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Association of Medical Liability Reform With Clinician Approach to Coronary Artery Disease Management

Steven A. Farmer, MD, PhD; Ali Moghtaderi, PhD, MBA; Samantha Schilsky, MPH; David Magid, MD, MPH; William Sage, MD, JD; Nori Allen, PhD, MPH; Frederick A. Masoudi, MD, MSPH; Avi Dor, PhD; Bernard Black, JD, MA

IMPORTANCE Physicians often report practicing defensive medicine to reduce malpractice risk, including performing expensive but marginally beneficial tests and procedures. Although there is little evidence that malpractice reform affects overall health care spending, it may influence physician behavior for specific conditions involving clinical uncertainty.

OBJECTIVE To examine whether reducing malpractice risk is associated with clinical decisions involving coronary artery disease testing and treatment.

DESIGN, SETTING, AND PARTICIPANTS Difference-in-differences design, comparing physician-specific changes in coronary artery disease testing and treatment in 9 new-cap states that adopted damage caps between 2003 and 2005 with 20 states without caps. We used the 5% national Medicare fee-for-service random sample between 1999 and 2013. Physicians (n = 75 801; 36 647 in new-cap states) who ordered or performed 2 or more coronary angiographies. Data were analyzed from June 2015 to January 2018.

MAIN OUTCOMES AND MEASURES Changes in ischemic evaluation rates for possible coronary artery disease, type of initial evaluation (stress testing or coronary angiography), progression from stress test to angiography, and progression from ischemic evaluation to revascularization (percutaneous coronary intervention or coronary artery bypass grafting).

RESULTS We studied 36 647 physicians in new-cap states and 39 154 physicians in no-cap states. New-cap states had younger populations, more minorities, lower per-capita incomes, fewer physicians per capita, and lower managed care penetration. Following cap adoption, new-cap physicians reduced invasive testing (angiography) as a first diagnostic test compared with control physicians (relative change, −24%; 95% CI, −40% to −7%; $P = .005$) with an offsetting increase in noninvasive stress testing (7.8%; 95% CI, −3.6% to 19.3%; $P = .17$), and referred fewer patients for angiography following stress testing (−21%; 95% CI, −40% to −2%; $P = .03$). New-cap physicians also reduced revascularization rates after ischemic evaluation (−23%; 95% CI, −40% to −4%; $P = .02$; driven by fewer percutaneous coronary interventions). Changes in overall ischemic evaluation rates were similar for new-cap and control physicians (−0.05%; 95% CI, −8.0% to 7.9%; $P = .98$).

CONCLUSIONS AND RELEVANCE Physicians substantially altered their approach to coronary artery disease testing and follow-up after initial ischemic evaluations following adoption of damage caps. They performed a similar number of ischemic evaluations but conducted fewer initial left heart catheterizations, referred fewer stress-tested patients for left heart catheterizations, and referred fewer patients for revascularization. These findings suggest that physicians tolerate greater clinical uncertainty in coronary artery disease testing and treatment if they face lower malpractice risk.

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Supplemental content

Author Affiliations: Author affiliations are listed at the end of this article.

Corresponding Author: Steven A. Farmer, MD, PhD, Center for Healthcare Innovation and Policy Research, George Washington University, 2100 Pennsylvania Ave, Office 316, Washington, DC 20037 (safarmer@gwu.edu).

Physicians frequently report practicing defensive medicine, including ordering marginally beneficial tests and interventions, to reduce malpractice liability.[1] Imaging and invasive diagnostic studies are often cited as overused defensive measures.[2]

A key policy question is whether legal reforms that reduce malpractice risk also decrease defensive medicine.[3,4] Many states have adopted noneconomic damage caps, which limit awards to compensate malpractice plaintiffs for "pain and suffering."[3,5] These caps produce substantial declines in the dollar amount of paid claims, which emerge gradually as precap lawsuits are resolved.[5] Lower risk would be observable to physicians through lower medical malpractice premiums[6] and local publicity about the reforms. Although early work by Kessler and McClellan[7,8] found that damage caps led to a 4% to 5% drop in hospital spending following a heart attack, later studies have not found significant changes in health care spending after cap adoption.[5,9,10] However, limited effect of damage caps on overall health care costs may obscure their effect on specific clinical decisions.

To our knowledge, this is the first study to examine the effects of damage caps on specific testing and treatment decisions for coronary artery disease (CAD). Diagnosing and treating CAD involves medical uncertainty, significant malpractice risk, and substantial cost. Coronary artery disease is the leading cause of death in the United States, and chest pain and other symptoms suggestive of CAD are common outpatient and emergency department symptoms.[11] Because unrecognized CAD can have catastrophic outcomes, with missed acute myocardial infarction an important cause of malpractice lawsuits, physicians are understandably cautious in their testing and intervention decisions.[12]

Unfortunately, CAD symptoms are variable and nonspecific, clinical guidelines for testing patients with suspected CAD symptoms are general, and test results can be ambiguous.[13] Clinicians must exercise judgment as to who should be tested, what test to use initially (definitive but invasive coronary angiography through left-heart or combined left- and right-heart catheterization [ie, angiography] vs noninvasive stress test), and how to treat CAD once diagnosed. Many experts believe that invasive tests and interventions are overused, with fear of malpractice liability a potential motivating factor.[14,15]

We hypothesized that if physicians faced lower malpractice risk, they would be willing to tolerate greater clinical uncertainty involving CAD, including the risk of future adverse events that earlier CAD diagnosis might have prevented. They would therefore be less likely to (1) test for CAD; (2) initiate testing with angiography rather than a noninvasive stress test; (3) progress patients from initial stress testing to angiography; and (4) refer patients with borderline stenoses for revascularization through percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG).

