Title
Association of STEMI regionalization of care with de facto NSTEMI regionalization

Authors
Montoy, Juan Carlos C
Shen, Yu-Chu
Krumholz, Harlan M
et al.

Publication Date
2021-12-01

DOI
10.1016/j.ahj.2021.07.002

Peer reviewed

Published in final edited form as:

Am Heart J. 2021 December ; 242: 1–5. doi:10.1016/j.ahj.2021.07.002.

Association of STEMI Regionalization of Care with *De Facto* NSTEMI Regionalization

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

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

[2]Naval Postgraduate School

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

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

[5]Center for Outcomes Research and Evaluation, Yale–New Haven Hospital

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

Abstract

The regionalization of care for ST elevation myocardial infarction (STEMI) may unintentionally concentrate patients with non-ST elevation myocardial infarction (NSTEMI) into percutaneous coronary intervention (PCI) capable hospitals. This could lead to benefits such as increased access to PCI-capable hospitals, but could cause harms such as crowding in some hospitals with decreased patient volume and revenue in others. We set out to assess whether STEMI regionalization programs concentrated patients with NSTEMI at STEMI-receiving hospitals.

Keywords

NSTEMI; STEMI; Emergency medical services; Health services research

Corresponding author: Juan Carlos C. Montoy, MD, PhD, University of California, San Francisco, Department of Emergency Medicine, 1001 Potrero Ave, Bldg 5, Rm 6A, San Francisco, CA 94110, Phone: 415-206-5758, Fax: 415-206-5818, juancarlos.montoy@ucsf.edu.

AUTHOR CONTRIBUTIONS

Study concept and design JCM, RH
Acquisition of the data RH, YCS
Analysis and interpretation of the data JCM
Drafting of the manuscript JCM
Critical revision of the manuscript for important intellectual content HK, RH, YCS, JCM
Statistical expertise JCM, YCS
Acquisition of funding RH, JCM

CONFLICTS OF INTEREST AND FINANCIAL DISCLOSURES

In the past three years, Harlan Krumholz received expenses and/or personal fees from United Health, IBM Watson Health, Element Science, Aetna, Facebook, the Siegfried and Jensen Law Firm, Arnold and Porter Law Firm, Martin/Baughman Law Firm, F-Prime, and the National Center for Cardiovascular Diseases in Beijing. He is an owner of Refactor Health and Hugo Health, and had grants and/or contracts from the Centers for Medicare & Medicaid Services, Medtronic, the U.S. Food and Drug Administration, Johnson & Johnson, and the Shenzhen Center for Health Information.

DATA ACCESS, RESPONSIBILITY, AND ANALYSIS

Dr. Juan Carlos C. Montoy had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

INTRODUCTION

Timely access to percutaneous coronary intervention (PCI) is critical to achieving better outcomes in patients with acute myocardial infarction (MI), particularly ST-elevation myocardial infarction (STEMI).[1] As most acute care hospitals in the United States, however, are not capable of providing percutaneous coronary intervention (PCI), regionalized systems of care for STEMIs has been used to direct first responders to transport potential STEMI patients only to centers with capable of performing immediate PCI.[2]

Yet the majority of MIs are non-ST segment elevation myocardial infarctions (NSTEMIs), for which PCI is usually not needed immediately, but rather recommended within two to three days of diagnosis.[3,4] Regionalization of STEMI patients could inadvertently result in a greater percentage of patients with NSTEMI being treated at PCI centers, with potential consequences for hospitals and patients with NSTEMI, including changes in patient volume, quality of care, and revenue streams.[5] We sought to determine whether regionalization of care has increased the proportion of patients with NSTEMI who receive care at PCI centers. We hypothesized that regionalization is associated with an increasing proportion of patients with NSTEMI at PCI centers, with a corresponding decrease at non-PCI centers.

METHODS

Conceptual model

The difference-in-differences approach compares the change in patients' likelihood of receiving care in a PCI-capable hospital before versus after regionalization as compared to the difference over the same time period for counties that were not regionalized. This method identifies the association between the change in policy and likelihood of receiving care at a PCI center while controlling for trends in location of care occurring for reasons other than the regionalization policy. We used a binary definition of regionalization (preliminary analysis showed no difference using different definitions); full description of the methods in appendix.

Study sample and data sources

This study was approved by the Institutional Review Board at UCSF. Methods followed the STROBE reporting guidelines.

