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## California hospitals serving large minority populations were more likely than others to employ ambulance diversion

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### Abstract

We evaluate whether hospitals serving a higher proportion of minorities experience disproportionate emergency department crowding, as proxied by ambulance diversion. In 202 hospitals across California, the median number of annual diversion hours was 374. After controlling for hospital characteristics, hospitals at the tenth percentile of fraction of minority visitors were on diversion only seventy-five hours per year, compared with hospitals at the ninetieth percentile, with 306 annual diversion hours. Emergency department crowding disproportionately affects minorities, and may contribute to health disparities in these communities. These findings suggest that establishing more uniform criteria regulating diversion may be one step toward decreasing disparities in access to emergency care.

### Keywords

Disparities; Organization and Delivery of Care; Public Health; Safety-Net Systems

### Introduction

Disparities in health care, including poorer outcomes experienced by racial and ethnic minorities, are well documented in the United States.<sup>1-6</sup> One possible contributor to health disparities is differential access to timely emergency care. Although minority populations disproportionately use emergency departments for safety net care,<sup>7</sup> there are limited data about the association between hospitals serving a large portion of minorities and access to emergency care. Specifically, no studies have observed whether emergency department crowding disproportionately affects minority populations.

Examining disparities in the acute care system is important, as utilization trends have strained the emergency care delivery system.<sup>8</sup> The number of nonrural emergency departments dropped 27 percent from 1990 to 2009,<sup>9</sup> while the number of visits to such facilities increased 40 percent.<sup>10</sup> Moreover, emergency department closures affect minority

populations more, as financial pressures force hospitals in low socioeconomic status communities to close.<sup>9,11</sup>

Ambulance diversion rates are often used as a proxy for emergency department overcrowding.<sup>18</sup> Ambulances are diverted to other facilities when an emergency department is too crowded to safely care for new patients.<sup>12,13</sup> Diversion is an increasingly common occurrence; it has been estimated that approximately one ambulance is diverted every minute in the United States.<sup>13</sup> Beyond indicating overcrowding, diversion is harmful in itself, as it increases time to definitive care and is associated with poor outcomes for patients with certain conditions, for instance acute myocardial infarction.<sup>14</sup> If crowding and subsequent diversion occurs disproportionately among hospitals serving minority populations, they may suffer poorer outcomes.<sup>15-17</sup>

We examined ambulance diversion data across all hospitals providing emergency services in the state of California in 2007. We hypothesized that hospitals serving high proportions of minority populations have disproportionately overcrowded emergency departments, as indicated by higher ambulance diversion rates.

## Methods

### Conceptual model

As described by Asplin et al.,<sup>18</sup> emergency departments provide three kinds of care: emergency care (where the patient needs immediate treatment for a potentially life-threatening condition), unscheduled urgent care (where the patient seeks after-hours treatment for an acute but non-life-threatening condition, such as a painful ear infection), and safety-net care (where the patient uses the emergency department because of a lack of access to primary care or specialty services). Since ambulances typically transport patients needing true emergency care, diversion reroutes the neediest patients away from their nearest hospital, representing a failure of the system to provide the intended care.

We included hospital-level summaries of patient characteristics that are known to be associated with emergency department utilization including the: race, age, gender, income, and insurance status of emergency department visitors to individual hospitals.<sup>11,19-21</sup> This allowed us to obtain a granular analysis of local demographics rather than simply using data at the county level.

As a measure of emergency department capacity, we calculated the ratio of daily emergency department visits to emergency department beds. Some hospitals may report hallway beds that are constantly in use and others may not.

To measure hospital capacity, known to be a major blockage in patient throughput,<sup>18,22</sup> we calculated the ratio of annual inpatient admissions to staffed bed-days. Finally, we prespecified our model to include hospital characteristics that have been associated with emergency department crowding in other literature, including ownership (county, for-profit, or not-for-profit), trauma center status, teaching status, and operating margin.<sup>23</sup>