Key Points

Question Do physicians change testing and treatment decisions for coronary artery disease after malpractice reform?

Findings In this study, physicians in the 9 states that adopted damage caps between 2002 and 2005 performed a similar number of ischemic evaluations for possible CAD but performed fewer initial invasive coronary angiography and more noninvasive stress tests relative to control physicians. Physicians in states that adopted damage caps also referred fewer patients for angiography following a stress test, and fewer patients progressed from evaluation to revascularization.

Meaning These findings provide evidence that physicians who face lower malpractice risk tolerate greater clinical uncertainty in testing for and treating CAD.

Methods

The study was approved by the George Washington University and Northwestern University institutional review boards. Because this was a retrospective study using administrative claims, it was deemed exempt from the need for informed consent. We used a difference-in-differences (DiD) research design to assess the association of damage cap adoption with physicians' decisions to test for and treat CAD. Difference-in-differences is a standard method for estimating the effect of policy changes using observational data.[16] We compared changes over time in testing and progression decisions by new-cap physicians, who practiced in 9 new-cap states, which adopted damage caps between 2002 and 2005 (Nevada, 2002; Florida, Mississippi, Ohio, Oklahoma, and Texas, 2003; and Illinois and South Carolina, 2005), to changes over time for no-cap physicians who practiced in 20 no-cap states, which had no damage caps during the study period. In sensitivity analyses, we also compared new-cap physicians against those in 22 old-cap states, which had caps in place throughout our study period. The eMethods in the Supplement lists these 3 groups of states (eTable 1 in the Supplement), provides additional methodologic details (eTable 2 in the Supplement), and includes results from extensive robustness checks (eTables 3-10 and eFigures 1 and 2 in the Supplement).

After mapping physician identities across the 2007 change from Unique Physician Identification Number to National Provider Identifier as the primary identifier, we used physician zip code, state, and quarter fixed effects as well as extensive patient-level and county-level covariates to examine the association between malpractice reforms and clinical decisions. The study design measures changes in testing and treatment decisions by the same physicians, followed up over time, relative to physicians seeing similar patients in control states.

We studied rates for any ischemic evaluation (stress test or angiography as an initial test, with no stress test in the prior 30 days), and the choice between stress test and angiography as the initial diagnostic test. We also assessed the proportion of patients who progressed within 30 days: (1) from stress test to angiography, (2) from angiography to revascularization, and (3) from any ischemic evaluation to revascularization. We studied the most common stress tests: stress electrocardiogram, stress echocardiogram, and single-photon emission computed tomography. We did not study positron emission tomography or coronary computed tomography angiography, which were uncommon during our sample period. Procedures examined were angiography, PCI, and CABG.

Data Sources and Physician Sample

We used the 5% random sample of Medicare fee-for-service beneficiaries (Parts A and B) between 1999 and 2013 for patients 65 years and older. This data set allows us to follow up patients over time, includes physician identities, and covers approximately 2 million beneficiaries annually.

We studied physicians who ordered or performed 2 or more angiographies during our sample period. Because we used a 5% sample of patients, a physician who orders 2 angiographies included in our data set is expected to order or perform approximately 40 such procedures across all of their Medicare patients. These physicians generally include cardiologists as well as some primary care clinicians and hospitalists. The denominator for rates is all Medicare beneficiaries seen by an included physician.

We used Healthcare Common Procedure Coding System, *International Classification of Diseases, Ninth Revision*, and Diagnosis Related Group codes to identify tests and procedures. Medicare does not require preauthorization for the tests and procedures we studied.

