Title

Impact Of Ambulance Diversion: Black Patients With Acute Myocardial Infarction Had Higher Mortality Than Whites

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Black Patients with Acute Myocardial Infarction Experience Higher Mortality During Moderate to Long Hours of Emergency Department Crowding

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Abstract

This study investigated whether emergency department (ED) crowding affects blacks more than their white counterparts and the mechanisms behind which this might occur. Using a non-public database of patients with acute myocardial infarction (AMI) between 2001–2011 and hospital-level diversion data, we found that hospitals treating a high share of black AMI patients were more likely to experience ambulance diversion and that black patients fared worse compared to white patients experiencing the same level of ED crowding as measured by ambulance diversion. The 90-day and 1-year mortality rates among blacks exposed to high diversion levels were 2.88 (95% CI 0.64–5.12) and 3.09 (95% CI 0.31–5.88) percentage points higher, respectively, relative to whites, representing a relative increase of 19% and 14% for 90-day and 1-year death, respectively. Interventions that decrease the need for diversion in hospitals serving a high volume of blacks could potentially reduce these disparities.

Introduction

Racial and ethnic disparities that exist among patients with cardiovascular diseases have been extensively documented in previous literature.(1, 2) Studies have also shown that emergency department (ED) crowding disproportionately affects minority patients seeking emergency care.(3) This is concerning given that ED crowding has been linked to decreased access to care,(3) delays in receiving treatment,(4–6) and increased mortality rates.(4, 7–10)

Little is known, however, about the connection of these two phenomena, and whether system-level mechanisms, such as ED crowding, specifically affect disparities found in cardiovascular diseases in racial and ethnic minorities. A rigorous analysis of this question is critical given that other literature supports that there could be other explanatory reasons for such disparities. Specifically, ample literature shows that racial and ethnic minorities often

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are poorly insured,(11–13) have more co-morbidities,(14–16) have decreased access to high-technology hospitals,(17, 18) and receive poorer care compared with their white counterparts.(19–21) If disparities in outcomes persist after controlling for other social determinants of health, a more compelling case exists for focusing on system-level interventions such as reducing crowding to decrease disparities.

A recent study found that hospitals treating large shares of black patients were more likely to be on diversion, but blacks and whites had similar adverse effects to ambulance diversion.(22) However, that study was limited to Medicare patients and had relatively small samples of black patients, whereas ED crowding affects all and can potentially have different effects on non-Medicare patients. In this paper, we sought to answer whether ED crowding affects blacks more than whites using non-public, all-payer, patient-level data from the state of California, as well as whether or not differences exist between black and white patients experiencing the same levels of diversion. Specifically, we analyzed changes in patient outcomes, as measured by mortality rates at 30 days, 90 days and 1 year, between black and white patients who experienced ambulance diversion, while controlling for patient and hospital factors, access to cardiac technology, and receipt of cardiac-related treatment.

Methods

Data

We obtained patient-level data from the California Office of Statewide Health Planning and Development (OSHPD) for years 2001–2011, which contain admissions to every non-federal, general, acute-care hospital in California. These files include patient demographics such as gender, age, insurance, race, co-morbidities, and zip code of their residence, as well as admission date, source of admission, and procedures received (e.g., cardiac thrombolysis, cardiac catheterization, coronary artery bypass). We also obtained a link to each patient's vital statistics to identify out-of-hospital mortality up to one year.

We used data from annual reports submitted to the Centers for Medicare & Medicaid Services (CMS)-maintained Healthcare Cost Report Information System (HCRIS) and annual surveys from the American Hospital Association for hospital-level information, including ownership, teaching status, system membership, total beds, occupancy rates, availability of cardiac care technology, and market competition (defined using the Herfindahl-Hirschmann index, commonly used to measure market concentration and applied to the hospital industry).(23) We used OSHPD's utilization files to confirm these characteristics and determine each hospital's level of cardiac technology, based on availability of cardiac coronary units (CCU), cardiac catheterization, and coronary artery bypass grafts (CABG) performed in hospital, which has been linked to differences in mortality.(24)

We identified the nearest ED to each patient based on driving time from Google Map queries. We first obtained the longitude and latitude of each hospital based on their heliport (if one exists) or physical address,(25) and the coordinates for each patient's ZIP code population centroid. We then determined driving distance between each pair of coordinates using automation codes developed in Stata.(26)

To determine a hospital's daily diversion hours, we obtained ambulance diversion logs from local emergency medical services (EMS) agencies in California, which contain data for seventeen of the twenty-three local EMS agencies that did not ban ambulance diversion during the years studied (2001–2011), covering 88 percent of the population of California.

