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Do patients hospitalised in high-minority hospitals experience more diversion and poorer outcomes? A retrospective multivariate analysis of Medicare patients in California

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ABSTRACT

Objective: We investigated the association between crowding as measured by ambulance diversion and differences in access, treatment and outcomes between black and white patients.

Design: Retrospective analysis.

Setting: We linked daily ambulance diversion logs from 26 California counties between 2001 and 2011 to Medicare patient records with acute myocardial infarction and categorised patients according to hours in diversion status for their nearest emergency departments on their day of admission: 0, <6, 6 to <12 and ≥12 h. We compared the amount of diversion time between hospitals serving high volume of black patients and other hospitals. We then use multivariate models to analyse changes in outcomes when patients faced different levels of diversion, and compared that change between black and white patients.

Participants: 29 939 Medicare patients from 26 California counties between 2001 and 2011.

Main outcome measures: (1) Access to hospitals with cardiac technology; (2) treatment received; and (3) health outcomes (30-day, 90-day, and 1-year death and 30-day readmission).

Results: Hospitals serving high volume of black patients spent more hours in diversion status compared with other hospitals. Patients faced with the highest level of diversion had the lowest probability of being admitted to hospitals with cardiac technology compared with those facing no diversion, by 4.4% for cardiac care intensive unit, and 3.4% for catheterisation laboratory and coronary artery bypass graft facilities. Patients experiencing increased diversion also had a 4.3% decreased likelihood of receiving catheterisation and 9.6% higher 1-year mortality.

Conclusions: Hospitals serving high volume of black patients are more likely to be on diversion, and diversion is associated with poorer access to cardiac technology, lower probability of receiving revascularisation and worse long-term mortality outcomes.

Strengths and limitations of this study

- Links unique daily diversion data from hospitals in 17 local emergency medical services agencies (LEMSAs) in California with patient-level data from Medicare between 2001 and 2011.
- Utilises actual driving distance between a patient's ZIP code and the nearest hospital's longitude and latitude coordinates to identify the closest emergency department to a patient.
- Analyses three dimensions of patient care—access, treatment and outcomes—to explore potential disparities between black and white patients experiencing ambulance diversion.
- Limitations include potential reporting bias due to self-reported data by LEMSAs, diversion status is measured at the hospital level and not for individual patient, lack of generalisability outside of California, and a small sample of black patients.

INTRODUCTION

Racial and ethnic differences in the burden of cardiovascular disease (CVD) contribute significantly to health disparities observed in the USA, and unfortunately have increased over time.[1 2] These disparities are particularly noticeable for critical and time-sensitive diseases such as acute myocardial infarction (AMI),[3] with studies showing that black patients are less likely than white patients to receive cardiac treatments such as angiography or thrombolytic therapy after AMI.[4] Many potential explanations for these disparities have been suggested, including individual patient factors such as a lack of awareness of AMI symptoms,[5] physician bias[6] and a distrust of the medical system that results in a hesitance to seek care.[7] However, it is also important to consider the possibility that system-level mechanisms may be partially responsible for these disparities,[8 9] and particularly whether black Americans are less likely than their white counterparts to receive needed treatment.[10]

One important system-level mechanism that is especially critical for time-sensitive conditions such as AMI is ambulance diversion. Ambulance diversion occurs when emergency departments (EDs) are temporarily closed to ambulance traffic due to a variety of reasons, such as overcrowding or lack of available resources,[11–17] and effectively creates a temporary decrease in ED access. Past studies have found that ambulance diversion is associated with poor health outcomes for patients suffering from AMI.[18 19] A recent study further explored the mechanisms through which ambulance diversions affect patients, and showed that patients whose nearest hospital experiences significant diversion have poorer access to hospitals with cardiac technologies, leading to a lower likelihood of receiving treatment with revascularisation, and increased mortality.[20] Few studies, however, have examined if ambulance diversion is associated with health disparities.

Conceptually, ambulance diversion is a signal of a hospital operating beyond capacity, and can affect patients who have to be diverted elsewhere as well as non-diverted patients within the overcrowded ED. Ambulance diversion has been used as a proxy for ED crowding.[21–23] In order to better target potential areas for intervention, it is essential to know exactly where the disparities occur when a patient experiences ambulance diversion. Figure 1 shows that in the first stage, a hospital experiences resource constraints, mostly due to overcrowding in the ED, such that it cannot accept incoming ambulance traffic. At this stage, a potential racial disparity exists if black patients are more likely to be diverted than white patients because the ED closest to them is more likely to be on diversion.