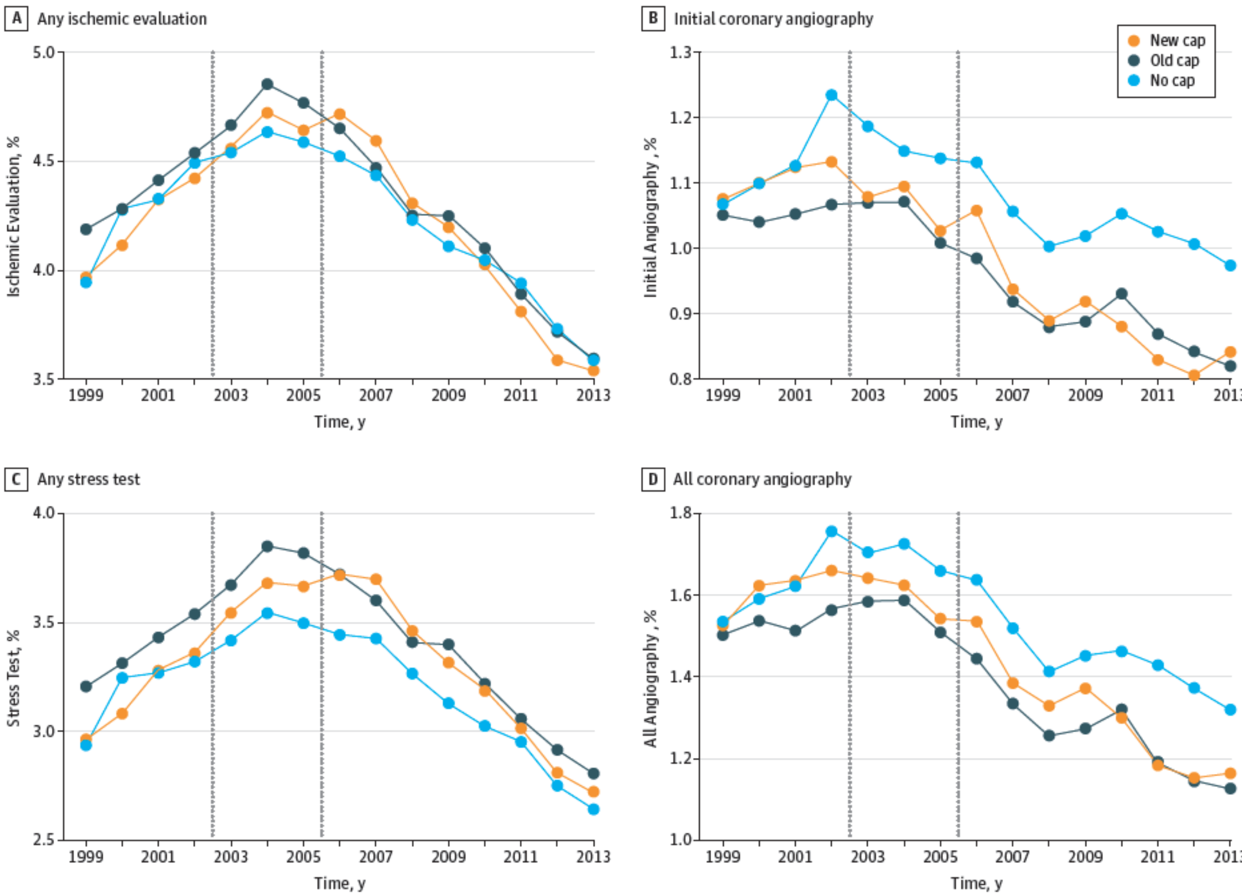
Table 1. Summary Statistics for 2002 (Just Before Third Cap Adoption Wave)[a]

Population Characteristics	No. (%) New Cap (n = 9)	No. (%) No Cap (n = 20)	*T* Test	*P* Value
County population variables				
County population, thousands	123.7	124.6	0.21	.83
CAD treatment intensity, per 1000 patients				
Initial ischemic evaluation (stress test or initial coronary angiography)	110.02	94.56	10.10	<.001
All coronary angiography	32.22	26.42	8.68	<.001
Revascularization (PCI or CABG)	14.82	13.28	4.83	<.001
Demographics				
Male	60 724 (49.09)	60 755 (48.76)	5.32	<.001
White	99 183 (80.18)	102 446 (82.22)	2.74	<.001
Black	20 212 (16.34)	16 484 (13.23)	4.48	<.001
Hispanic	20 373 (16.47)	11 276 (9.05)	9.33	<.001
Mean age	75.65	75.96	5.24	<.001
Physicians per 1000 persons	2.29	2.91	6.88	<.001
Median household income, $ thousands	41.17	43.96	5.05	<.001
Below poverty line, %	13.17	11.74	5.56	<.001
Unemployment rate, %	5.93	5.81	1.23	.22
Disabled, %	14.18	14.70	2.53	.01
Managed care penetration, %	10.99	13.28	3.43	<.001
Physician characteristics, No.				
Physicians	36 647	39 154	NA	NA
Distinct patients seen by these physicians	1 069 752	1 157 822	NA	NA
Patient characteristics (per-physician means)				
Age, y, mean	76.66	77.01	5.01	<.001
No. of comorbidities	1.85	1.88	1.64	.10
Male, %	34.91	35.29	0.90	.37
White, %	84.96	87.90	4.96	<.001
Black, %	9.30	7.49	3.64	<.001
Hispanic, %	2.96	1.32	6.06	<.001
CAD testing and progression rates				
Any stress test	3.35	3.31	0.32	.75
Any ischemic evaluation (stress test or initial coronary angiography)	4.42	4.49	0.47	.64
Stress test as % of ischemic evaluation	78.19	77.10	1.45	.15
All coronary angiography	1.66	1.75	0.89	.37
Initial angiography	1.13	1.23	1.08	.28
Progression rates				
Stress testing to angiography	13.91	13.15	1.40	.16
Ischemic evaluation to revascularization	10.32	9.99	0.85	.39
Angiography to revascularization	30.96	31.85	0.97	.33

Abbreviations: CABG, coronary artery bypass grafting; CAD, coronary artery disease; NA, not applicable; PCI, percutaneous coronary intervention.

