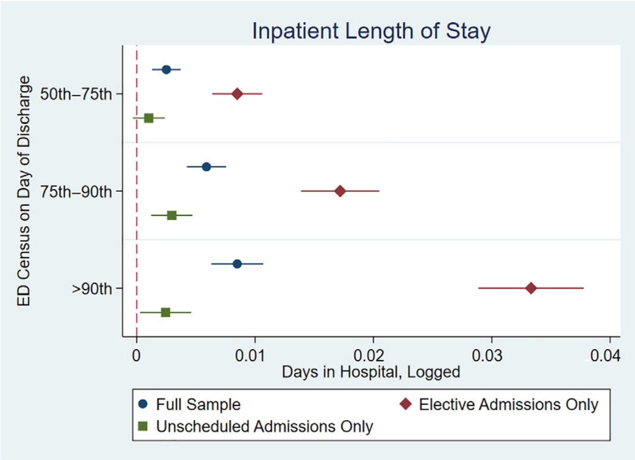

FIGURE 2 Association of emergency department (ED) census on day of inpatient discharge on log length of stay. Results from adjusted regression model with robust SEs. Controls for age, sex, diagnosis related group, discharge quarter, discharge year, admission from ED, Elixhauser comorbidities, discharge on a weekend, and hospital fixed effects. ED census on day of inpatient discharge is categorized based on percentile as indicated, based on ED census for the hospital, year, and day of week (weekday/weekend). *Source*: Authors' analyses of data from California's Department of Healthcare Access and Information (October 1, 2015 to December 31, 2017) [Color figure can be viewed at wileyonlinelibrary.com]

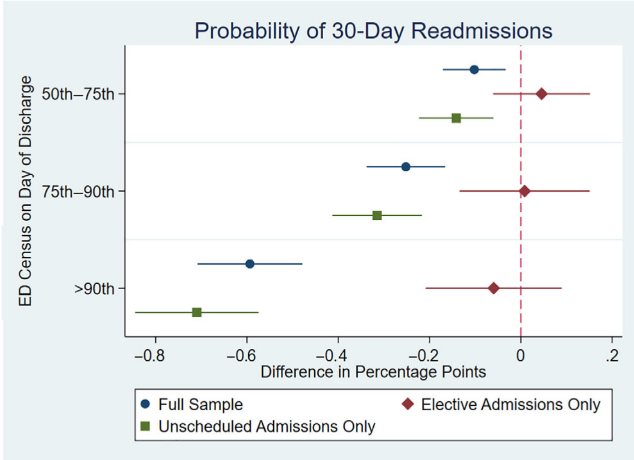

FIGURE 3 Probability of 30-day all cause readmission after inpatient discharge, by emergency department (ED) census on day of discharge. Linear probability model with robust SEs. Controls for age, sex, diagnosis related group, discharge quarter, discharge year, admission from ED, Elixhauser comorbidities, discharge on a weekend, and hospital fixed effects. ED census on day of inpatient discharge is categorized based on percentile as indicated, based on ED census for the hospital, year, and day of week (weekday/weekend). *Source*: Authors' analyses of data from California's Department of Healthcare Access and Information (October 1, 2015 to December 31, 2017) [Color figure can be viewed at wileyonlinelibrary.com]

(Table A3). [Correction added on 18 November 2022, after first online publication: '(odds rato [OR] 0.9%)', '(OR 2.4%)', and '(OR 5.6%)' of the preceding sentence have been corrected to '(or 0.9%)', '(or 2.4%)', and '(or 5.6%)', respectively, in this version.]

3.4 | ED census and in-hospital mortality

A mean of 2.6% of patients died during their inpatient stay (not shown). In adjusted analyses, the probability of mortality increased as ED census on the day of discharge increased (Figure 4). Specifically, compared to when ED census was below the median on the day of discharge, inpatients were 0.08 percentage points (or 3.1%) more likely to die when the ED was between the 50th–<75th percentile (95% CI: 0.0004–0.0011; $p < 0.001$), 0.10 percentage points (or 3.8%) more likely when the ED was between the 75th–<90th percentile (95% CI: 0.0006–0.0014; $p < 0.001$), and 0.14 percentage points (or 5.4%) more likely when the ED was in the 90th percentile (95% CI: 0.0009–0.0018; $p < 0.001$) (Table A4). [Correction added on 18 November 2022, after first online publication: '(OR 3.1%)', '(OR 3.8%)', and '(OR 5.4%)' of the preceding sentence have been corrected to '(or 3.1%)', '(or 3.8%)', and '(or 5.4%)', respectively, in this version.]

