Countywide Physician Organization Learning Collaborative and Changes in Hospitalization Rates

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ABSTRACT

OBJECTIVES: In 2011, the California Right Care Initiative implemented a countywide physician organization learning collaborative called University of Best Practices (UBP) in San Diego County for major healthcare systems and physician organizations to share best practices in managing cardiovascular and cerebrovascular risk factors. Our objective was to examine whether UBP was associated with fewer hospitalizations for heart attacks and strokes.

STUDY DESIGN: A quasi-experimental design was used to compare age-adjusted adult hospitalization rates before UBP initiation (2007-2010) against rates after UBP initiation (2011-2014) in San Diego County versus the rest of California.

METHODS: Difference-in-differences (DID) logistic regression models were estimated using hospitalization data from the California Office of Statewide Health Planning and Development for 2007 to 2014, including 372,205 and 642,455 hospitalizations for heart attacks and strokes, respectively.

RESULTS: In the UBP versus pre-UBP period, the odds of adults being hospitalized for a heart attack in San Diego County decreased (odds ratio [OR], 0.84), whereas the odds stayed the same for adults in the rest of California (OR, 1.00): DID ratio of OR, 0.84 (P <.001). This relative decrease was equivalent to 2735 (or 16.5%) fewer hospitalizations, totaling $61 million (2014 dollars). No robust association was found between UBP implementation and hospitalizations for strokes.

CONCLUSIONS: A countywide physician organization learning collaborative was associated with fewer hospitalizations for heart attacks, but not for strokes. Healthcare systems and physician organizations should consider forming collaboratives to share best practices to manage patients' cardiovascular and cerebrovascular risk factors, which may lead to fewer hospitalizations and reduced healthcare costs.

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Cardiovascular disease is the leading cause of death in the United States, and its annual costs, combined with those of stroke, averaged $316.6 billion per year in 2011 and 2012, including $193.1 billion in direct healthcare costs and $123.5 billion in indirect costs.[1-3] Achieving lower heart attack and stroke rates will not only save lives, but also generate substantial healthcare cost savings.

Quality improvement collaboratives have become a well-established approach for improving the quality of care in the United States.[4,5] Several national and regional models have emerged to reduce cardiovascular and cerebrovascular diseases and their risk factors. Million Hearts, for instance, an initiative launched by HHS in 2011, aims to prevent 1 million heart attacks and strokes over 5 years by convening and educating communities, physician groups, federal agencies, and other partners.[6] Regional models that aim to reduce cardiovascular and cerebrovascular risk factors include physician collaboratives focused on education, training, and data sharing. For example, South Carolina's Hypertension Initiative, which spread to 4 states in the stroke belt, contributed to a 43% decline in coronary heart disease deaths and a 42% decline in stroke deaths between 1996 and 2006.[7] Another collaborative in Ontario, Canada, promoted education in 11 primary care clinical practices, which resulted in reductions in patients' systolic blood pressure and 10-year cardiovascular risk scores during the 3-year study period.[8] Finally, a community-wide cardiovascular disease prevention collaboration in rural Franklin County, Maine, was associated with lower hospitalization and mortality rates over a 40-year period.[9]

University of Best Practices

The California Right Care Initiative (RCI) began in 2007, focusing on evidence-based and outcomes-improvement strategies to reduce preventable morbidity and mortality among Californians, particularly those with cardiovascular and/or cerebrovascular disease.[10] One of RCI's main strategies is to stimulate the sharing of best practices for managing risk factors (including diabetes) for these diseases among physician organizations, integrated delivery systems, and

other stakeholders through regional interorganizational learning communities known as University of Best Practices (UBP).[11]