The Institutional Board of Review of the University of California, San Francisco approved this study.

Patient Population

We identified patients with acute myocardial infarction (AMI) by extracting records on patients who had 410.x0 or 410.x1 as their primary diagnosis code.(8) Following previous work, we excluded all patients who were not admitted via the ED and patients in counties for which we did not have diversion data.(27) We also excluded patients admitted to hospitals over 100 miles from their mailing ZIP codes, as they likely did not reside there or were hospitalized while away from home.(10) Last, we excluded patients in counties with diversion bans, since they did not contribute to our understanding of the relationship between ambulance diversion and health outcomes.

Outcome

We used 30-day, 90-day, and 1-year mortality rates to evaluate the effects of ambulance diversion on patient outcomes.

Levels of Ambulance Diversion

As in previous literature,(7, 10) we used ambulance diversion, defined as an ambulance being diverted to the next closest ED/hospital because the closest one is saturated, as a proxy for ED crowding. We totaled the hours a patient's nearest ED was on diversion the day of the patient's admission and grouped the patients into four categories based on that number: 0 hours, <6 hours, 6 to <12 hours, and ≥12 hours.(8, 10)

Minority Status

Race categories include White, Black, Hispanic, Asian/Pacific Islander, Native-American/ Eskimo/Aleut, others, and unknown. Following standard literature, white patients served as the reference group, in comparison to black patients.

Because ambulance diversion is measured at the hospital level, we explored whether hospitals treating a large share of black patients ("black-serving hospitals") were more likely to experience ambulance diversion than non-black-serving hospitals. First, following previous literature, we ranked each hospital by the proportion of black patients at baseline (2001). Hospitals in the top decile were considered black-serving hospitals.(28) Second, if a hospital was not in the top decile for reasons such as being located in a white community, it was also defined as a black-serving hospital if it provided care to more than double the black patients compared with hospitals within a 15-mile radius in 2001.(8)

Statistical Models

We applied multivariate statistical models using the patient as the unit of analysis. We used a linear probability model that included fixed effects for the ED that was closest in proximity for each patient, and also controlled for time-dependent variables.(29) The key variables of interest were: 3 indicators for level of diversion (<6 hours, 6 to <12 hours, ≥12 hours on day of admission, no diversion is the reference group), and 3 interaction terms between black indicator and the 3 diversion indicators. We used the nearest ED operating under normal conditions on day of admission as the control group, and the three diversion indicators to compare patient health outcomes between a given hospital under control status and the same hospital under the 3 diversion categories (i.e., treatment groups). The interaction terms answer our research objective as they capture the black-white patient differences under the same diversion category.

The inclusion of ED fixed effects removed any baseline differences (such as differences in underlying patient population, hospital characteristics, and economic/resources) across ZIP codes or EMS agencies. We controlled for patient factors such as age, sex, and comorbidity measures based on prior work.(30) In order to capture macro-level trends, we included time markers and took organizational characteristics of different hospitals into account, like ownership, teaching status, and market competitiveness.

Given that previous literature has shown that blacks often receive treatment at hospitals with less technology,(17, 18) we controlled for patients' access to hospitals with better cardiac technology, defined as hospitals with a CCU, catheterization lab, and ability to perform CABG.(10) Because blacks are also less likely to receive care,(19, 20) we controlled for actual treatment received (specified as thrombolysis, catheterization, or CABG) that could potentially explain any differences in mortality.

Limitations

There are several limitations that should be taken into account when interpreting our results. First, our diversion data was self-reported by local EMS agencies, which leaves room for error or reporting bias. We believe that any potential bias would have minimal impact, however, because the data were drawn directly from agencies' online reporting systems, as opposed to using data that has been extracted and then reported to state agencies. In previous work, we aggregated our daily data to compare to the yearly levels of diversion that are reported by each hospital to the state, and found an extremely high degree of concurrence.

