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Authors
Shen, Yu-Chu

Krumholz, Harlan

Hsia, Renee

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Do PCI Facility Openings and Closures Affect Outcomes for AMI Patients Differently in High v. Average-Capacity Markets?

Yu-Chu Shen, PhD[1,2], **Harlan M. Krumholz, MD, SM**[3,4,5], **Renee Y. Hsia, MD, MSc**[6,7]

[1]Naval Postgraduate School, Monterey, California

[2]National Bureau of Economic Research, Cambridge Massachusetts

[3]Section of Cardiovascular Medicine, Department of Internal Medicine, Yale School of Medicine, New Haven, Connecticut

[4]Department of Health Policy and Management, Yale School of Public Health, New Haven, Connecticut

[5]Center for Outcomes Research and Evalution, Yale New Haven Hospital, New Haven, Connecticut

[6]Department of Emergency Medicine, University of California, San Francisco

[7]Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco

Abstract

Objective: We sought to determine whether openings and closures of percutaneous coronary intervention (PCI) hospitals have differentially impacted patient health outcomes in high-versus average-capacity PCI markets.

Background: Disparities in access to PCI for patients with acute myocardial infarction (AMI) may result from openings and closures of PCI-providing hospitals, potentially leading to low hospital PCI volume which is associated with poor outcomes.

Methods: In this retrospective cohort study, we identified PCI hospital availability within a 15-minute driving time of ZIP-code communities. We categorized communities by baseline PCI capacity and identified changes in outcomes associated with PCI-providing hospital openings and closures using community fixed-effects regression models.

Address for Correspondence: Renee Y. Hsia, MD, MSc, Department of Emergency Medicine, Box 1377, University of California, San Francisco, 1001 Potrero Ave., Building 5, Suite 6A, San Francisco, CA 94110, Tel: (628) 206-4612, Fax: (628) 206-5818, renee.hsia@ucsf.edu.

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Results: From 2006 to 2017, 20% and 16% of patients in average- and high-capacity markets, respectively, experienced a PCI opening within a 15-minute drive. In average-capacity markets, openings were associated with a 2.6-percentage-point decrease in admission to a high-volume PCI facility; high-capacity markets saw an 11.6-percentage-point decrease. After an opening, patients in average-capacity markets experienced a 6.5% and 8.6% relative increase in likelihood of same-day and in-hospital revascularization, respectively, as well as a 2.5% decrease in mortality. PCI hospital closures were associated with a 10.4% relative increase in admission to high-volume PCI hospitals and a 1.4-percentage-point decrease in receipt of same-day PCI. There was no change observed in high-capacity PCI markets.

Conclusions: After openings, patients in average-capacity markets derived significant benefits, while those in high-capacity markets did not. This suggests that past a certain threshold, facility opening does not improve access and health outcomes.

CONDENSED ABSTRACT

Openings and closures of PCI-providing hospitals may lead to disparities in access, treatment, and outcomes for AMI patients. In this retrospective cohort study, we identified communities' availability of PCI-providing hospitals within a 15-minute driving time. We categorized communities by baseline PCI capacity and identified changes in outcomes associated with PCI-providing hospital openings and closures. We found that from 2006 to 2017, PCI capacity grew for all communities, including those with high baseline capacity. Average-capacity markets derived significant benefits from openings, while high-capacity markets did not. This suggests that "more" is not necessarily better when it comes to the adoption of PCI technology.

Keywords

percutaneous coronary intervention; market capacity; PCI outcomes; PCI access; Medicare

INTRODUCTION

How does the geographic distribution of percutaneous coronary intervention (PCI) centers impact cardiac patients' health access and outcomes? Almost a decade ago, Concannon et al. demonstrated systemic duplication in the growth of PCI hospitals;[1] new PCI hospital growth occurred in areas that already had a sufficient number of PCI hospitals. Specifically, while the number of hospitals with PCI capability rose at a rate of 44% in a mere 5-year period, this expansion of availability improved access for less than 1% of the U.S. population.[2] Preferential expansion occurred in areas with existing PCI services, higher rates of private insurance, wealthier hospitals, and less state regulation of new cardiac catheterization labs.[1] Low-income, minority, and rural communities were left with poorer PCI access relative to advantaged communities.[1, 3, 4]

To date, no studies have evaluated the proliferation of PCI centers to determine how PCI center openings (and conversely, closures) have affected outcomes for patients with acute myocardial infarction (AMI), nor has the literature established whether there have been differential effects for patients in communities that already had high PCI capacity at baseline compared to those in average-capacity PCI markets. This research is necessary because the introduction of additional PCI services in high-capacity PCI markets could reduce per-hospital PCI volume, which has been associated with poorer outcomes.