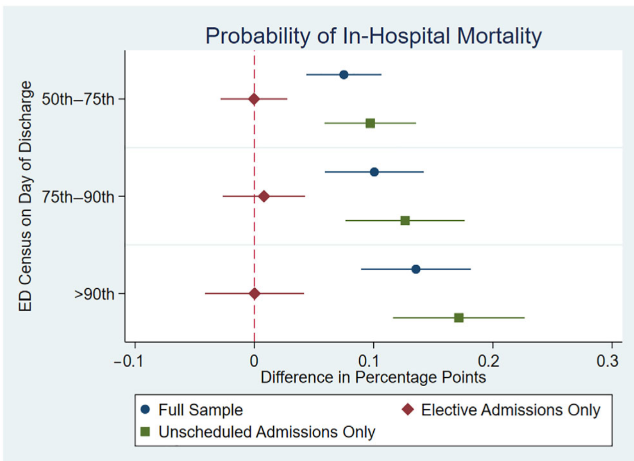

FIGURE 4 Emergency department (ED) census on day of inpatient discharge on in-hospital mortality. Results from adjusted linear probability model with robust SEs. Controls for age, sex, diagnosis related group, discharge quarter, discharge year, admission from ED, Elixhauser comorbidities, discharge on a weekend, and hospital fixed effects. ED census on day of discharge is categorized based on percentile as indicated, based on ED census for the hospital, year, and day of week (weekday/weekend). *Source*: Authors' analyses of data from California's Department of Healthcare Access and Information (October 1, 2015 to December 31, 2017) [Color figure can be viewed at wileyonlinelibrary.com]

3.5 | Elective and unscheduled admissions

We stratified analyses by whether patients had elective versus unscheduled admissions. For patients with an elective admission, who had an unadjusted mean length of stay of 4.1 days, higher ED census at discharge was associated with increased length of stay (50th–<75th percentile: 0.9% (95% CI: 0.6%–1.0%); 75th–<90th percentile: 1.8% (95% CI:

1.4%–2.1%); ≥90th percentile: 3.3% (95% CI: 2.9%–3.8%); all $p < 0.001$) (Figure 2). Similarly, patients with unscheduled admissions, who had an unadjusted mean length of stay of 5.4 days, had a longer length of stay when ED census at discharge was higher (75th–<90th percentile: 0.3% (95% CI: 0.1%–0.5%, $p = 0.001$); ≥90th percentile: 0.2% (95% CI: 0.3%–0.5%, $p = 0.027$)). ED crowding was not significantly associated with readmissions or in-hospital mortality for inpatients with elective admissions. For inpatients with unscheduled admissions, higher ED census on the day of discharge was associated with lower 30-day readmission (50th–<75th percentile: −0.14 percentage points [or 0.9%] [95% CI: −0.0022 to −0.0006; $p = 0.001$]; ≥90th percentile: −0.71 percentage points [or 5.1%] [95% CI: −0.0085 to −0.0057; $p < 0.001$]) (Figure 3). [Correction added on 18 November 2022, after first online publication: '(OR 0.9%)' and '(OR 5.1%)' of the preceding sentence have been corrected to '(or 0.9%)' and '(or 5.1%)', respectively, in this version.] For inpatients with unscheduled admissions, higher ED census on the day of discharge was also associated with higher in-hospital mortality (50th–<75th percentile: 0.10 percentage points [or 2.7%] [95% CI: 0.0006–0.0014; $p < 0.001$]; ≥90th percentile: 0.17 percentage points [or 5.4%] [95% CI: 0.0012–0.0023; $p < 0.001$]) (Figure 4). [Correction added on 18 November 2022, after first online publication: '(OR 2.7%)' and '(OR 5.4%)' of the preceding sentence have been corrected to '(or 2.7%)' and '(or 5.4%)', respectively, in this version.]