The San Diego County UBP (now called "Be There San Diego") is the longest running RCI learning collaborative. San Diego County's efforts began with a National Institutes of Health Grand Opportunity grant in October 2009, in which the California Department of Managed Health Care and physician leaders began to plan for the learning collaborative. The UBP meetings began in February 2011, and the monthly learning collaborative is attended by medical, pharmacy, and quality improvement directors from all of the major physician organizations, integrated delivery systems, and community clinics in the county. The attendees represent organizations that serve approximately 80% of San Diego County patients, including those who are commercially insured, Medicare, Medi-Cal, safety net, US Navy, and US Department of Veterans Affairs. Each meeting is devoted to presentations and discussions of better ways to care for patients with cardiovascular and cerebrovascular disease risk factors (eg, high blood pressure, high lipid levels, high blood sugar levels, diabetes, obesity, and smoking) through patient activation methods, healthcare team coordination, and uptake of medication protocols. Each organization reports and shares its progress on these measures because controlling these intermediate outcomes prevents unnecessary heart attacks and strokes.[12-15]

The objective of this study is to examine whether the California RCI's UBP in San Diego County was associated with fewer hospitalizations for acute myocardial infarctions (hereafter "heart attacks") and cerebrovascular events (hereafter "strokes"). Learning collaboratives to improve coordination and quality of care are becoming more prevalent, as evidenced by recent initiatives including the CMS State Innovation Model Initiative, CMS's Transforming Clinical Practice Initiative, the Medicaid program, and the Children's Health Insurance Program.[16-20] In spite of large-scale initiatives using regional learning collaboratives, no study has examined the impact of a physician organization learning collaborative in the context of a highly competitive managed care market that is attempting to collaborate on shared community-wide goals to better manage cardiovascular and cerebrovascular risk factors.

TAKEAWAY POINTS

This study evaluated the California Right Care Initiative's University of Best Practices (UBP) in San Diego County that began in 2011.

- UBP is a countywide physician organization learning collaborative that shares best practices in managing cardiovascular and cerebrovascular risk factors.
- UBP was associated with lower age-adjusted hospitalization rates for heart attacks in San Diego County compared with the rest of California.
- Healthcare systems and physician organizations should consider forming collaboratives to share best practices to manage patients' cardiovascular and cerebrovascular risk factors, which may lead to fewer hospitalizations and reduced healthcare costs.

METHODS

Data

Inpatient hospitalization data are from California Office of Statewide Health Planning and Development's (OSHPD) nonpublic Patient Discharge Data for 2007 to 2014 for adults 18 years or older. OSHPD collects these data from all hospitals in California. To identify relevant hospitalizations, we examined the principal discharge diagnosis code, which was based on the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*). We used code 410 to capture acute myocardial infarction (heart attack)[21,22] and codes 430 to 438 to capture strokes.[23] Hospitalizations were converted to age-adjusted rates, based on California's 2014 population,[24,25] using the direct standardization method for those aged 18 to 64 years and those 65 years or older.[26]

During the 2007 to 2014 study period, there were 25,287,552 hospitalizations in California, including 437,774 for heart attacks and 667,776 for strokes in acute care hospitals. To avoid counting multiple hospitalizations for the same event, we excluded hospitalizations when a patient was discharged to the admitting or another hospital for acute inpatient care. These transfers likely occurred because the patient needed care at a higher-acuity hospital. This reduced the number of hospitalizations to 372,205 (–15.0%) for heart attacks and 642,455 (–3.8%) for strokes.

Statistical Models

To estimate whether the California RCI's UBP in San Diego County was associated with changes in hospitalization rates for heart attacks and strokes, we estimated difference-in-differences (DID) models, which are used in quasi-experimental research designs.[27,28] A DID model reduces the potential for bias by controlling for baseline differences in hospitalization rates between San Diego County and the rest of California, and by controlling for hospitalization rate reductions that occurred in the whole state during this entire period. Equation 1:

$$ln\left(\frac{p(hosp_{i,c,t})=1}{1-p(hosp_{i,c,t})=1}\right) = \beta_0+\beta_1 SD_c+\beta_2 year11\_14_t+\beta_3 SD_c \times year11\_14_t+\beta_4 X_{c,t}$$

shows the logistic regression model used to estimate the DID models, where *Hosp* is 1 for a hospitalization for individual (*i*) in county (*c*) in year (*t*) and is 0 for no hospitalization; *SD* is 1 for a hospitalization in San Diego County and is 0 for a hospitalization in other counties; *year11_14* is 1 for years 2011 to 2014 and is 0 for years 2007 to 2010; *SD* × *year11_14* is the DID interaction term; and $X_{c,t}$ are time-varying, county-level control variables from the California Health Interview Survey,[29] including the percentage of the adult