Accordingly, we used a population-level approach to study how Medicare Fee-for-Service (FFS) patients with AMI are affected by changes in access to PCI centers in their communities. We hypothesized that in communities with average baseline PCI capacity, the opening of a PCI lab within a 15-minute drive would only slightly decrease the likelihood of being admitted to a high-volume PCI hospital, whereas PCI lab openings in communities with high baseline PCI capacity would significantly decrease those chances. We also hypothesized that the introduction of PCI hospitals in average-capacity PCI communities would markedly increase the likelihood of receiving same-day and in-hospital PCI, much less than in high-capacity PCI communities, and that mortality outcomes would improve in average-capacity PCI communities, more so than in high-capacity PCI communities. We examined all communities across the continental United States from 2006 to 2017 and compared outcomes prior to and following PCI capacity changes in high-capacity versus average-capacity PCI markets.

METHODS

Data Sources

We used the 100% Medicare Provider and Analysis Review (MedPAR) and Medicare outpatient claims between 2005–2017 to identify PCI volume and the patient cohort. We used the American Hospital Association (AHA) and the Healthcare Cost Report Information System to identify hospital characteristics, including their geographical coordinates. We used 2010 U.S. Census and 2011–2018 American Community Surveys to identify each ZIP code community's geographical coordinates and demographic information. Finally, we derived a driving-time database using web-based queries between each patient's ZIP code and surrounding PCI-providing hospitals based on the coordinates (longitude and latitude) of each location.[6] This study received the proper ethical approval.

Study Population

Our patient population included all Medicare FFS patients between January 2006 and December 2017 whose principal diagnosis was AMI. Using criteria from prior work,[7-10] we identified the AMI patient cohort using ICD-9-CM codes 410.x0 and 410.x1 for admissions that occurred before October 1, 2015, and ICD-10-CM code I21 for admissions that occurred on or after that date.

Identifying hospital PCI lab availability

Following prior work,[2, 11] we used a volume-based threshold to identify a hospital's PCI availability. A hospital was defined as providing PCI if it had performed at least five PCI procedures per year based on Medicare FFS records. The advantage of using this volume-based definition is that it minimizes errors from self-reported measurements (such as those published in AHA surveys).

Identifying communities' baseline PCI capacity

Our conceptual framework predicted that PCI hospital openings and closures had different implications for saturated markets compared with markets that had unmet needs. We measured PCI capacity as a percentage of patients who were admitted to PCI-capable hospitals (regardless of whether they received PCI) and classified communities as having "high capacity" (as a proxy for saturated markets) or "average capacity" at baseline based on their 2005–06 status. Following prior work,[12-14] we used Hospital Referral Regions (HRRs) as the broad market definition to classify communities and used a regression-based approach to rank markets' PCI lab capacity in the base years (2005 and 2006). ZIP code communities in HRRs ranked in the upper quartile were classified as "high-capacity" markets and the remaining communities were classified as "average-capacity" markets. We provide additional details of the regression-based approach to define community PCI capacity in the online technical supplement. In a sensitivity analysis, we used raw PCI capacity to rank the HRRs instead of using the regression-based rank, and our results were robust to the alternate definition.

Identifying PCI hospital openings and closures over time around the community

Our key variable was a PCI lab opening or closure within a 15-minute drive from the geographic center of a ZIP code community. We chose a threshold of 15 minutes driving time to the opened or closed facility based on thresholds reported in other studies[15-17] and prior literature showing that the majority of hospital visits are within 15 minutes of a patient's residence.[18] This decision was further supported by clinical data showing that, after 90 minutes, every 15-minute delay in receipt of care for ST-elevation myocardial infarction (STEMI) patients is associated with a significant increase in the risk of death.[19]

To identify changes in PCI capacity, we first identified the set of PCI-providing hospitals operating within a 15-minute drive for each year using the driving time database we derived from web-based queries. We then evaluated year-to-year changes and classified communities according to whether they experienced any PCI openings or closures within a 15-minute driving time for a given year.

Outcomes

The main outcomes of this study included: (1) admission to a high-volume PCI hospital (as defined below); (2) receipt of same-day PCI; (3) receipt of PCI during the hospitalization; and (4) time-specific, all-cause mortality (30-day, 90-day, and 1-year). We defined a hospital as "high-volume" using a threshold of 150 PCIs per year, as in prior literature. This was based on the recommendation of the American College of Cardiology Foundation and the American Heart Association, which have stated that PCI centers should provide at least 200 PCIs per year at the facility level (separate from the recommended 50 PCIs per year at the operator level).[21-23] Because we used only Medicare FFS data, we adjusted our definition to account for patients insured by other sources (or uninsured patients) who may not appear in our data: based on our tabulation of all-payer data from California, Medicare patients account for approximately 75% of AMI admissions.

Other treatment outcomes included receipt of coronary angiography since this procedure represents a prelude to revascularization and accounts for the clinical realities of failed PCI and/or anatomy that is not suitable for PCI. We also performed a sensitivity analysis using a more conservative approach whereby we counted PCI only to address concerns that including coronary angiography in outcome definitions might make the measure too broad. For health outcomes, we focused on time-specific mortality rather than in-hospital mortality rates so we would be able to detect effects on mortality, not only in the acute phase but in the longer term as well.