3.6 | Sensitivity analyses

Results from the sensitivity analyses were consistent with the main analysis. This was true even for the analysis that excluded inpatients admitted on the same day, meaning that our findings were consistent even for inpatients who were already admitted to the hospital at least a day before discharge (Appendix 3).

4 | DISCUSSION

Our study suggests that daily variation in ED crowding within a hospital was associated with changes in inpatient outcomes for *already-admitted* inpatients, namely increased inpatient length of stay, decreased readmissions, and increased mortality. Our original conceptual model was that ED crowding influences already-admitted inpatients both directly (through changes in inpatient discharge processes) and indirectly (through the influence of ED crowding on physician and nursing workload) (Figure 1).

Our results suggest the indirect route seems more relevant, although more research should be done to confirm this, particularly as more streamlined discharge processes including active bed management may also increase inpatient physician and staff workload. Consistent with the indirect pathway, we found that ED crowding was associated with a longer inpatient length of stay and a higher probability of death for already-admitted inpatients. The effect sizes of these associations were noticeable when ED census was highest, with a 3.3% longer length of stay for patients with elective admissions and a 5.4% higher probability of death for patients with unscheduled admissions.

Our study is consistent with the idea that when the ED is crowded, physicians and staff are inundated with demand for inpatient beds and services. This increased demand may increase workload, which in turn may delay discharge, leading to longer lengths of stay. For instance, hospitalists may be less able to discharge patients because they are managing ED and inpatient census.[47,61] This may help explain why there is a larger difference in length of stay for patients with elective admissions, for whom discharge planning is more easily anticipated and less complicated, often with a known disposition.

Our study also suggests that higher ED crowding may lead to higher mortality for patients who are sicker. Future studies can better examine the mechanism for this higher mortality. It could be that ED crowding leads to increased admissions from the ED, which increases physician and staff workload. Increased workload may explain why the mortality results are observed more for patients with unscheduled admissions, as these patients are generally less stable than patients with elective admissions, and may require more attention. It could also be that ED crowding increases ICU demand, which may lead to current ICU patients being more likely to be transferred out of the ICU. Perhaps premature transfer out of the ICU led to increased mortality, particularly if workload demands are high.

Our results were the opposite of our hypothesized direction for readmissions. Both the "indirect" and "direct" pathway hypothesized that ED crowding was associated with a higher readmission rate. In contrast, our analysis found a lower readmission rate for patients discharged on crowded days. This counter-intuitive result could be due to the change in which patients were discharged. Specifically, when workload is higher and cognitive burden larger, physicians may be more likely to make decisions that increase their productivity,[35] such as by inpatient physicians tending to discharge patients who are more stable, rather than spending time evaluating patients for whom discharge is not clearly indicated. If the patients being discharged are more stable than they would have been had workload not been as high, this may mean that they have lower readmission rates. In other words, perhaps higher ED occupancy is associated with lower readmissions because of selection bias in terms of which patients are being discharged. This post hoc explanation should be further tested with additional analyses, including whether different inpatients are discharged on days when the ED is crowded.

Many hospital administrators and policy makers see ED crowding as a problem specific to the ED,[62] despite the fact that ED crowding is often driven by a lack of inpatient beds.[13–15] Indeed, the Centers for Medicare and Medicaid Services has eliminated ED-2, a quality measure on ED boarding time from Hospital Compare, because of the belief that it has a limited association with patient mortality,[63] even though research suggests the association between ED crowding and mortality for patients admitted from the ED. Our study provides further evidence that ED crowding is a whole hospital problem. Specifically, our results suggest that ED crowding might be associated with inpatient outcomes *for already admitted patients*, including mortality, even for patients who never came through the ED. Indeed, this study supports the idea that ED crowding might be part of a feedback loop, where inpatient care influences ED crowding through bed availability, and ED crowding at discharge influences inpatient care. Given the complexity of the findings, further mixed methods research is critical to better understand the causal mechanism behind our results and the types of solutions that may best address issues related to ED crowding. In addition, future research can also examine whether the effect of ED crowding on inpatient outcomes varies by patient diagnosis, by race, or based on timing, that is, when during the hospital stay the ED is crowded.

