ORIGINAL RESEARCH

Association of Statewide Certificate of Need Regulations With Percutaneous Coronary Intervention Appropriateness and Outcomes

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***Background*—**Certificate of need (CON) regulations are intended to coordinate new healthcare services, limit expansion of unnecessary new infrastructure, and limit healthcare costs. However, there is limited information about the association of CON regulations with the appropriateness and outcomes of percutaneous coronary interventions (PCI). The study sought to characterize the association between state CON regulations and PCI appropriateness.

***Methods and Results*—**We used data from the American College of Cardiology's CathPCI Registry to analyze 1 268 554 PCIs performed at 1297 hospitals between January 2010 and December 2011. We used the Appropriate Use Criteria to classify PCI procedures as appropriate, maybe appropriate, or rarely appropriate and used Chi-square analyses to assess whether the proportions of PCIs in each Appropriate Use Criteria category varied depending on whether the procedure had been performed in a state with or without CON regulations. Analyses were repeated stratified by whether or not the procedure had been performed in the setting of an acute coronary syndrome (ACS). Among 1 268 554 PCI procedures, 674 384 (53.2%) were performed within 26 CON states. The proportion of PCIs classified as rarely appropriate in CON states was slightly lower compared with non-CON states (3.7% versus 4.0%, $P<0.01$). Absolute differences were larger among non-ACS PCI (23.1% versus 25.0% [$P<0.01$]) and were not statistically significantly different in ACS (0.62% versus 0.63% [$P>0.05$]).

***Conclusions*—**States with CON had lower proportions of rarely appropriate PCIs, but the absolute differences were small. These findings suggest that CON regulations alone may not limit rarely appropriate PCI among patients with and without ACS. **(*J Am Heart Assoc*. 2019;8:e010373. DOI: 10.1161/JAHA.118.010373.)**

Key Words: appropriateness criteria • outcomes research • percutaneous coronary intervention

More than 600 000 percutaneous coronary interventions (PCIs) are performed in the United States each year, accounting for over $12 billion in healthcare spending.[1] In part because of concerns about potential overuse of PCIs, the American College of Cardiology, American Heart Association, and other professional organizations released the appropriate use criteria (AUC) for coronary revascularization.[1–3] The AUC are intended to support improved selection of patients for PCI, particularly among patients with stable coronary artery disease. Although the proportion of rarely appropriate PCI (the AUC used the term "inappropriate" previously) has improved over time, nearly 1 in 7 non-acute PCIs performed in 2014 were classified as rarely appropriate, which varied substantially across hospitals.[4] These findings highlight the continued need to identify strategies to ensure that PCI procedures are being performed in patients in whom the benefits clearly outweigh the potential risks.

Certificate of need (CON) programs are 1 strategy to control costs, prevent overuse, and improve quality by regulating new facilities and capital equipment.[5,6] At present, 36 states have a CON program, and 26 states have CON regulations pertaining to cardiac services involving cardiac catheterization laboratories.[7] By regulating the supply of PCI programs, CON policies may reduce the number of excess cardiac catheterization facilities, thereby minimizing financial pressures of those facilities that may influence higher number of appropriate PCIs. Therefore,

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Accompanying Tables S1 and S2 are available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.118.010373

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Clinical Perspective

What Is New?

- Certificate of need (CON) programs are statewide regulations that aim to prevent overuse and improve quality.
- We assessed if states with CON regulations had significant differences in percutaneous coronary intervention appropriateness and rates of post-procedural adverse outcomes as compared with states without CON regulations.
- We found CON regulations are associated with only modest differences in the appropriateness and outcomes of percutaneous coronary intervention procedures.

What Are the Clinical Implications?