population that did not have health insurance, the percentage that did not have a usual place to go when sick or needing health advice, and the percentage that had an income from 0% to 199% of the federal poverty level because these factors are associated with the ability to pay for healthcare services and access to care. The DID interaction term compares how the odds of a hospitalization changed in the UBP period (2011-2014) versus the pre-UBP period (2007-2010) for San Diego County residents versus the residents in the rest of California. Separate models were estimated for heart attack and stroke hospitalizations.

In addition to the UBP in San Diego County, Sacramento and Los Angeles counties began UBPs in July 2012 and April 2013, respectively; however, they have far less physician organization participation and lower fidelity of implementation of learning collaborative models.[4] As a sensitivity analysis, we re-estimated the DID models by excluding these counties.

We also analyzed pre-UBP hospitalization trends for San Diego County and the rest of California, because a DID model assumes parallel pretreatment trends, which means that absent the UBP intervention, the hospitalization rates in San Diego County and the rest of California are expected to change at the same rate.[28] As a supplemental analysis, we extended the pre-UBP analysis by examining pre-UBP versus UBP period hospitalization trends in San Diego County and the rest of California using a piecewise linear regression difference-in-differences-in-differences (DIDID) model. The **eAppendix** describes these methods in detail (eAppendix available at **ajmc.com**).

Our data only include individuals who were hospitalized. Therefore, we estimated the logistic regression models using Stata version 12 (StataCorp; College Station, Texas) *blogit* command that implicitly includes individuals who were not hospitalized, because one variable within the *blogit* command is the population, which we obtained from the California Department of Finance.[24,25] The number of individuals who were not hospitalized equals the population minus the number of hospitalizations from individuals who were hospitalized, which allows for more than 1 hospitalization in a year for a separate medical event for an individual (eg, *ICD-9-CM* code 412 is for previous heart attacks, which we did not include). The other key variable within the *blogit* command is the age-adjusted number of hospitalizations, which we calculated by multiplying the aged-adjusted rate by the population for each county(s)-year. The *blogit* command produces the same results as if we had estimated our models as logistic regressions with individual-level data that include both hospitalized and nonhospitalized individuals.

Our blogit model estimation approach is similar to 2 studies that analyzed emergency department (ED) visits, which explicitly included individuals who were not present in the ED visit data.[30,31] We did not explicitly include individuals who were not present in our hospitalization data because we age-adjusted our hospitalization rates. Moreover, San Diego County did not experience gender and age demographic changes between the 2007-to-2010 period and the 2011-to-2014 period that substantively differed from changes in the rest of California.

To quantify the magnitude of our heart attack results from equation 1, we calculated how many additional hospitalizations would have occurred in San Diego County if there was no association between UBP and age-adjusted hospitalization rates. Furthermore, we calculated how many fewer hospitalizations would have needed to not occur in the rest of California if the same association between UBP and San Diego County's age-adjusted hospitalization rates was also found in the rest of California. To translate hospitalizations into dollars, we assumed a hospitalization cost a payer $22,427 in 2014 inflation-adjusted dollars.[32]

Our study was approved by the California Health and Human Services Agency's and University of California, Berkeley's institutional review boards.

