

Reducing Racial Disparities In Coronary Angiography

A New Jersey reform closed the gap—perhaps because competition spurred hospitals to meet more patients' needs.

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ABSTRACT: Racial disparities in cardiac services are well documented; however, policies to close these gaps have not been studied. This paper evaluates a New Jersey certificate-of-need reform to reduce disparities in diagnostic coronary angiography. The number of angiography facilities in New Jersey doubled following reform, and a large black-white disparity was eliminated—a trend not observed in nearby states. Surprisingly, increases in service to African American patients following reform were concentrated in hospitals licensed before reform, while the newly licensed facilities contributed relatively little to reducing disparities. We hypothesize that added hospital competition contributed to the reduction in disparities. [Health Aff (Millwood). 2009;28(5):1521–31; 10.1377/hlthaff.28.5.1521]

DESPITE A GREAT DEPTH OF EVIDENCE documenting racial disparities in access to cardiac diagnostic and treatment services, few studies have evaluated public policy strategies to reduce these gaps.^{1–4} The persistence of well-documented disparities and lack of clear guidance for interventions are particularly troubling because blacks are at higher risk than whites for developing heart disease, and blacks have higher cardiac death rates.¹

Research on the correlates of disparities suggests some potentially fruitful avenues for policy intervention. The importance of racial differences in health insurance coverage and socioeconomic status is well documented, but the race gap in use of diagnostic angiography and related procedures persists even after controlling for these factors.^{1,5,6} The availability and location of cardiac services may also contribute to variations in utilization, but it is unclear whether changing system capacity is a viable strategy for reducing access gaps.^{7–9}

This paper assesses the effect of hospital regulatory reforms begun in 1996 in New Jersey that were intended, in part, to address a documented disparity in

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angiography use.⁸ Like the majority of other states at that time, New Jersey used certificate-of-need (CON) regulations to control health system capacity, including cardiac services.¹⁰ A series of regulatory changes in New Jersey between 1996 and 2003 provided hospitals with progressively stronger incentives to reduce gaps in access to coronary angiography. Under these reforms, New Jersey doubled the number of angiography access points, mandated that the new facilities create outreach plans, and linked licensure for other profitable cardiac services to a successful record of improving access. In this study we examined coronary angiography utilization rates of black and white patients between 1995 and 2003 in New Jersey and contrasted them to trends in nearby states.

The New Jersey Reforms

Before 1996, New Jersey limited coronary angiography to twenty-six facilities—roughly a fourth of New Jersey hospitals—and constrained the programs' size. The 1996 reform created a thirty-month pilot program licensing additional hospitals to provide angiography to low-risk patients.¹¹ It aimed to test whether high-quality angiography services could be provided without generating excessive use. The regulations addressed quality by imposing minimum standards for procedure volume and sought to limit overuse by making continued licensure contingent on not exceeding a rate of one in four negative angiography findings.

The 1996 regulations also addressed access to care by requiring hospitals to prepare annual “community outreach, access and prevention” plans.¹² The plan requirements were applied only to low-risk pilot facilities and were nonprescriptive, mandating only that these facilities “develop and maintain appropriate mechanisms to assure access...among the underserved population in [their] service area[s].”¹² A patient registry was created to enable regulators to monitor compliance with volume, percentage negative findings, and access requirements.

Regulatory amendments in 1998 and 2001 extended the pilot program and sought to strengthen incentives for facilities to address access disparities. Amendments in 1998 created a process of competitive review for licensure of new cardiac surgery centers with eight criteria, the first of which was the applicant's “historic commitment to access to cardiac services, particularly with respect to invasive cardiac diagnostic services, to minority and underserved populations.”¹³ As were the 1996 regulations, the 1998 revisions were nonprescriptive, leaving it to hospitals to determine how they would demonstrate commitment to improving access. The 2001 changes ended the pilot nature of the program, making the low-risk facility provisions permanent, and it created a procedure for low-risk licensees to “graduate” to full-service licensure.¹⁴