Statistical Methods

Our unit of analysis was the patient. Because all outcomes were dichotomous, we implemented a linear probability model with community fixed-effects to control for any unobserved time-invariant heterogeneity across communities. We estimated robust standard errors that accounted for intra-community correlation among patients of the same community.[24] The key variables were the PCI hospital opening and closure indicators. Specifically, PCI opening indicators took on a value of 1 on and after the year that a community experienced a PCI opening within a 15-minute driving time. This set of indicators captured changes in outcomes among patients in communities that experienced a PCI opening *relative to* changes in health outcomes among patients in the reference community from the same type of market (i.e., no change in PCI capacity within 15 minutes). We defined a set of PCI closure indicators similarly. We also included year indicators to capture the macro-level trends of health outcomes from 2006 through 2017. In our fully adjusted model, we also included patient demographic co-variates (5-year age groups, race, gender) as well as a set of disease-related risk adjustments following prior work.[8, 25] We did not include community-level characteristics in the model because they are subsumed by the community fixed-effects. This study did not involve human subjects and was considered IRB-exempt based on guidelines from the University of California, San Francisco Human Research Protection Program.

RESULTS

Our study included 2,742,530 patients from 2006–2017. By study design, about a quarter of patients lived in a high-capacity market, while the remaining three-quarters lived in an average-capacity market. Table 1 shows that communities that were classified as having high PCI capacity at baseline had a lower proportion of Black residents (9%) compared to communities with average PCI capacity at baseline (14%), as well as a lower proportion of low-income families (29% compared to 34% for average capacity at baseline). Table 1 further shows that 16% of patients in high-capacity markets experienced a PCI opening during the study period, compared with 20% of patients in average-capacity areas. A slightly higher percentage of patients in high-capacity areas (11%) experienced a PCI facility closure during the study period, compared with 7% of patients living in average-capacity areas.

The remainder of Table 1 shows that among Medicare AMI patients, patient characteristics did not differ significantly between baseline average- and high-capacity communities. Over the study period, 95% of patients in high-capacity markets were admitted to a

PCI hospital (compared with 85% in average-capacity markets, not shown), and a larger proportion of patients in high-capacity markets underwent coronary angiography or PCI during hospitalization (66%) compared with patients in average-capacity markets (59%).

Figure 1 shows the overall trend of hospitals offering PCI in the United States from 2006–2018. The number of PCI-providing hospitals grew from 1,465 in 2006 to 1,804 in 2018. Both types of markets had PCI capacity growth: the growth rate was 30% in average-capacity markets (from 975 to 1,267) and 9.6% in high-capacity markets (from 490 to 537).

Figure 2 provides an event study graph showing changes in outcomes *relative to the national average* from five years before to five years after each community experienced a PCI opening within a 15-minute drive. We normalized all outcomes to have a yearly mean of zero since PCI openings occurred in different years across communities. For example, panel (a) shows that in average-capacity markets, the proportion of patients admitted to high-volume PCI hospitals was above the national average by about 5 percentage points prior to a PCI opening but decreased to the national average in the post-opening years. Panel (b) also shows that among high-capacity markets, the introduction of a new PCI facility was followed by a significant decrease in the likelihood that a patient would be admitted to a high-volume center.

Panel (e) shows that in an average-capacity market, the probability of receiving cardiac catheterization or PCI during hospitalization was roughly 3% below the national average prior to a PCI opening but increased the likelihood of receiving such procedures to approximately 2.5% above the national average after an opening. This trend was not observed in high-capacity markets: see panel (f). Panels (c) and (d) show a similar trend such that openings increased the likelihood of receiving same-day PCI in average-capacity markets but not in high-capacity markets. However, panels (g) and (h) in Figure 2 show no significant change in mortality after a PCI opening in either type of market.

While Figure 2 shows the raw trends in the effects of PCI openings, the Central Illustration and Table 2 illustrate the fully adjusted regression results of these effects in both types of communities. Complete regression results are included in Appendix Table 1. The introduction of a new PCI hospital only slightly decreased (by 2.6 percentage points) the likelihood of admission to a high-volume facility for patients with AMI in average-capacity markets (95% CI −3.91, −1.37), but there was a significant 11.6-percentage-point decrease (CI −14.1, −9.1) in the likelihood of being admitted to a high-volume hospital among patients in high-capacity markets, even after adjustment for patient characteristics. Given that at baseline, 58.6% of AMI patients were admitted to high-volume PCI hospitals, the 11.6-percentage-point decrease represents a 20% drop in the likelihood of receiving revascularization in a high-volume PCI center in high-capacity markets. Among average-capacity PCI markets, patients with AMI experienced a 2.42-percentage-point (CI 1.95, 2.9) increase, or a 6.5% relative increase, in the likelihood of receiving same-day PCI after a PCI facility opening. No change in this measure was seen for patients with AMI in high-capacity markets (−0.3, CI −1.3, 0.6). Similarly, patients with AMI in average-capacity markets were more likely (by 4.5 percentage points) to receive PCI during a hospitalization (CI 3.9, 5.1), reflecting an 8.6% relative increase, after the community experienced a PCI opening; again, patients in high-capacity markets did not experience any statistically significant change (0.2, CI −0.9, 1.3). Patients in average-capacity markets experienced a 0.4 percentage point reduction in 30-day mortality (CI −0.6, −0.1), 0.5 percentage point reduction in 90-day mortality (CI −0.8, −0.2), and 0.8 percentage point reduction in 1-year mortality (CI −1.2, −0.4) after they experienced a PCI opening in their communities relative to patients in average-capacity markets who did not experience a PCI opening. These percentage point changes are equivalent to a 2.2%−2.6% reduction in mortality rates for AMI patients in average-capacity markets. We did not observe a statistically significant change in mortality among patients with AMI in high-capacity markets when their communities experienced PCI openings.