RESULTS

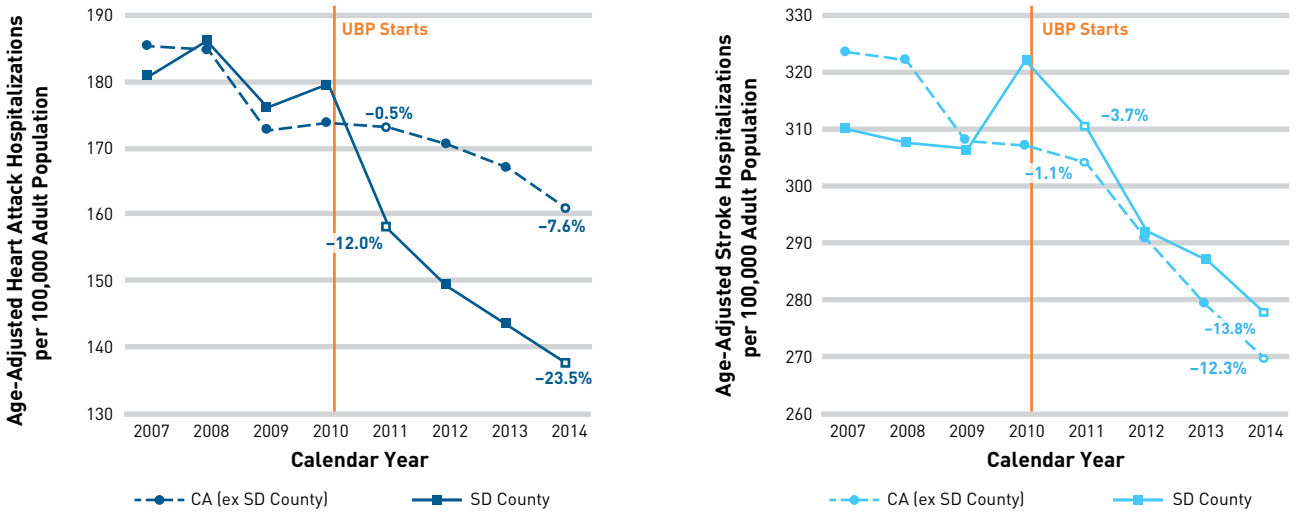
Figure 1 shows the age-adjusted number of hospitalizations per 100,000 adult population for heart attacks and strokes in San Diego County versus the rest of California between 2007 and 2014 (see **eAppendix Table 1** for the underlying data). During this period, the rate for heart attacks decreased sharply in San Diego County from 180.8 to 137.4 (24.0%), but the decrease was more moderate in the rest of California, from 185.5 to 160.8 (13.3%). For strokes, the rate decreased in San Diego County from 310.1 to 277.6 (10.5%), but the percentage decrease was larger in the rest of California, from 323.6 to 269.5 (16.7%). During the UBP period, the rate for heart attacks decreased more in San Diego County (23.5%) than in the rest of California (7.6%), but decreases for strokes were similar in San Diego County (13.8%) and the rest of California (12.3%).

Figure 2 shows the age-adjusted number of hospitalizations per 100,000 adult population for heart attacks by gender, which shows the rate for males is approximately twice the rate of females, but both genders experienced similar decreases during the UBP period.

Table 1 shows the DID logistic regression results for heart attacks (models A1-A3) and strokes (models A4-A6). The top portion of the heart attack and stroke sections show the summary DID results based on the logistic regression models: they report each odds ratio (OR) that makes up the DID parameter, which is a ratio of 2 ORs. The summary result from equation 1 for San Diego County is $\beta_2+\beta_3$, for the rest of California is β_2, and for the DID ratio of the ORs is β_3. Below the summary DID results, the table reports the regression parameter estimates for each model.

In the UBP versus pre-UBP period, the odds of adults being hospitalized for a heart attack in San Diego County decreased (OR, 0.84), while the odds stayed the same for adults in the rest of California (OR, 1.00): DID ratio of OR, 0.84 (P <.001) (model 1). The results were substantively the same for males and females (models 2

FIGURE 1. Age-Adjusted Hospitalizations per 100,000 Adult Population for Heart Attacks and Strokes in California, 2007 to 2014[a]