Strengths of this study include that our definition of ED crowding is based on a hospital-specific measure, and our use of hospital-fixed effects, which means that we are comparing inpatient outcomes within a hospital based on daily variation in ED crowding, as opposed to differences in ED crowding across hospitals. In addition, our results were robust to the many sensitivity analyses conducted. However, like all studies, our study has limitations. First, because our data are hospital discharge data, we are limited by the variables available. For instance, our data lacked information about hour of admission or discharge; this may underestimate the influence of ED crowding on inpatient outcomes since we are not able to control for ED boarding times, observe changes in inpatient length of stay that is shorter than 1 day, or identify differences in outcomes associated with Friday morning versus afternoon. Our data also did not permit us to directly measure ED crowding; we instead followed the previous literature[49,50] using ED census as a proxy. While this may introduce measurement error, we do not think that it biases results since ED census has been shown to closely approximate ED crowding.[49,53] Furthermore, this error is likely minimal because our ED census measure is based on a hospital-level percentile, rather than mean, and we explicitly controlled for key factors that may influence ED crowding, including seasonality, day of the week, and hospital fixed effects, which account for any time-invariant hospitals characteristics that influence ED crowding. Finally, our data do not permit us to distinguish between observation and non-observation ED stays. This may also introduce measurement error; although it is likely minimal to the extent that ED census is correlated with observation stays since our ED census measure is a hospital-level percentile. In addition, because the majority of observation stays have an ED length of stay of less than 24 h,[64] lacking information on observation stays likely has a minimal effect on our results since results were robust when we treated all ED stays as if they were 24–48 h long.

Second, our length of stay outcome may reflect reverse causality. As mentioned above, previous research suggested that ED crowding is driven by lack of inpatient beds[13–15]; thus, inpatient length of stay may be driving ED crowding, rather than the reverse. However, we think this unlikely, since any reverse causality would appear only when the ED is most crowded, and our results suggest a "dose relationship" that does not indicate a change in trends when ED census is extremely high. Nonetheless, this study cannot fully disentangle the causal direction for the length of stay outcome; future research should address this concern.

Third, our study may have limited generalizability because it only includes a single state. Because California is the only state that mandates minimum nurse staffing ratios, our results may differ from states that do not have such a law. However, California accounts for 12% of the US population, making these results important. We used data from California because there are few other data sources that allow for an analysis of by-day ED census at the whole hospital (rather than just ED census of Medicare patients, for example).

5 | CONCLUSION

Our study suggests that ED crowding has a complex relationship with inpatient care, where ED crowding on the day of inpatient discharge resulted in a slightly longer length of stay and lower probability of readmission, but higher in-hospital mortality. This was true even for already-admitted inpatients. Our results support the idea that ED crowding is a whole hospital problem requiring multi-pronged solutions that hospital administrators and the health care system should address, but future research should explore the causal mechanism behind our results.

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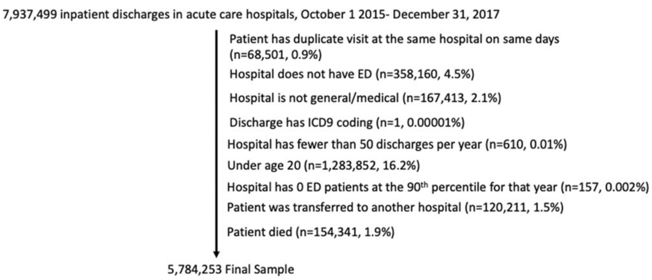
APPENDIX 1

FLOWCHART



APPENDIX 2

EMERGENCY DEPARTMENT CENSUS

In the main analysis, we did not have emergency department (ED) length of stay. To generate a hospital-specifical daily ED census, we assumed that ED patients were treated the same day (i.e., that length of stay was 1 day). To test this assumption, we analyzed data from the National Hospital Ambulatory Medical Care Survey (2015) to examine approximately how many ED visits were discharged the same day, versus a subsequent day. To do so, we calculated a patient's discharge date (based on arrival time and ED length of stay) and then calculated whether the discharge date was the same day as the arrival date.

Our results suggest that 93% of ED visits (both unweighted and weighted) were discharged within the same day.