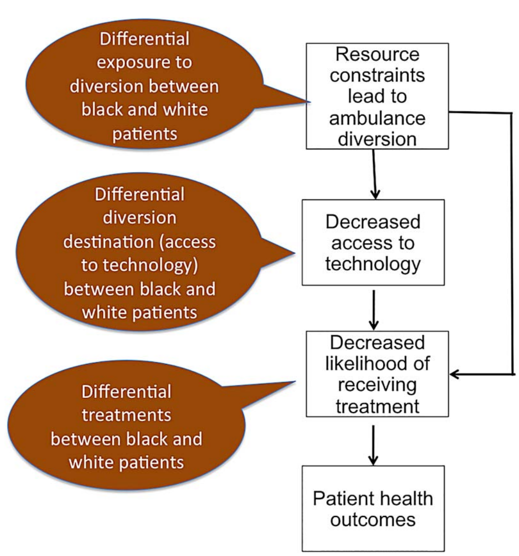

Figure 1 Conceptualising stages of ambulance diversion and potential racial disparity.

Some patients might then be routed to hospitals less technologically equipped to handle complicated cardiac cases. At this stage, disparities could occur if black patients are more likely to be diverted to less desirable settings than white patients, resulting in worse outcomes.

The decreased access to cardiac technology in turn could decrease the likelihood of patients receiving needed treatment. In addition, it is also possible that patients who need advanced cardiac intervention during ambulance diversion periods have a lower likelihood of receiving treatment even in a hospital equipped with cardiac technology, if crowding and limited resources outstrip the capability of the staff to deploy their technology appropriately. At this stage, a potential disparity exists if black patients receive inferior treatments compared with white patients, leading to worse patient outcomes, when both are exposed to the same level of ambulance diversion.[17]

Our study therefore explored potential differences between black and white patients at different stages of ambulance diversion, using 100% of Medicare claims and daily ambulance diversion logs from 26 California counties between 2001 and 2011. We first compared amount of ambulance diversion between hospitals serving large share of black patients (henceforth 'minority-serving hospitals') and others. We then examined whether racial disparities in ambulance diversion, if any, resulted in differential health outcomes between black and white patients.

METHODS

Data

We obtained patient data from 100% Medicare Provider Analysis and Review (MedPAR), linked with vital files, between 2001 and 2011. We linked them with the Healthcare Provider Cost Reporting Information System and American Hospital Association annual surveys to obtain additional hospital-level information.

To identify each hospital's daily ambulance diversion hours, we acquired daily ambulance diversion logs provided by the California local emergency medical services agencies (LEMSAs). California has a total of 33 LEMSAs, but 10 of them banned diversion for the years of 2001–2011. We excluded counties with diversion bans from our analysis, since they did not contribute to our understanding of the relationship between diversion and patient outcomes. Those excluded counties tended to be much smaller than counties without diversion bans, but they had comparable shares of black patients (4.6% among counties with the diversion ban vs 5.4% without the diversion ban; p=0.80). Figure 2 identifies counties with the diversion ban over this period and ZIP code communities that had high shares of black population (ie, those communities that were in the top tertile of black population distribution in California).

Figure 2 California map showing counties with diversion ban and communities with high shares of black patients.

We obtained data for 17 out of the 23 LEMSAs that did not ban diversion (actual coverage dates vary by LEMSA). The 17 LEMSAs together represented 88% of the California population. To identify the closest ED for a patient, we supplemented our hospital data with longitude and latitude coordinates of the hospital's physical address or heliport (if one existed).[24] We obtained actual driving distance from the patient's ZIP code centroid to nearest hospital's latitude and longitude coordinates based on Google Maps, using automation codes developed in Stata.[25]

Patient population

We identified the AMI population by extracting from 100% MedPAR records that had 410.x0 or 410.x1 as the principal diagnoses as done in previous studies,[18] were hospitalised between 2001 and 2011, and resided in counties for which we had diversion data. We excluded all patients who were not admitted through the ED, and patients whose admitting hospital was >100 miles away from their mailing ZIP codes. For analysis of 30-day readmission, we excluded patients who could not be readmitted to the hospital (eg, if the patient died during the index admission) per Centers for Medicare & Medicaid Services (CMS) guidelines.[26]

