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Permalink
https://escholarship.org/uc/item/4mn1c16n

Journal
Journal of the American Heart Association, 10(3)

ISSN
2047-9980

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Publication Date
2021-02-01

DOI
10.1161/jaha.120.016932

Peer reviewed
ORIGINAL RESEARCH

Impact of ST-Segment–Elevation Myocardial Infarction Regionalization Programs on the Treatment and Outcomes of Patients Diagnosed With Non–ST-Segment–Elevation Myocardial Infarction

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BACKGROUND: Many communities have implemented systems of regionalized care to improve access to timely care for patients with ST-segment–elevation myocardial infarction. However, patients who are ultimately diagnosed with non–ST-segment–elevation myocardial infarctions (NSTEMIs) may also be affected, and the impact of regionalization programs on NSTEMI treatment and outcomes is unknown. We set out to determine the effects of ST-segment–elevation myocardial infarction regionalization schemes on treatment and outcomes of patients diagnosed with NSTEMIs.

METHODS AND RESULTS: The cohort included all patients receiving care in emergency departments diagnosed with an NSTEMI at all nonfederal hospitals in California from January 1, 2005 to September 30, 2015. Data were analyzed using a difference-in-differences approach. The main outcomes were 1-year mortality and angiography within 3 days of the index admission. A total of 293,589 patients with NSTEMIs received care in regionalized and nonregionalized communities. Over the study period, rates of early angiography increased by 0.5 and mortality decreased by 0.9 percentage points per year among the overall population (95% CI, 0.4–0.6 and −1.0 to −0.8, respectively). Regionalization was not associated with early angiography (−0.5%; 95% CI, −1.1 to 0.1) or death (0.2%; 95% CI, −0.3 to 0.8).

CONCLUSIONS: ST-segment–elevation myocardial infarction regionalization programs were not statistically associated with changes in guideline-recommended early angiography or changes in risk of death for patients with NSTEMI. Increases in the proportion of patients with NSTEMI who underwent guideline-directed angiography and decreases in risk of mortality were accounted for by secular trends unrelated to regionalization policies.

Key Words: angiography ■ mortality ■ non–ST-segment–elevation myocardial infarction ■ ST-segment–elevation myocardial infarction

Many communities have established region-alized systems of care for ST-segment–elevation myocardial infarction (STEMI) over the past decade.1–3 Although this focus on the organization and delivery of care may improve treatment and outcomes for patients with STEMI, regionalization could have unintended effects on patients with non–ST-segment–elevation myocardial infarction (NSTEMI), a condition with high prevalence and significant mortality, and for which angiography and...
In this study, we set out to determine whether and to what extent STEMI regionalization might impact treatment and outcomes for patients with NSTEMIs. We hypothesized that risk-adjusted outcomes for patients with NSTEMIs improved more in regionalized compared with nonregionalized communities. We also hypothesized that the probability of receiving invasive therapy (ie, guideline-directed angiography and possible PCI within 72 hours) increased for patients with NSTEMI in regionalized communities compared with nonregionalized communities.

**CLINICAL PERSPECTIVE**

**What Is New?**
- In this study of almost 300,000 patients with non–ST-segment–elevation myocardial infarction, likelihood of early angiography increased by 0.5 and mortality decreased by 0.9 percentage points per year over the course of >10 years.
- Regionalization of care for ST-segment–elevation myocardial infarction was not associated with changes in angiography, percutaneous coronary intervention, or 1-year mortality of patients presenting with non–ST-segment–elevation myocardial infarction.

**What Are the Clinical Implications?**
- Treatment and outcomes for non–ST-segment–elevation myocardial infarction have improved recently, but ST-segment–elevation myocardial infarction regionalization programs were not responsible for these changes and policy makers should not expect ST-segment–elevation myocardial infarction regionalization programs to have large unintended consequences for patients presenting with non–ST-segment–elevation myocardial infarction.

**METHODS**

Because of the sensitive nature of the data collected for this study, requests to access the data set from qualified researchers trained in human subject confidentiality protocols may be sent to the California Office of Statewide Health Planning and Development at oshpd.ca.gov.

**Conceptual Model**

STEMI regionalization could change the type of care given to patients with NSTEMI in several ways. First, after regionalization, a greater proportion of patients with NSTEMIs could receive care at PCI-capable hospitals if emergency medical services providers transport them to PCI centers because of immediate concern for a possible STEMI or if they self-present to PCI-capable centers. Second, patients with NSTEMI may be more likely to undergo timely invasive therapy (ie, PCI within 72 hours) as a first-line treatment. Third, PCI centers may provide better NSTEMI care because of experience derived from a higher volume of treated patients. Finally, regionalized centers may provide better follow-up care, including medical optimization for secondary prevention.