APPENDIX 3

ADDITIONAL DESCRIPTIVE STATISTICS

1. Difference and percent difference in emergency department (ED) census between 50th and 90th percentile (in 2016)

Size	Weekend mean (minimum to maximum)		Weekday mean (minimum to maximum)	
	Difference in ED census	% Difference in ED census	Difference in ED census	% Difference in ED census
500+ beds	19 (16–27)	12% (7%–16%)	23 (19–29)	8% (7%–9%)
250–499 beds	25 (12–43)	13% (8%–29%)	23 (10–55)	13% (8%–22%)
100–249 beds	16 (7–34)	19% (10%–130%)	16 (7–34)	19% (9% to 132%)
<100 beds	10 (4–25)	24% (12%–45%)	10 (5–23)	26% (10%–76%)
Overall	18 (4–43)	18% (7%–132%)	18 (5–55)	18% (7%–132%)

2. ED crowding and inpatient admission (in 2016)

We examined the relationship between ED crowding and inpatient admission by looking at each hospital day in 2016 and calculating the daily inpatient admission volume. We then calculated the mean daily inpatient admission for each ED census category, stratified by hospital size. This table suggests that as the ED was more crowded, inpatient admission was higher.

Size	ED < median	ED 50th–<75th	ED 75th–90th	ED > 90th
500+ beds	74.4	77.0	78.3	81.7
250–499 beds	46.4	48.7	49.2	51.4
100–249 beds	20.6	21.7	22.4	23.1
<100 beds	7.0	7.6	7.5	7.8

3. Unconditional intraclass correlation (ICC)

Outcome	ICC
LOS	0.024
Mortality	0.003
Readmission	0.007

APPENDIX 4

SENSITIVITY ANALYSES

We conducted several sensitivity analyses.

First, we controlled for emergency department (ED) census on both the day of discharge and day before discharge. This was because our data did not contain hours, so we could not determine who might have been discharged at the beginning of the day versus the end of the day.

Second, we controlled for hospital-specific daily inpatient occupancy and the hospital-specific daily percent of inpatient admissions from the ED. Inpatient occupancy and the daily percent of inpatient admissions from the ED may be mediators of the relationship between ED census on the day of discharge and our outcomes (e.g., when ED occupancy is high, the hospital may reduce the number of inpatients admitted or the percent of admissions from the ED may be increased).

Third and fourth, we controlled for two possible confounders, payer and day of week.

Fifth, the main analysis included all inpatients. In the sensitivity analysis, we excluded patients who were admitted on the same day. These results, therefore, examine how ED census on the day of discharge influences only inpatients who were already admitted to the hospital.

Sixth, for the length of stay analysis, we examined whether results were robust when we restricted the analysis to just patients who were discharged home.

TABLE A1 Association of emergency department (ED) census on day of inpatient discharge on length of stay (logged)

a. Full sample	Main analysis, β (SE)	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)	Only patients discharged home, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	0.003 (0.001)***	0.003 (0.001)***	0.003 (0.001)***	0.003 (0.000)***	0.003 (0.001)***	0.002 (0.001)***	0.002 (0.001)**	0.005 (0.001)***	0.003 (0.001)***
75th–90th	0.006 (0.001)***	0.005 (0.001)***	0.007 (0.001)***	0.006 (0.001)***	0.007 (0.001)***	0.006 (0.001)***	0.004 (0.001)***	0.009 (0.001)***	0.006 (0.001)***
>90th	0.008 (0.001)***	0.006 (0.001)***	0.010 (0.001)***	0.009 (0.001)***	0.010 (0.001)***	0.009 (0.001)***	0.006 (0.001)***	0.014 (0.001)***	0.009 (0.001)***
N	5,784,253	7,062,172	5,784,253	5,784,253	5,776,721	5,784,253	5,784,253	5,658,146	3,881,629

b. Elective admissions	Main analysis, β (SE)	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)	Only patients discharged home, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	0.008 (0.001)***	0.008 (0.001)***	0.009 (0.001)***	0.008 (0.001)***	0.008 (0.001)***	0.008 (0.001)***	0.009 (0.001)***	0.011 (0.001)***	0.008 (0.001)***
75th–90th	0.017 (0.002)***	0.018 (0.002)***	0.018 (0.002)***	0.016 (0.002)***	0.016 (0.002)***	0.017 (0.002)***	0.017 (0.002)***	0.021 (0.002)***	0.015 (0.002)***
>90th	0.033 (0.002)***	0.032 (0.002)***	0.035 (0.002)***	0.031 (0.002)***	0.032 (0.002)***	0.033 (0.002)***	0.034 (0.002)***	0.040 (0.002)***	0.030 (0.002)***
N	1,166,434	1,214,737	1,166,434	1,166,434	1,165,121	1,166,434	1,166,434	1,138,397	867,276

