

# Health Affairs

At the Intersection of Health, Health Care and Policy

Cite this article as:

Charles Liu, Tanja Srebotnjak and Renee Y. Hsia  
California Emergency Department Closures Are Associated With Increased Inpatient  
Mortality At Nearby Hospitals  
*Health Affairs*, 33, no.8 (2014):1323-1329

doi: 10.1377/hlthaff.2013.1203

The online version of this article, along with updated information and services, is  
available at:

<http://content.healthaffairs.org/content/33/8/1323.full.html>

**For Reprints, Links & Permissions:**

[http://healthaffairs.org/1340\\_reprints.php](http://healthaffairs.org/1340_reprints.php)

**E-mail Alerts :** <http://content.healthaffairs.org/subscriptions/etoc.dtl>

**To Subscribe:** <http://content.healthaffairs.org/subscriptions/online.shtml>

*Health Affairs* is published monthly by Project HOPE at 7500 Old Georgetown Road, Suite 600, Bethesda, MD 20814-6133. Copyright © 2014 by Project HOPE - The People-to-People Health Foundation. As provided by United States copyright law (Title 17, U.S. Code), no part of *Health Affairs* may be reproduced, displayed, or transmitted in any form or by any means, electronic or mechanical, including photocopying or by information storage or retrieval systems, without prior written permission from the Publisher. All rights reserved.

Not for commercial use or unauthorized distribution

By Charles Liu, Tanja Srebotnjak, and Renee Y. Hsia

# California Emergency Department Closures Are Associated With Increased Inpatient Mortality At Nearby Hospitals

DOI: 10.1377/hlthaff.2013.1203  
HEALTH AFFAIRS 33,  
NO. 8 (2014): 1323–1329  
©2014 Project HOPE—  
The People-to-People Health  
Foundation, Inc.

**ABSTRACT** Between 1996 and 2009 the annual number of emergency department (ED) visits in the United States increased by 51 percent while the number of EDs nationwide decreased by 6 percent, which placed unprecedented strain on the nation's EDs. To investigate the effects of an ED's closing on surrounding communities, we identified all ED closures in California during the period 1999–2010 and examined their association with inpatient mortality rates at nearby hospitals. We found that one-quarter of hospital admissions in this period occurred near an ED closure and that these admissions had 5 percent higher odds of inpatient mortality than admissions not occurring near a closure. This association persisted whether we considered ED closures as affecting all future nearby admissions or only those occurring in the subsequent two years. These results suggest that ED closures have ripple effects on patient outcomes that should be considered when health systems and policy makers decide how to regulate ED closures.

**Charles Liu** is a medical student at Harvard Medical School, in Boston, Massachusetts.

**Tanja Srebotnjak** is a senior fellow at the Ecologic Institute, in San Mateo, California.

**Renee Y. Hsia** (renee.hsia@emergency.ucsf.edu) is an associate professor in the Department of Emergency Medicine and the Institute of Health Policy Studies, University of California, San Francisco.

**B**etween 1996 and 2009 the annual number of visits to emergency departments (EDs) in the United States increased by 51 percent, from 90.3 million<sup>1</sup> to 136.1 million.<sup>2</sup> During the same period the number of EDs nationwide decreased by 6 percent, from 4,884 to 4,594.<sup>3</sup> These trends have contributed to increased ED crowding and wait times,<sup>4,5</sup> overextension of ED staff,<sup>6</sup> and the diversion of ambulance traffic from busy EDs.<sup>7,8</sup> All of this prompted the Institute of Medicine to conclude, in a 2007 report, that EDs in the United States are “at the breaking point.”<sup>9</sup>

ED closures pose a particular threat to the care of vulnerable populations. Because they are required by law to care for all comers, EDs often play the role of the “safety net of the safety net” for patients without access to regular medical care.<sup>10</sup> Yet communities with higher proportions of residents who are enrolled in Medicaid, have low incomes, and belong to racial or ethnic mi-

nority groups are at heightened risk of having their local ED close.<sup>11,12</sup>

Furthermore, EDs and trauma centers—which often experience greater financial pressures than their parent hospitals overall<sup>13</sup>—are more likely to close at hospitals with negative profit margins and less likely to close at hospitals that receive more generous Medicare reimbursements compared to their peer institutions.<sup>14</sup> Therefore, ED closures may widen disparities by further reducing access to care in communities that are already characterized by having vulnerable patients and underpaid hospitals.