However, there is a possibility that treatment and outcomes could worsen under certain conditions: first, if the focus on STEMIs leads physicians at either PCI or non-PCI centers to focus less on caring for patients with NSTEMIs; second, if non-PCI centers fall out of practice because they admit and treat fewer NSTEMIs; and, finally, if regionalization results in fragmentation of local care and thus poorer follow-up and secondary prevention.

A difference-in-differences approach compares the changes in treatment and outcomes for counties that regionalized (difference between preregionalization and postregionalization) compared with the difference over the same time period for counties that were not regionalized. This approach helps identify the association between the change in policy and changes in treatment and outcomes separate from the trends in treatment and outcomes occurring for reasons other than the change in policy, such as changes in the epidemiological features of NSTEMI.

**Study Sample and Data Sources**

We linked nonpublic discharge data and non-public emergency department data from the California Office of Statewide Health Planning and Development for the study period from January 1, 2005 to September 30, 2015. As Office of Statewide Health Planning and Development records data from all emergency department and inpatient encounters...
at all nonfederal, general acute-care hospitals, and patients are identified by record linkage number, we comprehensively observed procedures and diagnoses for all patients with NSTEMI during the study period. All patient encounters in the data, identified as having an International Classification of Diseases, Ninth Revision (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 in our analysis. We linked each patient observation to California Vital Statistics data through 2013 (the most recent data available) using a unique patient identifier.

Hospitals and counties were linked to the STEMI Network Database and Hospital STEMI Designation data set, 2 data sets we previously collected for related research. These data sets contain the degree of regionalization and dates of implementation of California’s 33 local emergency medical services agencies, which provide emergency medical services for California’s 58 counties. Although the term regionalization is used broadly in the literature as “matching of medical resources to patient needs to maximize health benefits and outcomes while minimizing cost and use of resources over a specified geographic area,” this leaves some degree of subjectivity in defining regionalization. Following previous work conducted by the research team, we denoted a county as achieving complete regionalization on and after the year that 95% of its local emergency medical services system has: (1) emergency medical systems that direct prehospital transport to bypass the nearest hospitals that do not offer emergent PCI to facilities that offer emergent PCI for patients with STEMI; and (2) interhospital transfer protocols specifically for patients with STEMI.

Outcomes
The primary outcomes were angiography within 3 days and death at 1 year. We chose angiography instead of PCI because this represents an attempt at an invasive strategy regardless of whether a culprit lesion was identified or subject to intervention. We identified angiography using ICD-9 procedure codes 3721-3 and 8850-7. Secondary outcomes included death at 7, 30, and 90 days, as identified through the linked vital statistics files. As a sensitivity analysis, we also used receipt of PCI as another outcome (Table S1).

Statistical Analysis
We used a multivariable linear regression model to measure the association between regionalization status of each patient’s county of residence and risk of death within 1 year of NSTEMI diagnosis. The model included regionalization status, year, patient characteristics, hospital characteristics, and treatments. An indicator for regionalization was specified as one on and after the year in which a community achieved STEMI regionalization, and zero otherwise. Our model included year of encounter to account for secular trends common across all counties, regardless of regionalization status. Patient characteristics included sex, age group, race/ethnicity, comorbidities (categorized according to Elixhauser comorbidity index), and expected insurance. Race/ethnicity categories included Asian, Black, Hispanic, and Native American. Age groups were defined as <40, 40 to 64, 65 to 69, 70 to 74, 75 to 79, 80 to 84, and ≥85 years. Hospital characteristics included annual emergency department volume, critical access designation, teaching hospital designation, government hospital, not-for-profit status, and whether the hospital was PCI capable (defined as capable for a given year if that year’s PCI procedures were ≥5) or non-PCI capable. We included an interaction term between PCI capability and regionalization status to measure differences between non-PCI centers and PCI centers separately within nonregionalized and regionalized communities. Angiography (without PCI) within 3 days and PCI within 3 days were both included as indicators. We analyzed secondary outcomes for death (7, 30, and 90 days) using the same model specification. We used a multivariable linear regression model to measure the association between regionalization status of each patient’s county of residence and the likelihood of undergoing angiography within 3 days of diagnosis. This model used angiography as the outcome of interest and excluded PCI; it was otherwise identical to the mortality model. The PCI model used as a sensitivity analysis used the same specification as the angiography model, with PCI as the outcome of interest. All models used county fixed effects to account for unobserved differences across counties that did not vary over the study period. Given our sample size of ≈290 000, we had 80% power at an α of 0.05 to detect a 1 percentage point difference in likelihood of angiography or death. SEs were clustered at the county level for all models. All analyses were conducted using STATA 15 (StataCorp, College Station, TX). Permission to conduct this study was granted by the University of California, San Francisco, Institutional Review Board with a waiver of informed consent.