[a] Data are at county level and weighted by county population. Progression is within 30 days. Per-physician rates are fraction of patients receiving indicated test or procedure.

Figure 1. Calendar Time Graphs for Stress Test and Angiography Rates



Annual rates for indicated outcomes separately for new-cap, no-cap, and old-cap states between 1999 and 2013. States are equally weighted within each group. Vertical lines indicate start and end of third reform wave period. Outcomes for rates are the fraction of the patients seen by each physician who received the indicated test; outcomes for progressions are the fraction of patients seen by these physicians who progress to angiography or revascularization as indicated.

Covariates

In addition to physician zip code, state, and calendar-quarter fixed effects, we controlled for a broad set of both patient characteristics (age, sex, race, ethnicity, and the presence of each of the Charlson comorbidities) and county characteristics (percentage of patients who were men, white, black, Hispanic, disabled, and aged 65-74 years, 75-84 years, and 85 years and older; population size; physicians per capita; unemployment rate; median household income; and managed care penetration). The fixed-effects control for time-constant physician and state factors that might influence our results; the quarter fixed effects address general trends in CAD testing and treatment that affect both treated and control states.

Statistical Analysis

We conducted our analyses in event time relative to each state's cap-adoption year, defined as year zero. We combined treated and control states in a panel data set and turn-on reform for each new-cap state in the cap-adoption year. We conducted 3 separate analyses: (1) simple DiD regressions, which measure the mean effect of the institution of caps for physicians in new-cap states in the postreform period (dropping year zero) relative to control physicians; (2) distributed lag regressions, which allow the effect of caps to vary during the postreform period; and (3) leads-and-lags regressions, which let us estimate the effect both before and after cap adoption. We clustered standard errors on state. Analyses were performed using Stata, version 14.0 (StataCorp). For DiD estimates, *P* less than .05 was considered statistically significant.

Effect of National Factors

Several national factors besides malpractice risk may have influenced CAD testing and treatment, especially later in our sample period. The principal factors are Appropriate Use Criteria (AUC), adopted for single-photon emission computed tomography in 2005 and extended to other stress tests in 2009[17-19]; the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) trial (2007), which found no mortality benefit from PCI for patients with stable angina[20]; and the Choosing Wisely campaign (2012).[21] Practice guidelines also changed for management of stable ischemic heart disease (2002),[22] PCI (2001 and 2007),[23,24] and CABG

Table 2. Difference-in-Difference Regressions: Results Summary[a]

Outcome	Observation, No.	Base Rate, %	Regression Coefficient	Change, % (95% CI)	P Value
Simple DiD regressions					
Testing					
All initial ischemic evaluation	38 474 986	4.42	−0.002	−0.05 (−8.01 to 7.90)	.98
Stress testing	38 474 986	3.35	0.262	7.84 (−3.61 to 19.28)	.17
Initial angiography	38 474 986	1.13	−0.270	−23.90 (−40.11 to −7.70)	.005
Initial angiography as fraction of initial evaluation	1 457 799	23.39	−5.581	−23.86 (−41.82 to −5.91)	.01
All angiography	38 474 986	1.66	−0.344	−20.76 (−36.05 to −5.46)	.01
Progression					
Stress test to angiography	1 197 663	13.91	−2.914	−20.95 (−40.08 to −1.81)	.03
Ischemic evaluation to revascularization	1 567 591	10.33	−2.368	−22.92 (−40.05 to −3.80)	.02
Angiography to revascularization	450 958	30.96	−2.418	−7.81 (−24.86 to 9.23)	.36
Distributed lag regressions					
	Sum of lag coefficients				
Testing					
All initial ischemic evaluation	39 344 579	4.42	0.090	2.03 (−11.00 to 15.09)	.75
Stress testing	39 344 579	3.35	0.495	14.78 (−0.81 to 23.22)	.07
Initial angiography	39 344 579	1.13	−0.437	−38.67 (−58.61 to −14.97)	.002
Initial angiography as fraction of initial evaluation	1 499 680	23.39	−9.231	−39.47 (−60.62 to −18.31)	.001
All angiography	39 344 579	1.66	−0.545	−32.83 (−54.03 to −11.59)	<.001
Progression					
Stress test to angiography	1 232 209	13.91	−4.854	−34.89 (−61.39 to −8.39)	.01
Ischemic evaluation to revascularization	1 612 985	10.33	−3.102	−30.03 (−58.45 to −1.61)	.04
Angiography to revascularization	484 387	30.96	−4.200	−13.56 (−37.02 to 9.88)	.25

Abbreviation: DiD, difference in differences.