Recent studies have shown that ED crowding<sup>7,15</sup> and increased distance to the nearest ED<sup>16</sup> are associated with worse patient outcomes. However, we know of no analysis that has investigated the ripple effects of ED closures on surrounding communities. Most previous studies have also limited their analyses to patients with acute myocardial infarction (AMI) and other time-sensitive conditions.<sup>7,16,17</sup>

We examined the association between ED closures and inpatient mortality for all patients receiving care in hospitals located near EDs that closed. We hypothesized that ED closures would be associated with a heightened risk of inpatient mortality for patients who were hospitalized nearby.

## Study Data And Methods

**DATA SOURCES** We used the California Office of Statewide Health Planning and Development's Hospital Annual Utilization Data files for the period 1999–2010 to identify hospital characteristics and the incidence and timing of ED closures. We excluded all hospitals whose license category was not general acute care. We defined an *ED closure* as the closure of a hospital with a basic or comprehensive ED license or such a hospital's conversion of its ED license to a stand-by or no ED license.

We verified closure dates through phone calls to hospital administrators and public health authorities. We also searched newspaper and local government archives, a process that identified three additional closures. In eight cases, an ED closure was timed to coincide with the simultaneous opening of a new ED serving the same community; we did not count these events as ED closures.

We obtained data on patient characteristics and inpatient mortality from the nonpublic files on patient discharge data from the California Office of Statewide Health Planning and Development for the period 1999–2010. The patient admission was our unit of analysis.

We excluded admissions not made via the ED (for example, elective surgeries and transfers from other hospitals), because nearby ED closures likely affect these admissions differently than admissions made via the ED. For example, if a nearby ED closure affected admitted patients' outcomes by increasing resource constraints and crowding at a hospital's ED, elective admissions to that hospital would not be affected because they bypass the ED.

We also excluded admitted patients younger than age eighteen, because their outcomes may be influenced by additional factors and should be studied separately. As was done in previous studies,<sup>7,16,17</sup> we excluded admitted patients whose residential ZIP codes were not in California, since they were likely not residents of the area in which they were hospitalized. Our study was approved by the Committee on Human Research at the University of California, San Francisco.

**GEOGRAPHICAL DEFINITION OF AREAS AFFECTED BY CLOSURES** We defined the *geographic area*

*affected by an ED closure* as the hospital service area (HSA) in which the ED was located. HSAs are groups of ZIP codes organized by the Dartmouth Atlas Project to reflect hospitalization patterns of Medicare beneficiaries.<sup>18</sup>

We assigned each hospital to an HSA using hospital ZIP codes and the 1999–2010 ZIP code–HSA crosswalk files from the Dartmouth Atlas Project. This allowed us to determine which HSAs experienced closures in each month of our twelve-year study period.

**COVARIATES** To adjust for factors that could confound the relationship between ED closures and inpatient mortality, we included in our multivariate regression model multiple patient- and hospital-level covariates that have been used in previous analyses of the effects of ED closures and crowding.<sup>15,17</sup> These include demographic characteristics such as the patient's age, race or ethnicity, and insurance coverage and the median income of the patient's ZIP code of residence.

To adjust for the severity of the patient's illness, we also included Elixhauser comorbidities for each patient<sup>19</sup> based on his or her *International Classification of Diseases*, Ninth Revision, Clinical Modification (ICD-9-CM), diagnosis codes. This allowed us to control for the possibility that apparent increases in mortality at hospitals near an ED closure were simply the result of the redistribution of sicker patients to these hospitals.

In addition, we included hospital characteristics such as case-mix index (a measure of overall patient severity), hospital ownership, and urban or rural location. Finally, we clustered patients within hospitals, since patients admitted to the same hospital will have correlated outcomes as a result of similar hospital and physician practice styles, and we included a fixed-effects variable for calendar year to control for secular trends in inpatient mortality.