Defining minority serving hospitals

In the first part of our analysis, we performed a trend analysis of ambulance diversion hours between hospitals serving large share of black patients and other hospitals. We characterised hospitals' share of black patients in two ways, using metrics from prior work. First, we ranked each hospital by the proportion of total Medicare patient volume that is black at baseline (2001),[27] and defined minority-serving hospitals as those who ranked in the top 10%. Second, we also designated hospitals as minority-serving if they provided care to more than double the number of black patients compared with competing hospitals within a 15-mile radius of the facility in 2001.[18] This approach accounted for the distribution of the local population.

Defining access, treatment and health outcomes

We evaluated three dimensions of patient care. We defined *access* as whether a patient was admitted to a hospital with the following cardiac technology: cardiac care intensive unit, catheterisation laboratory and coronary artery bypass graft (CABG) surgery capacity.

We defined *treatment received* as whether a patient received a given procedure, identified by the International Classification of Diseases (ICD)-9 procedure codes on the MedPAR. We examined three common treatments for AMI: percutaneous coronary intervention (PCI), thrombolytic therapy or CABG.

Finally, we analysed two sets of patient health outcomes: death (whether a patient died within X days from his ED admission, where X=30, 90 and 365 days) and readmission to the hospital within 30 days of the index discharge.

Statistical models

We first explored whether racial disparities exist in the absolute amount—for example, number of hours—of ambulance diversion. Because diversion is measured at the hospital level, we compared daily diversion trends between minority serving and non-minority serving hospitals using the mean daily ambulance diversion hours. We used the non-parametric Kolmogorov-Smirnov tests to test whether the two groups' diversion trend distributions were the same.[28]

We then implemented a multivariate model to examine the patient outcomes (in terms of access, treatment received and health). For all outcomes, we implemented a linear probability model with fixed effects for each ED that was identified as the closest ED for each patient while controlling for time-dependent variables. The ED fixed effects eliminated any underlying differences across EDs and the communities they serve. Baseline differences might include but not limited to possible differences in baseline diversion rate, baseline mortality rates, quality of care, case-mix of the patient population or other unobserved characteristics that might be confounded with the outcomes.

For the key variables of interest, we created three dichotomous variables based on the diversion level of the patient's nearest ED, using previously defined categories of diversion: no diversion (reference group), <6, 6 to 12 and ≥12 h.[18 20] To also investigate possible differential outcomes as the result of diversion between black and white patients, we added the interaction term between indicator for black patients and the three diversion categories.

We controlled for race (African-American, Hispanic, Asian, other minority, unknown/missing race), age, gender, as well as 22 comorbid measures based on prior work.[29] For admitting hospital organisational characteristics, we controlled for hospital ownership, teaching status, size (measured by log-transformed total inpatient discharges), occupancy rate, system membership and Herfindahl index to capture the competitiveness of the hospital market within 15-mile radius (0 being perfectly competitive and 1 being monopoly). Last, we included year indicators to capture the macro trends.

For treatment outcomes, we estimated an additional model that controlled for cardiac technology access. Results from these two models allowed us to compare whether differences in treatment received, if any, are the result of lack of technology access. For mortality outcomes, we estimated a third model accounting for both cardiac technology and actual treatment received. All models were estimated using Stata V.13 (StataCorp. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP, 2013). This study was exempted from the Committee on Human Research at the University of California, San Francisco.

RESULTS

Figure 3 shows the trend in mean daily diversion hours among hospitals reporting any diversion hours between non-minority-serving and minority-serving hospitals. Mean daily diversion hours were higher in minority-serving hospitals than in non-minority-serving hospitals, with an average difference 2 h/day between the two groups (p<0.001 by non-parametric Kolmogorov-Smirnov tests). We also examined the per cent of patients who experienced diversion over time if their closest ED was minority-serving compared with other hospitals, and observed the same pattern. Table 1 shows that the minority-serving and other hospitals are similar in most dimensions (bed size, cardiac care capacity, occupancy rate, teaching status), except that a higher share of minority serving hospitals are government-run (22% vs 12%, p<0.01) and are located in more concentrated markets as measured by the Herfindahl index (0.20 vs 0.15, p<0.01).