We also examined the effects of PCI closure on these same outcomes. We found that PCI center closure in average-capacity PCI markets resulted in an increase in the likelihood of receiving care in a high-volume PCI hospital (6.1 percentage points, 95% CI 4.4, 7.9), a 10.4% relative increase from baseline. We did not observe any change in likelihood of receiving care in a high-volume PCI hospital for patients in high-capacity areas. Patients in average-capacity PCI markets also experienced a 1.4-percentage-point decrease in the likelihood of receiving same-day PCI (95% CI −2.0, −0.8), whereas no change was observed in high-capacity PCI markets. After PCI closure in either market, similar decreases were observed in the likelihood of receiving PCI at any time during the patient’s hospitalization, and no differential change in mortality was observed.

For our sensitivity analysis using PCI alone as the treatment outcome (as opposed to PCI and cardiac catheterization in the main model), we found similar results (Appendix Table 2). Patients in average-capacity markets with a PCI opening experienced a statistically significant increase in the likelihood of receiving PCI, which was not the case in high-capacity markets. Similarly, closures of PCI facilities were associated with statistically significant decreases in the likelihood of receiving PCI in average-capacity markets, but no changes were observed in high-capacity PCI markets.

DISCUSSION

In this analysis of PCI openings and closures using national data from 2006–2017, PCI center openings within a 15-minute drive in average-capacity markets were associated with significant benefits in treatment access and outcomes for patients with AMI. These effects were not seen in high-capacity PCI markets. Specifically, in average-capacity markets, patients with AMI had a 6.5% and 8.6% relative increase in the likelihood of receiving revascularization on the day of admission and during an in-hospital care episode, respectively, as well as an approximately 2.5% decrease in mortality across all timepoints studied. These changes were not observed for patients with AMI in high-capacity markets. However, a PCI facility opening in a high-capacity market was associated with a 20% drop in the probability of admission to a high-volume hospital. Similarly, closures of PCI services in average-capacity markets resulted in a 10.4% relative increase in patients with AMI being admitted to high-volume PCI hospitals and a 3.7% decrease in the likelihood of receiving same-day or in-hospital revascularization.

To our knowledge, there are no published population-level studies exploring how PCI hospital openings and closures might affect treatment access and outcomes of patients with AMI, much less how these changes differ by communities' baseline PCI capacity. What we do know is that PCI services have preferentially expanded in more affluent areas with a greater proportion of commercial payers, and that access to PCI services is worse in poorer areas.[1, 2, 4] There is also a wealth of literature documenting a strong positive association between PCI volume and improved patient outcomes.[21-23, 26-29] Taken together, our results can be interpreted to mean that PCI center openings in areas of low or average PCI capacity yield greater benefits for patients in those communities, likely because of the large unmet need for PCI in those areas. This contrasts our findings for high-capacity markets, where the probability of receiving PCI does not change — presumably because these areas are already able to provide PCI services to those who need them, and PCI openings simply redistribute patients across more facilities.

Our findings have implications for the quality of AMI care, providing support for the idea that harmful consequences may result from the preferential adoption of PCI in markets where such services are already saturated. AMI has well-defined treatment guidelines, and we would not expect the opening of a PCI center to increase or decrease the need for PCI among AMI patients in a community. The relatively fixed community-level PCI demand implies that opening a PCI center in a high-capacity market results in lower per-facility volumes, as confirmed in our findings. These lower per-facility volumes may negatively affect patients in more advantaged communities as low volume has been associated with poorer patient outcomes. More entrants in an already saturated PCI market put providers in these areas at risk of becoming "low-volume operators," who have been associated with higher rates of inappropriate procedures.[30] In our analysis, we did not find an increased mortality risk after the introduction of additional PCI hospitals to high-capacity markets, which could be because such risks are theoretical or potentially because mortality is rare enough in these cases (which would be done in healthier patients than those receiving emergent intervention with definitive benefit).