**STATISTICAL METHODS** Having created both a file containing admissions assigned to HSAs and a file of ED closure events by HSA and month, we coded all admissions as “affected” (if there was a previous ED closure in the admitting hospital's HSA) or “unaffected” (if there was no previous ED closure in the HSA). We then carried out multivariate logistic regression analysis using the statistical software SAS, version 9.2.

Our dependent variable was mortality during the inpatient hospital stay, and the primary predictor of interest was whether the admitting hospital was affected by a previous ED closure in its HSA. The model also included all of the covariates described above.

**SENSITIVITY ANALYSES** We prespecified three sensitivity analyses to verify the robustness of our approach and to examine the potentially

# These findings suggest the need to study and consider interventions that minimize ED closures in vulnerable neighborhoods.

differential effect of ED closure on specific inpatients. For the sake of efficiency, we conducted these analyses on a simple random sample of 2,039,084 admissions taken from the full data set.

Since our primary analysis defined an HSA as *affected* indefinitely after an ED closure in that HSA, our first sensitivity analysis was to repeat our analysis defining an HSA as *affected* for only the two-year period immediately following an ED closure. This choice of a two-year period follows previous literature, which has shown a stronger association between ED closures and outcomes in the first two years.<sup>16</sup>

We also conducted subgroup analyses on two age-stratified groups of adult patients (non-elderly adults, those ages 18–64; and elderly adults, those ages 65 and older), and on patients with four specific time-sensitive conditions defined in the previous literature (AMI, stroke, asthma or chronic obstructive pulmonary disease, and sepsis) to determine if ED closures had differential effects on these patients.<sup>17,20</sup>

**LIMITATIONS** Our study had several limitations.

►**DATA FROM ONLY ONE STATE:** First, our analysis was limited to ED closures in California. Although California contains 12 percent of the US population, it differs demographically from the United States as a whole. For example, the proportion of black residents is much lower in California and the proportion of other nonwhite minorities much higher, compared to the whole country. Therefore, our findings might not be generalizable to other parts of the United States, especially states whose demographics differ substantially from those of California.

►**RETROSPECTIVE ANALYSIS:** Second, ours was a retrospective analysis that used administrative data. Thus, the increase in mortality that we observed in patients visiting hospitals affect-

ed by a nearby ED closure could have been a result of confounding factors not included in our model. For example, increased socioeconomic strife in a neighborhood along dimensions not captured by our covariates might drive both ED closure and increased inpatient mortality in that area.

We attempted to minimize this potential confounding through numerous mechanisms. One mechanism was including clustering by hospital and year fixed effects to analyze changes in mortality, within the same hospital before and after it was affected by a closure, that were above and beyond changes caused by general secular trends. Furthermore, we included Elixhauser comorbidities in an effort to standardize the effects for patients with a similar severity of illness. We also included demographic characteristics such as race, median income in patients' ZIP codes, and insurance coverage to attempt to standardize patient-level socioeconomic influences on mortality.

However, our ability to control for confounding factors was limited by the categories of administrative data available. This means that the possibility of some degree of residual confounding will always exist.

Additionally, we realize that there is a potential alternative causal pathway through which increased mortality near ED closures could be observed: Otherwise sicker patients—that is, those who are sicker in ways not captured by the Elixhauser comorbidities—could be redirected to nearby institutions from the EDs that closed. To specifically investigate this potential alternative mechanism, we compared mortality rates during the year before a closure at hospitals with EDs that would close in the following year with rates at hospitals whose EDs stayed open. We found no significant difference in mortality rates between these two groups (for a detailed plot illustrating this comparison, see online Appendix Exhibit A1).<sup>21</sup> This indicates that sicker patients were not redistributed to nearby hospitals and that our effect was likely the result of system stresses following an ED closure.

►**SOME PATIENT DEATHS NOT CAPTURED:** Third, our data did not capture patients who died before they could generate a hospital admission. For example, a severely ill patient who is likely to die shortly after admission and who lives in the vicinity of an ED closure might delay seeking care because of the closure and thus be more likely to die at home. Alternatively, such a patient might seek care but experience a longer ED travel or wait time, and thus be more likely to die en route or in the ED. In either scenario, this patient's outcome would be counted as one inpatient death if the person were unaffected by an

25%

**Had an ED closure**

During the study period, 24.9 percent of admissions had an ED closure in their hospital service area.