- Our study suggests there may be limited efficacy in CON regulations as public policies to improve percutaneous coronary intervention appropriateness and outcomes.
- Additional research is needed to evaluate whether the effectiveness of CON regulations for facilities performing invasive cardiac procedures outweigh the opportunity costs of implantation and maintenance.

one might expect that patients undergoing PCI in states with cardiac CON might have more favorable appropriateness ratings and quality as assessed by lower rates of adverse outcomes compared with patients treated in states without cardiac CON. Investigators have examined the association of CON regulations with appropriateness and outcomes, but the studies have been inconsistent and did not use contemporary updated AUC criteria.[1,5,8–10]

To address these gaps in knowledge, we used data from the American College of Cardiology National Cardiovascular Data Registry's CathPCI Registry. Specifically, we compared the appropriateness of procedures performed for both acute and non-acute indications in states with and without cardiac CON regulations. Given known associations of patient outcome variations with PCI appropriateness,[11] we also investigated whether state CON status was associated with differences in adverse outcomes including peri-procedural complications and in-hospital mortality. We hypothesized that there will be modest differences in PCI appropriateness such as states without CON will have a lower proportion of rarely appropriate PCIs and lower rates of adverse outcomes compared with states without CON regulation.

Methods

Data Sources

The National Cardiovascular Data Registry's CathPCI registry is cosponsored by the American College of Cardiology and the Society for Cardiovascular Angiography and Interventions and collects detailed information on patient and hospital characteristics, clinical presentations, treatments, and outcomes from participating hospitals in the United States.[12,13] For this analysis, we used data from PCIs performed between January 1, 2010 and December 31, 2011 using Version 4.0 of the data collection form. This study period was chosen to correlate with availability of CON information that was validated for accuracy. The data and analytical methods will not be made available to other researchers for the purpose of replicating the results of this study.

Study Design and Population

We performed a cross-sectional analysis of all hospitals in the CathPCI registry that reported at least 20 PCI procedures during the study time period, excluding 34 low volume hospitals and resulting in a total of 1297 facilities included in the analysis. Among patients with >1 PCI performed during a hospitalization, we only considered information from the initial procedure.

CON Regulation

Information about state's CON regulation was obtained through reports published by the National Conference of State Legislation.[7] Individual states and the District of Columbia were categorized according to whether they had cardiac catheterization CON regulations from 2010 to 2011. All information was verified using published information from individual states and from the American Health Planning Association National Directory.[14] No states discontinued or initiated CON regulations pertaining to cardiac catheterization during the study period.

We further characterized states with CON regulations into 3 groups according to the stringency of the CON regulations (high, moderate, and low stringency; Table S1).[5] Stringency categories were assigned based on data from 2001 to 2002, the most recent time period for which state CON stringency had been assessed.[15] A total of 3 states met criteria for high CON stringency, 7 states met criteria for moderate CON stringency, and 16 met criteria for low CON stringency.

Appropriateness

We classified the appropriateness of PCI procedures using the 2012 AUC. The committee defined appropriateness as the following: *Coronary revascularization is appropriate when the expected benefits, in terms of survival or health outcomes (symptoms, functional status, and/or quality of life) exceed the expected negative consequences of the procedure.* In the process of creating the criteria, a 21-member expert panel

designated the appropriateness of coronary revascularization for the most common clinical scenarios encountered in clinical practice for consideration of PCI. Additional details about the methodology on the AUC has been previously described elsewhere.[2,4] The AUC criteria classify the majority of PCIs performed in the context of whether the procedure was performed for an acute indication (ie, acute coronary syndrome [ACS] including myocardial infarction and unstable angina) or non-acute indication (ie, non-ACS). Procedures without the appropriate requisite data were considered unmappable and excluded from our analyses.

Outcomes Measures

We examined in-hospital procedural complications and mortality. Procedural complications included vascular complications requiring treatment, red blood cell/whole blood transfusion, major bleeding event within 72 hours, stroke, and emergency or salvage coronary artery bypass grafting. We also calculated a risk-adjusted composite end point of any adverse outcome (complication and death). Risk-adjusted outcomes were performed in a manner consistent with prior studies and adjusted for variables previously shown to be associated with risk of adverse events (Table S2).[1,9,16]

Statistical Analysis

We compared patient and hospital characteristics of PCI procedures performed in states with and without CON regulations for cardiac catheterization using t test and x^2 analyses. Patient characteristics included information about demographics, clinical presentation, comorbid diseases, and relevant past medical history and risk factors. Hospital characteristics included geographic region, teaching status, and cardiac surgery capabilities. We compared the proportions of PCI procedures classified as appropriate, may be appropriate, and rarely appropriate in states with and without CON regulations, and further stratified analyses by whether the procedure was performed for acute and non-acute indications. We repeated analyses stratifying patients in CON states by state CON stringency. Finally, we repeated these analysis adjusting for within-facility clustering and hospital characteristics.