Study Design And Methods

■ **Comparison states.** To disentangle the effects of the New Jersey reforms from underlying trends in practice patterns, we selected comparison states based on their

geographic proximity, demographic similarity, and hospital regulatory histories. Two of the comparison states, New York and Massachusetts, had CON policies in place throughout the study period that limited angiography capacity. Neither of these states introduced new regulatory provisions to address access disparities during the study period. The third comparison state, Pennsylvania, repealed its CON program in 1996. The contrast with Pennsylvania enables us to compare New Jersey's controlled expansion of angiography capacity to an environment in which hospitals were free to develop new cardiac services at will.

■ **Data.** Hospital discharge abstract data for 1995–2003 were drawn from uniform billing records collected by, and obtained from, the respective states. Discharges were assigned to patients' state of residence, regardless of where the hospitalization occurred. The states' data sets include records for all inpatient hospitalizations for all study years and same-day (that is, outpatient) procedure data for New Jersey (all years), Pennsylvania (except 1995), and Massachusetts (except 1995–1997). The Pennsylvania analysis was limited to residents of twenty-one counties in the southeastern part of the state.¹⁵

Adults (age eighteen and older) with *International Classification of Diseases*, Ninth Revision, Clinical Modification (ICD-9-CM), procedure codes 37.21–37.23 and 88.53–88.57 were classified as having received coronary angiography. Data on patient demographics and residential location were also drawn from the discharge abstracts. Rates of coronary angiography use per 10,000 people were calculated separately for black and white populations, regardless of Hispanic ethnicity.^{16, 17} Race-specific rates were adjusted for age and sex using the direct method,¹⁸ with data for annual population denominators from the U.S. Census Bureau.¹⁵ Additionally, characteristics of New Jersey hospitals were obtained from the state's hospital cost reports and the 2003 American Hospital Association (AHA) Annual Survey.¹⁹ The study design was reviewed and approved by the Institutional Review Board at the authors' university.

■ **Analysis.** Changes in angiography capacity following the New Jersey reforms were assessed by hospital licensure category, teaching status, size (number of staffed beds), number of “high-technology” services, sources of payment, proportion of total discharges to discharges of black patients, and urban versus nonurban.^{20, 21}

Trends in age- and sex-adjusted angiography rates per 10,000 black and white New Jersey residents were contrasted with the trends in the comparison states for three periods of time: 1995–1996, the baseline period prior to implementation of the New Jersey reforms; 1997–2001, when new angiography facilities were permitted to serve only low-risk patients; and 2002–2003, when low-risk facilities were permitted to “graduate” to full-service licensure. We included 1997 in the postimplementation period even though some of the new catheterization facilities were open for part of that year, providing a conservative estimate of policy impact. For each period and state, we calculated 95 percent confidence intervals (CIs) around the utilization rates. Regression analyses comparing annual trends in the black-

white gap in angiography rates between New Jersey and the comparison states were also used to confirm the aggregate comparisons across the three periods.²²

Finally, changes in angiography service volume for black and white patients in New Jersey hospitals licensed before and after the change were examined for the three intervals. Chi-square tests were used to determine whether changes in the racial distribution of procedures varied significantly by licensure category.

Study Findings

■ **Capacity changes and outreach plans.** Prior to the CON reforms, twenty-six “incumbent” hospitals provided coronary angiography in New Jersey. In 1997–98, following the reforms, twenty-six additional hospitals began to offer low-risk angiography. Three low-risk angiography programs closed in 1999, leaving forty-nine hospitals providing the procedure until 2003, when five additional hospitals were granted licenses. In 2003, fifteen hospitals operated with low-risk angiography licenses, and thirteen had “graduated” from low-risk to full-service licensure. In 2004, the first hospital added a cardiac surgery program under the 2001 regulations. Each of the hospitals licensed to deliver angiography after reform was required to file outreach and access plans. However, a review of plans filed by the initial twenty-six post-reform licensees showed that few included outreach strategies that were likely to be effective.²³ Moreover, in interviews, New Jersey regulators reported having little belief that the outreach plan requirements were effective.²⁴