ED closure but as no death if he or she were affected by a closure.

This limitation tends to reduce the observed mortality rate in the affected admission group. As a result, our estimate of the increased odds of inpatient mortality associated with ED closure should be considered conservative.

► **IMPERFECT SURROGATES FOR LOCALITIES:** Fourth, HSAs reflect geographic patterns of hospitalization, but they are not perfect surrogates for the area around an ED that is affected by its closure. In urban areas with high hospital density, affected HSAs likely included some hospitals

that did not receive any redirected patients from the closed ED. Conversely, in rural areas with low hospital density, patients redirected from a closed ED probably often presented to hospitals outside the affected HSA and were thus not captured in our analysis. The fact that our affected group may have included some unaffected admissions and excluded some affected admissions again means that our estimate of the increased odds of inpatient mortality associated with ED closure is likely to be conservative.

## Study Results

The final data set consisted of 16,246,892 admissions to California hospitals via the ED during the period 1999–2010. In this period there were forty-eight ED closures in California—twenty-six in which the parent hospital also closed and twenty-two in which it remained open while the ED closed.

Based on an unadjusted comparison of these two groups, we found that affected admissions were more likely than unaffected admissions to be of non-Hispanic black patients, Hispanic patients, women, and nonelderly adults (Exhibit 1). They were also more likely to be paid for by Medicaid or to be uninsured or self-pay admissions. In addition, median household income was lower in the ZIP codes of patients with affected versus unaffected admissions. Patients with affected admissions were sicker, with higher rates of twenty-four out of the twenty-nine Elixhauser comorbidities.<sup>19</sup> Finally, affected admissions were more likely than unaffected admissions to be admitted to government-owned (for example, county) hospitals.

After we adjusted for patient and hospital characteristics, we found that admissions affected by ED closure experienced higher odds of inpatient mortality than unaffected admissions (odds ratio: 1.05; 95% confidence interval: 1.02, 1.07; see Exhibit 2). In our sensitivity analysis that classified admissions as affected only when they occurred within two years of an ED closure in their HSA, we also found increased mortality for patients affected by ED closure (OR: 1.04; 95% CI: 1.02, 1.07; see Appendix Exhibit A2).<sup>21</sup>

When we stratified our analysis by age, non-elderly patients (those ages 18–64) whose admissions were affected by ED closure had an even greater increase in the odds of inpatient mortality than patients in the main model (OR: 1.10; 95% CI: 1.03, 1.16). Elderly patients (those ages sixty-five and older) affected by ED closure also had increased odds of inpatient mortality (OR: 1.05; 95% CI: 1.00, 1.10). However, this association fell just short of statistical significance (see Appendix Exhibit A3).<sup>21</sup>

### EXHIBIT 1

#### Admissions That Were Unaffected Or Affected By An Emergency Department (ED) Closure Within Their Hospital Service Area (HSA) In California, 1999–2010