We linked non-public patient discharge and emergency department data from the California Office of Statewide Health Planning and Development from January 1, 2005 to September 30, 2015. All patient encounters in the data identified as having an ICD-9 code for NSTEMI (410.70 and 410.71) or STEMI (410.xx, except 410.7x and 410.x2) during the study period were included. Hospitals and counties were linked to the STEMI Network Database and Hospital STEMI Designation dataset, two datasets that we previously created for related research.[6,7]

Study Outcomes

The primary outcome was the proportion of patients with NSTEMI receiving care at PCI-capable hospitals within each EMS district (equivalent to the probability that a given patient

received care at a PCI-capable hospital). For patients transferred between hospitals, the destination hospital was used as the hospital. Secondary outcomes included the number of patients diagnosed with NSTEMIs, STEMIs, and all AMIs diagnosed within each county.

Statistical Analysis

We used multivariable linear regression to measure the association between the likelihood of each NSTEMI patient receiving care at a PCI-capable hospital and regionalization status of the patient's county of residence. We report the raw linear regression coefficients as they are directly interpretable as differences in proportions. Year of encounter accounts for secular trends, and county fixed effects account for unobserved differences across counties that did not vary over the study period. An indicator for regionalization status was specified as one on and after the year in which a community achieved complete STEMI regionalization as defined earlier, and zero otherwise. We also conducted the analysis with a similar multivariable model including patient characteristics (sex, race/ethnicity, age, insurance). We clustered standard errors at the county level. Differences between groups were tested using t-tests for continuous variables, and Pearson's Chi-squared test for all others. We performed all analyses using Stata 15.

RESULTS

During the study period, 453,136 patients were diagnosed with AMI, 64.8% with NSTEMI and 35.2% with STEMI. Among NSTEMI patients, 42.9% were female and the median age was 71 (IQR 60 – 82).

From 2005 to 2015, the annual incidence of NSTEMIs increased and STEMIs decreased (Figure 1). NSTEMI incidence increased by an average of 75 cases per county per year while STEMI incidence decreased by 69 cases per county per year; an increase of 18% and decrease 28%, respectively, estimated at the midpoint of the dataset. The percentage of NSTEMI patients receiving care at PCI-capable hospitals increased from 62% in 2005 to 71% in 2015. The number of PCI-capable hospitals increased from 134 to 136, and the number of counties with STEMI regionalization programs increased from 4 to 58 out of 58 counties (Figure 1).

At baseline, 214,712 (73.0%) NSTEMI patients and 106,732 (67.1%) STEMI patients received their care in regionalized systems. Most patients received their NSTEMI care at PCI-capable hospitals: 63.3% of NSTEMI patients in non-regionalized communities and 69.9% of those in regionalized communities received care at a PCI-capable hospital ($p<0.001$). Patients in regionalized communities were less likely to be White, had more comorbidities, and lived in higher-income areas (Table 1).

At baseline – non-regionalized counties in 2005 – 61.0% of NSTEMI patients were admitted to PCI-capable hospitals. The probability that patients with NSTEMI were admitted to a PCI-capable hospital increased by 2.2 percentage points (95% confidence interval [CI] 1.6 – 2.7) after the county implemented STEMI regionalization program (Table 2). Overall, there was an average of a 0.9 percentage point (CI 0.8 – 1.0) increase in probability that NSTEMI patients received care in a PCI-capable hospital for each year after the base year.

The cumulative time trend over the study period was an increase in probability of receiving care at a PCI-capable hospital of 10.0 percentage points. Including patient characteristics in the model (eTable I, Supplement) did not change the association between regionalization and probability of receiving care at PCI-capable hospitals or the year trend.

DISCUSSION

Our retrospective analysis of over 294,000 patients with NSTEMI over almost 11 years found that regionalization of STEMI care was associated with a minor unintended consequence of regionalization of care for patients with NSTEMI. The magnitude of this association was small – only a 2.2% increase in likelihood of NSTEMI patients receiving care in PCI-capable centers – in absolute terms as well as in comparison to the change attributable to a secular trend. This suggests that regionalization did not lead to the collateral benefit of increasing access to PCI, and also was unlikely to have led to unintended harms such as crowding at PCI-capable hospitals or significantly decreasing patient volumes for non-PCI hospitals. It is unlikely that hospitals experienced large changes in patient volume or revenue due to regionalization.