### Study Design and Population

This retrospective cohort study included all emergency departments at acute, nonfederal hospitals operating in California in 2007. The study cohort includes hospitals that offer either basic or comprehensive emergency department services,<sup>24</sup> based on California's Office of Statewide Health Planning and Development (OSHPD) data. As defined by the California Code of Regulations (Title 22, Division 5, Sections 70413-70419), basic services include a 24-hour presence of an emergency physician on call. A comprehensive ED

includes 24-hour presence of certain specialist surgeons (thoracic, neurosurgery, orthopedics, and pediatric) and provides burn care, dialysis, and cardiovascular surgery. We excluded freestanding emergency departments and hospitals with standby emergency department services either because they were not staffed by medical doctors or they were not open twenty-four hours a day. Additionally, we excluded pediatric hospitals given that they generally do not treat adult patients, and hospitals whose emergency departments were not open for all of 2007. Finally, certain counties forbid the practice of ambulance diversion for either the entire county or certain hospitals. Therefore, we excluded all hospitals and counties that did not allow ambulance diversion for the full year of 2007 (n=86 hospitals, and 28 counties) and analyzed only hospitals where diversion was allowed for all of 2007, giving n=202 hospitals in 20 counties. Characteristics of included and excluded counties and hospitals are included in Appendix 1, with no significant differences except in population density and hospital ownership.

This study was approved by the California Committee for Protection of Human Subjects, the University of California Los Angeles Institutional Review Board, and the University of California San Francisco Committee on Human Research.

### Data sources

We linked data from the Emergency Medical System (EMS) agencies in 20 California counties allowing diversion in 2007, OSHPD, the US Census,<sup>25</sup> and the Area Resource File.<sup>26</sup>

Each EMS system provided electronic logs that contained information on all episodes of diversion, including: facility, date, duration in minutes, and reason for diversion. For the purposes of this analysis, we excluded diversion episodes for causes other than emergency department saturation, such as internal disaster and unavailability of specialty services (for instance, trauma, cardiac catheterization lab, computed tomography imaging). All episodes of ambulance diversion were aggregated to generate annual facility-specific summaries of diversion hours.

Four of the EMS systems were missing data due to software upgrades; three underwent such upgrades for two to four weeks and one for three months. For these, we estimated the annual diversion hours by inflating available diversion data proportionate to the amount of missing data. Systems issues were the only cause for missing data. Because the distribution of annual diversion hours was highly skewed, we transformed this variable to log (annual diversion hours+1) prior to analysis.

Each EMS system implemented unique diversion policies for specific counties or hospitals. The directors of all EMS systems verified their diversion policies for the year 2007 (some of which have subsequently changed). We included only those hospitals where diversion was allowed for all of 2007.

We obtained OSHPD non-public use files for all emergency department visits in 2007. All non-federal hospitals in California are mandated to report visit-level data on emergency department encounters that did not result in hospitalization (Emergency Discharge Data, or EDD), emergency department encounters that did result in hospitalizations (Patient Discharge Data, or PDD), and hospital-level structural and financial characteristics to OSHPD on an annual basis. Hospital financial and structural data were extracted from year 2007 OSHPD public-use files. Further details on the creation of the analytic cohort are presented in Appendix 2.

## Outcome Measure

The primary outcome of this study was the annual number of diversion hours in 2007 for each hospital in the cohort. Diversion data is self-reported annually to OSHPD, however, this information underestimates the true diversion hours when compared with reports by local EMS agencies.<sup>27</sup> Therefore, we used the “gold standard” ambulance diversion data directly from EMS agencies for the twenty counties. Our own comparisons using actual ambulance diversion data with self-reported data from hospitals were similar, although as reported elsewhere<sup>27</sup> were slightly lower when they differed from the actual EMS reports, likely due to more conservative estimates when personnel filled out the forms rather than using actual data.

## Minority population

We calculated the proportion of minorities treated by the emergency department of each hospital by aggregating all visits from the EDD and PDD from OSHPD in 2007 to the facility level. Minority population was determined by calculating what percentage of all patients with known race/ethnicity were non-White, as done in our previous work.<sup>23</sup> This definition includes traditionally underrepresented minorities (African Americans and Hispanics) as well as Asians, Pacific Islanders, Native Americans, and any other category designated as “other.”