A second source of measurement error comes from the possibility that a patient's AMI did not take place in their home, as assumed in our analysis. However, 80–85 percent of AMIs are estimated to occur in a patient's home.(31, 32) Because we excluded patients admitted to hospitals far from their home addresses, we do not believe this affected our results.

Third, we did not capture patients admitted to the ED but not to the inpatient setting. However, it would be very unlikely for an AMI to be documented in the ED and discharged directly home without admission. In addition, patients who died before they arrived to the hospital were not included in this study, as they were not present in our data. While this measurement error can introduce a downward bias in estimating the relationship between

ambulance diversion and health outcomes,(8) it did not affect the estimated results of the interaction terms (i.e., the black-white differences) since we did not expect a proportion of patients in this category to differ between blacks and whites.

Fourth, while the fixed effects remove time-invariant unobserved differences across EDs and we controlled for a wide range of key patient and additional hospital characteristics in our analysis, there may be unobserved time-varying hospital characteristics associated with ED overcrowding and diversion that we cannot capture in the data.

Last, our study was limited to California and all the counties in our analysis were considered urban areas. Even though California is a diverse state representing 12% of U.S. population, our results might not be generalized to the rest of the U.S., especially not to rural America.

Results

Exhibit 1 shows the monthly trend of ambulance diversion separately for black-serving hospitals and others. While we observed an overall downward trend in percent of patients affected by ambulance diversion, patients in communities where a nearby ED was black-serving were more likely to encounter ambulance diversion across almost all months than patients in communities where nearest ED is not black-serving. The non-parametric Kolmogorov-Smirnov test confirms that the two groups' diversion trend distributions were statistically significantly different ($p<0.01$).(33)

Our sample included 91,263 AMI patients admitted to all non-federal, general, acute care hospitals in California during 2001–2011. Exhibit 2 shows patient characteristics by diversion level experienced and full patient characteristics are listed in Appendix Exhibit 1. (34) 52% of whites compared with 48% of blacks did not experience diversion on day of admission. 16% of blacks and only 10% of whites were admitted when their nearest ED experienced 12 or more hours of diversion ($p<0.01$ black-white difference). Additionally, 53% of blacks lived nearby black-serving hospitals compared to 21% of whites ($p<0.01$).

Regarding cardiac technology access, 73% of whites were admitted to hospitals with a catheterization lab, compared with 67% of blacks ($p<0.01$). 53% of whites received cardiac catheterization compared with 44% of blacks ($p<0.01$). Higher proportions of blacks were admitted to government (19% vs. 12%, $p<0.01$) and teaching hospitals (18% vs. 10%, $p<0.01$), and were Medicaid-insured (14%) or uninsured (5%) compared with whites (5% and 3%, respectively). Blacks tended to be younger, with 47% less than 65 compared with 31% in whites. A larger proportion of blacks had diabetes (41% vs. 29%), renal failure (22% vs. 14%), and hypertension (81% vs. 67%). Without adjustment, blacks had lower mortality at all points in time compared with whites. All black-white differences reported were statistically significantly different at the 0.05 level.

In our analysis, we found that longer exposure to ambulance diversion was associated with higher longer-term mortality rates for blacks relative to whites. Exhibit 3 shows the interactive effect between diversion and black patients. Blacks and whites had similar experiences when exposed to low levels of diversion (<6 hours). However, the mortality rate among blacks exposed to medium levels on days of admission (6 to <12 hours) was 3.10

(95% CI 0.65–5.55) percentage points higher at 90 days and 4.10 (95% CI 1.58–6.62) percentage points higher at 1 year relative to whites. To put this in context, a 4.10 percentage point increase in 1-year mortality given a base rate of 22% is a 19% increase in the risk of 1-year death. Among patients exposed to high levels of diversion (12 hours or greater), the rate was 2.88 (95% CI 0.64–5.12) percentage points higher at 90 days and 3.09 (95% CI 0.31–5.88) percentage points higher at 1 year for blacks compared to whites, translating to a relative increase of 19% and 14% for 90-day and 1-year death, respectively. Full results are available in Appendix Exhibit 2.(34)

Because Exhibit 1 shows that patients living near black-serving hospitals were more likely to experience diversion, in a sensitivity analysis, we further explored black-white differences by diversion status in those communities only (n=23,323 in this sub-analysis). Exhibit 4 shows that the black-white differences were even more pronounced within those communities that were served by black-serving hospitals. Specifically, relative to whites from the same community where nearby ED was a black-serving hospital, 1-year mortality among blacks who were admitted on days with medium diversion was 5.02 (95% CI 1.43–8.60) percentage points higher (representing a 23% increase in 1-year mortality). Likewise, 90-day and 1-year mortality among black patients admitted on high diversion days were 3.52 (95% CI 0.55–6.49) and 4.97 (95% CI 1.36–8.59) percentage points higher (i.e., 23% higher) than their white counterparts, respectively.