c. Unscheduled admissions	Main analysis, β (SE)	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)	Only patients discharged home, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)*	0.001 (0.001)*	0.002 (0.001)*	0.001 (0.001)	0.000 (0.001)	0.003 (0.001)***	0.002 (0.001)
75th–90th	0.003 (0.001)**	0.003 (0.001)**	0.004 (0.001)***	0.004 (0.001)***	0.004 (0.001)***	0.003 (0.001)**	0.001 (0.001)	0.006 (0.001)***	0.003 (0.001)**
>90th	0.002 (0.001)	0.000 (0.001)	0.004 (0.001)	0.004 (0.001)***	0.004 (0.001)**	0.002 (0.001)*	0.000 (0.001)	0.008 (0.001)***	0.003 (0.001)*
N	4,616,329	4,855,745	4,616,329	4,616,329	4,610,110	4,616,329	4,616,329	4,518,303	3,013,327

Note: Results from adjusted linear regression model with robust SEs. Controls for age, sex, diagnosis related group, discharge quarter, discharge year, admission from ED, Elixhauser comorbidities, discharge on a weekend, and hospital fixed effects. ED census on day of discharge (and day before discharge) is categorized based on percentile as indicated, based on ED census for the hospital, year, and day of week (weekday/weekend).

*p < 0.05; **p < 0.01; *** < 0.001.

Source: Authors' analyses of data from California's Department of Healthcare Access and Information (October 1, 2015 to December 31, 2017).

TABLE A2 Association of emergency department (ED) census on day of and day before inpatient discharge on ED revisits

a. Full sample	Main analysis	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	−0.0000 (0.0002)	−0.0000 (0.0002)	−0.0000 (0.0002)	0.0000 (0.0002)	−0.0000 (0.0002)	−0.0000 (0.0002)	−0.0001 (0.0002)	−0.0001 (0.0002)
75th–90th	−0.0001 (0.0002)	−0.0000 (0.0002)	−0.0001 (0.0003)	−0.0001 (0.0002)	−0.0002 (0.0002)	−0.0001 (0.0002)	−0.0002 (0.0002)	−0.0003 (0.0002)
>90th	−0.0001 (0.0003)	−0.0000 (0.0002)	0.0001 (0.0003)	0.0002 (0.0003)	−0.0000 (0.0003)	0.0000 (0.0003)	−0.0001 (0.0003)	−0.0001 (0.0003)
N	5,784,253	7,062,172	5,784,253	5,784,253	5,776,721	5,784,253	5,784,253	5,658,146

b. Elective admissions	Main analysis	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	0.0000 (0.0004)	0.0001 (0.0004)	0.0000 (0.0004)	0.0000 (0.0004)	−0.0000 (0.0004)	−0.0000 (0.0004)	0.0000 (0.0004)	−0.0000 (0.0004)
75th–90th	0.0001 (0.0004)	0.0003 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0000 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	−0.0001 (0.0004)
>90th	0.0003 (0.0005)	0.0003 (0.0005)	0.0003 (0.0006)	0.0004 (0.0005)	0.0002 (0.0005)	0.0003 (0.0005)	0.0004 (0.0005)	0.0002 (0.0005)
N	1,166,434	1,214,737	1,166,434	1,166,434	1,165,121	1,166,434	1,166,434	1,138,397

c. Unscheduled admissions	Main analysis	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	−0.0000 (0.0002)	−0.0001 (0.0002)	−0.0000 (0.0002)	0.0000 (0.0002)	−0.0001 (0.0002)	−0.0000 (0.0002)	−0.0001 (0.0002)	−0.0001 (0.0002)
75th–90th	−0.0002 (0.0003)	−0.0001 (0.0003)	−0.0002 (0.0003)	−0.0001 (0.0003)	−0.0002 (0.0003)	−0.0002 (0.0003)	−0.0003 (0.0003)	−0.0003 (0.0003)
>90th	0.0000 (0.0003)	0.0001 (0.0003)	0.0001 (0.0003)	0.0002 (0.0003)	−0.0000 (0.0003)	0.0000 (0.0003)	−0.0002 (0.0003)	−0.0001 (0.0003)
N	4,616,329	4,855,745	4,616,329	4,616,329	4,610,110	4,616,329	4,616,329	4,518,303