This lower facility volume is particularly concerning given that median annual PCI operator volumes have declined over time.[31, 32] Operator volumes have been declining such that, in 2009, the median number of PCIs performed annually by each operator was 33, with 25% of operators performing ≥15 PCIs per year.[31] A more recent study by Fanaroff revealed that 44% of PCI operators had fewer than 50 PCIs per year, the minimum threshold recommended by the American Heart Association and American College of Cardiology to be considered clinically competent.[32] Both studies showed the highest mortality at low-volume centers and the lowest mortality at the highest-volume centers.[31, 32]

Understanding the effects of the *de facto* growth in PCI centers across different communities is vital since upstream factors such as differential access to care across communities can have unexpected effects on health treatment and outcome disparities. In this case, preferential adoption of PCI in high-capacity markets could decrease the gap between the average-capacity and high-capacity markets – by unintentionally worsening outcomes for patients in high-capacity markets. Studies that are designed to evaluate differential effects of technology between and across communities with varying access to care can reveal deeply embedded mechanisms by which disadvantaged populations have fewer resources but also how advantaged populations may indirectly be harmed by too much healthcare. This perspective is crucial to incorporate in the evaluation of other technologically intensive services, such as transcatheter aortic valve replacement (TAVR), which has also been shown to be more available in hospitals serving wealthier patients, compounding inequities of treatment.[33]

While a full discussion of solutions to the imbalanced distribution of cardiac services is beyond the scope of this paper, it is important to recognize that an estimated 25–40% of a hospital's net revenue is derived from cardiac services alone and likely motivates PCI openings and closures.[34] A clearer understanding of how changes in the geographic concentration of cardiac care facilities affect individuals and communities differently[35] could inform local or state health agencies to more carefully consider issues of baseline access to healthcare services before approving new designations or facilities. Alternatively, community equity metrics that incorporate access measures could be required from hospitals applying for certification as new PCI centers. Further research examining how policy interventions may affect access to revascularization and the use of inappropriate procedures, will be important.

At a broader level, our study demonstrates that "more" is not necessarily better and that the current pattern of technology expansion can have unintended consequences. Technology in medicine is often deployed without explicit attention to equity of service, with the idea being that "a rising tide lifts all boats."[36] Although technology, in many areas, has certainly led to benefits in overall population health, our findings contribute to existing evidence in healthcare that more technology does not necessarily lead to better outcomes. Research in this vein considers the entire lifespan — from surfactant therapy for premature newborns,[37] or the screening and treatment of cancer,[38] to medical technology for the elderly[39] — and finds that such benefits do not always accrue equally to all segments of the population. Thus, careful consideration of how the healthcare system allocates these resources is necessary.

Limitations

This study has several important limitations. Our data included only Medicare FFS beneficiaries. For this reason, we adjusted our thresholds to define high-volume centers as described in the Methods section. We did not expect that PCI openings and closures would affect Medicare Advantage or private patients differently from Medicare FFS patients. It is possible that the geographic distribution of patients not enrolled in Medicare FFS is systematically different from that of Medicare FFS patients: for example, suppose all Medicare Advantage patients are located in wealthier communities. However, such differences do not invalidate our estimated results because our results were identified based on comparing within-community differences. Nonetheless, our results would not be generalizable to patients who are not Medicare FFS patients.

Second, our patient population only included inpatient admissions, and not all cardiac catheterizations and PCIs are done in the inpatient setting. While the proportion of outpatient PCI procedures among Medicare patients with AMI grew (from 0.5% in 2006 to 1% in 2017), outpatient PCI is still rare, and we would not expect this growth to affect our findings.

Third, driving time was measured with errors because we used the same geographical coordinates for all patients from the same community. This measurement error would bias our results toward zero, making our estimated results a conservative estimate.

Fourth, our study period spanned over 11 years, and patient mobility or changes in community characteristics over time could potentially confound our results if such changes differ systematically between average and high-capacity markets. Appendix Table 3 shows that community characteristics are highly correlated over time, so any observed changes would have a minimal effect on our results. In both average and high-capacity markets, we see similar growth in the population self-identifying as Hispanic. The time dummies included in our model would capture such macro trends and would not confound our results.

Lastly, our Medicare data is from an administrative database and thus provides limited clinical information. Avoiding this limitation was not possible because more detailed datasets with richer clinical information, such as CathPCI Registry®, capture only patients who received PCI and therefore preclude evaluation of all AMI patients.

CONCLUSIONS

PCI capacity has continued to grow in all communities, including communities with high baseline capacity, since 2006. Our findings lend credence to the notion that the opening of PCI services in a hospital has markedly different effects on communities depending on their baseline access to PCI services. Patients with AMI in average-capacity markets benefit substantially, whereas the effect observed for patients in high-capacity markets is small—or possibly even detrimental.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS AND ACRONYMS

ACS	American Community Survey
AHA	American Hospital Association
AMI	acute myocardial infarction
FFS	Fee-for-Service

HCRIS	Healthcare Cost Report Information System
HRR	hospital referral region
MedPAR	Medicare Provider and Analysis Review
PCI	percutaneous coronary intervention
STEMI	ST-elevation myocardial infarction
TAVR	transcatheter aortic valve replacement

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CLINICAL PERSPECTIVES

WHAT IS KNOWN?

We know that PCI services have preferentially expanded in more affluent areas with a greater proportion of commercial payers, and that access to PCI services is worse in poorer areas. Prior literature has also documented a strong positive association between PCI volume and improved patient outcomes.

WHAT IS NEW?

Our study found that PCI center openings within a 15-minute drive in average-capacity markets were associated with significant benefits in treatment, access, and outcomes for patients with AMI, but these effects were not observed in communities that already had high PCI capacity at baseline.