## Covariates

We constructed other socioeconomic characteristics identified in our Conceptual Model, by creating facility-specific socioeconomic status profiles by aggregating episode-level OSHPD data from all emergency department visits in 2007 for age, gender, insurance, and income.<sup>29</sup> Insurance was categorized into four groups: (i) private; (ii) Medicare; (iii) Medi-Cal and uninsured/self-pay; and (iv) other (including Worker's Compensation, other federal programs, automobile, or disability coverage). Patient income is not available in the hospital patient data. Instead, we imputed the median household income reported for a patient's residential ZIP code from the 2000 U.S. Census socioeconomic data. This method of using aggregate information from the Census as a proxy for individual socioeconomic status has been verified in previous studies.<sup>28,30</sup> We averaged these within each hospital to calculate the facility mean of the ZIP code median income.

For hospital structure and process characteristics identified in the Conceptual Model that could affect ambulance diversion and crowding, we used the public-use utilization and financial databases from OSHPD. Hospital structural characteristics include teaching hospital (yes=1), trauma center (1 for Level 1 or 2 trauma designation, otherwise 0), two indicators for ownership (county, for-profit, or not-for-profit),<sup>23</sup> and operating margin. Operating margin was defined as net from operations divided by total operating revenue. This definition has been used in the economic literature to identify financially distressed hospitals.<sup>31</sup> We generated proxy measures of demand relative to supply for emergency department and for inpatient services. For emergency department demand relative to supply, we divided the number of daily emergency department visits by the number of emergency department treatment stations. For inpatient demand relative to supply, we divided the total number of patient bed-days by licensed bed-days, which is equivalent to the mean inpatient occupancy rate. These proxy measures of demand are modeled on Reeder and Garrison's methods of assessing overcrowding in EDs.<sup>32</sup>

Finally, we acquired county population for 2007 from the 2008 Area Resource File,<sup>26</sup> which includes statistics from numerous health professional organizations including the Centers for Medicare and Medicaid Services as well as the Bureau of Labor Statistics. We calculated population density and transformed it with a log transformation because it is skewed.

## Statistical analysis

To identify hospital-level factors associated with ambulance diversion, we fit hierarchical multivariate models. The outcome was log (annual diversion hours + 1), and the unit of analysis was the hospital. To account for clustering of hospitals by county, our models included a random county effect. In other words, our model contains a separate level for each county. To improve interpretability of the results, we provide back-transformed coefficients corresponding to percentage changes in (annual diversion hours plus one).

We identified a single outlier with 5,087 annual diversion hours (58 percent of 8,760 possible hours in a year), which was almost 70 percent higher than the facility with the next highest diversion hours. Diversion hours reported from the EMS agency and in OSHPD were concordant for this facility. In exploratory analysis, the qualitative interpretation of all variables except inpatient occupancy was unchanged when this outlier was removed.

To illustrate the effects of each factor on annual diversion hours, we estimated annual diversion at the 10th and 90th percentile value of each continuous factor while holding other covariates fixed. We held categorical variables at the modal values, using the most common value of each variable to calculate predicted diversion hours. To investigate effects of categorical variables, we varied each variable separately. We used SAS 9.2 (Cary, NC) for all analyses, and multivariate modeling was performed using SAS Proc Mixed.

## Limitations

This study has several potential limitations. Diversion is an imperfect measure of crowding and may fail to capture more accurate specifications of crowding. Diversion prevents access to the ED only for patients arriving via ambulance. Approximately 70 percent of patients are transported to the ED by private vehicle or walk-in and lawfully cannot be turned away.<sup>33</sup> Even when an emergency department is on diversion, certain patients--depending on the rules governing the particular emergency medical services system--can still be brought to a hospital. For example, if a hospital is the only trauma center in the county, that particular hospital may divert only non-trauma patients and still accept trauma patients. Thus, diversion does not completely reroute all emergency department volume. However, diversion has face and construct validity, and has been proposed as a candidate measure for emergency department crowding given that it is simple, objective, and readily-measured.<sup>34,35</sup> Furthermore, diversion is a barrier to access for patients being transported by ambulance independent of crowding. Other crowding indices have been reported, including the Emergency Department Work Index,<sup>36</sup> the National Department Overcrowding Scale,<sup>37</sup> the Real-time Emergency Analysis of Demand Indicators,<sup>38</sup> and the Work Scale.<sup>39</sup> However, these formula-based scales require input on various patient and operational measures, such as patient acuity, emergency department and hospital occupancy rates, and provider staffing, and are limited by their complexity, need for specialized data measurement, and lack of reproducibility.<sup>40,41</sup>

Second, there were ten hospitals that were missing race data in more than 20 percent of patients. We found that the majority of missing data were in the emergency department data file (patients who were not admitted). In a sensitivity analysis, we imputed the race data for hospitalized patients to non-hospitalized patients for these ten hospitals. There were no qualitative differences in our results.