Hospitals starting angiography programs after the reforms differ from both the incumbent facilities and those without angiography services. Data from 2003 (Exhibit 1) show that hospitals licensed after reform were generally smaller, were less likely to have teaching programs, served fewer self-pay or Medicaid patients, and offered fewer high-technology services compared with the incumbent facilities. Although not statistically significant, incumbent facilities were more likely than either low-risk or graduate facilities to be located in an urban center.

■ **Trends in coronary angiography rates.** Despite evidence that the hospitals licensed after reform did not disproportionately serve black patients and that their outreach plans were weak, utilization trends show that the black-white gap closed after reform. In 1995–96, the period before the New Jersey policy change, there were significant gaps between the white and black angiography rates in New Jersey and the comparison states (Exhibit 2). This gap declined significantly in New Jersey following the CON reforms, and by 2002–03 it had disappeared. The greatest decline occurred in the year following the reforms, between 1997 and 1998 (Exhibits 3 and 4). Angiography rates increased during the study period for both blacks and whites, but the rate increased considerably more for the black population.

Unlike New Jersey, the disparity in the two comparison states with continuous CON regulations remained comparatively stable throughout the study period. In New York, where only inpatient statistics are available, the disparity declined only modestly during the study period, and by 2002–03 the adjusted rate was 11.2

EXHIBIT 1
Characteristics Of New Jersey Hospitals, By Coronary Angiography Licensure, 2003

Characteristic	Total	Licensure status				p value
		Full-service				
		Incumbent	Graduate	Low-risk	None	
Urban location ^a	35.4%	50.0%	15.4%	26.7%	35.7%	0.157 ^b
Teaching program	14.8%	40.0%	15.4%	0.0%	0.0%	<0.001 ^b
Staffed beds	287	411	291	251	195	<0.001 ^c
Technology index ^d	2.54	4.12	2.44	1.64	1.31	<0.001 ^c
Black patient discharges	14.0%	16.9%	6.8%	9.9%	16.3%	0.001 ^b
Medicaid discharges	12.3%	13.1%	7.4%	13.2%	13.6%	0.001 ^b
Self-pay discharges	8.7%	9.0%	6.2%	7.1%	12.5%	0.006 ^b
Number	82	26	13	15	28	

SOURCE: Authors' tabulations of data from the 2003 New Jersey Annual Cost Report, American Hospital Association Annual Survey, and New Jersey Hospital Discharge Abstract Data.

^a Municipalities with at least 25,000 people and population density of at least 9,000 per square mile.

^b Based on a chi-square test.

^c Based on analysis of variance.

^d Number of the following seven "high technology" services offered: heart surgery, extracorporeal shock-wave lithotripter, megavoltage radiation therapy, nuclear magnetic resonance imaging, organ/tissue transplant, level three obstetrics care, and certified trauma center. See Zuckerman S, Hadley J, Iezzoni L. Measuring hospital efficiency with frontier cost functions. *J Health Econ.* 1994;13(3):255–80.

per 10,000 population higher for whites than for blacks. In Massachusetts, in both inpatient-only and total statistics, the disparity showed an increase.

The white-black disparity in southeastern Pennsylvania, which repealed its CON program in 1996, was lower than in New Jersey in 1995–96. This area experienced extensive growth in total angiography volume over the study period, mainly in same-day procedures—patterns not evident in New Jersey or Massachusetts for the years that same-day procedure data are available. A significant racial disparity in angiography use was evident in southeastern Pennsylvania throughout the study period when same-day procedures are included. In 2002–03, the racial disparity in total use in southeastern Pennsylvania was significantly smaller than the gap in total procedures in Massachusetts but greater than the gap in New Jersey. Results of linear models contrasting annual trends across the study states before and after reform confirm that the racial gap closed significantly in New Jersey relative to trends in the comparison states.