We also compared unadjusted PCI complications and mortality events, as described previously, in patients in states with CON and without CON status. We then used multivariate logistical regression to examine the association of CON status with the composite end point of any adverse outcome including death. Analyses were conducted using SAS version 9.3 (SAS Institute, Cary, NC). All reported *P* values are reported as 2-sided with significance at $P<0.05$. The Yale University Human Investigations Committee approved analysis of a limited National Cardiovascular Data Registry's data set for research and waived the requirement for informed consent.

Results

Patient Demographics

A total of 1 268 554 PCI procedures performed at 1297 facilities between January 2010 and December 2011 met criteria for inclusion in this study. In our analysis, 53.2% of patients were from 26 states with CON regulations, 67.5% were male, 88.0% were white, and the mean age was aged 64.7 years (Table 1). Compared with patients treated in non-CON states, patients treated in CON states were modestly more likely to be a current or recent smoker, have hypertension, diabetes mellitus, hyperlipidemia, and a history of prior myocardial infarction or PCI. Patients treated in non-CON states were more likely to have been transferred from an outside emergency department. Median and interquartile ranges (25th, 75th) of PCI volume performed in facilities in states with CON was 445 (215–824) and in states without CON, 385 (198–611). A higher proportion of PCIs performed in states with CON regulations were considered elective compared with states without CON regulations. Additional clinical demographics and clinical characteristics of patients before PCI are shown in Table 1.

Association of CON Status With PCI Appropriateness

The proportions of procedures that did not have the data elements needed to map to an AUC indication were similar in CON and non-CON states (11.7% versus 11.1%) .The proportion of PCIs classified as appropriate or maybe appropriate in states with CON regulations was higher than in states without CON (85.2% versus 84.3%, $P<0.01$) (Table 2) and a lower proportion of procedures were considered rarely appropriate (3.7% versus 4.0%, $P<0.01$) (FigureA). Absolute differences were larger in patients undergoing PCI for non-acute indications. In this group, 76.9% of procedures were classified as appropriate or maybe appropriate in states with CON compared with 75.0% in states without CON ($P<0.01$) (Table 2). Furthermore, in cases of non-acute PCI, 23.1% of procedures performed were classified as rarely appropriate (FigureB). Among acute PCIs, there were no statistically significant differences between states with and without CON regulations seen in the proportions of procedures considered appropriate (99.4% versus 99.4%) or rarely appropriate (0.6% versus 0.6%). Within CON states, the stringency of CON was associated with differences in PCI appropriateness, both overall and among PCIs performed for non-acute indications.

Table 1. Patient Baseline Clinical Characteristics in States With and Without CON Programs