WHAT IS NEXT?

Further research on potential policy interventions addressing where new PCI hospitals are opening and how PCI resources are allocated is crucial.

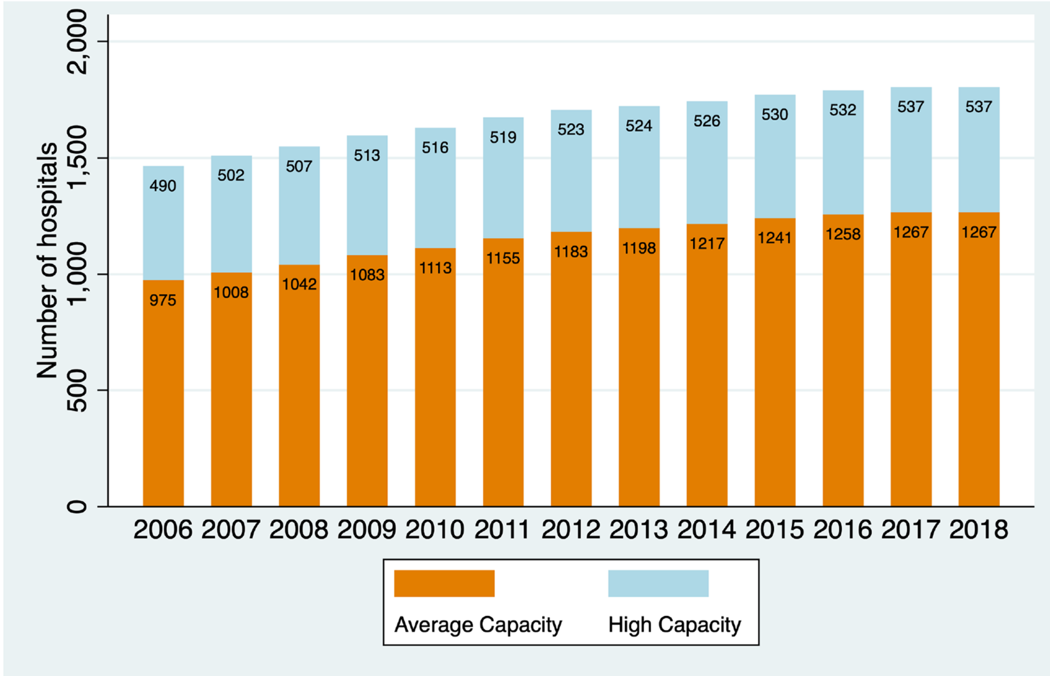


Figure 1.
Number of PCI Hospitals by Community Baseline Capacity, 2006-2018

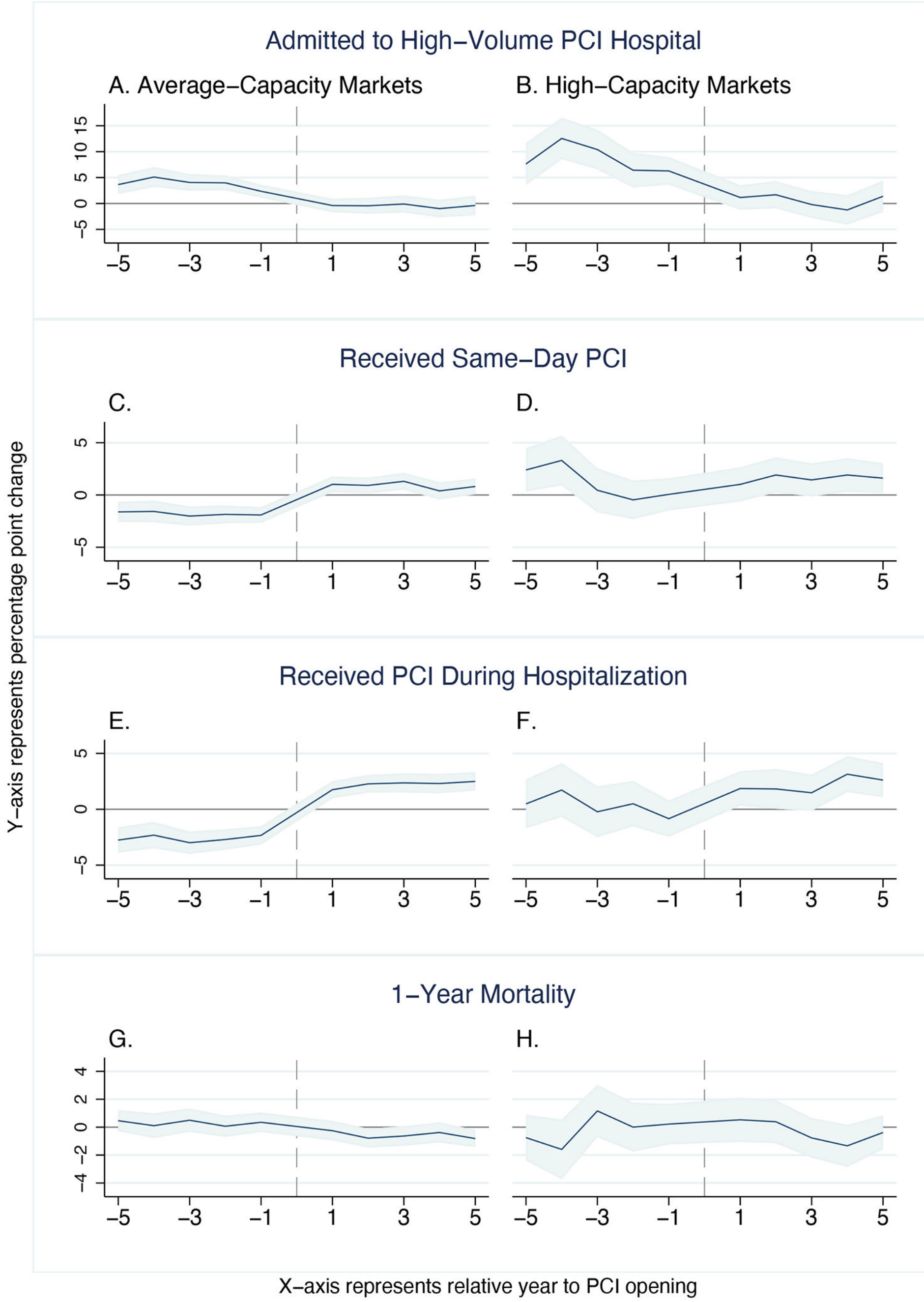
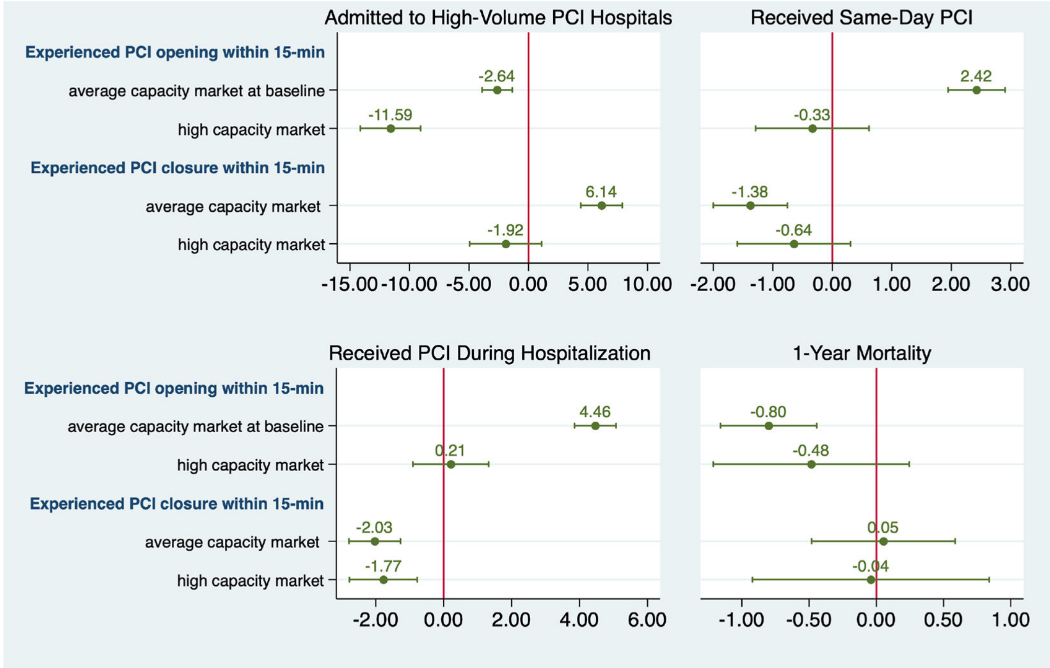


Figure 2. Changes in Outcomes when Communities Experience PCI Openings within a 15-Minute Driving Time

Note: trend lines represent percentage point changes in outcomes relative to the national average from five years before to five years after each community experienced a PCI opening within 15 minutes.



Central Illustration.

Risk-Adjusted Percentage Point Changes in Outcomes When There is a PCI Access Change Within a 15-Minute Driving Time

Table 1.

Descriptive Statistics of Community and Patient Characteristics

	Whole Sample		High Capacity		Average Capacity	
	N or mean	%	N	%	N	%
N	2,742,530	100%	653,247	24%	2,089,283	76%
Community characteristics based on Census (Mean/SD)						
proportion of White population	74%	22%	76%	20%	73%	23%
proportion of Black population	13%	19%	9%	17%	14%	19%