■ **Volume changes by facility type.** The increase in volume of angiography procedures among blacks in New Jersey was concentrated in the incumbent facilities (Exhibit 5). Between the prereform period (1995–96) and the period when new low-risk licenses were granted (1997–2001), the average annual number of blacks receiving angiography at incumbent facilities rose by 817, offsetting a decline of 773 procedures per year among whites. The 2001 regulatory revisions permitted incumbent facilities to expand service capacity without regulatory review, and the yearly vol-

EXHIBIT 2**Inpatient And Same-Day Age- And Sex-Adjusted Coronary Angiography Rates Per 10,000 Adults, By Year And State, 1995–2003**

	Inpatient procedure rate			Inpatient and same-day procedure rate		
	1995–1996	1997–2001	2002–2003	1995–1996 ^a	1997–2001 ^b	2002–2003
New Jersey						
Total black and white	56.1	61.9	65.7	69.6	76.0	78.8
White	57.3	61.9	65.0	71.2	76.3	78.5
Black	43.1	58.7	68.0	53.2	69.8	77.3
Disparity	14.2	3.2	–3.0	18.0	6.5	1.2
New York						
Total black and white	50.0	49.9	54.6	– ^c	– ^c	– ^c
White	52.2	51.6	55.8	– ^c	– ^c	– ^c
Black	33.4	36.6	44.6	– ^c	– ^c	– ^c
Disparity	18.8	15.0	11.2	– ^c	– ^c	– ^c
Massachusetts						
Total black and white	43.3	47.1	54.3	– ^c	51.9	58.6
White	43.6	47.3	54.7	– ^c	52.2	59.2
Black	34.1	39.3	40.8	– ^c	42.9	43.3
Disparity	9.5	8.1	14.0	– ^c	9.3	15.9
SE Pennsylvania						
Total black and white	63.0	58.9	66.1	71.3	80.3	95.6
White	63.0	58.7	65.2	71.7	81.1	95.7
Black	59.9	57.3	69.8	64.4	70.0	90.4
Disparity	3.1	1.4	–4.7	7.3	11.2	5.3

SOURCE: Hospital discharge abstract data, various states (see text).

NOTE: A version of this exhibit with 95 percent confidence intervals is available in an appendix, online at <http://content.healthaffairs.org/cgi/content/full/28/5/1521/DC1>.

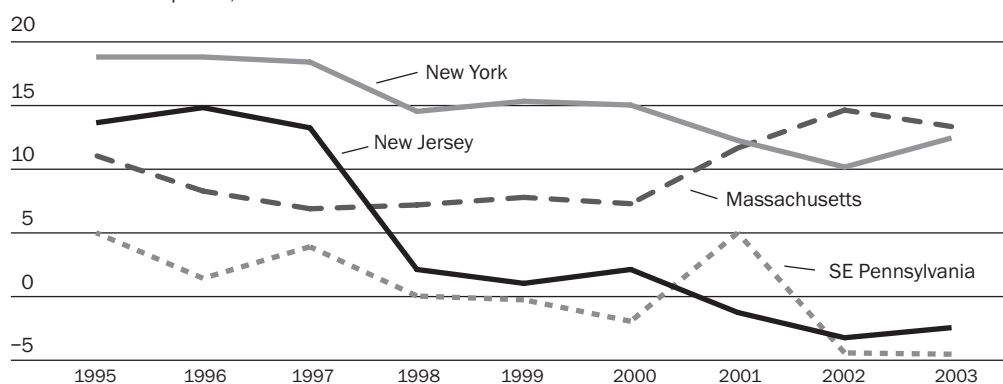
^a Same-day procedure data not available for Pennsylvania for 1994; estimate includes same-day cases for 1996 only.