Characteristic	Unaffected		Affected	
	Number	Percent	Number	Percent
<b>PATIENT LEVEL</b>				
Sex				
Male	6,595,105	54.1	2,118,718	52.3
Female	5,603,017	45.9	1,929,614	47.7
Unknown or invalid	337	0.0	101	0.0
Age (years)				
18–44	2,436,014	20.0	916,444	22.6
45–64	3,459,249	28.4	1,270,487	31.4
65–74	2,035,226	16.7	627,427	15.5
75–84	2,594,770	21.3	743,516	18.4
85 or more	1,673,200	13.7	490,559	12.1
Race or ethnicity				
White, non-Hispanic	7,239,001	59.3	2,032,642	50.2
Black, non-Hispanic	1,118,087	9.2	526,176	13.0
Hispanic	2,573,041	21.1	1,013,581	25.0
Other <sup>a</sup>	1,076,435	8.8	423,564	10.5
Unknown, invalid, or missing	191,895	1.6	52,470	1.3
Insurance status				
Private	2,892,342	23.7	902,144	22.3
Medicare	6,257,169	51.3	1,903,066	47.0
Medi-Cal (Medicaid)	1,842,222	15.1	742,343	18.3
Uninsured or self-pay	961,207	7.9	411,079	10.2
Other	242,096	2.0	89,049	2.2
Missing	3,423	0.0	752	0.0
Elixhauser comorbidities <sup>b</sup>				
Hypertension	5,805,979	47.6	2,039,414	50.4
Fluid and electrolyte disorders	2,882,018	23.6	992,032	24.5
Deficiency anemias	2,243,995	18.4	815,763	20.2
Median household income (\$)	53,766	— <sup>c</sup>	50,258	— <sup>c</sup>
<b>HOSPITAL LEVEL</b>				
Hospital ownership				
Not for profit	9,217,000	75.6	2,893,407	71.5
For profit	2,105,339	17.3	676,344	16.7
Government	876,120	7.2	478,682	11.8

**SOURCE** Authors' analysis of data from the California Office of Statewide Health Planning and Development. **NOTES** Of the admissions, 12,198,459 (75.1 percent) were unaffected—that is, there was no ED closure in the HSA—and 4,048,433 (24.9 percent) were affected. All differences between affected and unaffected admissions were significant ( $p < 0.001$ ). <sup>a</sup>Asian, Pacific Islander, and Native American. <sup>b</sup>Only the three most common Elixhauser comorbidities are listed. Appendix Exhibit A5 (see Note 21 in text) lists all twenty-nine Elixhauser comorbidities. <sup>c</sup>Not applicable.

In our final sensitivity analysis we found that patients admitted with AMI, stroke, or sepsis experienced a greater increase in odds of inpatient mortality when affected by ED closure, compared to the general patient population (OR: 1.15; 95% CI: 1.05, 1.27 for AMI; OR: 1.10; 95% CI: 1.03, 1.17 for stroke; and OR: 1.08; 95% CI: 1.03, 1.13 for sepsis; see Appendix Exhibit A4).<sup>21</sup> Patients admitted because of asthma or chronic obstructive pulmonary disease did not experience higher odds of inpatient death when affected by ED closure (OR: 0.97; 95% CI: 0.84, 1.13).

## Discussion

We found that patients admitted to hospitals in the vicinity of an ED closure (affected hospitals) experienced 5 percent greater odds of inpatient mortality than patients admitted to unaffected hospitals. This adverse association persisted even when we carried out a sensitivity analysis that limited our definition of affected admissions to those occurring at affected hospitals within two years of the ED closure.

In contrast to many past studies, we used ED closures themselves as our independent variable, instead of measures of ED crowding or change in travel time to the nearest ED. This allowed us to investigate the possibility that closures influenced outcomes in ways not captured by changes in these surrogate variables.

We also used the hospital service area as a novel approach to defining the area around an ED closure in which ripple effects might feasibly occur. In this way, we focused our analysis on detecting such effects in a geographic area that was determined by documented patterns of inpatient care use.

As our dependent variable, we examined inpatient mortality of all patients instead of mortality of only patients with time-sensitive conditions. We did this because we recognized the possibility that the redistribution of patients after an ED closure would also affect patients at those hospitals with nonurgent conditions via more generalized crowding effects. Furthermore, by examining statewide hospital discharge data instead of Medicare claims data, we were able to study the outcomes of all patients, not just elderly ones.

**EFFECTS OF CLOSURES** An ED closure could affect patient care in various ways. For example, closures could increase travel times, wait times, or crowding at EDs in the surrounding area. Closures could also lead some affected patients to delay seeking care, at which point their condition might be less responsive to life-saving interventions.<sup>22</sup> Our study examined the overall