RESULTS
During our 10-year study period, we evaluated 293 589 patients with NSTEMI; of these patients, 78 923 (26.8%) received care in communities that were not regionalized the year of their admission.
and 214,666 (73.2%) received care in hospitals in STEMI-regionalized communities (Table 1). Patients in regionalized communities were more likely to be minorities and had more comorbidities than patients in nonregionalized communities; they did not differ by age or sex.

Over the study period, the incidence of NSTEMI increased. As more counties became regionalized, an increasing proportion of patients received care in regionalized communities and a decreasing proportion received care at nonregionalized communities (Figure 1). By 2014, all communities had regionalized. Over the study period, most patients with NSTEMI received care in PCI-capable hospitals; they had a higher likelihood of doing so in regionalized than in nonregionalized communities (69.9% regionalized and 63.3% nonregionalized; \( \chi^2, P<0.0005 \)).

When controlling for patient and hospital characteristics, the multivariable regression examining regionalization and probability of undergoing angiography (Table 2) did not show any impact from regionalization (−0.3 percentage points; 95% CI, −1.2 to 0.5 percentage points). The probability of undergoing angiography increased by 0.5 percentage points each year (95% CI, 0.4−0.6 percentage points) across all counties, regardless of regionalization status. The strongest predictor of whether a patient underwent angiography was whether the hospital was PCI capable (49.4 percentage points; 95% CI, 48.8−50.2 percentage points). There was no difference in this association between regionalized and nonregionalized communities (interaction, −0.2 percentage points; 95% CI, −1 to 0.6 percentage points). Patients were less likely to undergo angiography at critical access hospitals (−10.0 percentage points; 95% CI, −15.7 to −4.3 percentage points) or teaching hospitals (−3.5 percentage points; 95% CI, −4.1 to −2.8 percentage points). In terms of patient demographics, increasing age (>70 years) and most (23 of 29) comorbidities were associated with a lower likelihood of angiography (coefficients for comorbidities not presented). Patients with Medicare and Medicaid insurance were less likely to undergo angiography than those with private insurance (−2.8 percentage points [95% CI, −3.3 to −2.2 percentage points] and −3.5 percentage points [95% CI, −4.2 to −2.8 percentage points], respectively). Black patients had a 5.6 percentage point lower probability of receiving angiography (95% CI, −6.3 to −4.9 percentage points) compared with non-Hispanic White patients.

Figure 2 shows trends for the proportion of patients with NSTEMI undergoing angiography within 30 days of diagnosis. There was a steady increase in the proportion of patients who received angiography over the study period; most of this was attributable to the increased proportion of patients undergoing angiography within 2 days of diagnosis.

The probability of death within 1 year of NSTEMI diagnosis decreased over time across all counties in the multivariable model (−0.9 percentage points per year; 95% CI, −1.0 to −0.8 percentage points per year; Table 3). No significant association between regionalization and death was found (0.0 percentage points; 95% CI, −0.8 to 0.7 percentage points). Receiving care in a PCI center was associated with a 3.7 percentage point increase risk of death (95% CI, 3.0−4.3 percentage points). This relationship did not differ between regionalized and nonregionalized communities: interaction between PCI capability and regionalization was 0.4 percentage points (95% CI, −0.3 to 1.2 percentage points). The probability of death increased with increasing age and with most (21 of 29) comorbidities. Undergoing angiography within 3 days of NSTEMI diagnosis was associated with a 10.1 percentage point decrease in risk of death (95% CI, −10.5 to 9.7 percentage points), and PCI within 3 days was associated with a 10.5 percentage point decrease in mortality (95% CI, −11.0 to −10.1 percentage points). Regionalization was not associated with risk of death across different time horizons: 7 days, 30 days, 90 days, and 1 year (Figure S1).

**DISCUSSION**

In this retrospective cohort study from 2005 through 2015 of nearly 294,000 patients with NSTEMIs, we found that regionalization was not associated with significant changes in the likelihood of patients who received timely angiography or decreased mortality. Over the 10-year study period, the proportion of patients with NSTEMI undergoing angiography increased and their risk of death decreased, but these changes were not attributable to regionalization.