Finally, our data are limited to California and therefore may not generalize elsewhere.

## Results

Characteristics of the 20 counties and the 202 hospitals in our study are presented in Exhibit 1. The mean number of hours on diversion for these hospitals was 724 per year (SD 889), with a median of 374 (IQR 52–1082) and a range of 0–5088. The distribution of annual diversion hours within county is illustrated in Exhibit 2. There is substantial inter- and intra-county variation in annual diversion hours. The magnitude of intra-county variance increases as a function of the median diversion hours. Appendix 3 illustrates the distribution of annual diversion hours for the 202 hospitals that were allowed to divert. Our multivariate model is presented in Exhibit 3. Hospitals serving high proportions of minority populations, our main predictor, were at higher risk of experiencing diversion (mean ratio 1.02 for each 1 percent increase in minority emergency department visitors [95% CI: 1.00, 1.04]). When we calculated the predicted number of annual hours on diversion for the hospitals with the tenth and ninetieth percentile of minority emergency department visitors, holding all others constant at their mean, hospitals at the 90<sup>th</sup> percentile of percent of minority emergency department visitors experienced 306 hours (95% CI: 104, 899) of annual diversion, which is 4.1 times (95% CI: 1.26, 13.3) that of hospitals serving the tenth percentile of percent of minority emergency department visitors, which experienced only seventy-five hours (95% CI: 27, 210).

## Discussion

Our study provides a unique hospital-level analysis of how vulnerable populations are affected by emergency department crowding in California. We found that hospitals serving minorities were more likely to divert, even when controlling for hospital ownership, emergency department capacity, and other hospital-level demographic and structural factors. Other studies have examined system-level predictors of diversion,<sup>13,29,42,43</sup> but none have evaluated the association of diversion with race/ethnicity. Our results indicating disproportionate diversion from hospitals serving greater numbers of minority patients are concerning given that ambulance diversion has been associated with poorer health outcomes.<sup>17</sup>

The disparate effect of diversion on hospitals serving a large proportion of minorities may indicate a fundamental mismatch in supply and demand of emergency department services. Minority populations may live in areas where there are fewer emergency departments or trauma centers and thus may face higher rates of emergency department crowding and consequent diversion. This is concordant with literature suggesting that both emergency departments and trauma centers are closing more frequently in areas with vulnerable populations, including racial and ethnic minorities,<sup>44,45</sup> and that non-White patients have longer lengths of stay when admitted to the hospital.<sup>46</sup>

Our findings take on increased urgency as our study establishes a higher prevalence and raw number of diversion hours in California than previously reported in national studies.<sup>22,29</sup> Almost all hospitals that could be on diversion were so in 2007 (188 out of 202, or 92 percent). Three potential explanations for the comparatively high levels of diversion hours in our study could be that (i) we used more recent data, suggesting that emergency department crowding could be worsening, (ii) that California experiences more crowding than most states, or (iii) we used actual EMS data rather than self-reported data from state or regional agencies. This final point highlights another important contribution of this work, given the increased accuracy of using computerized tracking data from each local EMS agency and calculation of diversion hours. Finally, these results add to the literature of alternative measures of emergency department crowding. These studies also indicate that emergency

department crowding is worsening nationally when measured by the rate of patients who leave without being seen,<sup>23</sup> wait times,<sup>47</sup> and length of stay.<sup>48</sup>

Our findings provide substantive evidence on which to base policy decisions concerning ambulance diversion. It is known that hospitals have different thresholds to activate diversion.<sup>49</sup> It is precisely this variation, along with our findings, that allows us to conclude that system-level policies regulating ambulance diversion provides policy-makers, healthcare providers, and hospital administrations may help reduce diversion and its associated inequalities. Indeed, statewide and national efforts have been undertaken to implement no-diversion policies, although none yet in California.<sup>50,51</sup> There have been individual attempts in various counties to reduce crowding and encourage a higher threshold for activating diversion, but there are no statewide criteria regulating diversion policies.