Variable	Total		CON		No CON	
	#	%	#	%	#	%
n	1 268 795	100.00	594 411	46.85	674 384	53.15
Demographics						
Age, y: Mean (SD)	64.70	12.08	64.11	12.03	65.22	12.11
Sex:Female	412 546	32.51	195 517	32.89	217 029	32.18
Race:White	1 115 986	87.96	511 788	86.10	604 198	89.59
Insurance:Private	445 043	35.08	201 347	33.87	243 696	36.14
History and risk factors						
BMI:Mean (SD)	29.93	6.18	30.04	6.22	29.84	6.15
Current/recent smoker (<1 y)	349 974	27.60	174 463	29.37	175 511	26.04
Hypertension	1 039 722	81.98	491 856	82.79	547 866	81.28
Dyslipidemia	1 011 549	79.81	477 014	80.34	534 535	79.35
Family history of CAD	314 490	24.80	146 894	24.72	167 596	24.86
Prior MI	381 457	30.08	180 856	30.44	200 601	29.76
Prior HF	150 985	11.91	71 195	11.99	79 790	11.84
Prior valve surgery/procedure	18 638	1.47	8243	1.39	10 395	1.54
Prior PCI	515 908	40.67	248 062	41.74	267 846	39.72
Prior CABG	234 904	18.52	112 476	18.92	122 428	18.16
Currently on dialysis	30 073	2.37	13 818	2.33	16 255	2.41
Cerebrovascular disease	156 442	12.34	75 572	12.72	80 870	12.00
Peripheral artery disease	159 268	12.56	75 005	12.63	84 263	12.50
Chronic lung disease	192 731	15.20	94 588	15.92	98 143	14.56
Diabetes mellitus	461 911	36.42	220 078	37.04	241 833	35.87
Clinical evaluation before procedure						
CAD presentation						
No symptom, no angina	105 985	8.35	47 399	7.98	58 586	8.69
Symptom unlikely to be ischemic	36 100	2.85	16 767	2.82	19 333	2.87
Stable angina	216 721	17.08	99 158	16.68	117 563	17.44
Unstable angina	472 465	37.24	228 959	38.53	243 506	36.11
NSTEMI	233 281	18.39	108 531	18.26	124 750	18.50
STEMI or equivalent	204 032	16.08	93 491	15.73	110 541	16.39
Anginal classification w/in 2 wks						
No symptoms	160 651	12.70	72 341	12.21	88 310	13.12
CCS I	75 136	5.94	29 183	4.93	45 953	6.83
CCS II	248 589	19.65	114 698	19.36	133 381	19.90
CCS III	413 901	32.71	200 995	33.93	212 906	31.64
CCS IV	366 969	29.00	175 133	29.57	191 836	28.51
Anti-anginal medications	870 262	68.62	419 495	70.61	450 767	66.87
Heart failure w/in 2 wks	122 348	9.65	54 179	9.12	68 169	10.11
Cardiomyopathy or LV systolic dysfunction	127 302	10.04	57 431	9.66	69 871	10.36
Cardiogenic shock w/in 24 h	24 843	1.96	10 814	1.82	14 029	2.08

Continued

Table 1. Continued

Variable	Total		CON		No CON	
	#	%	#	%	#	%
Cardiac arrest w/in 24 h	24 585	1.94	10 843	1.82	13 742	2.04
Preoperative evaluation before non-cardiac surgery	25 473	2.01	11 500	1.94	13 973	2.07
Stress imaging studies performed	426 392	33.63	200 516	33.77	225 876	33.51
PCI procedure						
Transfer from outside ED	464 013	36.57	206 880	34.80	257 133	38.13
Hospital status						
Outpatient	304 797	24.03	143 413	24.14	161 384	23.94
Outpatient converted to inpatient	229 880	18.13	104 494	17.59	125 386	18.60
Inpatient	733 510	57.84	346 173	58.27	387 337	57.46
PCI status						
Elective	558 873	44.07	269 787	45.41	289 086	42.89
Urgent	481 428	37.96	221 510	37.28	259 918	38.56
Emergency	223 759	17.64	101 095	17.02	122 664	18.2
Salvage	4109	0.32	1728	0.29	2381	0.35
Cardiogenic shock at start of PCI	28 018	2.21	12 179	2.05	15 839	2.35

BMI indicates body mass index; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CCS, Canadian Cardiovascular Society; CON, certificate of need; ED, emergency department; HF, heart failure; LV, left ventricular; MI, myocardial infarction; NSTEMI, non-ST-segment–elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation MI.

More stringent CON regulations were associated with a higher proportion of rarely appropriate PCIs although the absolute difference was small (least stringent: 3.75% versus most stringent: 4.03%; $P<0.01$). Among PCIs performed for non-acute indications, statewide CON stringency was associated with reduced rates of rarely appropriate PCI such that states with more stringent CON regulations were associated with lower proportions of rarely appropriate PCIs (least stringent: 22.92% versus most stringent: 20.58%; $P<0.01$) (Table 3).