Our study is, to our knowledge, the first analysis of the relationship between regionalization of STEMI care and the treatment and outcomes for patients with NSTEMI. Previous work on STEMI regionalization has focused on the process of establishing such programs and intermediate outcomes, such as door-to-balloon times.19,21,22 These studies address primary questions about STEMI regionalization programs, but do not consider possible impacts on the management of patients with NSTEMI. The recent literature on NSTEMIs does include evaluations of incidence (eg, the impact of newer troponin assays and changes in patient demographics),23 treatment (timing of and selection of patients for PCI),11,24,25 and outcomes (mortality).26 However, such analyses have not considered these trends and outcomes vis-à-vis STEMI regionalization programs.
## Table 1. Patient and Hospital Characteristics

| Characteristics                        | Not Regionalized (n=78,923) | Regionalized (n=214,666) | P Value |
|----------------------------------------|-----------------------------|--------------------------|---------|
| **Patient characteristics**            |                             |                          |         |
| Women                                  | 33,126 (42)                 | 89,864 (41.9)            | 0.545   |
| Age, median (IQR), y                   | 70.0 (58–80)                | 69.0 (58–80)             | 0.7942  |
| **Race/ethnicity**                     |                             |                          |         |
| White                                  | 53,194 (67)                 | 122,510 (57)             | <0.0005 |
| Black                                  | 5,205 (7)                   | 18,143 (8)               |         |
| Hispanic                               | 10,712 (14)                 | 43,799 (20)              |         |
| Asian                                  | 6,589 (8)                   | 20,883 (10)              |         |
| **Insurance**                          |                             |                          |         |
| Private                                | 19,257 (24)                 | 48,797 (22)              | <0.0005 |
| Medicare                               | 49,875 (63)                 | 134,368 (63)             |         |
| Medicaid                               | 5,176 (7)                   | 20,901 (10)              |         |
| Indigent                               | 1,225 (2)                   | 3,617 (2)                |         |
| Self-pay                               | 2,194 (3)                   | 5,726 (3)                |         |
| Other                                  | 1,184 (2)                   | 3,253 (2)                |         |
| **Comorbidities**                      |                             |                          |         |
| Anemia                                 | 17,311 (22)                 | 52,943 (25)              | <0.0005 |
| Arrhythmia                             | 129 (0)                     | 416 (0)                  | 0.094   |
| Arthritis                              | 1,804 (2)                   | 5,480 (3)                | <0.0005 |
| Cancer                                 | 741 (1)                     | 2,313 (1)                | 0.001   |
| Congestive heart failure               | 27,663 (35)                 | 77,918 (36)              | <0.0005 |
| Coagulopathy                           | 3,088 (4)                   | 11,495 (5)               | <0.0005 |
| COPD                                   | 17,913 (23)                 | 48,073 (21)              | <0.0005 |
| Depression                             | 5,403 (7)                   | 13,732 (6)               | <0.0005 |
| Dementia                               | 2,420 (3)                   | 6,076 (3)                | <0.0005 |
| Diabetes mellitus, uncomplicated        | 22,036 (28)                 | 60,246 (28)              | 0.408   |
| Diabetes mellitus with chronic complications | 88,833 (11) | 31,158 (15) | <0.0005 |
| Fluid and electrolyte disorders        | 15,492 (20)                 | 48,712 (23)              | <0.0005 |
| HIV                                    | 159 (0)                     | 420 (0)                  | 0.796   |
| Hypertension                           | 59,367 (75)                 | 170,802 (80)             | <0.0005 |
| Hypothyroid                            | 9,226 (12)                  | 26,955 (13)              | <0.0005 |
| Liver disease                          | 1,374 (2)                   | 4,782 (2)                | <0.0005 |
| Lymphoma                               | 423 (1)                     | 1,377 (1)                | 0.001   |
| Metastatic cancer                      | 1,945 (12)                  | 5,459 (3)                | 0.249   |
| Neurological disorder                  | 4,998 (6)                   | 14,915 (7)               | <0.0005 |
| Obesity                                | 10,211 (13)                 | 33,701 (16)              | <0.0005 |
| Paralysis                              | 2,221 (3)                   | 6,016 (3)                | 0.805   |
| Psychoses                              | 1,925 (2)                   | 8,287 (4)                | <0.0005 |
| Pulmonary circulation disorder         | 3,445 (4)                   | 11,428 (5)               | <0.0005 |
| Renal failure                          | 16,995 (22)                 | 62,573 (29)              | <0.0005 |
| Substance abuse                        | 3,853 (5)                   | 12,352 (6)               | <0.0005 |
| Ulcer, peptic                          | 71 (0)                      | 91 (0)                   | <0.0005 |
| Vascular disease                       | 10,456 (13)                 | 34,381 (16)              | 0.153   |
| Valvular disease                       | 11,201 (14)                 | 30,097 (14)              | <0.0005 |
| Weight loss                            | 1,534 (2)                   | 8,702 (4)                | <0.0005 |
| **Hospital characteristics**           |                             |                          |         |
| ED annual volume, median (IQR)         | 40,210 (27 035–53 291)      | 45,995 (29 908–66 346)   | <0.0005 |