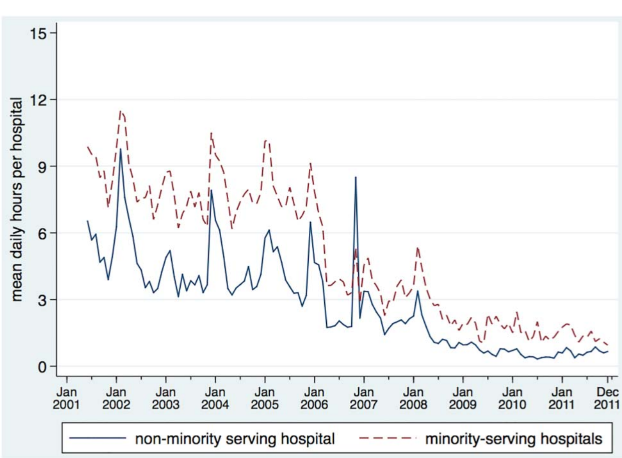

Figure 3 Monthly trend in ambulance diversion between minority-serving and non-minority-serving hospitals: 2001–2011.

Our sample included 29 939 patients for all outcomes, except for the readmission analysis where the sample size was 23 199 patients. Among all patients, 15 202 patients (51%) experienced no diversion at their nearest ED on their day of admission; for 25%, their nearest ED was on diversion for <6 h; for 15%, their nearest ED was on diversion for 6–12 h; and for 10%, their nearest ED was on diversion for ≥12 h of diversion (table 2). In addition, a larger percentage of black patients experienced ≥12 h of diversion than white patients (12% vs 9%, p<0.01). In general, African-Americans had a lower probability of being admitted to hospitals with cardiac care technology, and a lower probability of receiving catheterisation. The raw mortality outcomes were similar between African-Americans and Caucasians, but African-Americans had a higher probability of being readmitted to hospitals within 30 days of discharge (40 vs 34%, p<0.01).

Table 2 also reveals underlying demographic and comorbid differences between black and white patients. Compared with Caucasians, African-Americans who suffered from AMI were more likely to be female, younger and comorbid with either diabetes, renal failure or hypertension.

While informative, the raw rates in table 2 do not take into account potential differences across individuals, hospitals and communities. Table 3 shows estimated results from model 1 (complete results in online supplementary table S1). After controlling for multiple factors, patients exposed to the highest level of diversion (≥12 h) had worse access to cardiac technology—by −2.61 percentage points for access to cardiac care intensive unit (95% CI −4.81 to −0.40) compared with patients who were admitted on a day with no diversion; by −2.44 percentage points for access to catheterisation laboratory (95% CI −4.24 to −0.65); and by −2.25 percentage points for access to CABG facilities (95% CI −4.02 to −0.48). This is equivalent to a 4.4% reduction in cardiac care unit (CCU) access (the base rate for CCU is 60%), and 3.4% reduction in access to catheterisation laboratory and CABG facilities. In addition, patients exposed to the highest level of diversion were less likely to receive catheterisation, by −2.19 percentage points (95% CI −4.19 to −0.19), and had a higher 1-year mortality rate, by 2.78 percentage points (95% CI 0.76 to 4.80). In other words, patients in the highest diversion category had a decreased likelihood of

Table 1 Descriptive statistics of hospital characteristics

Mean (SD)	All hospitals	Non-minority-serving hospitals	Minority-serving hospitals
Minority-serving hospitals	24% (43%)		
Owing to definition 1: in the top decile for proportion of all back patients in California	17% (38%)		
Owing to definition 2: treat twice as many black patients than other hospitals in their geographic proximity	7% (25%)		
Cardiac care capacity			
Has catheterisation laboratory	60% (49%)	60% (49%)	59% (49%)
Has cardiac care unit	57% (50%)	58% (49%)	54% (50%)
Has CABG capacity	48% (50%)	49% (50%)	48% (50%)
For-profit hospitals	26% (44%)	26% (44%)	28% (45%)
Government hospitals	14% (35%)	12% (32%)	22%** (41%)
Teaching hospitals	9% (29%)	9% (29%)	9% (29%)
Member of a system	68% (47%)	69% (46%)	64% (48%)
Mean total beds in hospital	232.89 (130.69)	231.39 (130.14)	237.58 (132.47)
Mean occupancy rate	0.64 (0.16)	0.64 (0.16)	0.65 (0.15)
Mean HHI index†	0.16 (0.18)	0.15 (0.16)	0.20** (0.22)
Number of hospital years	1563	1186	377