## EXHIBIT 2

### Adjusted Association Between Emergency Department (ED) Closure And Inpatient Mortality In California, 1999–2010

	Number	Percent	Adjusted OR	95% CI
<b>ED CLOSURE IN HOSPITAL SERVICE AREA</b>				
No	12,198,459	75.1	Ref	Ref
Yes	4,048,433	24.9	1.05	1.02, 1.07
<b>PATIENT-LEVEL COVARIATES<sup>a</sup></b>				
Race or ethnicity				
White, non-Hispanic	9,271,643	57.1	Ref	Ref
Black, non-Hispanic	1,644,263	10.1	0.90	0.90, 0.91
Hispanic	3,586,622	22.1	0.94	0.93, 0.95
Other <sup>b</sup>	1,499,999	9.2	1.02	1.01, 1.03
Unknown, invalid, or missing	244,365	1.5	1.14	1.11, 1.18
Insurance status				
Private	3,794,486	23.4	Ref	Ref
Medicare	8,160,235	50.2	1.00	1.00, 1.01
Medi-Cal (Medicaid)	2,584,565	15.9	1.07	1.05, 1.08
Uninsured or self-pay	1,372,286	8.4	0.95	0.92, 0.98
Other	331,145	2.0	0.96	0.94, 0.98
Missing	4,175	0.0	1.07	1.00, 1.15
Elixhauser comorbidities <sup>c</sup>				
Hypertension	7,845,393	48.3	0.83	0.82, 0.83
Fluid and electrolyte disorders	3,874,050	23.8	1.68	1.65, 1.71
Deficiency anemias	3,059,758	18.8	0.91	0.91, 0.92
<b>HOSPITAL-LEVEL COVARIATES</b>				
Hospital ownership				
Not for profit	12,110,407	74.5	Ref	Ref
For profit	2,781,683	17.1	0.99	0.92, 1.07
Government	1,354,802	8.3	1.34	1.20, 1.49

**SOURCE** Authors' analysis of data from the California Office of Statewide Health Planning and Development. **NOTES** Adjusted for patient and hospital characteristics, as well as clustering by hospital and year fixed effects. OR is odds ratio. CI is confidence interval. <sup>a</sup>Only selected patient-level covariates are listed. Appendix Exhibit A6 (see Note 21 in text) lists additional patient-level covariates that were included in the regression analysis. <sup>b</sup>Asian, Pacific Islander, and Native American. <sup>c</sup>Only the three most common Elixhauser comorbidities are listed. The odds ratio was calculated for each comorbidity in reference to admissions without that comorbidity. Appendix Exhibit A6 lists all twenty-nine Elixhauser comorbidities.

impact of ED closures on patient outcomes. However, we could not disentangle the specific mechanisms by which closures might contribute to increased inpatient mortality.

We found that the increase in odds of inpatient mortality associated with ED closure was greater among nonelderly adults (10 percent) and patients with AMI (15 percent), stroke (10 percent), and sepsis (8 percent), compared to the general patient population (5 percent). The results for patients with AMI, stroke, and sepsis corroborate the findings of past studies of ED crowding and increased drive time to the nearest ED.<sup>7,16,17</sup> This may reflect these patients' susceptibility to experiencing worse outcomes if it takes them longer to receive medical attention. Nonelderly adults, in contrast, may be more likely than elderly patients to delay seeking care after an ED closure or may be disproportionately affected by

closures through some other mechanism.

ED closures affect a large proportion of communities, as evidenced by the fact that 24.9 percent of admissions in the study period had an ED closure in their HSA, and the distribution of closures is not uniform. Past studies have shown that hospitals serving higher proportions of black patients, Medicaid beneficiaries, and patients living in poverty are at higher risk of closing their EDs<sup>11,23</sup> and that communities with higher proportions of Hispanic and low-income patients are more likely to experience deterioration in ED access.<sup>12</sup>

**POLICY IMPLICATIONS** Combined with the results of these past studies, our findings indicate that disproportionate numbers of ED closures may be driving up inpatient mortality in communities and hospitals with more minority, Medicaid, and low-income patients and contributing to existing disparities in health outcomes.<sup>24</sup> These findings suggest the need to study and consider interventions that minimize ED closures in vulnerable neighborhoods. Potential solutions include improving reimbursement to EDs for the care of indigent patients and preventing ED closures that are likely to increase patient mortality significantly.