proportion of Hispanic population	16%	20%	18%	21%	16%	20%
proportion of low-income population[a]	33%	47%	29%	45%	34%	47%
proportion of population in rural communities	18%	39%	16%	37%	19%	39%
proportion of population 65 years or older	13%	6%	13%	6%	14%	6%
Community PCI opening during study period (2006–2017)						
Within 15 minutes driving distance	527,208	19%	101,640	16%	425,568	20%
Community PCI closure during study period (2006–2017)						
Within 15 minutes driving distance	221,379	8%	70,185	11%	151,194	7%
Patient demographics						
White	2,345,209	86%	564,550	86%	1,780,659	85%
Black	246,851	9%	51,189	8%	195,662	9%
Hispanic	53,038	2%	12,169	2%	40,869	2%
Other non-white races	52,048	2%	12,943	2%	39,105	2%
Female	1,309,102	48%	305,918	47%	1,003,184	48%
Age distribution at time of admission						
65-69 years	555,878	20%	134,178	21%	421,700	20%
70-74 years	505,704	18%	122,002	19%	383,702	18%
75-79 years	491,721	18%	117,245	18%	374,476	18%
80-84 years	481,765	18%	114,073	17%	367,692	18%
85+ years	707,462	26%	165,749	25%	541,713	26%
Patient conditions						
STEMI	603,966	22%	152,625	23%	451,341	22%
Peripheral vascular disease	272,428	10%	64,911	10%	207,517	10%