Discussion

Our findings suggest that blacks in California experience a “double burden” of ED crowding – not only are black-serving hospitals more likely to experience ambulance diversion, but black AMI patients also have worse mortality outcomes relative to whites when exposed to the same diversion levels. Our interaction models show that even under the same levels of diversion, blacks have a 19% higher 1-year mortality compared with whites if the nearby ED experiences 6 to <12 hours of diversion, and 14% if the nearby ED experiences 12 or more hours of diversion on day of admission. Furthermore, black-white differences in mortality rates were even larger in communities where the nearest ED was a black-serving hospital.

While other studies have looked at various predictors of ambulance diversion,(35–37) few studies have evaluated the impact of diversion on racial or ethnic disparities when controlling for patient and hospital factors. Our finding that black-serving hospitals were more likely to experience diversion is consistent with prior studies.(3, 22) More importantly, our results show that blacks have worse health outcomes than whites when faced with the same diversion level, a contrast to a recent study that found no such differences in an older (Medicare-only) study, which could be explained by patient population and sample size differences.(22) Our patient population was younger and potentially more sensitive to changes in access to care.(38)

What are possible reasons that could explain our findings? Our analyses controlled for access to hospital technology and treatment received, thereby removing the possibility that differences in mortality are due to variations in treatment. Since blacks have higher mortality rates than whites even after controlling for cardiac technology access, our findings raise

concern that blacks are receiving poorer quality care. This could be occurring at the individual level or the systems level, the latter more likely. We found that when both whites and blacks experienced high diversion, 26% of whites were admitted to black-serving hospitals compared with 80% of blacks. But for no/low diversion, the difference was much smaller (22% of whites vs. 44% of blacks). It is possible that these differential black-white effects do not arise from deficiencies in care that might lead to in-hospital death, but could be attributable to delayed care that happens more often in black-serving hospitals. For example, delayed administration of appropriate medical therapy (e.g., aspirin, statins) or unmeasured cardiac care quality (e.g., processes of care) could result in poorer heart function (a.k.a., ejection fraction) that would manifest itself in differences in longer-term mortality. This is supported by our findings showing significant black-white differences at 90 days and 1 year, but not at 30 days. It is also possible that there are disparities in the availability of non-cardiac resources, and while exploration of this is beyond the scope our study, substantial literature documents lower quality in black-serving hospitals.(39–41) The widening gap in percent of black and white patients treated at black-serving hospitals during prolonged ED crowding periods may contribute to the widening gap in black-white mortality when both experience ED crowding in the same community. Certainly, a number of factors involving the quality of care following the hospital visit may also affect black-white long-term mortality differences in AMI patients, such as poor primary care access, lack of cardiac rehabilitation access, and high stress environments. These reasons reduce any optimism one may have toward diversion bans, especially in these already overcrowded contexts where blacks have much higher ED visit rates,(42) and where the ED plays a dual “safety net” and “acute care” role.

While the discussion of how to improve quality at black-serving hospitals is beyond the scope of this paper and has been discussed elsewhere, such as improving hospital governance,(40) our findings suggest that interventions that decrease ambulance diversion by reducing ED crowding can potentially reduce disparities in outcomes. The re-allocation of resources for emergency care in minority communities may be another solution to reduce associated racial disparities with diversion given the potential mismatch in supply and demand of ED services.(2)