Although “diversion ban” policies address only a symptom of the larger problem of emergency department crowding (and diversion is only a symptom crowding issues), banning diversion may force hospitals to examine issues such as hospital flow, which may contribute to emergency department crowding.<sup>8,52</sup> Preliminary data from Massachusetts's ban on diversion, implemented as of January 2009, reveal that thus far the policy has created no significant increases in waiting times. This may be due to improvements in hospital flow mechanisms that are regionally applied.<sup>53,54</sup> EMS agencies and regional health authorities could reduce diversion with more carefully crafted policies such as explicit criteria for enacting diversion, limiting its duration and frequency, and requiring hospital CEOs to approve diversion episodes.<sup>55</sup>

Our study provides evidence that minority patients in the acute care system disproportionately experience crowding when measured by ambulance diversion. Our findings suggest that disparities arise from “upstream” causes before patients reach their hospital destination and that intervention at this level to decrease disparities may be warranted.

## Appendix 1

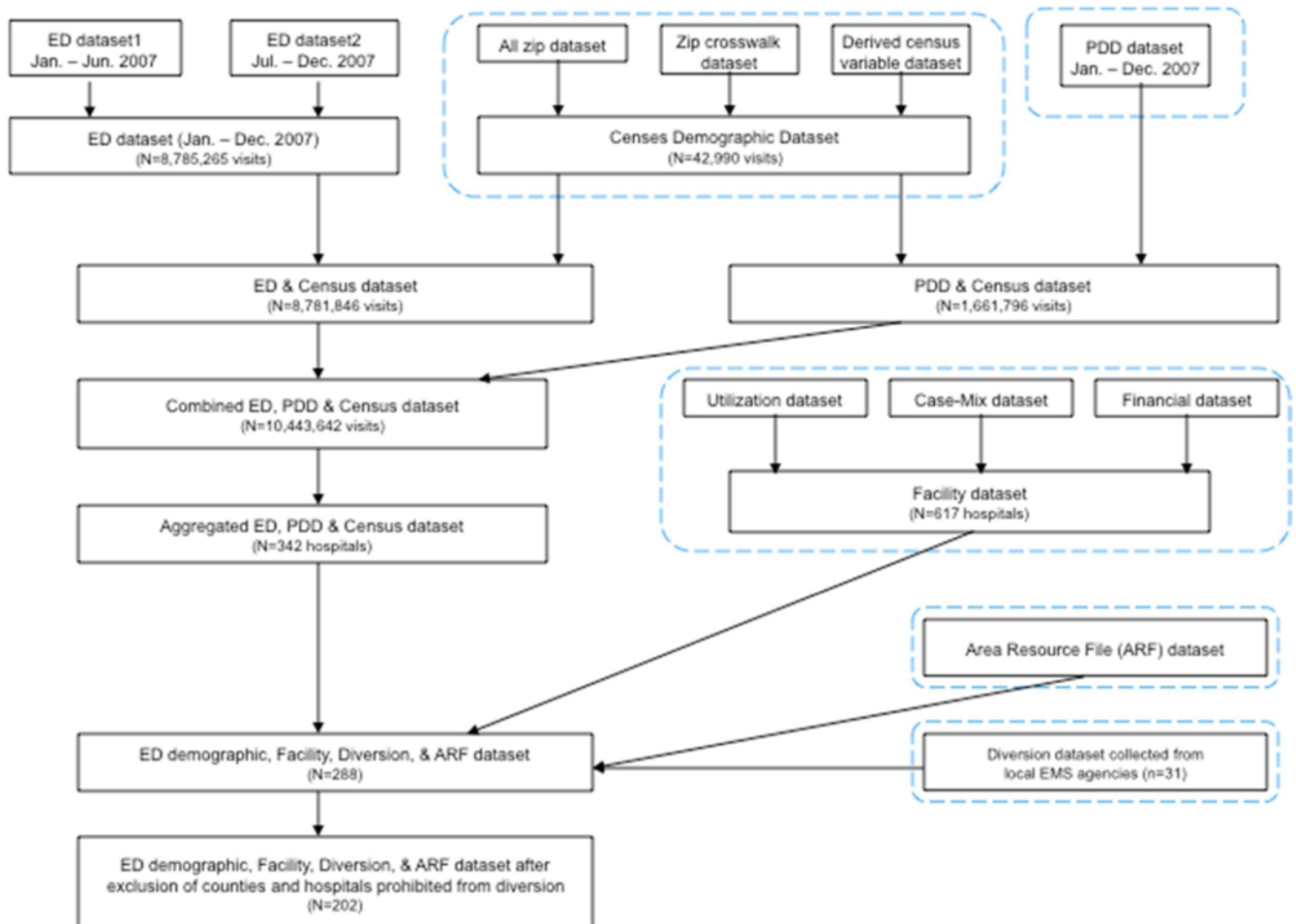
### Characteristics of Included and Excluded Hospitals\*