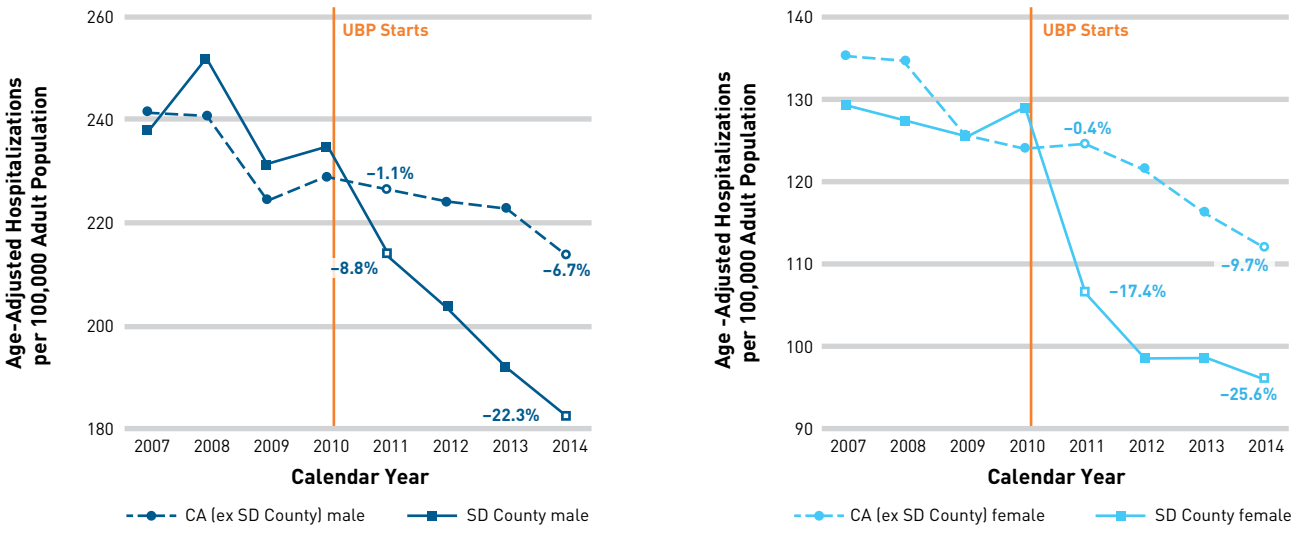


CA (ex SD County) indicates California excluding San Diego County; SD County, San Diego County; UBP, University of Best Practices.

[a]UBP started in February 2011, just after the 2010 data points. Percentages are percent changes since 2010. Principal discharge diagnosis codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) were used for heart attacks (*ICD-9-CM* code 410) and strokes (*ICD-9-CM* codes 430-438).

Source: Authors' analysis of California Office of Statewide Health Planning and Development's 2007 to 2014 Patient Discharge Data.

FIGURE 2. Age-Adjusted Hospitalizations per 100,000 Adult Population by Gender for Heart Attacks in California, 2007 to 2014[a]



CA (ex SD County) indicates California excluding San Diego County; SD County, San Diego County; UBP: University of Best Practices.

[a]UBP started in February 2011 just after the 2010 data points. Percentages are percent changes since 2010. Principal discharge diagnosis codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) were used for heart attacks (*ICD-9-CM* code 410).

Source: Authors' analysis of California Office of Statewide Health Planning and Development's 2007 to 2014 Patient Discharge Data.

and 3, respectively). In the UBP period versus pre-UBP period, the odds of adults being hospitalized for a stroke in San Diego County decreased (OR, 0.95) slightly more than for adults in the rest of California (OR, 0.97), but the ratio of the ORs was not significant at the 0.05 level (OR, 0.98; $P = .08$) (model 4). The stroke results were sensitive to inclusion of the control variables, whereas the heart attack results were not. For example, if the percentage of the adult population that reports no usual place of care is removed from the stroke model 4, then the DID ratio of OR increases to above 1.00 (DID ratio of OR, 1.05; $P < .001$). It is important to control for this

TABLE 1. Logistic Regression Results for Age-Adjusted Hospitalizations for the Full Sample and by Gender for Heart Attacks and Strokes in California, 2007 to 2014