^b Same-day procedure data not available for Massachusetts for 1997; estimate includes same-day cases for 1998–2001 only.

^c Same-day procedure data not available.

EXHIBIT 3**Trends In White-Black Differences In Age- And Sex-Adjusted Inpatient Coronary Angiography Rates In New Jersey And Three Comparison States, Per 10,000 Adults, 1995–2003**

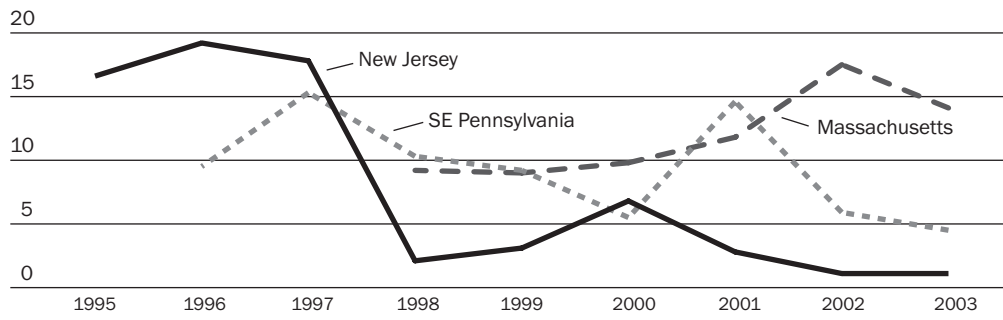
Difference in rate per 10,000



SOURCE: State hospital discharge abstract data; see text.

EXHIBIT 4**Trends In White-Black Differences In Age- And Sex-Adjusted Total Coronary Angiography Rates In New Jersey And Two Comparison States, Per 10,000 Adults, 1995–2003**

Difference in rate per 10,000

**SOURCE:** State hospital discharge abstract data; see text.**NOTES:** Includes both inpatient and same-day procedures. New York is excluded because data were available for inpatient procedures only.

ume of procedures among black and white patients grew by just over 1,000 in 2002–03, with more than half of this growth occurring among black patients.

The number of angiography procedures performed among blacks by the newly licensed low-risk facilities in 1997–2001 averaged fewer than 500 per year. Across

EXHIBIT 5**Average Annual Volume Of Coronary Angiography Procedures, By Hospital Licensure Category And Year, New Jersey, 1995–2003**

Licensure status	1995–1996	1997–2001		2002–2003		p value ^c
	Number	Number	Percent change ^a	Number	Percent change ^b	
All facilities						
Total black and white	32,245	38,066	18.1	40,998	7.7	<0.001
White	29,431	33,956	15.4	36,143	6.4	
Black	2,814	4,109	46.0	4,855	18.1	
Incumbent facilities						
Total black and white	32,245	32,289	0.1	33,280	3.1	<0.001
White	29,431	28,658	–2.6	29,130	1.6	
Black	2,814	3,631	29.0	4,150	14.3	
New facilities ^d						
Total black and white	– ^e	5,776	– ^e	7,718	33.6	0.09
White	– ^e	4,298	– ^e	7,013	32.4	
Black	– ^e	479	– ^e	705	47.2	

SOURCE: New Jersey Hospital Discharge Abstract Data.^a Compared to 1995–1996.^b Compared to 1997–2001.^c Based on chi-square test comparing the racial distribution of procedures across time periods.^d Includes facilities with low-risk licenses and those that “graduated” from low-risk to full-service licenses.^e Not applicable.

all New Jersey hospitals, the average annual number of procedures among blacks rose by 46 percent between 1995–96 and 1997–2001, compared to growth of only about 15 percent for whites. The pattern of annual growth in angiography volume moderated during the period when low-risk facilities were permitted to graduate to full-service licensure (2002–03), but the number of procedures continued to grow faster among blacks than among whites. Faster volume growth among blacks in this later period was evident among the incumbent and newly licensed hospitals, although the difference in trend between black and white patients among hospitals licensed after reform was not statistically significant.