Non-minority-serving and minority-serving hospital differences statistically significant at *p<0.05, **p<0.01.
†The HHI index captures competitiveness of the hospitals' market (defined as within 15-mile radius): the scale goes from 0 to 1 where 0 represents perfectly competitive market and 1 represents monopoly.[30]
CABG, coronary artery bypass graft; HHI, Herfindahl-Hirschman Index.

receiving catheterisation by 4.3% (base rate is 51%) and higher 1-year mortality by 9.6% (base rate is 29%).

Results from the interaction terms between black patients and diversion status showed that in general, black and white patients had a similar experience when facing the same level of diversion. The interaction terms in general were not statistically significant at the conventional level, with two exceptions. African-Americans in the highest diversion category were less likely to receive thrombolytic therapy relative to Caucasians facing the same amount of diversion, and African-Americans in the low diversion category (<6 h) had a higher 1-year mortality relative to Caucasians.

Table 4 shows results from the additional model where we controlled for cardiac technology access (for both treatment and health outcomes) and treatment received (for health outcomes only). The notable difference, compared with table 3, is that once we controlled for technology access, the probability of receiving PCI was comparable across the diversion levels. We still observed higher 1-year mortality rates among patients in the highest diversion category, albeit with a slightly smaller magnitude. The interaction results were similar to those in table 3.

DISCUSSION

Our study provides a unique perspective into the mechanisms behind ambulance diversion and health disparities. We hypothesised that ambulance diversion might affect black and white patients differently through three potential mechanisms: differential amount of exposure to diversion, differential access to cardiac technology and differential treatment received when both experience diversion. While these possibilities are not mutually exclusive and could happen concurrently, our results mainly support the hypothesis of differential exposure to ambulance diversion—in other words, African-Americans with AMI have higher exposure to ambulance diversion because a larger share of black patients go to minority-serving hospitals, and longer exposure to ambulance diversion is associated with higher long-term mortality. This is in contrast to explanations where African-Americans receive differentially less access to

Table 2 Descriptive statistics of patient characteristics

	Whole sample		White		Black	
	N	(%)	N	(%)	N	(%)
Nearest ED's exposure to diversion on the day of admission						
No diversion	15 202	(51)	11 439	(53)	798	(50)**
<6 h	7514	(25)	5169	(24)	374	(23)
(6–12) hours	4472	(15)	3006	(14)	263	(16)*
≥12 h	3069	(10)	1998	(9)	194	(12)**
Access						
Admitted to hospital with cardiac care unit	19 846	(66)	14 265	(67)	1066	(66)
Admitted to hospital with catheterisation laboratory	22 257	(74)	16 101	(75)	1180	(73)**
Admitted to hospital with CABG capacity	20 042	(67)	14 761	(69)	1016	(63)**
Treatment received						
Received catheterisation	14 181	(47)	10 532	(49)	649	(40)**
Received thrombolytic therapy	450	(2)	305	(1)	16	(1)
Received CABG	1695	(6)	1216	(6)	69	(4)*
Health outcomes						
30-day mortality	4835	(16)	3507	(16)	234	(15)*
90-day mortality	6593	(22)	4759	(22)	355	(22)
1-year mortality	9447	(32)	6824	(32)	516	(32)
30-day all-cause readmission	7974	(34)	5638	(34)	507	(40)**
Patient demographics						
White	21 414	(72)				
Black	1612	(5)				
Hispanic	1578	(5)				
Asian	2126	(7)				
Other non-white races	1391	(5)				
Unknown/missing race	1818	(6)				
Female	14 906	(50)	10 612	(50)	913	(57)**
Age distribution						
65–69	4231	(14)	2920	(14)	335	(21)**
70–74	4756	(16)	3292	(15)	305	(19)**
75–79	5531	(18)	3764	(18)	330	(20)**
80–84	6197	(21)	4455	(21)	271	(17)**
85+	9224	(31)	6983	(33)	371	(23)**
Patient comorbid conditions						
Peripheral vascular disease	2195	(7)	1623	(8)	127	(8)
Pulmonary circulation disorders	683	(2)	494	(2)	48	(3)
Diabetes (uncomplicated+complicated)	8028	(27)	5127	(24)	530	(33)**
Renal failure	3965	(13)	2669	(12)	301	(19)**
Liver disease	241	(1)	155	(1)	18	(1)
Cancer	1127	(4)	837	(4)	79	(5)*
Dementia	1171	(4)	865	(4)	67	(4)
Valvular disease	4070	(14)	3085	(14)	184	(11)**
Hypertension (uncomplicated+complicated)	18 196	(61)	12 667	(59)	1127	(70)**
Chronic pulmonary disease	5965	(20)	4340	(20)	369	(23)*
Rheumatoid arthritis/collagen vascular	489	(2)	383	(2)	29	(2)
Coagulation deficiency	988	(3)	690	(3)	49	(3)
Obesity	1062	(4)	796	(4)	80	(5)*
Substance abuse	461	(2)	343	(2)	44	(3)**
Depression	790	(3)	625	(3)	34	(2)*
Psychosis	405	(1)	298	(1)	30	(2)
Hypothyroidism	2462	(8)	2004	(9)	58	(4)**
Paralysis and other neurological disorder	2565	(9)	1806	(8)	178	(11)**
Chronic peptic ulcer disease	19	(0)	12	(0)	1	(0)
Weight loss	623	(2)	416	(2)	51	(3)**
Fluid and electrolyte disorders	6187	(21)	4267	(20)	392	(24)**
Anaemia (blood loss and deficiency)	4034	(13)	2735	(13)	270	(17)**
Patient	29 939		21 414		1612	