(Continued)
The absence of a positive finding contributes to an increased understanding of the implications of STEMI regionalization programs. In previous work, we found that regionalization was not associated with a significant impact on whether patients with NSTEMI received care in PCI-capable hospitals: likelihood of patients with NSTEMI receiving care in PCI-capable hospitals increased by only 2.2 percentage points. We thus did not expect to find a difference in treatment or outcomes caused by increased likelihood of care in PCI-capable hospitals and herein focused on whether the care patients received (ie, angiography and possible PCI) changed over the regionalization process.

Our analysis tested for differences in treatment and outcomes between regionalized and nonregionalized communities, and tested for differences between PCI and non-PCI centers within regionalized communities. This approach is important because there could be changes at the population level, and changes within the population that are obscured by a population-level analysis. For example, regionalization could lead to improvements in treatment and outcomes at PCI centers and worsening at non-PCI centers, but if these

| Characteristics                                | Not Regionalized (n=78 923) | Regionalized (n=214 666) | P Value |
|------------------------------------------------|----------------------------|--------------------------|---------|
| Critical access hospital                       | 135 (0.2)                  | 185 (0.1)                | <0.0005 |
| Teaching hospital                              | 7034 (9)                   | 20 829 (10)              | <0.0005 |
| Government hospital                            | 10 511 (13)                | 29 243 (14)              | 0.028   |
| Not for profit                                 | 57 746 (73)                | 147 468 (69)             | <0.0005 |
| Catheterization laboratory in hospital         | 49 945 (63)                | 150 034 (70)             | <0.0005 |

Values are number (percentage) unless otherwise stated. Race/ethnicity: Native American, other, and invalid combine to <5% of the sample. P values for age and ED volume calculated using t test; all other P values from the Pearson χ² test for independence between samples. COPD indicates chronic obstructive pulmonary disease; ED, emergency department; and IQR, interquartile range.

Figure 1. Non–ST-segment–elevation myocardial infarction (NSTEMI) incidence, according to regionalization status. Cases of NSTEMI per year for both regionalized and not regionalized communities. *Data end on September 30, 2015.
are similar in magnitude, a population-level analysis will find no net effect. We did not find this was the case; there was no evidence that regionalization led to changes compared with nonregionalized communities, nor was there evidence that treatment and outcomes changed within regionalized communities. The most likely interpretation of our finding is that STEMI regionalization may not have impacted the management strategy of NSTEMIs, with no discernable effect on 1-year mortality.

Because of the mounting evidence of the use of early PCI for patients with NSTEMI that became apparent around the same time that STEMI regionalization programs took shape, it is possible that hospitals adopted timely PCI for NSTEMI before regionalization and thus there was no apparent effect of regionalization. Alternatively, hospitals could have increased their angiography capability in preparation for regionalization and thus had no apparent change in treatment because of regionalization. However, the lack of association between regionalization and treatment and outcomes suggests that neither of these changes took place, with instead slow adoption of a timely invasive strategy in the management of NSTEMI over the study period separate from regionalization. The proportion of patients we observed undergoing timely angiography was similar to the proportion found in other observational studies over similar time periods,\textsuperscript{17,27,28} although lower than that reported by the NCOR (National Cardiovascular Data Registry) ACTION (Acute Coronary Treatment