Variable	Included	Excluded	p-value
Number of Counties	20	28	
Number of Hospitals in County			
With 1 hospital	0	13	
With 2 hospitals	4	5	
With >2 hospitals	16	10	
Number of Hospitals	214	74	
<b>Hospital-Level Mean Profile of ED Visitors</b>			
Age (Years, SD)	38.91 (7.41)	38.66 (7.09)	0.7985
Male (% , SD)	46.37 (3.45)	46.24 (3.05)	0.7739
Non-White (% , SD)	53.38 (23.16)	39.09 (23.88)	<.0001
Income (in \$1000, SD)	48.92 (12.15)	43.83 (11.94)	0.002
Insurance - Med-Cal+Uninsured (% , SD)	40.87 (19.94)	42.61 (18.78)	0.5041
Operating Margin (% , SD)	-1.88 (18.78)	2.33 (13.55)	0.0539
Population Density (Log Scal per Sq Mile, SD)	7.00 (1.36)	4.91 (1.30)	<.0001

Variable	Included	Excluded	p-value
Ratio of ED visits to ED beds per day (SD)	4.83 (1.43)	5.24 (1.81)	0.0835
Inpatient occupancy rate (% , SD)	62.5 (45.4)	59.8 (16.9)	0.4695
Hospital Characteristics			
Teaching Hospital (n, %)	20 (9)	2 (3)	0.0637
Ownership (n, %)*			0.0032
County	13 (6)	4 (5)	
For Profit	57 (27)	6 (8)	
Non Profit	144 (67)	64 (87)	
Trauma Center (%)	34 (16)	8 (11)	0.2861

\* We studied 48 unique counties in our dataset; while there are 58 counties in California, 10 counties did not have eligible hospitals (no hospitals, or no hospitals with basic/comprehensive EDs).