Black and white differences statistically significant at *p<0.05, **p<0.01.
CABG, coronary artery bypass graft; ED, emergency department.

Table 3 Association between ambulance diversion of the nearest ED and access, treatment and outcomes, based on model 1

Base rate (among patients in reference group)	Access (admitting hospital has)			Treatment			Outcomes			
	Cardiac care unit (60%)	Catheterisation laboratory (73%)	CABG (65%)	Catheterisation/ PCI (51%)	Thrombolytic therapy (1%)	CABG (6%)	30-day mortality (16%)	90-day mortality (22%)	1-year mortality (29%)	30-day readmission (34%)
Diversion status (reference group: nearest ED not on diversion on the day of admission)										
Nearest ED's exposure to diversion on the day of admission										
<6 h	−1.40*	−1.70**	−0.94	−0.86	0.18	−0.42	−0.24	0.11	−0.20	−0.02
	(−2.74, −0.05)	(−2.91, −0.49)	(−2.11, 0.23)	(−2.23, 0.51)	(−0.23, 0.59)	(−1.17, 0.34)	(−1.31, 0.83)	(−1.15, 1.36)	(−1.66, 1.25)	(−1.86, 1.82)
(6–12) hours	−0.40	−0.79	−0.25	−1.27	−0.27	−0.50	0.29	0.40	0.21	0.57
	(−2.03, 1.22)	(−2.41, 0.82)	(−1.83, 1.33)	(−2.91, 0.37)	(−0.72, 0.18)	(−1.42, 0.42)	(−1.04, 1.62)	(−1.08, 1.89)	(−1.43, 1.86)	(−1.48, 2.62)
≥12 h	−2.61*	−2.44**	−2.25*	−2.19*	−0.14	−0.29	1.10	1.78*	2.78**	2.12
	(−4.81, −0.40)	(−4.24, −0.65)	(−4.02, −0.48)	(−4.19, −0.19)	(−0.72, 0.43)	(−1.29, 0.71)	(−0.60, 2.81)	(0.01, 3.55)	(0.76, 4.80)	(−0.55, 4.79)
Interaction between black patients and diversion level										
X low diversion	−0.76	2.51	3.79	−2.16	−1.11	0.12	0.20	2.71	5.56*	2.35
(<6 h)	(−5.62, 4.10)	(−2.15, 7.17)	(−1.18, 8.77)	(−7.85, 3.52)	(−2.51, 0.29)	(−2.48, 2.72)	(−4.16, 4.56)	(−1.71, 7.12)	(0.25, 10.86)	(−4.13, 8.83)
X medium diversion	−0.12	1.08	3.05	−0.08	−0.93	2.77	3.43	4.94	2.55	0.60
(6–12) hours	(−5.73, 5.49)	(−4.81, 6.98)	(−2.89, 9.00)	(−7.13, 6.97)	(−2.25, 0.39)	(−0.40, 5.94)	(−2.28, 9.14)	(−0.65, 10.53)	(−3.16, 8.26)	(−7.81, 9.02)
X high diversion	3.37	−2.38	1.41	0.30	−2.70**	−0.87	2.58	2.49	1.61	−0.28
(≥12 h)	(−2.88, 9.63)	(−8.82, 4.05)	(−4.54, 7.36)	(−6.24, 6.84)	(−4.20, −1.19)	(−4.32, 2.58)	(−3.33, 8.50)	(−4.29, 9.27)	(−5.83, 9.05)	(−11.01, 10.45)
Control for tech access	NA	NA	NA	No	No	No	No	No	No	No
Control for treatment	NA	NA	NA	NA	NA	NA	No	No	No	No
N	29 939	29 939	29 939	29 939	29 939	29 939	29 939	29 939	29 939	23 199