Although the small number of hospitals studied does not permit rigorous statistical comparisons, it appears that incumbent hospitals located in urban areas increased services to blacks the most. Specifically, the number of black angiography patients per 1,000 white patients increased by nearly twenty-three per year in urban incumbent hospitals, compared to only five per year in nonurban incumbent facilities and eight per year in the new postreform facilities.

Discussion And Policy Implications

A New Jersey policy intended to increase diagnostic coronary angiography service capacity and address access gaps for underserved populations appears to have eliminated a large age- and sex-adjusted difference in utilization between black and white patients. The number of hospitals providing angiography initially doubled as a result of the New Jersey reforms, with the new facilities required to create plans to improve access for underserved groups. Surprisingly, however, the disparity-reducing impact of the policy appears to have stemmed not from the location of new access points or from outreach and access regulations, but from the behavior of largely urban hospitals that were licensed before the change.

The disparity reduction evident in New Jersey was not observed in New York or Massachusetts, which had continuous CON programs throughout the study period. The same year that New Jersey modified its regulations, Pennsylvania repealed its CON program. Unlike in New Jersey, angiography use grew rapidly in southeastern Pennsylvania, without a clear pattern of disparity reduction.

Coronary angiography use among both whites and blacks increased far more in southeastern Pennsylvania than in New Jersey following the CON changes. In contrast to Pennsylvania, provisions of New Jersey's regulatory reforms designed to discourage inappropriate use of angiography may have contributed to limiting overall utilization. This finding adds to the existing literature, which remains divided on whether and how CON constrains utilization.^{25, 26}

New Jersey hospitals receiving angiography licenses under the new regulatory regime served smaller proportions of black, Medicaid, and uninsured patients than the incumbent facilities. Still, the volume of procedures provided to black patients in New Jersey rose much faster than among whites. This trend is most striking in the incumbent hospitals, where volume of angiography provided to whites

declined slightly during the five years following the 1996 reforms, while volume among black patients rose by nearly a third. This finding supports the hypothesis that angiography capacity “freed” in incumbent hospitals following the introduction of competition from new licensees led to the disparity reduction.

Following the 2001 regulatory revisions, service by incumbent hospitals to white patients grew slowly, while volume among black patients continued fairly rapid growth. The 2001 regulatory changes permitted incumbent facilities to expand without CON review and allowed low-risk facilities to graduate to full-service licensure. These changes enabled growth in service to black patients in the incumbent facilities without offsetting reductions among whites. In addition, the emergence of graduate facilities may have increased competitive pressures.

■ **Other studies.** Other studies have also associated reduced racial access disparities with increased health service capacity. For instance, Dana Mukamel and colleagues concluded that a decline in the black-white disparity in coronary artery bypass graft surgery in New York may have stemmed from an increase in available cardiac surgeon capacity.²⁷

■ **Limitations.** Observational studies relying on administrative data have limitations. Such data do not readily permit adjustment for disease severity or medical appropriateness. However, there is no reason to suspect that changes in severity could have taken place over the short period during which the disparity reduction in New Jersey was observed. Moreover, because it is well documented that underlying risk of heart disease among African Americans is higher than among whites, it seems reasonable to posit that the observed disproportionate increase in use among blacks following the New Jersey policy change was medically appropriate.¹

The validity of analyses of discharge data depends on the quality of procedure coding. It seems unlikely that coding bias would differentially affect blacks and whites; thus, comparisons of trends should reflect actual changes in service levels. Utilization rates in our study include the patients who received care in bordering states, which is necessary to calculate accurate population-based rates and fully evaluate changes in access. A review of CON regulations and interviews with officials in neighboring states gave us no reason to believe that out-of-state use could have accounted for the large observed increase in angiography among black New Jersey residents.²⁴ The timing of disparity reduction, shortly after the New Jersey policy change, is also consistent with a causal relationship to the reforms.²⁸