Note: Results from adjusted linear regression model with robust SEs. Controls for age, sex, diagnosis related group, discharge quarter, discharge year, admission from ED, Elixhauser comorbidities, discharge on a weekend, and hospital fixed effects. ED census on day of discharge (and day before discharge) is categorized based on percentile as indicated, based on ED census for the hospital, year, and day of week (weekday/weekend).

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Source: Authors' analyses of data from California's Department of Healthcare Access and Information (October 1, 2015 to December 31, 2017).

TABLE A3 Association of emergency department (ED) census on day of and day before inpatient discharge on readmissions

	Main analysis	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
a. Full sample								
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	−0.0010 (0.0003)*	−0.0008 (0.0003)*	−0.0007 (0.0003)*	−0.0008 (0.0004)*	−0.0010 (0.0004)**	−0.0010 (0.0003)**	−0.0011 (0.0003)**	−0.0010 (0.0004)*
75th–90th	−0.0025 (0.0004)***	−0.0021 (0.0004)***	−0.0020 (0.0004)***	−0.0020 (0.0004)***	−0.0025 (0.0004)***	−0.0025 (0.0004)***	−0.0026 (0.0004)***	−0.0025 (0.0004)***
>90th	−0.0059 (0.0006)***	−0.0051 (0.0004)***	−0.0049 (0.0005)***	−0.0047 (0.0006)***	−0.0059 (0.0006)***	−0.0060 (0.0006)***	−0.0061 (0.0006)***	−0.0061 (0.0006)***
N	5,784,253	7,062,172	5,784,253	5,784,253	5,776,721	5,784,253	5,784,253	5,658,146
Adj R^2	0.0748	0.0925	0.0748	0.0751	0.0749	0.0763	0.0748	0.0739
b. Elective admissions								
	Main analysis	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	0.0005 (0.0005)	0.0006 (0.0005)	0.0005 (0.0005)	0.0006 (0.0005)	0.0004 (0.0005)	0.0004 (0.0005)	0.0004 (0.0005)	0.0003 (0.0005)
75th–90th	0.0001 (0.0007)	0.0001 (0.0007)	0.0002 (0.0007)	0.0003 (0.0007)	0.0001 (0.0007)	0.0001 (0.0007)	−0.0000 (0.0007)	0.0001 (0.0007)
>90th	−0.0006 (0.0008)	−0.0009 (0.0008)	−0.0003 (0.0008)	−0.0001 (0.0008)	−0.0006 (0.0008)	−0.0006 (0.0008)	−0.0007 (0.0008)	−0.0010 (0.0007)
N	1,166,434	1,214,737	1,166,434	1,166,434	1,165,121	1,166,434	1,166,434	1,138,397
Adj R^2	0.1271	0.1320	0.1271	0.1271	0.1271	0.1275	0.1271	0.1213
c. Unscheduled admissions								
	Main analysis	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	−0.0014 (0.0004)**	−0.0012 (0.0004)**	−0.0011 (0.0004)**	−0.0011 (0.0004)*	−0.0014 (0.004)**	−0.0014 (0.0004)**	−0.0014 (0.0004)**	−0.0014 (0.0004)**
75th–90th	−0.0031 (0.0005)***	−0.0030 (0.0005)***	−0.00025 (0.0005)***	−0.0025 (0.0005)***	−0.0032 (0.0005)***	−0.0032 (0.0005)***	−0.0032 (0.0005)***	−0.0031 (0.0005)***
>90th	−0.0071 (0.0007)***	−0.0070 (0.0007)***	−0.0060 (0.0006)***	−0.0057 (0.0007)***	−0.0072 (0.0007)***	−0.0071 (0.0007)***	−0.0072 (0.0007)***	−0.0072 (0.0007)***
N	4,616,329	4,855,745	4,616,329	4,616,329	4,610,110	4,616,329	4,616,329	4,518,303

Note: Results from adjusted linear regression model with robust SEs. Controls for age, sex, diagnosis related group, discharge quarter, discharge year, admission from ED, Elixhauser comorbidities, discharge on a weekend, and hospital fixed effects. ED census on day of discharge (and day before discharge) is categorized based on percentile as indicated, based on ED census for the hospital, year, and day of week (weekday/weekend).