We investigated a previously-unexplored area, thus expanding the scope of our understanding of the effects of regionalization on patients with NSTEMI and providing the first estimates of the effect of a major policy at the population level. Our findings inform policy discussions regarding the development of regional care systems, allowing stakeholders to have a more complete understanding of the consequences of regionalization, including whether regionalization of STEMI is an efficient use of public health resources.[5]

Our findings also add to the literature regarding trends in MI and access to PCI-capable hospitals. Early in the study period it became accepted that PCI should be considered first-line therapy during index hospitalization for NSTEMI,[4] but although early PCI for NSTEMI became more common, it did not become universal.[8] Our results show that four in five NSTEMI patients in 2015 were treated at hospitals with PCI capability, which is similar to previous studies.[9] This fairly high proportion of access of MI patients to PCI-capable hospitals is not attributable to regionalization of STEMI care; rather, the increase is mostly accounted for by increased PCI capability in both regionalized and non-regionalized communities.

Our study was limited to California, which is not necessarily representative of other regions, though the trends in incidence parallel national trends.[3,9] The decision whether to regionalize could be endogenous; however, because all counties became regionalized, this would have affected the timing but not whether to regionalize. Further, the definition of regionalization may differ from that used by others; there is no standard definition of regionalization, but we used one with precedent in the literature.[10] We used a functional definition of PCI-capable hospitals that has been used previously,[11] but other definitions exist and there is no gold standard used to define PCI capability.[12] Next, we did not explore changes in the proportion of transferred patients, which is important but a separate question; the final hospital is more relevant to our policy-related question of whether NSTEMI patients became concentrated. Last, limitations in the dataset (e.g. mode of presentation)

precluded us from identifying the mechanism(s) responsible for the changes we observed. More patients may have gone to PCI-capable hospitals because of EMS transport decisions, patient behavior, or some other mechanism.

CONCLUSIONS

We found that STEMI regionalization policies were associated with negligible shifts in the proportion of patients with NSTEMI receiving care at PCI-capable hospitals, and thus unlikely to lead to benefits or harms for patients or hospitals. Policymakers may not need to worry about being overwhelmed by large increases in patient volume and should not rely on regionalization to increase access to first-line care for patients with NSTEMI.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGMENTS

We are grateful to all the medical directors and administrators of the local Emergency Medical Services agencies in the state of California who participated in the initial survey of regionalization.

FUNDING/SUPPORT AND ROLE OF FUNDER/SPONSOR

Research reported in this publication was supported by the National Heart, Lung, And Blood Institute of the National Institutes of Health under Award Number R01HL134182 for Drs. Renee Y. Hsia and Juan Carlos C. Montoy. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The funding organization had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

REFERENCES

1. O'Gara PT, Kushner FG, Ascheim DD, et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines: developed in collaboration with the American College of Emergency Physicians and Society for Cardiovascular Angiography and Interventions. Catheter Cardiovasc Interv. 2013;82(1):E1–27 [PubMed: 23299937]
2. Concannon TW, Nelson J, Kent DM, Griffith JL. Evidence of systematic duplication by new percutaneous coronary intervention programs. Cir Cardiovasc Qual Outcomes. 2013;6(4):400–408.
3. Mozaffarian D, Benjamin EJ, Go AS, et al. Heart disease and stroke statistics-2016 update: a report from the American Heart Association. Circulation. 2016;133(4):e38–360. [PubMed: 26673558]
4. Amsterdam EA, Wenger NK, Brindis RG, et al. 2014 AHA/ACC guideline for the management of patients with non-ST-elevation acute coronary syndromes: a report of the American College of Cardiology/American Heart Association task force on practice guidelines. J Am Coll Cardiol. 2014;64(24):e139–e228. [PubMed: 25260718]
5. Rathore SS, Epstein AJ, Volpp KG, Krumholz HM. Regionalization of care for acute coronary syndromes: more evidence is needed. JAMA. 2005;293(11):1383–1387. [PubMed: 15769973]
6. Rokos IC, Sporer K, Savino PB, et al. A novel survey tool to quantify the degree and duration of STEMI regionalization across California. Crit Pathw Cardiol. 2016;15(3):103–105. [PubMed: 27465005]
7. Hsia RY, Sabbagh S, Sarkar N, et al. Trends in regionalization of care for ST-segment elevation myocardial infarction. West J Emerg Med. 2017;18(6):1010–1017. [PubMed: 29085531]

8. Yong CM, Ungar L, Abnousi F, Asch SM, Heidenreich PA. Racial differences in quality of care and outcomes after acute coronary syndrome. Am J Cardiol. 2018;121(12):1489–1495. [PubMed: 29655881]

9. Krumholz HM, Normand SL, Wang Y. Trends in hospitalizations and outcomes for acute cardiovascular disease and stroke, 1999–2011. Circulation. 2014;130(12):966–975. [PubMed: 25135276]