### Table 2. Probability of Undergoing Catheterization Within 3 Days of Admission

| Variable                                         | Coefficient | 95% CI            | P>|t|
|--------------------------------------------------|-------------|-------------------|------|
| Regionalized                                     | −0.003      | −0.012 to 0.005   | 0.415|
| Year                                             | 0.005       | 0.004 to 0.006    | <0.0005|
| Patient characteristics                          |             |                   |      |
| Women                                            | −0.031      | −0.034 to −0.027  | <0.0005|
| Age group, y                                     |             |                   |      |
| 40–64                                            | 0.014       | 0.000 to 0.027    | 0.048|
| 65–69                                            | −0.003      | −0.018 to 0.012   | 0.689|
| 70–74                                            | −0.024      | −0.039 to −0.009  | 0.001|
| 75–79                                            | −0.060      | −0.075 to −0.046  | <0.0005|
| 80–84                                            | −0.128      | −0.142 to −0.113  | <0.0005|
| 85–99                                            | −0.289      | −0.303 to −0.274  | <0.0005|
| Race/ethnicity                                   |             |                   |      |
| Black                                            | −0.056      | −0.063 to −0.049  | <0.0005|
| Hispanic                                         | 0.001       | −0.003 to 0.006   | 0.56 |
| Asian                                            | 0.002       | −0.004 to 0.008   | 0.594|
| Insurance                                        |             |                   |      |
| Medicare                                         | −0.028      | −0.033 to −0.022  | <0.0005|
| Medicaid                                         | −0.035      | −0.042 to −0.028  | <0.0005|
| Indigent                                         | 0.039       | 0.026 to 0.052    | <0.0005|
| Self-pay                                         | −0.009      | −0.019 to 0.002   | 0.102|
| Other                                            | −0.007      | −0.021 to 0.007   | 0.316|
| Hospital characteristics                         |             |                   |      |
| Catheterization laboratory within hospital        | 0.485       | 0.488 to 0.502    | <0.0005|
| Catheterization laboratory×regionalized           | −0.002      | −0.010 to 0.006   | 0.58 |
| ED volume (log)                                   | 0.006       | 0.003 to 0.009    | <0.0005|
| Critical access hospital                          | −0.100      | −0.157 to −0.043  | 0.001|
| Teaching hospital                                 | −0.035      | −0.041 to −0.028  | <0.0005|
| Government hospital                               | 0.009       | 0.002 to 0.016    | 0.008|
| Not for profit                                    | 0.002       | −0.003 to 0.007   | 0.376|
| County population (log)                           | 0.439       | 0.340 to 0.538    | <0.0005|

Multivariable regression also includes other race/ethnicity categories (Native American, other, and invalid) and comorbidities (indicator variable for each Elixhauser category). Comorbidities are not presented. Catheterization laboratory×regionalized is an interaction term equal to 1 if catheterization laboratory is present and community is regionalized. Reference categories include the following: not regionalized, year 2005, men, aged <40 years, White race, no comorbidities, privately insured, and no catheterization laboratory in hospital. ED indicates emergency department.
Regionalization of STEMI care has been established in much of the United States and in other countries, but many areas still do not have such a system in place and, in those that do, its execution has been heterogeneous. Beyond the initial calls for regionalization by the American Heart Association and American College of Cardiologists, the Mission: Lifeline initiative has identified these systems as an important intervention to improve the outcomes of STEMI care; implementation and evaluation are ongoing. Understanding the collateral effects on a related condition, NSTEMI, is relevant to communities considering regionalization, particularly in communities with fewer resources.

Our results may improve policy makers’ expectations about the unintended consequences of establishing a regionalized system of STEMI care on patients with NSTEMI.

Our results also suggest that further research is needed to determine how patients are being selected for angiography and possible PCI. Our finding that angiography (without PCI) and PCI were both associated with a 10 percentage point decrease in 1-year mortality suggests that undergoing angiography selects for healthier patients; our analysis of the predictors of angiography and PCI corroborates this, showing that younger patients with fewer comorbidities were more likely to undergo angiography. However, the administrative nature of our data set does not allow us to observe patient stability or other clinical factors informing the decision of whether to undergo angiography; patients may have been appropriately deemed too sick to undergo an invasive strategy. Alternatively, an invasive strategy may not have been within the goals of care of some older patients with more comorbidities. Although our retrospective design precludes causal inferences between early invasive therapy and mortality, it does...
inform how angiography and PCI are used in practice and raises questions such as whether guidelines are being applied appropriately and whether and why subpopulations receive this intervention at different rates.