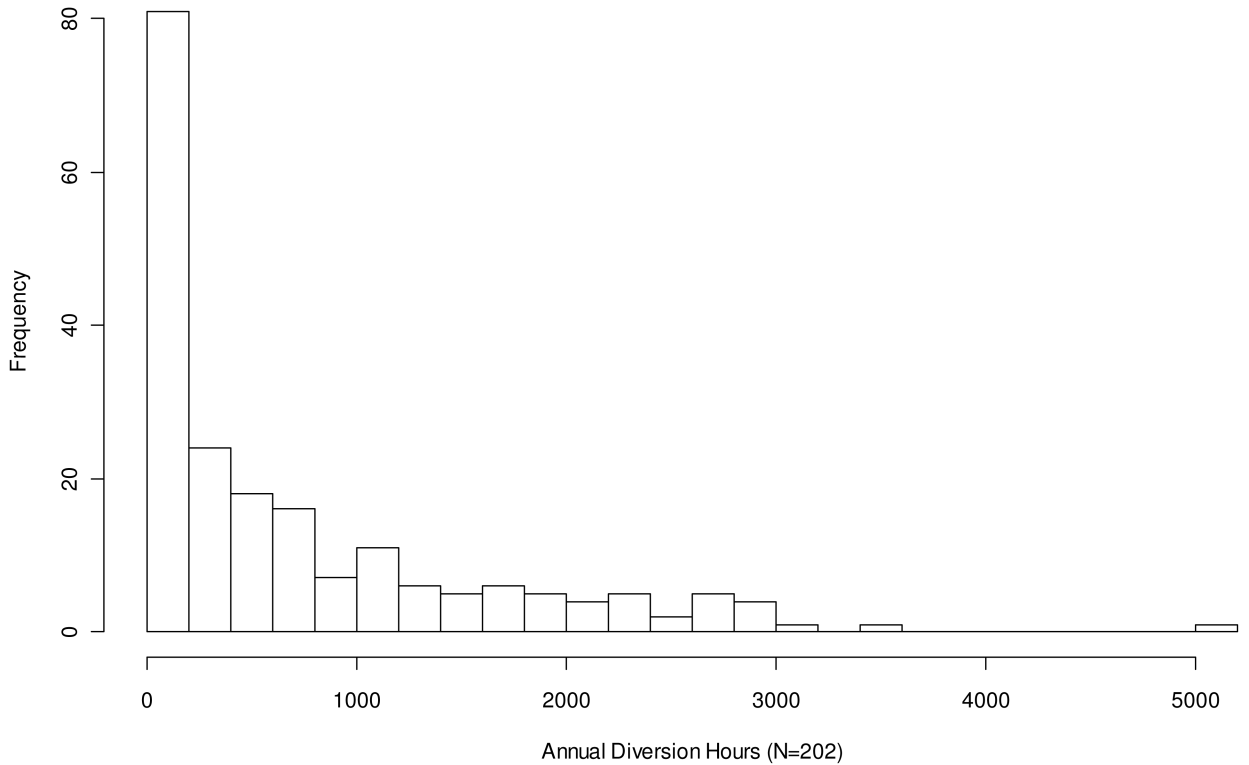
### Appendix 2



Creation of analytic cohort



### Appendix 3



Histogram of Annual Diversion Hours (N=202; “frequency” represents number of hospitals)

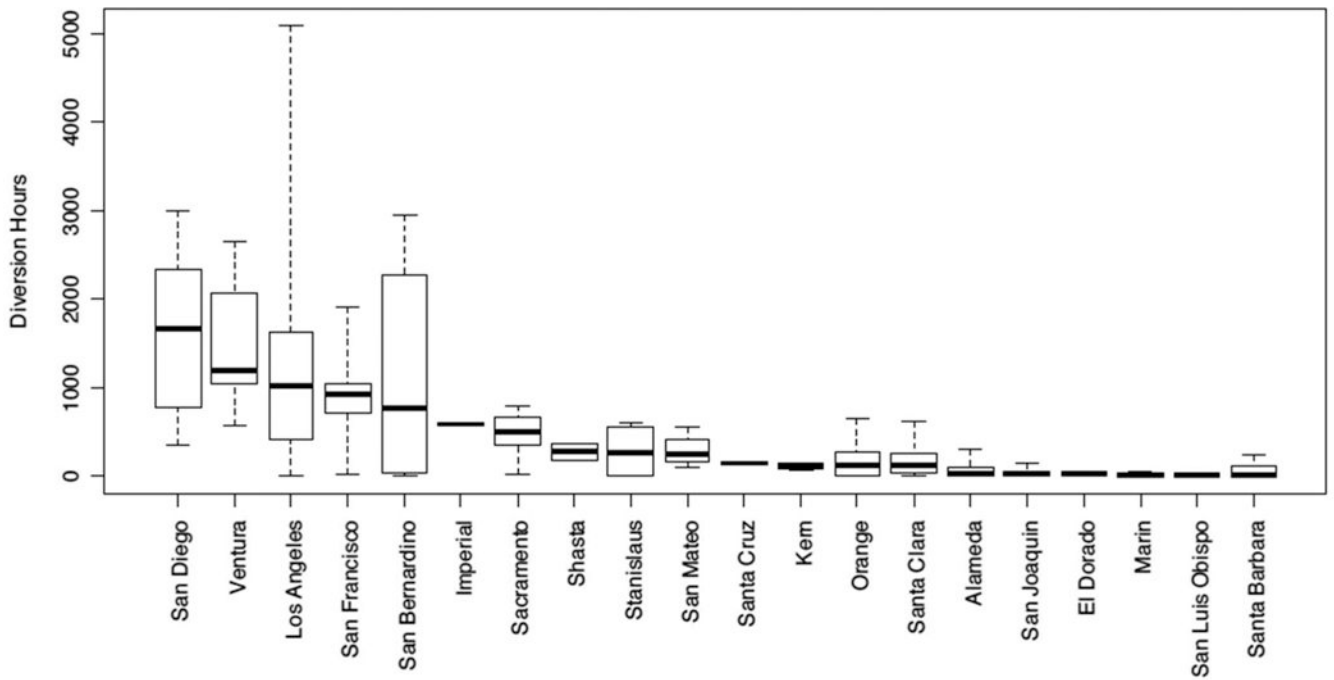
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**Exhibit 2.**