Conclusions

In conclusion, our analysis demonstrated that black AMI patients differentially experienced higher 90-day and 1-year mortality relative to whites when both experienced moderate to high levels of ambulance diversion. The black-white differences persisted even after we controlled for a comprehensive set of patient and hospital factors. Our findings suggest that policies that address ED crowding within the context of an interconnected healthcare system and target efforts in communities with black-serving hospitals may help reduce disparities in quality of care and health outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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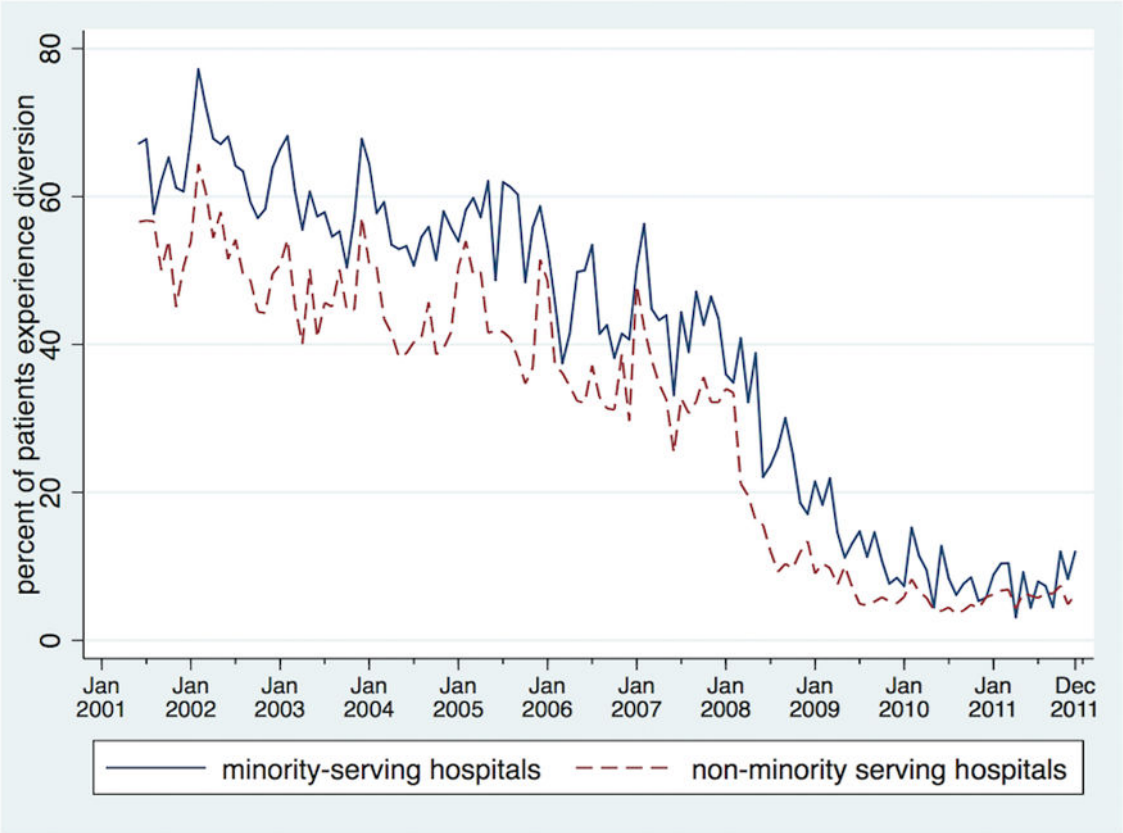

Exhibit 1.

Trend in Ambulance Diversion between Black-Serving and Non-Black-Serving Hospitals, 2001–2011; *SOURCE:* Authors' analysis of data from the California Office of Statewide Health Planning and Development

Exhibit 2

Descriptive Statistics of Patient Characteristics; *SOURCE:* Authors' analysis of data from the California Office of Statewide Health Planning and Development