**Limitations**

Our study was limited to nonfederal hospitals in California, which is not necessarily representative of hospitals in other states or regions. It is, however, a large state with a diverse population and a wide range of urban and rural regions and could reflect trends seen in other regions and states within the United States. The increasing NSTEMI incidence and the increased likelihood of undergoing angiography reported in this study are consistent with trends reported for other populations, as is the finding that the proportion of patients undergoing angiography is still suboptimal.27,36–38 Second, as with many administrative data sets, the data sets we used did not provide detailed information about nonprocedural patient care (such as adherence to medical management guidelines), nor did it offer the opportunity to examine

**Table 3. Probability of Death Within 1 Year of NSTEMI**

| Variable                                      | Coefficient | 95% CI            | P>|t|  |
|-----------------------------------------------|-------------|-------------------|-----|
| Regionalized                                  | 0.000       | −0.008 to 0.007   | 0.99|
| Year                                          | −0.009      | −0.010 to −0.008  | <0.0005|
| Patient characteristics                        |             |                   |     |
| Women                                         | −0.019      | −0.022 to −0.015  | <0.0005|
| Age group, y                                  |             |                   |     |
| 40–64                                         | 0.015       | 0.003 to 0.028    | 0.018|
| 65–69                                         | 0.028       | 0.015 to 0.042    | <0.0005|
| 70–74                                         | 0.048       | 0.035 to 0.062    | <0.0005|
| 75–79                                         | 0.074       | 0.061 to 0.088    | <0.0005|
| 80–84                                         | 0.122       | 0.108 to 0.136    | <0.0005|
| 85–99                                         | 0.220       | 0.206 to 0.233    | <0.0005|
| Race/ethnicity                                |             |                   |     |
| Black                                         | −0.008      | −0.015 to −0.002  | 0.008|
| Hispanic                                      | −0.015      | −0.020 to −0.011  | <0.0005|
| Asian                                         | −0.017      | −0.022 to −0.011  | <0.0005|
| Insurance                                     |             |                   |     |
| Medicare                                      | 0.014       | 0.009 to 0.019    | <0.0005|
| Medicaid                                      | 0.007       | 0.001 to 0.014    | 0.03|
| Indigent                                      | −0.015      | −0.026 to −0.003  | 0.011|
| Self-pay                                      | −0.005      | −0.014 to 0.005   | 0.332|
| Other                                         | 0.000       | −0.013 to 0.012   | 0.947|
| Hospital characteristics                      |             |                   |     |
| ED volume (log)                                | −0.001      | −0.003 to 0.002   | 0.553|
| Critical access hospital                      | 0.015       | −0.036 to 0.066   | 0.564|
| Teaching hospital                             | −0.010      | −0.016 to −0.004  | 0.001|
| Government hospital                           | 0.014       | 0.007 to 0.020    | <0.0005|
| Not for profit                                | −0.011      | −0.015 to −0.006  | <0.0005|
| County population (log)                       | 0.150       | 0.055 to 0.245    | 0.002|
| Catheterization laboratory within hospital    | 0.037       | 0.030 to 0.043    | <0.0005|
| Catheterization laboratory×regionalized       | 0.004       | −0.003 to 0.012   | 0.246|
| Patient care                                  |             |                   |     |
| Angiography without intervention within 3 d   | −0.101      | −0.105 to −0.097  | <0.0005|
| PCI within 3 d                                 | −0.105      | −0.110 to −0.101  | <0.0005|

Multivariable regression also includes other race/ethnicity categories (Native American, other, and invalid) and comorbidities (indicator variable for each Elixhauser category). Comorbidities are not presented. Catheterization laboratory×regionalized is an interaction term equal to 1 if catheterization laboratory is present and community is regionalized. Reference categories include the following: not regionalized, year 2005, men, aged <40 years, White race, no comorbidities, privately insured, and no catheterization laboratory in hospital. ED indicates emergency department; NSTEMI, non–ST-segment–elevation myocardial infarction; and PCI, percutaneous coronary intervention.
social determinants of health, what treatments were offered but not rendered, or access to and quality of outpatient care. This also limited our ability to investigate whether other care recommendations were followed, such as immediate angiography and revascularization for hemodynamically unstable patients or angiography within 24 hours for patients with high risk scores. Furthermore, coding could affect apparent incidence if hospitals updated what they define as an NSTEMI during the regionalization process.39

Also, our inclusion criteria relied on a primary diagnosis of NSTEMI acute myocardial infarction and could have mistakenly included patients with type 2 myocardial infarction who were misclassified as having NSTEMI or excluded patients with NSTEMI who had this listed as a secondary diagnosis. However, unless there was a systematic difference in the way these were coded across regionalization areas, it is unlikely to pose significant problems in interpreting our final model.