Nearest ED based on Google query of driving distance.
When compared to the reference group, the regression-adjusted difference is statistically significant at *p<0.05, **p<0.01.
CABG, coronary artery bypass graft; ED, emergency department; PCI, percutaneous coronary intervention.

Table 4 Association between ambulance diversion of the nearest ED and access, treatment and outcomes, based on alternative models

Base rate (among patients in reference group)	Treatment: Catheterisation/PCI (51%)	Treatment: Thrombolytic therapy (1%)	Treatment: CABG (6%)	Outcomes: 30-day mortality (16%)	Outcomes: 90-day mortality (22%)	Outcomes: 1-year mortality (29%)	Outcomes: 30-day readmission (34%)
Diversion status (reference group: nearest ED not on diversion on the day of admission)							
Nearest ED's exposure to diversion on the day of admission							
<6 h	−0.51	0.16	−0.37	−0.25	0.09	−0.24	0.00
	(−1.85, 0.84)	(−0.24, 0.57)	(−1.13, 0.38)	(−1.31, 0.82)	(−1.16, 1.35)	(−1.68, 1.21)	(−1.84, 1.84)
(6–12) hours	−1.15	−0.27	−0.49	0.30	0.40	0.21	0.60
	(−2.77, 0.47)	(−0.72, 0.18)	(−1.41, 0.43)	(−1.03, 1.62)	(−1.08, 1.89)	(−1.43, 1.85)	(−1.46, 2.65)
≥12 h	−1.46	−0.18	−0.17	1.07	1.74	2.70**	2.07
	(−3.40, 0.48)	(−0.75, 0.40)	(−1.16, 0.83)	(−0.63, 2.76)	(−0.02, 3.50)	(0.69, 4.71)	(−0.61, 4.74)
Interaction between black patients and diversion level							
X low diversion (<6 h)	−3.42	−1.03	−0.10	0.29	2.79	5.73*	2.53
	(−9.05, 2.20)	(−2.44, 0.38)	(−2.73, 2.53)	(−4.08, 4.65)	(−1.63, 7.22)	(0.41, 11.05)	(−3.96, 9.03)
X medium diversion (6–12) hours	−1.00	−0.87	2.58	3.52	5.01	2.69	0.63
	(−7.65, 5.64)	(−2.18, 0.45)	(−0.56, 5.72)	(−2.21, 9.24)	(−0.59, 10.62)	(−3.04, 8.41)	(−7.85, 9.12)
X high diversion (≥12 h)	0.22	−2.67**	−1.01	2.67	2.54	1.66	−0.44
	(−5.89, 6.33)	(−4.19, −1.16)	(−4.42, 2.40)	(−3.26, 8.60)	(−4.22, 9.31)	(−5.79, 9.11)	(−11.13, 10.26)
Control for tech access	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for treatment	NA	NA	NA	Yes	Yes	Yes	Yes
N	29 939	29 939	29 939	29 939	29 939	29 939	23 199

Nearest ED based on Google query of driving distance.
When compared to the reference group, the regression-adjusted difference is statistically significant at *p<0.05, **p<0.01.
CABG, coronary artery bypass graft; ED, emergency department; PCI, percutaneous coronary intervention.