[a] Sample is 75 801 physicians (36 647 in new-cap states), between 1999 and 2013. Stress testing was defined as stress electrocardiogram, stress echo, and single-photon emission computed tomography. Ischemic evaluation was defined as stress testing or initial coronary angiography. Revascularization was defined as percutaneous coronary intervention or coronary bypass grafting. Based on panel regressions with physician zip code, state, and quarter fixed effects and patient-level and demographic covariates. Base rate is annual percentage rate in 2002. Regression coefficients are for new-cap state indicator and are multiplied by 400 to provide annual percentage rates. Percentage change was defined as reported regression coefficient/base rate. We dropped the cap adoption year (event year 0) for physicians in treated states and cap reversal year and after for states (Illinois and Georgia) where caps were reversed by state supreme courts.

(2004).[25] We assessed whether these national factors could explain our findings in 2 ways. First, we limited the treated states to 6 states that adopted caps in 2002/2003 and ended the study period in 2009. Second, we studied the 17 states with the highest stress-testing rates in 2002 (including 8 new-cap states) plus the 17 states with the lowest rates (including the ninth new-cap state). We then ran regressions that compared the effect of the actual damage-cap shock with a hypothetical AUC-driven shock in high-rate states in 2005.

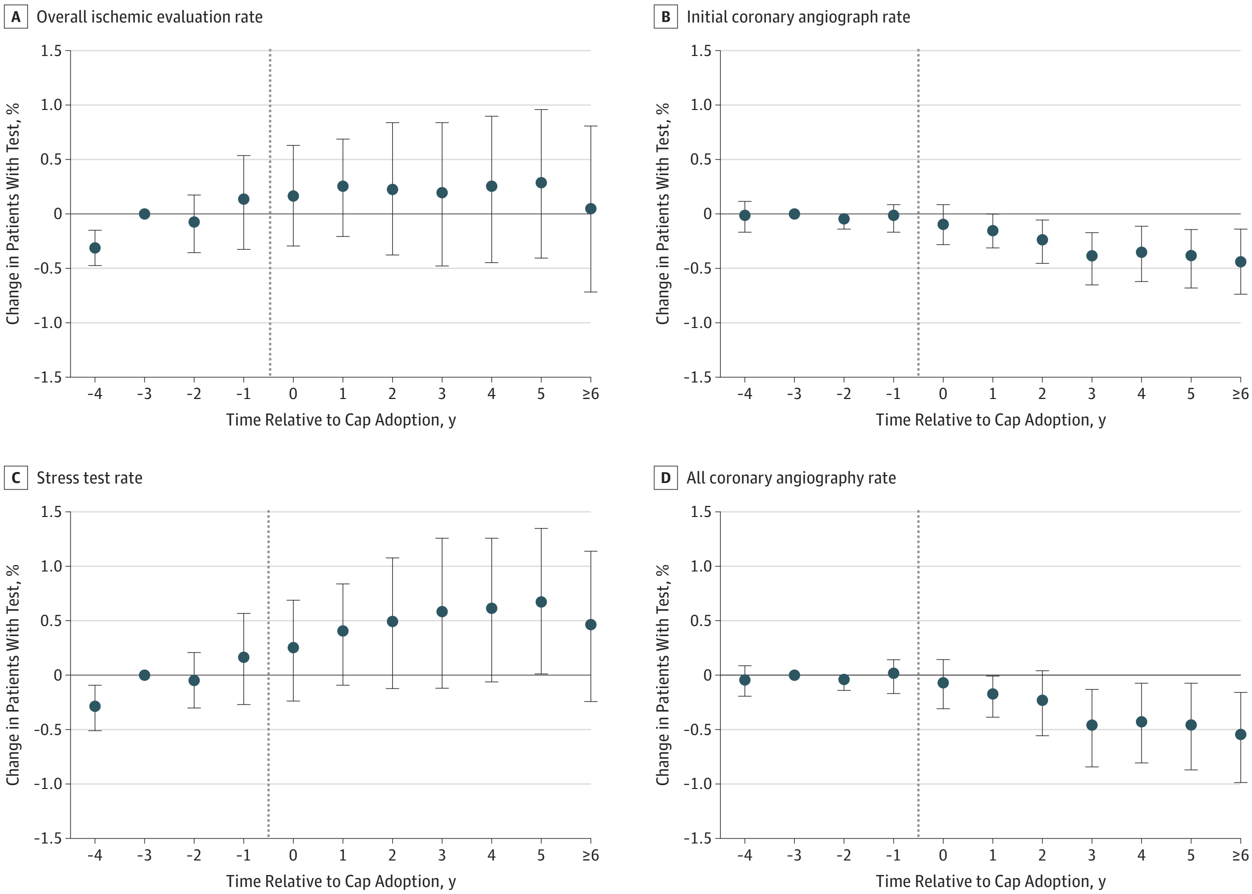
Results

Our physician cohort included 75 801 physicians, of whom about half (36 647) practiced in new-cap states. New-cap states had younger populations, more minorities, lower per-capita incomes, fewer physicians per capita, and lower managed care penetration. They also had higher base rates for ischemic evaluation, angiography, and revascularization in 2002, just before the cap adoptions we studied (**Table 1**). There were differences in population testing and treatment rates between the 2 groups of states. However, our study focuses on physician behavior, and the precap behavior of our physician sample, ie, the fraction of each physician's patients who received CAD tests or procedures, was similar in treated and control states.