Whether or not to limit ED closures or regulate which EDs are permitted to close is a complex, multifactorial decision that must be weighed by communities and policy makers. However, our findings regarding the ripple effect of closures on surrounding communities suggest that it may be time to reassess the extent to which market forces are allowed to dictate ED closures and access.

Proposals to regulate the closure of EDs are not new: Patient advocates called for such regulation as long as three decades ago.<sup>25</sup> Current policy on this matter differs by state. For example, Illinois requires hospitals to operate an ED as a requirement for licensure, but Arizona has no such regulation.<sup>26</sup> In 1998 the California legislature amended the state's Health and Safety

## It may be time to reassess the extent to which market forces are allowed to dictate ED closures and access.

Code to require that a hospital conduct an impact evaluation and hold a public hearing before closing or downgrading its ED.<sup>27</sup> However, a proposal to strengthen this law by prohibiting ED closures that would “not be in the best interest of the general public” failed to pass in the following legislative session.<sup>28</sup>

Regulatory interventions can be difficult to enact and implement. Nonetheless, our findings indicate that policies such as requiring a hospital to show that surrounding communities would retain adequate access to emergency care before allowing it to close an ED could save lives and reduce disparities.

### Conclusion

We found that ED closures were associated with a 5 percent increase in the odds of inpatient mortality at the remaining hospitals in the closure's hospital service area. The associated increase in odds of mortality was even greater for nonelderly patients and patients with time-sensitive conditions such as AMI, stroke, and sepsis. Further research is necessary to elucidate the mechanisms underlying this association and the appropriateness of interventions to regulate ED closures. ■

This research was supported by the National Center for Advancing Translational Sciences, National Institutes of Health, through the University of California, San Francisco, Clinical and Translational Science Institute (Grant No. KL2TR000143;

principal investigator: Renee Hsia), and by the Robert Wood Johnson Foundation Physician Faculty Scholars Program (principal investigator: Renee Hsia). The contents of the article are solely the responsibility of the authors and do not necessarily represent the official views

of any of the funding agencies. The authors thank Amy J. Markowitz for her editorial assistance, Judy Maselli for her help with the analysis, and Julia Brownell for her editorial and technical support.