	Whole Sample		High Capacity		Average Capacity	
	N or mean	%	N	%	N	%
Pulmonary circulation disorders	137,773	5%	33,651	5%	104,122	5%
Diabetes	826,475	30%	190,341	29%	636,134	30%
Renal failure	627,179	23%	147,965	23%	479,214	23%
Liver	23,639	1%	5,424	1%	18,215	1%
Cancer	99,367	4%	23,233	4%	76,134	4%
Dementia	117,894	4%	26,489	4%	91,405	4%
Valvular disease	359,358	13%	83,203	13%	276,155	13%
Hypertension	1,867,504	68%	443,123	68%	1,424,381	68%
Chronic pulmonary disease	560,608	20%	130,113	20%	430,495	21%
Rheumatoid arthritis/collagen vascular	59,747	2%	14,765	2%	44,982	2%
Coagulation deficiency	123,257	4%	30,729	5%	92,528	4%
Obesity	194,634	7%	47,521	7%	147,113	7%
Substance abuse	34,405	1%	8,523	1%	25,882	1%
Depression	126,790	5%	29,160	4%	97,630	5%
Psychosis	85,525	3%	19,632	3%	65,893	3%
Hypothyroidism	302,081	11%	74,898	11%	227,183	11%
Paralysis and other neurological disorder	215,238	8%	50,386	8%	164,852	8%
Ulcer	5,845	0%	1,383	0%	4,462	0%
Weight loss	82,204	3%	20,707	3%	61,497	3%
Fluid and electrolyte disorders	593,376	22%	145,140	22%	448,236	21%
Anemia	363,516	13%	85,672	13%	277,844	13%
Admission status and treatment received						
Admitted to high-volume PCI hospital	1,609,347	59%	377,676	58%	1,231,671	59%
Received catheterization or PCI on admission day	1,249,834	46%	335,020	51%	914,814	44%
Received catheterization or PCI during hospitalization episode	1,654,873	60%	431,672	66%	1,223,201	59%
Health outcomes						
30-day mortality	355,628	13%	84,220	13%	271,408	13%
90-day mortality	502,645	18%	117,782	18%	384,863	18%
1-year mortality	773,583	28%	179,417	27%	594,166	28%

Abbreviations: PCI - percutaneous coronary intervention; STEMI = ST-elevation myocardial infarction

Values are N (%) or mean and SD.

[a] low-income population is defined as population in communities where medium family income is in the bottom tertile of family income distribution

Table 2.

Risk Adjusted Changes in Probability of Access, Treatment, and Health Outcomes when Communities Experience a PCI Access Change within a 15-minute Driving Time

	Admitted to high-volume PCI hospital	Received cath/PCI within 1 day of admission	Received cath/PCI during care episode	30-day mortality	90-day mortality	1-year mortality
Outcome base rate	58.6%	37.5%	52.1%	15.0%	20.8%	31.2%
Changes in probability after ZIP code gained a PCI hospital within 15-min driving time						
Average-capacity market	−2.64** [−3.91,−1.37]	2.42** [1.95,2.90]	4.46** [3.85,5.07]	−0.37** [−0.64,−0.10]	−0.46** [−0.77,−0.15]	−0.80** [−1.16,−0.44]
High-capacity market	−11.59** [−14.12,−9.06]	−0.33 [−1.29,0.62]	0.21 [−0.91,1.32]	−0.33 [−0.89,0.23]	−0.49 [−1.12,0.15]	−0.48 [−1.21,0.24]
Changes in probability after ZIP code lost a PCI hospital within 15-min driving time						
Average-capacity market	6.14** [4.40,7.88]	−1.38** [−2.00,−0.75]	−2.03** [−2.79,−1.27]	0.09 [−0.31,0.49]	0.01 [−0.46,0.47]	0.05 [−0.48,0.59]
High-capacity market	−1.92 [−4.95,1.11]	−0.64 [−1.59,0.31]	−1.77** [−2.77,−0.78]	−0.31 [−0.96,0.34]	−0.18 [−0.93,0.58]	−0.04 [−0.92,0.84]
N	2742530					

Abbreviations: PCI - percutaneous coronary intervention

Values are coefficient [95% CI]

* p<0.05

** p<0.01