After adjustment for hospital clustering and characteristics, CON remained significantly associated with PCI appropriateness in all cases ($P<0.05$) and in non-acute PCI

Table 2. Appropriateness of PCI Procedures Stratified by CON Status

	Total		No CON		CON		*P* Value
	#	%	#	%	#	%	
All							
Appropriate use criteria							
Appropriate/Maybe appropriate	1 074 517	84.70	568 131	84.26	506 386	85.21	<0.0001
Rarely appropriate	49 111	3.87	27 142	4.03	21 969	3.70	
Acute indications							
Appropriate use criteria							
Appropriate/Maybe appropriate	929 985	99.37	491 522	99.38	438 463	99.37	0.79
Rarely appropriate	5860	0.63	3087	0.62	2773	0.63	
Non-acute indications							
Appropriate use criteria							
Appropriate/Maybe appropriate	136 278	75.91	72 263	75.03	64 015	76.93	<0.0001
Rarely appropriate	43 251	24.09	24 055	24.97	19 196	23.07	

CON indicates certificate of need.

(P<0.05). There again was no association between CON and PCI appropriateness in acute causes (P=0.94). Within CON states, CON stringency was no longer associated with PCI appropriateness in all cases (P=0.95), acute causes (P=0.69), and non-acute cases (P=0.78).

Association of CON Status With PCI Outcomes

Statewide CON regulations were inconsistently associated with unadjusted peri- and post-procedural complication rates. States with CON regulations had significantly higher bleeding events (1.74% versus 1.59%, P<0.01) and a lower proportion of post-PCI patients requiring emergency or salvage coronary artery bypass grafting (0.27% versus 0.30%, P<0.01) (Table 4). The proportions of patients experiencing vascular complications, stroke, or requiring a blood transfusion were similar in CON and non-CON states. (Table 4). States with CON regulations had lower crude in-hospital mortality rates compared with states without CON (1.3% versus 1.5%). In our multivariate analysis, CON status was associated with a modest increase in the composite end point of any adverse outcome (odds ratio: 1.11 [1.01–1.21]).

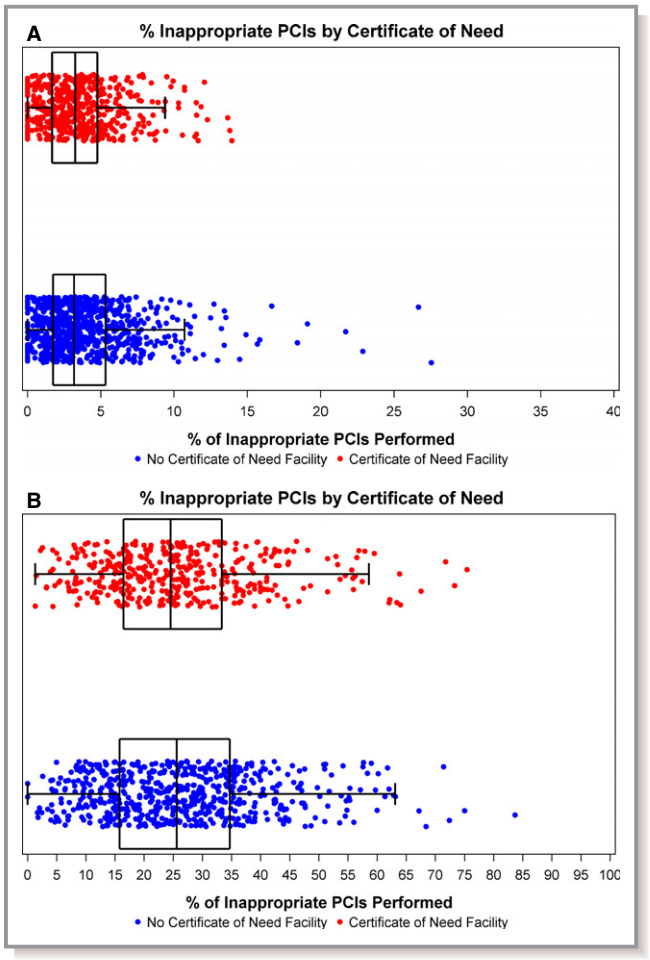

Figure. **A**, Percentages of rarely appropriate PCIs of all patients by certificate of need status. Horizontal box plot with each dot representing a facility. Dots are stretched vertically to figuratively show a distribution. **B**, Percentages of rarely appropriate PCIs of non-acute coronary syndrome patients by certificate of need status. Horizontal box plot with each dot representing a facility. Dots are stretched vertically to figuratively show a distribution. PCI indicates percutaneous coronary intervention.