Boxplots of diversion hours in the 20 counties in California allowing diversion

*Source:* Authors' analysis of California OSHPD, U.S. Census Bureau & Area Resource File data as cited above (references 26 & 27)

**Exhibit 1**

Characteristics of included California Counties and Hospitals in 2007

*Source:* Authors analysis of California OSHPD, U.S. Census Bureau & Area Resource File data as cited above (references 26 & 27)

<b>Description of counties</b>	
<b>Number of Counties</b>	20
<b>With 1 Hospital</b>	0
<b>With 2 Hospitals</b>	4
<b>With &gt; 2 Hospitals</b>	16
<b>Number of Hospitals</b>	202
<b>Total Number of ED Visits</b>	7,148,712
<b>Hospital Mean (SD)</b>	
<b>Age (Yr)</b>	39.91 (7.41)
<b>Male (%)</b>	46.37 (3.45)
<b>Non-White Visitors (%)</b>	53.38 (23.16)
<b>Income (in \$1000)</b>	48.92 (12.15)
<b>Insurance – Medi-cal +Uninsured (%)</b>	40.87 (19.94)
<b>Operating Margin (%)</b>	-1.88 (18.78)
<b>Population Density (Log Population per Sq Mile)</b>	7.00 (1.36)
<b>Ratio of ED visits to ED beds per day</b>	4.83 (1.43)
<b>Inpatient occupancy rate (%)</b>	62.5 (45.4)
<b>Number of Hospitals (%)</b>	
<b>Teaching Hospital (%)</b>	20 (9)
<b>Ownership (%)</b>	
County	13 (6)
For Profit	57 (27)
Not-for-Profit	144 (66)
<b>Trauma Center (%)</b>	
Yes	34 (16)

**Exhibit 3**

Predictors of Ambulance Diversion Using Hierarchical Hospital-level analysis\* (n=202)

Source: Authors' analysis of California OSHPD, U.S. Census Bureau & Area Resource File data as cited above (references 26 & 27)

Predictor	Multiplicative Increase for Unit Change in Predictor	95%CI Lower Bound	95%CI Upper Bound	p-value
<b>Non-White (%)</b>	<b>1.024</b>	<b>1.004</b>	<b>1.044</b>	<b>0.0193</b>
<b>Other socioeconomic determinants of ED care</b>				
Age (years)	0.999	0.933	1.071	0.9833
Gender – Male (%)	0.999	0.891	1.119	0.9806
Income (per \$1000)	0.988	0.948	1.028	0.5482
Insurance (% Med-Cal + % Uninsured)	0.963	0.941	0.985	0.0013
Population Density (Log Scale)	1.392	0.829	2.339	0.2219
<b>Supply of ED Care010</b>				
Ratio of ED Visits to ED Beds per Day	1.261	1.041	1.527	0.0191
Inpatient admissions to inpatient bed-days (%)	1.022	1.004	1.041	0.0177
<b>Hospital Structural Characteristics</b>				
Trauma status (Ref=No)	2.874	1.306	6.325	0.0096
<i>Ownership (Ref=NFP)</i>				0.0988
County	2.153	0.457	10.14	0.3335
For Profit	0.576	0.314	1.057	0.0772
Teaching status (Ref=No)	1.339	0.451	3.971	0.6000
Operating Margin	0.994	0.978	1.010	0.4314

\* Hierarchical model with hospitals nested in county. Outcome is transformed annual diversion hours (log of annual diversion hours + 1)