	Whole Sample		White		Black		
	N	%	N	%	N	%	
Nearest ED's exposure to diversion on the day of admission							
No diversion	46056	50%	28826	52%	3339	48%	**
<6	22319	24%	13487	24%	1501	21%	**
[6–12)	12879	14%	7870	14%	1042	15%	
≥12	10009	11%	5606	10%	1112	16%	**
Nearest ED is black-serving hospitals	23323	26%	11940	21%	3723	53%	**
Access							
Admitted to hospital with cardiac care unit	58626	64%	36561	66%	4553	65%	
Admitted to hospital with cath lab	64528	71%	40518	73%	4660	67%	**
Admitted to hospital with CABG capacity	56320	62%	36343	65%	3864	55%	**
Treatment received							
Received catheterization	47357	52%	29789	53%	3093	44%	**
Received thrombolytic therapy	3048	3%	1741	3%	175	3%	*
Received CABG	5333	6%	3251	6%	258	4%	**
Health Outcomes							
30-day mortality	10684	12%	6869	12%	674	10%	**
90-day mortality	14555	16%	9368	17%	1013	14%	**
1-year mortality	21212	23%	13538	24%	1609	23%	*
30-day all cause readmission	15680	23%	9557	23%	1376	27%	**
Patient	91263		55789		6994		

*p<0.05

**p<0.01

†Full patient characteristics are listed in Appendix Exhibit 1. (34) Statistical significance indicates whether the black-white difference is significantly different from zero based on the t-test. CABG - coronary artery bypass graft.

Exhibit 3

Regression Adjusted Mortality Rate Differences Between Black and White Patients When Both Experienced Ambulance Diversion at their Nearest Emergency Department (ED), All Patients, 2001–2011; *SOURCE:* Authors' analysis of data from the California Office of Statewide Health Planning and Development

	Outcomes		
	30-day mortality	**90-day mortality**	**1-year mortality**
Base rate (among patients in reference group)	11%	15%	22%
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 hours	−0.07 [−0.63,0.48]	0.12 [−0.49,0.72]	0.08 [−0.60,0.76]
[6–12) hours	−0.05 [−0.77,0.67]	−0.07 [−0.89,0.74]	−0.29 [−1.16,0.59]
≥12 hours	−0.32 [−1.24,0.60]	−0.33 [−1.36,0.71]	−0.24 [−1.35,0.86]
Interaction between black patients and diversion level:			
X low diversion (<6 hours)	0.64 [−1.14,2.41]	1.36 [−0.71,3.42]	1.14 [−1.11,3.38]
X medium diversion [6–12) hours	1.66 + [−0.30,3.62]	3.10 * [0.65,5.55]	4.10 ** [1.58,6.62]
X high diversion (≥12 hours)	1.51 [−0.63,3.66]	2.88 * [0.64,5.12]	3.09 * [0.31,5.88]
Control for tech access	Yes	Yes	Yes
Control for treatment	Yes	Yes	Yes
N	91263	91263	91263

† Nearest ED based on Google Maps query of driving distance. Statistical significance indicates whether the coefficient is significantly different from zero based on the regression model.

+ p<0.10

* p<0.05

** p<0.01

Exhibit 4

Regression Adjusted Mortality Rate Differences Between Black and White Patients When Both Experienced Ambulance Diversion at their Nearest Emergency Department (ED), Only Patients Nearby Black-Serving Hospitals, 2001–2011; *SOURCE:* Authors' analysis of data from the California Office of Statewide Health Planning and Development

	Outcomes		
	30-day mortality	**90-day mortality**	**1-year mortality**
Base rate (among patients in reference group)	11%	15%	22%
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 hours	−0.53 [−1.98,0.92]	−0.29 [−1.76,1.18]	0.12 [−1.44,1.67]
[6–12) hours	0.13 [−1.61,1.88]	0.09 [−1.78,1.96]	0.02 [−1.91,1.95]
≥12 hours	−0.87 [−2.99,1.24]	−0.18 [−2.32,1.96]	−0.18 [−2.33,1.98]
Interaction between black patients and diversion level:			
X low diversion (<6 hours)	−0.01 [−2.79,2.77]	−0.41 [−3.44,2.62]	0.00 [−3.91,3.91]
X medium diversion [6–12) hours	1.50 [−1.38,4.37]	3.16 $^{+}$ [−0.10,6.42]	5.02 ** [1.43,8.60]
X high diversion (≥ 12 hours)	2.25 [−0.64,5.13]	3.52 * [0.55,6.49]	4.97 ** [1.36,8.59]
Control for tech access	Yes	Yes	Yes
Control for treatment	Yes	Yes	Yes
N	23323	23323	23323

†Nearest ED based on Google Maps query of driving distance. Statistical significance indicates whether the coefficient is significantly different from zero based on the regression model.

$^{+}$ p<0.10

* p<0.05

** p<0.01