Third, there are known changes in the epidemiological features of acute myocardial infarction, in particular NSTEMIs, caused in part by increased sensitivity of troponin assays and changes in patient demographics and health-related risk factors, but it was beyond the scope of this study to investigate which assays were used or investigate state-wide changes in case mix.24,40 Last, the decision by any given community to undergo regionalization of STEMI care may have been because of unobserved factors that also influenced care. For example, a community may have regionalized because it already functioned as if it were regionalized and thus the cost of regionalization was low, or because care was so poor or disorganized that the potential benefits of regionalization were large. Similarly, we used a dichotomous variable for regionalization, although in practice regionalization exists on a spectrum, so the change from nonregionalized to regionalized may be large for one agency and small for another. Thus, we could not make any causal inferences between regionalization and changes in treatment and outcomes for NSTEMI, but rather report the association between these 2 variables. Because there is considerable heterogeneity in how regionalization has been implemented in other communities, our findings may not generalize to other regions.32

CONCLUSIONS

We found that STEMI regionalization policies were not associated with changes in angiography, PCI, or 1-year mortality of patients presenting with NSTEMI. Mortality from NSTEMI is decreasing, and early invasive therapy is becoming increasingly common, but these trends are not attributable to STEMI regionalization policies and nearly half of patients with NSTEMIs still do not receive guideline-directed timely angiography. Policy makers should not expect STEMI regionalization programs to have either positive or negative unintended consequences for patients presenting with NSTEMIs.

ARTICLE INFORMATION

Received July 13, 2020; accepted October 27, 2020.

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Acknowledgments

Dr Montoy had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Sources of Funding

Research reported in this publication was supported by the National Heart, Lung, and Blood Institute of the National Institutes of Health under Award No. R01HL134182 for Drs Hsia and Montoy, and R01HL14822 for Drs Hsia and Shen. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Disclosures

Dr Brindis has a contract with the American College of Cardiology for his role as a senior medical officer in the National Cardiovascular Data Registry. In the past three years, Harlan Krumholz received expenses and/or personal fees from UnitedHealth, IBM Watson Health, F-Prime, 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 HugoHealth, 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.

Supplementary Material

Table S1
Figure S1

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SUPPLEMENTAL MATERIAL
Table S1. Probability of percutaneous coronary intervention (PCI) within 3 days of admission.

|                          | Coefficient | [95% Conf. Interval] | P>t  |
|--------------------------|-------------|----------------------|------|
| Regionalized             | -0.002      | -0.008, 0.004        | 0.508|
| Year                     | 0.005       | 0.004, 0.006         | <0.0005|
| Patient characteristics  |             |                      |      |
| Female                   | -0.044      | -0.047, -0.040       | <0.0005|
| Age group                |             |                      |      |
| 40-64                    | 0.071       | 0.058, 0.084         | <0.0005|
| 65-69                    | 0.048       | 0.034, 0.062         | <0.0005|
| 70-74                    | 0.035       | 0.021, 0.049         | <0.0005|
| 75-79                    | 0.013       | -0.002, 0.027        | 0.08 |
| 80-84                    | -0.017      | -0.031, -0.002       | 0.022|
| 85-99                    | -0.082      | -0.096, -0.068       | <0.0005|
| Race / ethnicity         |             |                      |      |
| Black                    | -0.053      | -0.060, -0.047       | <0.0005|
| Hispanic                 | -0.025      | -0.029, -0.020       | <0.0005|
| Asian                    | -0.022      | -0.028, -0.016       | <0.0005|
| Comorbidities no presented |       |                      |      |
| Insurance                |             |                      |      |
| Medicare                 | -0.026      | -0.031, -0.021       | <0.0005|
| Medicaid                 | -0.045      | -0.051, -0.038       | <0.0005|
| Indigent                 | 0.018       | 0.006, 0.031         | 0.003|
| Self-pay                 | -0.018      | -0.028, -0.009       | <0.0005|
| Other                    | -0.014      | -0.027, -0.001       | 0.041|
| Hospital characteristics |             |                      |      |
| ED volume (log)          | -0.007      | -0.009, -0.004       | <0.0005|
| Critical access hospital | -0.014      | -0.069, 0.041        | 0.617|
| Teaching hospital        | -0.002      | -0.008, 0.004        | 0.506|
| Government hospital      | -0.004      | -0.011, 0.003        | 0.227|
| Not for profit hospital  | 0.002       | -0.003, 0.007        | 0.438|
| County population (log)  | 0.371       | 0.276, 0.466         | <0.0005|
| Cath lab within hospital | 0.311       | 0.307, 0.315         | <0.0005|

ED – emergency department
Multivariable regression also includes other race categories (Native American, other, invalid) and comorbidities (indicator variable for each Elixhauser category).
Figure S1. Probability of death for NSTEMI patients associated with regionalization.

Point estimate and 95% confidence intervals for the association between regionalization status and risk of death at various time points. Values were calculated from a series of multivariable regressions with death as the dependent variable, as presented in Table 3.