10. Shen YC, Krumholz H, Hsia RY. Association of cardiac care regionalization with access, treatment, and mortality among patients with ST-segment elevation myocardial infarction. Circulation: Cardiovascular Quality and Outcomes. 2021 3;14(3):e007195. [PubMed: 33641339]

11. Epstein AJ, Rathore SS, Volpp KG, Krumholz HM. Hospital percutaneous coronary intervention volume and patient mortality, 1998 to 2000: does the evidence support current procedure volume minimums? J Am Coll Cardiol. 2004;43(10):1755–1762. [PubMed: 15145095]

12. Concannon TW, Nelson J, Goetz J, Griffith JL. A percutaneous coronary intervention lab in every hospital? Circ Cardiovasc Qual Outcomes. 2012;5(1):14–20. [PubMed: 22147882]

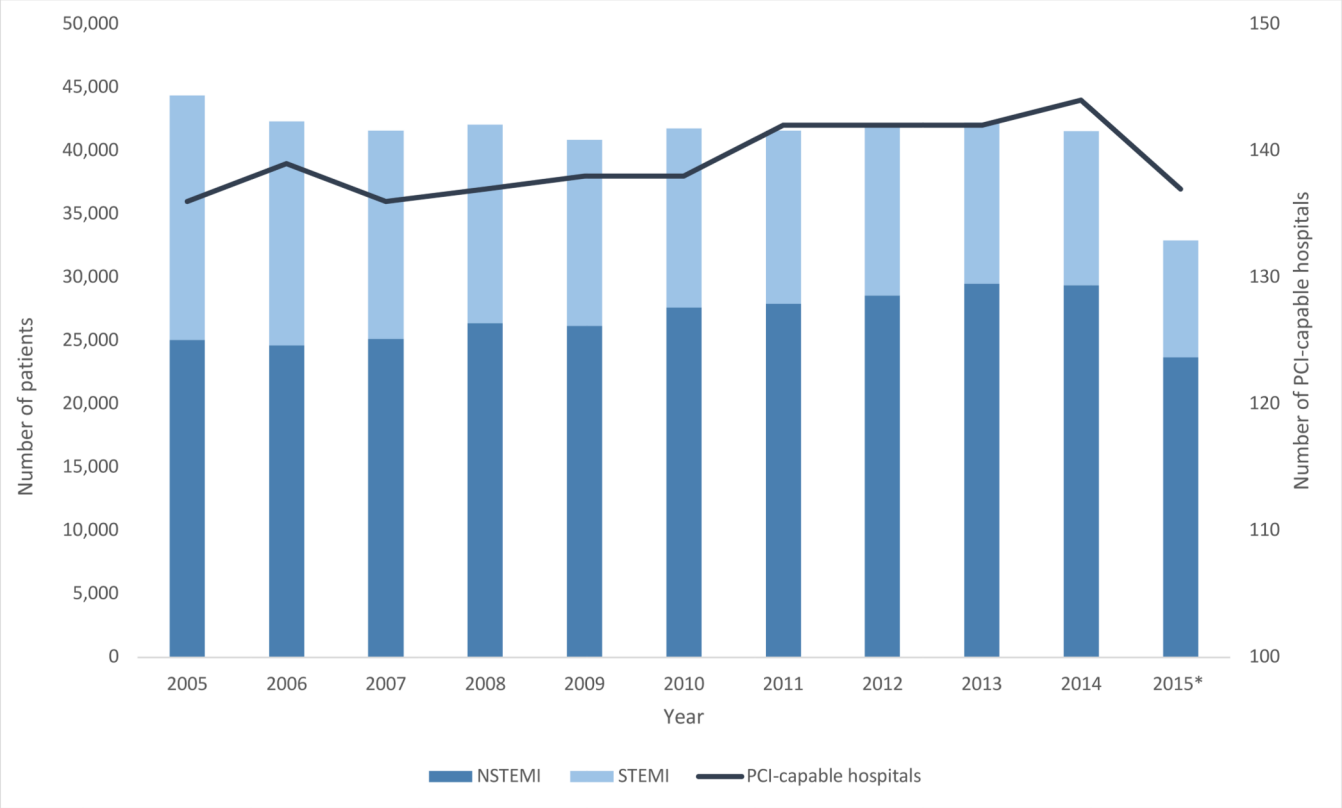

Figure 1. Acute myocardial infarction incidence and PCI capable hospitals

The left y-axis represents the yearly incidence of NSTEMI and STEMI. The right y-axis shows the number of PCI-capable hospitals observed in each year.

* 2015 data ends on 9/30/2015.

Table 1.