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Source: Authors' analyses of data from California's Department of Healthcare Access and Information (October 1, 2015 to December 31, 2017).

TABLE A4 Association of emergency department (ED) census on day of and day before inpatient discharge on mortality

a. Full sample	Main analysis, β (SE)	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	0.0008 (0.0002)***	0.0005 (0.0001)***	0.0007 (0.0002)**	0.0007 (0.0002)***	0.0007 (0.0002)***	0.0008 (0.0002)***	0.0007 (0.0002)***	0.0006 (0.0002)***
75th–90th	0.0010 (0.0002)***	0.0008 (0.0002)***	0.0009 (0.0002)**	0.0009 (0.0002)***	0.0009 (0.0002)***	0.0010 (0.0002)***	0.0011 (0.0002)***	0.0008 (0.0002)***
>90th	0.0014 (0.0002)***	0.0012 (0.0002)***	0.0012 (0.0002)***	0.0012 (0.0002)***	0.0013 (0.0002)***	0.0014 (0.0002)***	0.0014 (0.0002)***	0.0011 (0.0002)***
N	5,938,594	7,219,660	5,938,594	5,938,594	5,930,853	5,938,594	5,938,594	5,801,032

b. Elective admissions	Main analysis, β (SE)	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	−0.0000 (0.0001)	0.0000 (0.0001)	−0.0000 (0.0001)	−0.0000 (0.0001)	−0.0000 (0.0001)	−0.0000 (0.0001)	−0.0000 (0.0001)	−0.0000 (0.0001)
75th–90th	0.0001 (0.0002)	−0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)
>90th	0.0000 (0.0002)	0.0001 (0.0002)	−0.0000 (0.0002)	−0.0000 (0.0002)	−0.0000 (0.0002)	0.0000 (0.0002)	−0.0000 (0.0002)	−0.0001 (0.0002)
N	1,171,221	1,219,584	1,171,221	1,171,221	1,169,898	1,171,221	1,171,221	1,142,915

c. Unscheduled admissions	Main analysis, β (SE)	Includes children, β (SE)	Includes ED census of previous day, β (SE)	Inpatient occupancy, β (SE)	% admission from ED, β (SE)	Payer, β (SE)	Day of week, β (SE)	Excludes inpatients admitted on the same day, β (SE)
<50th	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
50th–75th	0.0010 (0.0002)***	0.0008 (0.0002)***	0.0009 (0.0002)***	0.0009 (0.0002)***	0.0009 (0.0002)***	0.0010 (0.0002)***	0.0010 (0.0002)***	0.0008 (0.0002)***
75th–90th	0.0013 (0.0003)***	0.0012 (0.0002)***	0.0012 (0.0002)***	0.0012 (0.0002)***	0.0012 (0.0002)***	0.0013 (0.0003)***	0.0013 (0.0003)***	0.0010 (0.0002)***
>90th	0.0017 (0.0003)***	0.0018 (0.0003)***	0.0016 (0.0003)***	0.0016 (0.0003)***	0.0016 (0.0003)***	0.0017 (0.0003)***	0.0018 (0.0003)***	0.0014 (0.0003)***
N	4,765,840	5,006,166	4,765,840	4,765,840	4,759,422	4,765,840	4,765,840	4,656,632

Note: Results from adjusted linear regression model with robust SEs. Controls for age, sex, diagnosis related group, discharge quarter, discharge year, admission from ED, Elixhauser comorbidities, discharge on a weekend, and hospital fixed effects. ED census on day of discharge (and day before discharge) is categorized based on percentile as indicated, based on ED census for the hospital, year, and day of week (weekday/weekend).

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Source: Authors' analyses of data from California's Department of Healthcare Access and Information (October 1, 2015 to December 31, 2017).