Figure 1 shows rates in calendar time for new-cap, no-cap, and old-cap states for any ischemic evaluation, initial angiography, any stress test, and all angiography (either initial or following stress test). The graphs are reasonably parallel during the prereform period (1999-2002), except for a puzzling jump in 2002 in initial angiography rates in no-cap states. This supports the parallel trends assumption underlying DiD analysis.

Table 2 shows the magnitude and statistical significance of changes in ischemic evaluation and progression rates for new-cap physicians relative to changes for no-cap physicians. The first half of the Table presents simple-DiD regression results, which assume physician behavior changes immediately after reform. **Figures 2** and **3** present leads-and-lags graphs in event time. These graphs show annual changes in CAD evaluation and progression rates for new-cap vs no-cap physicians from 4 years before cap adoption (to assess whether pretreatment trends were parallel) through 6 years after cap adoption and show how the estimated treatment effect evolves after reform. Postcap

Figure 2. Ischemic Evaluation Rates for Physicians in New-Cap States Relative to No-Cap States



Graphs show differences in ischemic evaluation rates as an absolute percentage of patients receiving the indicated test or procedure, for physicians in 9 new-cap states and 20 no-cap states, from leads and lags regressions with physician fixed effects and covariates (indicated in the text), for 75 801 physicians who ordered or performed at least 2 angiographies (36 925 in the new-cap states). Years are in event time relative to cap adoption year. Relative rate for year −3 is set to zero. Squares show annual point estimates, vertical lines show 95% confidence intervals. Ischemic evaluation was defined as stress testing (stress electrocardiogram, stress echocardiogram, or single-photon emission computed tomography) or angiography. Number of precap years with available data are 3 to 5 depending on each new-cap state's cap adoption year; number of postcap years with available data are 7 to 9, depending on cap adoption year.

changes generally occurred during the first 3 postreform years before stabilizing.

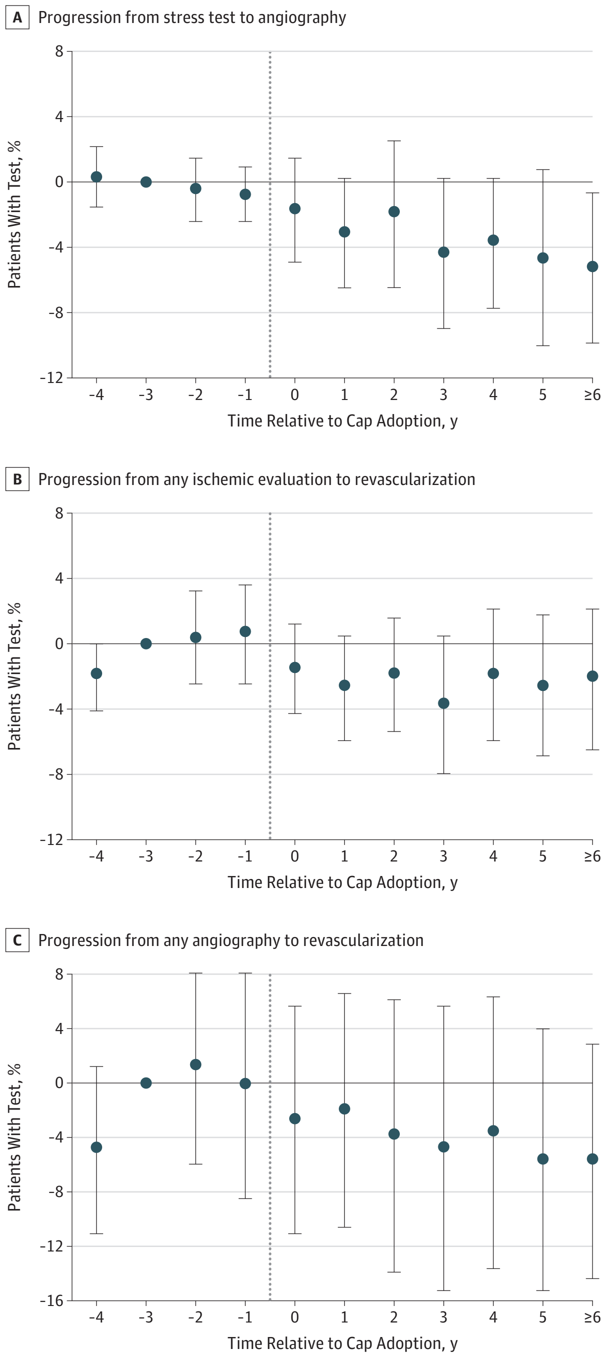
Baseline ischemic evaluation rates rose for new-cap physicians relative to no-cap physicians from year −4 to −3 but were reasonably flat for the remainder of the precap period (Table 2; Figure 2A). These rates did not significantly change after cap adoption (simple DiD point estimate: relative change, −0.05%; 95% CI, −8% to 8%; *P* = .98). However, new-cap physicians changed the type of initial evaluation performed. During the 3 years following cap adoption, new-cap physicians ordered fewer initial angiographies (−24%; 95% CI, −40% to −8%; *P* = .005, Figure 2B) but more initial stress tests (8%; 95% CI, −4% to 19%; *P* = .18, Figure 2C).