Patient and hospital characteristics

	Not regionalized (N=79,356)		Regionalized (N=214,712)		*p*-value
Patient characteristics					
Female, *n* (%)[a]	33,319	42.0%	89,535	41.7%	< 0.001
Age, median (25–75% IQR)	70	58 – 80	69	58 – 80	0.0606
Race					
White	53,506	67.4%	122,558	57.1%	< 0.001
Black	5,237	6.6%	18,145	8.5%	
Hispanic	10,778	13.6%	43,804	20.4%	
Asian	6,624	8.3%	20,888	9.7%	
Native American	193	0.2%	476	0.2%	
Other	2,191	2.8%	7,326	3.4%	
Invalid	827	1.0%	1,515	0.7%	
Comorbidities					
Anemia	17,460	22.0%	52,958	24.7%	<0.001
Arrhythmia	130	0.2%	416	0.2%	0.094
Arthritis	1,817	2.3%	5,481	2.6%	<0.001
Cancer	743	0.9%	2,313	1.1%	0.001
CHF	27,928	35.2%	77,943	36.3%	<0.001
Coagulopathy	3,120	3.9%	11,497	5.4%	<0.001
COPD	18,033	22.7%	46,081	21.5%	<0.001
Depression	5,437	6.9%	13,735	6.4%	<0.001
Dementia	2,442	3.1%	6,077	2.8%	<0.001
Diabetes without complications	22,150	27.9%	60,262	28.1%	0.408
Diabetes with complications	8,941	11.3%	31,164	14.5%	<0.001
Electrolyte abnormality	15,610	19.7%	48,727	22.7%	<0.001
HIV	159	0.2%	420	0.2%	0.796
HTN	59,700	75.2%	170,837	79.6%	<0.001
Hypothyroid	9,269	11.7%	26,960	12.6%	<0.001
Liver disease	1,376	1.7%	4,784	2.2%	<0.001
Lymphoma	426	0.5%	1,377	0.6%	0.001
Metastatic cancer	1,958	2.5%	5,459	2.5%	0.249
Obesity	10,258	12.9%	33,704	15.7%	<0.001
Neurologic disease	5,046	6.4%	14,918	6.9%	<.001
Paralysis	2,238	2.8%	6,019	2.8%	0.805
Psychiatric illness	1,937	2.4%	8,287	3.9%	<0.001
Pulmonary disease	3,464	4.4%	11,431	5.3%	<0.001
Renal disease	17,088	21.5%	62,586	29.1%	<0.001
Substance abuse	3,872	4.9%	12,354	5.8%	<0.001
Ulcer	71	0.1%	91	0.0%	<0.001

	Not regionalized (N=79,356)		Regionalized (N=214,712)		*p*-value
Valvular disease	11,290	14.2%	30,104	14.0%	0.153
Vascular disease	10,532	13.3%	34,388	16.0%	<0.001
Weight loss	1,557	2.0%	8,703	4.1%	<0.001
Insurance					
Private	17,696	22.3%	47,451	22.1%	< 0.001
Medicare	49,915	62.9%	134,624	62.7%	
Medicaid	6,031	7.6%	19,539	9.1%	
Indigent	2,301	2.9%	4,080	1.9%	
Self-pay	3,412	4.3%	9,018	4.2%	
Hospital characteristics					
ED annual volume (25–75% IQR)	40,210	(27,035 – 53,291)	45,995	(29,908 – 66,346)	<0.001
Critical access hospital	136	0.2%	185	0.1%	<0.001
Teaching hospital	7,083	8.9%	20,831	9.7%	<0.001
Government hospital	10,550	13.3%	29,251	13.6%	0.028
Not for profit	58,063	73.2%	147,505	68.7%	<0.001

Notes: Values are n (%) unless otherwise stated. Comorbidities are not mutually exclusive. P values for age and ED volume calculated using t test; all other P values from Pearson's Chi-squared test for independence between samples.

Abbreviations: IQR – interquartile range; ED – emergency department; CHF – congestive heart failure; COPD – chronic obstructive pulmonary disease; HIV – human immunodeficiency virus; HTN – hypertension

[a]Two observations with invalid data.

Table 2.

Probability of receiving care at a PCI-capable hospital

Baseline probability[a]	61.0%
	(60.6 -- 61.3)
Regionalized community	2.2%***
	(1.6 -- 2.7)
Yearly change	0.9%***
	(0.8 -- 1.0)

Notes: Coefficients represent percentage difference for each variable (95% confidence intervals in parentheses). Coefficient for yearly change represents the average increase in probability of receiving care at a PCI-capable hospital for each year after the base year, 2005.

[a]Non-regionalized communities in 2005

*** p<0.01

** p<0.05

* p<0.10