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technology or treatment compared with Caucasians when both experience the same diversion condition.

Our findings that minority-serving hospitals are more likely to experience ambulance diversion than non-minority-serving hospitals is concerning. Despite the overall decrease in ambulance diversion over time, it appears that this decrease has not helped improve the disparities in diversion. The disparate amount of diversion experienced by minority-serving hospitals is concordant with previous literature, suggesting that there may be a fundamental misalignment in the supply and demand of emergency services at minority-serving hospitals relative to non-minority-serving hospitals.[31–33]

Our findings add support to evidence[18] that policies to reduce ambulance diversion can improve access, treatment and outcomes for patients. However, in order to narrow the gap in disparities between black and white patients, more effort should be made to reduce the amount of ambulance diversion at minority-serving hospitals. These interventions to target excessive ambulance diversion in at minority-serving hospitals could also be in keeping with national goals to decrease disparities at the system level. For example, the Department of Health and Human Services has stated that one of their strategies to reduce disparities in the quality of care specific to CVDs is to implement policy and health system changes that include reimbursement incentives.[34] In addition to devoting resources on individually oriented initiatives geared at educating physicians about biases in offering cardiac catheterisation, then, our findings suggest that thoughtful reflection about approaches to achieve equitable resource allocation could be another effective mechanism in the long term towards decreasing racial disparities in healthcare.

Our results should be interpreted in light of several limitations. First, our diversion data are self-reported by LEMSAs, with potential for errors and reporting bias. Second, our diversion status is identified at the hospital level and not at the individual patient level, and our patient data identify date but not time of admission. While we cannot verify with absolute certainty that a patient was diverted, it is reasonable to assume longer hours of diversion is associated with a lower probability that a patient is admitted to this ED. In addition, the inability to clearly identify the diverted and the non-diverted patients in our analysis implies that what we observe is the net effect of ambulance diversion.

Third, our data set contains the mailing ZIP codes for the patients, which may or may not be the same as their ZIP code of residence. There is also a possibility that the patient's AMI did not occur at home. With the exclusion criteria we imposed in selecting our sample, we believe that this limitation should not affect our analyses.

We are aware that using driving distance to determine a patient's geographical access to EDs means that our study ignores the availability of the aeromedical transport network. We believe that this omission does not affect our findings as aeromedical transportation is almost always limited to interhospital (or trauma scene-to-hospital) transport, and is rarely, if ever, an option for patients with AMI in the field, even in remote rural areas.

Fourth, our study design necessitates that we exclude counties with a diversion ban. However, if diversion bans disproportionally favour communities with predominantly white population, then we did not capture this important source of discrimination. Based on our comparison, however, the two types of communities had similar shares of black patient population, so it does not appear to be the case that diversion bans only occurred among mostly white communities.

Lastly, our data set is limited to California, which, while a large and diverse state representing 12% of the US population, is not representative of the nation as a whole. Because our patient sample is based on the Medicare population, our findings may not be applicable to non-elderly population. Last, we have a relatively small sample of black patients. Future studies that incorporate non-Medicare populations could also increase the sample size for black patients, and improve the statistical power of the analysis.

CONCLUSIONS

Our study showed that hospitals treating high volume of black patients experienced a significantly greater amount of ambulance diversion than non-minority-serving hospitals. In addition, patients whose nearest hospital experienced significant diversion had poorer access to hospitals with cardiac technologies, leading to a lower likelihood of receiving treatment with revascularisation and lower 1-year survival. We did not find that other downstream consequences of ambulance diversion, such as decreased access to technology and treatment, were differentially worse for black patients. Because diversion is asymmetrically experienced by hospitals that treat high volume of black patients, targeted efforts to decreased ED crowding and ambulance diversion in these communities may be able to reduce disparities in quality of care and, ultimately, outcomes.

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Contributors YS had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. YS and RYH were involved in study concept and design, acquisition of data, and analysis and interpretation of data. RYH was involved in drafting of the manuscript. YS was involved in critical revision of the manuscript for important intellectual content, statistical analysis and study supervision. YS and RYH obtained funding and provided administrative, technical or material support.

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