Discussion

In this cross-sectional analyses of data from the CathPCI registry, we found that state CON status was associated with a small but statistically significantly lower proportion of PCIs classified as rarely appropriate compared with non-CON states. Similarly, when we stratified our results by statewide CON stringency, our findings did not vary significantly according to the stringency of CON regulations. Our study also demonstrated that state CON status was associated with a higher risk of selected adverse events. Taken together, our findings suggest that CON regulations may have a limited potential to prevent overuse of invasive cardiac procedures and improve outcomes for these patients.

This analysis builds upon a prior study that examined the relationship between state cardiac CON regulations and procedural appropriateness solely in patients with acute myocardial infarction.[8] Our analysis extends this prior work by replicating the work in ACS patients using contemporary AUC criteria and being the first to characterize the association between CON and appropriateness in PCI patients with stable ischemic coronary disease. This finding is important, as a higher proportion of PCI procedures performed on non-ACS patients are considered rarely appropriate than in ACS patients, and our present study highlights that the modest association of CON with PCI appropriateness is largely driven by the proportion of PCI done for non-acute indications. Furthermore, our study is the first to study the association between CON status and PCI appropriateness using contemporary AUC criteria. As such, the proportion of PCIs within each appropriateness category in our study sample differs from previous analyses. Despite this discrepancy, our results are consistent with prior literature in that the absolute differences in procedural appropriateness between CON and non-CON states are small.

We found that CON status was inconsistently associated with individual PCI complications and mortality rates. However, when we considered all adverse outcomes as a composite, patients treated in CON states were at increased risk of adverse outcomes compared with patients treated in non-CON states, and this risk appeared driven by increased risk of bleeding. Our findings are consistent with previous studies that suggest an equivocal association between CON

Table 3. Appropriateness of PCI Procedures as Stratified by CON Stringency

	Total		Less		Moderate		Most		
	#	%	#	%	#	%	#	%	*P* Value
All									
n	594 306	100.00	347 271	58.43	201 388	33.89	45 647	7.68	
Appropriate/Maybe appropriate	506 386	85.21	297 324	85.62	170 340	84.58	38 722	84.83	<0.0001
Rarely appropriate	21 969	3.70	13 027	3.75	7102	3.53	1840	4.03	
Acute indications									
n	441 236	100.00	258 283	58.54	150 464	34.10	32 489	7.36	
Appropriate/Maybe appropriate	438 463	99.37	256 677	149 551	145 690	99.39	32 235	99.22	0.79
Rarely appropriate	2773	0.63	1606	0.62	913	0.61	254	0.78	
Non-acute indications									
n	83 211	100.00	49 831	59.89	25 672	30.85	7708	9.26	
Appropriate/Maybe appropriate	64 015	76.93	38 410	77.08	19 483	75.89	6122	79.42	0.14
Rarely appropriate	19 196	23.07	11 421	22.92	6189	24.11	1586	20.58	

CON indicates certificate of need; PCI, percutaneous coronary intervention.

regulations and mortality after coronary bypass surgery or cardiac catheterization.[6,8,17–19] Taken together, these findings raise questions about the effectiveness of CON in improving patient outcomes following PCI. From a policy perspective, the maintenance of CON regulations is not without opportunity cost and should be continued only if there is evidence of improvements in healthcare delivery. Our findings emphasize the importance of regularly analyzing and examining the effectiveness of public policies to ensure they remain relevant and effective.