The postreform drop in initial angiographies was accompanied by lower progression rates. Compared with no-cap physicians, new-cap physicians referred fewer patients for angiography after stress testing (−21%; 95% CI, −49% to −2%; *P* = .02; Figure 3A). The combination of lower initial angiography rates and lower progression from stress testing to angiography produced a large percentage decline in overall angiography rates after cap adoption (−21%; 95% CI, −31% to −5%; *P* = .01; Figure 2D). Additionally, fewer patients progressed from any ischemic evaluation to revascularization (−26%; 95% CI, −45% to −6%; *P* = .01; Figure 3B and C). The lower revascularization rates are driven by fewer PCIs; CABG rates did not change (eAppendix in the Supplement).

The second half of Table 2 presents distributed-lag regression results, which allow the reform effect to phase in over time. The estimated percentage changes were generally larger in magnitude than in the simple-DiD results. For example, initial angiography as a fraction of ischemic evaluation declined by 32.8% (95% CI, −54.0% to −11.6%; *P* < .001) and progression from stress test to angiography declined by 34.9% (95% CI, −61.4% to −8.4%; *P* = .01).

The decreased tendency for patients of new-cap physicians to progress from ischemic evaluation to revasculariza-

Figure 3. Progression Rates for Physicians in New-Cap States Relative to No-Cap States



Graphs show differences in percentage progression rates for physicians in 9 new-cap states and 20 no-cap states, from leads-and-lags regressions with physician fixed effects and covariates (indicated in the text), for physicians who ordered or performed at least 2 angiographies. Sample period is 1999 to 2013. Years are in event time relative to cap adoption year. Relative rate for year −3 is set to zero. Squares show annual point estimates; vertical lines show 95% confidence intervals. Ischemic evaluation was defined as stress testing (stress electrocardiogram, stress echocardiogram, or single-photon emission computed tomography) or initial angiography. Revascularization is percutaneous coronary intervention or coronary artery bypass grafting. Number of precap years with available data are 3 to 5 depending on each new-cap state's cap adoption year; number of postcap years with available data are 7 to 9, depending on cap adoption year.

tion has 3 possible channels: fewer initial angiographies, less progression from stress testing to angiography, and less progression from angiography to revascularization. The first 2 channels are statistically significant. The third is directionally consistent (−8%; 95% CI, −26% to 9%; $P = .31$; Figure 3C).

Effect of National Factors

Our principal results remain statistically strong after allowing for the potential effects of the national factors discussed in the Methods section. First, the effect of damage caps appears by event year 3 (2005-2006) and thus precedes the COURAGE trial, Choosing Wisely, and the 2009 expansion of AUCs (Figures 2 and 3). Second, new-cap states have higher population stress testing rates (Table 1). They might therefore have experienced greater rate reductions in response to national factors. However, in sensitivity tests (eFigure 3 in the Supplement), we found no evidence that either the 2005 AUC or later national factors had a larger effect in high-rate than in low-rate states.

Additional Sensitivity Analyses

We conducted extensive additional sensitivity analyses, reported in the eAppendix in the Supplement. First, we used a broader control group (no-cap states plus old-cap states), and a narrower control group (9 no-cap states, chosen for geographic and cultural similarity to the new-cap states) (eFigure 4 in the Supplement). Second, we studied both broader and narrower physician cohorts (eFigure 5 in the Supplement). Third, we ran leave-one-out regressions, in which we removed individual states from the treatment group. Fourth, we used county as place of service (instead of state) fixed effects. Our findings were consistent across these variations.

Discussion

Physicians often report practicing defensive medicine, but previous studies of damage caps and other malpractice reforms show little evidence that malpractice reform affects overall health care spending. Prior studies, except for those focusing on cesarean section rates, have also not assessed whether and how changes in malpractice risk alter specific clinical decisions under uncertainty.[26-30] We studied specific cardiac care decisions that involve both significant clinical uncertainty and substantial malpractice risk.

Following cap adoption, overall ischemic testing rates remained constant, but testing became less invasive, and revascularization through PCI, following initial testing, declined. These findings suggest that physicians are willing to tolerate greater clinical uncertainty in CAD testing if they face lower malpractice risk. Our confidence intervals are wide, but even their upper bounds suggest meaningful changes in clinical behavior.