Our study used nearby states to draw inferences about the impact of the New Jersey policy change. Studies using nonequivalent control groups are not as strong as randomized trials, but the New Jersey policy change offered a “natural experiment” and the opportunity to observe changes over a fairly short period of time. Because trends in underlying system dynamics and patient populations are likely to occur much more slowly, the inferences we draw about policy impact are strengthened. It is nevertheless possible that changes in medical technology, demographic shifts, or other policy or market forces may have contributed to dispar-

ity reduction in New Jersey in ways we could not measure. It is, therefore, important to continue to monitor access to angiography and related procedures by black patients and other vulnerable populations.

■ **Policy implications.** The experience following CON reform in New Jersey offers two important lessons for policymakers. First, caution should be used when developing policies that limit the franchise for profitable services to hospitals that serve patients from traditionally underserved groups. One rationale for limiting service capacity under CON is to promote the financial health of such hospitals.²⁹ Although the incumbent hospitals in New Jersey may well have used profits from their angiography programs prior to the reforms to subsidize care for the indigent, the policy might have contributed to a racial disparity in access to angiography. Second, although our study provides strong evidence that limiting capacity can exacerbate disparities, the contrasting experiences of New Jersey and southeastern Pennsylvania suggest that it is possible to construct a regulatory regime with provisions to limit excessive use while promoting access to services for the underserved.

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NOTES

1. Geiger HJ. Racial and ethnic disparities in diagnosis and treatment: a review of the evidence and a consideration of causes. In: Smedley BD, Stith AY, Nelson AR, editors. Unequal treatment: confronting racial and ethnic disparities in health care. Washington (DC): National Academies Press; 2002. p. 216–47.
2. Henry J. Kaiser Family Foundation and American College of Cardiology Foundation. Racial/ethnic differences in cardiac care: the weight of the evidence. Menlo Park (CA): Kaiser Family Foundation; 2002.
3. Kressin NR, Petersen LA. Racial differences in the use of invasive cardiovascular procedures: review of the literature and prescription for future research. *Ann Intern Med.* 2001;135(5):352–66.
4. Sheifer SE, Escarce JJ, Schulman KA. Race and sex differences in the management of coronary artery disease. *Am Heart J.* 2000;139(5):848–57.
5. Carlisle DM, Leake BD. Differences in the effect of patients' socioeconomic status on the use of invasive cardiovascular procedures across health insurance categories. *Am J Public Health.* 1998;88(7):1089–92.
6. Mirvis DM, Burns R, Gaschen L, Cloar FT, Graney M. Variation in utilization of cardiac procedures in the Department of Veterans Affairs health care system: effect of race. *J Am Coll Cardiol.* 1994;24(5):1297–304.
7. Carlisle DM, Leake BD, Shapiro MF. Racial and ethnic differences in the use of invasive cardiac procedures among cardiac patients in Los Angeles County, 1986 through 1988. *Am J Public Health.* 1995;85(3):352–6.
8. Gregory PM, Rhoads GG, Wilson AC, O'Dowd KJ, Kostis JB. Impact of availability of hospital-based invasive cardiac services on racial differences in the use of these services. *Am Heart J.* 1999;138(3 Pt 1):507–17.
9. Stanley A, DeLia D, Cantor JC. Racial disparity and technology diffusion: the case of cardioverter defibrillator implants, 1996–2001. *J Natl Med Assoc.* 2007;99(3):201–7.
10. National Conference of State Legislatures. Certificate of need: state health laws and programs [Internet]. Washington (DC): NCSL; 2008 Feb [cited 2009 Jun 16]. Available from: <http://www.ncsl.org/Issues/Research/Health/CONCertificateofNeedStateLaws/tabid/14373/Default.aspx>