## NOTES

- 1 McCaig LF, Stussman BJ. National Hospital Ambulatory Medical Care Survey: 1996 emergency department summary. *Adv Data*. 1997;(293):1–20.
- 2 National Center for Health Statistics. National Hospital Ambulatory Medical Care Survey: 2009 emergency department summary tables [Internet]. Hyattsville (MD): NCHS; [cited 2014 Jun 4]. Available from: [http://www.cdc.gov/nchs/data/ahcd/nhamcs\\_emergency/2009\\_ed\\_web\\_tables.pdf](http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2009_ed_web_tables.pdf)
- 3 American Hospital Association. *TrendWatch* chartbook 2012: Appendix 3, Table 3.3. Chicago (IL): AHA; 2012.
- 4 Pitts SR, Pines JM, Handrigan MT, Kellermann AL. National trends in emergency department occupancy, 2001 to 2008: effect of inpatient admissions versus emergency department practice intensity. *Ann Emerg Med*. 2012;60(6):679–86.
- 5 Lambe S, Washington DL, Fink A, Laouri M, Liu H, Scura Fosse J, et al. Waiting times in California's emergency departments. *Ann Emerg Med*. 2003;41(1):35–44.
- 6 Derlet RW, Richards JR. Overcrowding in the nation's emergency departments: complex causes and disturbing effects. *Ann Emerg Med*. 2000;35(1):63–8.
- 7 Shen YC, Hsia RY. Association between ambulance diversion and survival among patients with acute myocardial infarction. *JAMA*. 2011;305(23):2440–7.
- 8 Pham JC, Patel R, Millin MG, Kirsch TD, Chanmugam A. The effects of ambulance diversion: a comprehensive review. *Acad Emerg Med*. 2006;13(11):1220–7.
- 9 Institute of Medicine. *Hospital-based emergency care: at the breaking point*. Washington (DC): National Academies Press; 2007.
- 10 Tang N, Stein J, Hsia RY, Maselli JH, Gonzales R. Trends and characteristics of US emergency department visits, 1997–2007. *JAMA*. 2010;304(6):664–70.
- 11 Hsia RY, Srebotnjak T, Kanzaria HK, McCulloch C, Auerbach AD. System-level health disparities in California emergency departments: minorities and Medicaid patients are at higher risk of losing their emergency departments. *Ann Emerg Med*. 2012;59(5):358–65.
- 12 Shen YC, Hsia RY. Changes in emergency department access between 2001 and 2005 among general and vulnerable populations. *Am J Public Health*. 2010;100(8):1462–9.
- 13 Eastman AB, Rice CL, Bishop G, Richardson JD. An analysis of the critical problem of trauma center reimbursement. *J Trauma*. 1991;31(7):920–5.
- 14 Shen YC, Hsia RY, Kuzma K. Understanding the risk factors of trauma center closures: do financial pressure and community characteristics matter? *Med Care*. 2009;47(9):968–78.
- 15 Sun BC, Hsia RY, Weiss RE, Zingmond D, Liang LJ, Han W, et al. Effect of emergency department crowding on outcomes of admitted patients. *Ann Emerg Med*. 2013;61(6):605–11.
- 16 Shen YC, Hsia RY. Does decreased access to emergency departments affect patient outcomes? Analysis of acute myocardial infarction population 1996–2005. *Health Serv Res*. 2012;47(1 Pt 1):188–210.
- 17 Hsia RY, Kanzaria HK, Srebotnjak T, Maselli J, McCulloch C, Auerbach AD. Is emergency department closure resulting in increased distance to the nearest emergency department associated with increased inpatient mortality? *Ann Emerg Med*. 2012;60(6):707–15.
- 18 Dartmouth Atlas of Health Care. Data by region [Internet]. Lebanon (NH): Dartmouth Institute for Health Policy and Clinical Practice; c2014 [cited 2014 Jun 4]. Available from: <http://www.dartmouthatlas.org/data/region/>
- 19 Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36(1):8–27.
- 20 Carr BG, Conway PH, Meisel ZF, Steiner CA, Clancy C. Defining the emergency care sensitive condition: a health policy research agenda in emergency medicine. *Ann Emerg Med*. 2010;56(1):49–51.
- 21 To access the Appendix, click on the Appendix link in the box to the right of the article online.
- 22 Lee JE, Sung JH, Ward WB, Fos PJ, Lee WJ, Kim JC. Utilization of the emergency room: impact of geographic distance. *Geospat Health*. 2007;1(2):243–53.
- 23 Hsia RY, Kellermann AL, Shen YC. Factors associated with closures of emergency departments in the United States. *JAMA*. 2011;305(19):1978–85.
- 24 Smedley BD, Stith AY, Nelson AR, editors. *Unequal treatment: confronting racial and ethnic disparities in health care*. Washington (DC): National Academies Press; 2003.
- 25 Rose MG. Can hospital relocations and closures be stopped through the legal system? *Health Serv Res*. 1983;18(4):551–74.
- 26 Malone RE, Dohan D. Emergency department closures: policy issues. *J Emerg Nurs*. 2000;26(4):380–3.
- 27 California Legislative Information. Assembly Bill No. 2103 [Internet]. Sacramento (CA): State of California; [cited 2014 Jun 5]. Available from: [https://leginfo.ca.gov/faces/billTextClient.xhtml;jsessionid=48d06508119a7c9381e28cc9439e?bill\\_id=201120120AB2103](https://leginfo.ca.gov/faces/billTextClient.xhtml;jsessionid=48d06508119a7c9381e28cc9439e?bill_id=201120120AB2103)
- 28 California Legislative Information. Assembly Bill No. 421 [Internet]. Sacramento (CA): State of California; [cited 2014 Jun 10]. Available from: [http://www.leginfo.ca.gov/pub/99-00/bill/asm/ab\\_0401-0450/ab\\_421\\_bill\\_19990427\\_amended\\_asm.pdf](http://www.leginfo.ca.gov/pub/99-00/bill/asm/ab_0401-0450/ab_421_bill_19990427_amended_asm.pdf)