This study has several limitations that may warrant consideration. First, our cross-sectional analyses study design cannot discern a cause-and-effect relationship between CON status and PCI appropriateness or PCI outcomes. Second, any associations noted in the study may reflect other aspects of healthcare delivery not captured in our analyses and are independent of CON status. Examples of these factors include regional physician practice variation, institutional and hospital policies, and managed care penetration. Statewide mandated public reporting represents another policy that may affect PCI appropriateness in our study. However, the large majority of states with public reporting are also states with CON regulations and therefore, we do not expect significant differences in our results to be attributable to public reporting. Third, there is substantial heterogeneity of the cardiac CON regulations across states. Legal statutes and processes for CON regulations vary by state, and it is challenging to quantify the potential impact of a state's regulations on cardiac services. Although we attempted to address this limitation by applying CON stringency to our analyses, the most recent categorization of CON stringency was completed over a decade ago and did

Table 4. Proportion of PCI Procedures With Complications by CON Status

Variable	Total		No CON States		CON States		
Procedural Complications	#	%	#	%	#	%	*P* Value
Vascular complications requiring treatment	5554	0.44%	2904	0.43	2650	0.45	0.19
RBC/Whole blood transfusion	33 243	2.62	17 637	2.62	15 606	2.63	0.71
Bleeding event w/in 72 h	21 075	1.66	10 725	1.59	10 350	1.74	<0.01
Stroke	2787	0.22	1496	0.22	1291	0.22	0.57
Post-PCI patients requiring emergency or salvage CABG	3662	0.29%	2050	0.30	1612	0.27	<0.01
In-hospital mortality	17 958	1.42	9994	1.48	7964	1.34	<0.01
Any adverse events	84 279	6.64	44 806	6.64	39 473	6.64	0.87

CABG indicates coronary artery bypass grafting; CON, certificate of need; PCI, percutaneous coronary intervention; RBC, red blood cell.

not pertain specifically to CON regulations for invasive cardiac procedures. Fourth, our study sample only included patients undergoing PCI and may not be representative of patients undergoing other invasive procedures or diagnostic testing. Our findings of a lack of association between CON status with procedural appropriateness and outcomes also should not be generalized to other facets of CON such as reducing total healthcare expenditure or duplication of services. Additionally, we appreciate that the AUC may not be perfect in capturing true appropriateness. Nevertheless, studies have identified hospital performance on AUC criteria as a clinically important outcome, and the imperfections of AUC criteria presumably would apply equally to both CON and non-CON states. Finally, a major intent of CON programs is to reduce costs and our analyses could not assess this important outcome.

Conclusion

CON regulations are associated with small differences in PCI appropriateness and a modest, increased risk of adverse events following PCI procedures. These findings raise questions on the effectiveness of statewide CON regulations in improving the use of PCI and the short-term outcomes of PCI procedures. This information is relevant to any efforts to reevaluate the potential effectiveness of CON regulations for invasive cardiac procedures.

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SUPPLEMENTAL MATERIAL

Table S1. States certification of need status, stratified by stringency.

States without certificate of need for cardiac cathertizations	States with certificate of need for cardiac cathertizations		
	Low stringency	Moderate stringency	High stringency
Arizona	Alabama	Georgia	Connecticut
Arkansas	Alaska	Maine	Maryland
California	Delaware	Michigan	New Jersey
Colorado	Hawaii	North Carolina	
Florida	Illinois	South Carolina	
Idaho	Iowa	Rhode Island	
Indiana	Kentucky	West Virginia	
Kansas	Mississipi		
Louisiana	Missouri		
Massachusetts	New Hampshire		
Minnesota	New York		
Montana	Tennessee		
Nebraska	Vermont		
Nevada	Virginia		
New Mexico	Washington		
North Dakota	Washington, DC		
Ohio			
Oklahoma			
Oregon			
Pennsylvania			
South Dakota			
Texas			
Utah			

Wisconsin			
Wyoming			

Table S2. Variables adjusted for in multivariate analysis for adverse events.

Age
STEMI patients
BMI
Diabetes (insulin and non-insulin)
EF
Prior PCI
History of cerebrovascular disease
History of chronic lung disease
History of peripheral artery disease
Glomerular filtration rate (GFR)
Renal failure, GFR <30, or dialysis
Sustained cardiogenic shock
Transient cardiogenic shock
Emergeny PCI without shock/salvage
Urgent PCI without shock/salvage
NYHA class within past two weeks
Cardiac arrest within 24 hours
In-stent thrombosis
Highest risk lesion (proximal LAD or left main vs other)
Number of diseased vessels
Chronic total occlusion