11. Patients not considered low risk are those with diagnoses of left main coronary syndrome, unstable myocardial infarction, acute myocardial infarction within three days, unstable angina with persistent angina, congestive heart failure class III or IV, cardiogenic shock or severe hemodynamic instability, aortic stenosis with mean gradient over 40 mm of Hg, ejection fraction below 30 percent, or concomitant severe medical or vascular problems. See New Jersey Administrative Code 8:33E (1996).
12. New Jersey Administrative Code 8:33E-1.17 (1996).
13. New Jersey Administrative Code 8:33E-2.16(a)(1) (1998).
14. New Jersey Administrative Code 8:33E (2001).
15. Southeastern Pennsylvania is adjacent and demographically similar to New Jersey and includes more than half of the commonwealth's population. See U.S. Census Bureau, Population Division. Population estimates [Internet]. Washington (DC): Census Bureau; 2008 Mar 26 [cited 2009 Jun 16]. Available from: <http://www.census.gov/popest/datasets.html>
16. Data on ethnicity were not used because they have historically lacked reliability. See, for example, Boehmer U, Kressin NR, Berlowitz DR, Christiansen CL, Kazis LE, Jones JA. Self-reported versus administrative race/ethnicity data and study results. *Am J Public Health*. 2002;92(9):1471-2.
17. Polednak AP. Agreement in race-ethnicity coding between a hospital discharge database and another database. *Ethn Dis*. 2001;11(1):24-9.
18. Newman S. Biostatistical methods in epidemiology. New York (NY): John Wiley and Sons; 2001.
19. American Hospital Association. Annual survey database—fiscal year 2003. Chicago (IL): Health Forum; 2005.
20. The number of high-technology services was calculated following Zuckerman S, Hadley J, Iezzoni L. Measuring hospital efficiency with frontier cost functions. *J Health Econ*. 1994;13(3):255-80.
21. Municipalities with at least 25,000 people and a population density of at least 9,000 per square mile are classified as "urban."
22. An appendix describing the modeling approach and results is available online at <http://content.healthaffairs.org/cgi/content/full/28/5/1521/DC1>
23. Durain D. An evaluation of a state health policy designed to improve cardiac care to underserved populations. Piscataway (NJ): School of Public Health, University of Medicine and Dentistry of New Jersey; 2000 (unpublished).
24. Cantor JC, et al. State policy, health care disparities, and the invisible hand of the market. Poster session presented at: AcademyHealth State Health Research and Policy Interest Group; 2008 Jun 7; Washington, D.C.
25. Salkever D. Regulation of prices and investment in hospitals in the United States. In Culyer A, Newhouse JP, editors. *Handbook of health economics*. 1st ed. New York (NY): Elsevier; 2000.
26. Ross JS, Ho V, Wang Y, Cha SS, Epstein AJ, Masoudi FA, et al. Certificate of need regulation and cardiac catheterization appropriateness after acute myocardial infarction. *Circulation*. 2007;115(8):1012-9.
27. Mukamel DB, Weimer DL, Buchmueller TC, Ladd H, Mushlin AI. Changes in racial disparities in access to coronary artery bypass grafting surgery between the late 1990s and early 2000s. *Med Care*. 2007;45(7):664-71.
28. A low volume of out-of-state utilization of angiography services also makes it unlikely that border crossing could have contributed to our finding of disparity reduction. For instance, in 2002-03, the net effect of removing the out-of-state inpatient angiography procedures by New Jersey residents from population-based rates is to increase the white rate by 0.05 per 10,000 relative to the black rate; this reduces the observed difference between black and white angiography rates from 3.0 per 10,000 (see Exhibit 2) to 2.95.
29. Campbell ES, Fournier GM. Certificate-of-need deregulation and indigent hospital care. *J Health Polit*. 1993;18(4):905-25.