Stress tests are less definitive than angiography for diagnosing CAD.[31-33] For example, stress tests only provide evidence on obstructive CAD, and single-photon emission computed tomography may produce ambiguous findings because of ramp or motion artifacts, obesity, and breast or diaphragmatic attenuation.[34] Physicians were more willing to tolerate this uncertainty after cap adoption. Referrals from initial stress test to angiography also fell substantially, although reduced use as an initial test should have increased the fraction of stress tests producing abnormal or marginal results.

New-cap physicians also accepted greater clinical uncertainty in treating CAD after diagnosis. Obstructive CAD may be treated medically or with revascularization. However, many patients incorrectly believe that PCI for stable obstructive CAD reduces AMI risk.[35,36] Many cardiologists also perceive performing PCI, or referring for CABG, as reducing malpractice risk. After cap adoption, fewer patients in new-cap states progressed from ischemic evaluation to revascularization, suggesting greater reliance on medical treatment.

This study spans a period during which multiple factors other than introduction of damage caps might have differentially affected new-cap vs old-cap states, particularly because the new-cap states had higher baseline testing and intervention levels than control states. However, in extensive robustness checks, we find no evidence that the AUC, the COURAGE trial, or the Choosing Wisely campaign account for our findings.

Our finding that reducing malpractice was associated with a lower intensity of CAD testing and treatment has important policy implications. A 2011 study found that 12% of PCIs for nonacute indications were inappropriate.[37,38] Moreover, ischemic evaluation and revascularization rates are far lower in Medicare Advantage plans than in Medicare fee-for-service, which suggests overuse in Medicare fee-for-service.[39] Curtailing marginal or unnecessary angiography and revascularization spares patients invasive procedures and associated risk and saves resources. In addition, both the Department of Health and Human Services and commercial payers are moving rapidly toward alternate payment models.[40] A core issue for these models is provider resistance to changing established practice patterns. Our study suggests that physicians who face lower malpractice risk may be less concerned with that risk, and thus more receptive to new care delivery strategies associated with alternate payment models.[41,42]

Limitations

Our study has several limitations. The modest number of new-cap states is an inherent limitation of a DiD design based on state-level reforms. A core DiD assumption is parallel trends: both groups of states would have followed similar CAD testing and treatment trends without cap adoption.[16] This assumption cannot be formally tested, but an important check is whether prereform trends appear reasonably parallel. They appear parallel for angiography (Figure 2B), but a rising relative pretreatment trend for stress testing (Figure 2C) could partly explain the postcap rise in stress tests that we found.

We studied testing and treatment decisions by the same physicians in the same locations. We did not study physicians who moved between states, but noted that movement between no-cap and new-cap states was limited (eFigure 6 in the Supplement). We lack clinical data and could not assess the appropriateness of testing or treatment. The study was also not designed to assess health outcomes.

We studied the third wave of cap adoptions, between 2002 and 2005. Since 2010, there has been accelerated integration of cardiology practices into hospitals and larger practice groups. Physician responses to caps could depend on their practice setting, but we lack data on practice settings and cannot test this possibility. We studied only Medicare fee-for-service patients, older than 65 years. Physicians may behave differently for younger patients or for those insured by other payers; for example, commercial payers may have preauthorization requirements.

As with all observational studies, we cannot account for unobserved variables. However, our models use physician zip code, geographic, and quarter fixed effects and extensive time-varying covariates to control for factors that may have influenced CAD testing and treatment. Mean comorbidity scores moved in parallel for new-cap and no-cap states (eFigure 7 in the Supplement). Our results were robust to numerous sensitivity analyses.

Conclusions

We studied the association of damage caps with specific cardiac care decisions that involve clinical uncertainty, high patient risks, and significant malpractice risk. To our knowledge, ours is the first paper to show changes in clinical behavior following up cap adoption in the particular setting of CAD testing and treatment. We found evidence that physicians altered their CAD testing and intervention practices following adoption of damage caps. Overall testing rates did not change, but testing became less invasive (fewer initial angiographies and less progression from initial stress test to angiography), and revascularization through PCI following initial testing declined. These findings suggest that physicians are willing to tolerate greater clinical uncertainty in CAD testing and treatment if they face lower malpractice risk.

ARTICLE INFORMATION

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Author Affiliations: School of Medicine and Health Sciences, George Washington University, Washington, DC (Farmer, Moghtaderi, Schilsky); Milken Institute School of Public Health, George Washington University, Washington, DC (Farmer, Moghtaderi, Dor); Feinberg School of Medicine, Northwestern University, Chicago, Illinois (Farmer, Allen); Kellogg School of Management, Northwestern University, Chicago, Illinois (Farmer, Black); University of Colorado Anschutz Medical Campus, Denver (Magid, Masoudi); Texas Law, University of Texas at Austin (Sage); Dell Medical School, University of Texas at Austin (Sage); Institute for Health Research, Kaiser Permanente Medical Group, Denver, Colorado (Masoudi); Pritzker School of Law, Northwestern University, Chicago, Illinois (Black).

Author Contributions: Dr Farmer and Prof Black had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: Farmer, Moghtaderi, Magid, Sage, Black.
Acquisition, analysis, or interpretation of data: All authors.
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