	Model 1: Full Sample		Model 2: Males		Model 3: Females	
Variables	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Heart attacks[a]						
Summary DID results from regression models						
San Diego County (UBP vs pre-UBP)	0.84***	(0.82-0.87)	0.85***	(0.82-0.88)	0.82***	(0.78-0.87)
Rest of California (UBP vs pre-UBP)	1.00	(0.99-1.01)	1.00	(0.98-1.01)	0.99	(0.97-1.01)
Ratio of the odds ratios (DID)[b]	0.84***	(0.82-0.87)	0.85***	(0.82-0.88)	0.83***	(0.79-0.87)
Regression results						
San Diego County	0.99	(0.95-1.02)	1.02	(0.97-1.06)	0.95	(0.90-1.01)
UBP period (2011-2014)	1.00	(0.99-1.01)	1.00	(0.98-1.01)	0.99	(0.97-1.01)
San Diego County × UBP period (2011-2014)[b]	0.84***	(0.82-0.87)	0.85***	(0.82-0.88)	0.83***	(0.79-0.87)
Uninsured (%)	1.01***	(1.01-1.01)	1.02***	(1.01-1.02)	1.01**	(1.00-1.01)
No usual place for care (%)	1.01***	(1.01-1.01)	1.01***	(1.00-1.01)	1.02***	(1.01-1.02)
Income 0%-199% of FPL (%)	0.99***	(0.99-0.99)	0.99***	(0.99-0.99)	0.99***	(0.98-0.99)
Constant	0.00***	(0.00-0.00)	0.00***	(0.00-0.00)	0.00***	(0.00-0.00)
Model χ^2 likelihood ratio *P* value	<.001		<.001		<.001	
N[c]	225,871,212		111,324,852		114,546,357	

	Model 4: Full Sample		Model 5: Males		Model 6: Females	
Variables	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Strokes[a]						
Summary DID results from regression models						
San Diego County (UBP vs pre-UBP)	0.95***	(0.93-0.97)	0.95***	(0.92-0.97)	0.97	(0.94-1.01)
Rest of California (UBP vs pre-UBP)	0.97***	(0.96-0.98)	0.97***	(0.96-0.98)	0.97***	(0.96-0.98)
Ratio of the odds ratios (DID)[b]	0.98	(0.96-1.00)	0.97	(0.95-1.00)	1.00	(0.97-1.03)
Regression results						
San Diego County	1.00	(0.97-1.03)	1.05*	(1.01-1.09)	0.94**	(0.91-0.98)
UBP period (2011-2014)	0.97***	(0.96-0.98)	0.97***	(0.96-0.98)	0.97***	(0.96-0.98)
San Diego County × UBP period (2011-2014)[b]	0.98	(0.96-1.00)	0.97	(0.95-1.00)	1.00	(0.97-1.03)
Uninsured (%)	1.02***	(1.02-1.02)	1.03***	(1.02-1.03)	1.01***	(1.01-1.01)
No usual place for care (%)	1.01***	(1.01-1.01)	1.01***	(1.01-1.02)	1.01***	(1.01-1.02)
Income 0%-199% of FPL (%)	0.99***	(0.99-0.99)	0.99***	(0.99-0.99)	0.99***	(0.99-0.99)
Constant	0.00***	(0.00-0.00)	0.00***	(0.00-0.00)	0.00***	(0.00-0.00)
Model χ^2 likelihood ratio *P* value	<.001		<.001		<.001	
N[c]	225,871,213		111,324,852		114,546,357	

CI indicates confidence interval; DID, difference-in-differences; FPL, federal poverty level; OR, odds ratio (for interaction terms, it is the ratio of 2 odds ratios); UBP, University of Best Practices.

"*" indicates *P* <.05; "**" indicates *P* <.01; "***" indicates *P* <.001.

[a]Principal discharge diagnosis codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) were used for heart attacks (*ICD-9-CM* 410) and strokes (*ICD-9-CM* 430-438).

[b]In each model, San Diego County x UBP Period (2011 to 2014) is the DID parameter. The DID parameter is the ratio of the San Diego County's (UBP vs pre-UBP) odds ratio to the rest of California's (UBP vs pre-UBP) odds ratio, all which are reported in the summary results sections of the table.

[c]The N for the full sample does not equal the sum of the number of observations in the sub-samples, because California Department of Finance population estimates were not integers, but had to be rounded to integers for the blogit model.

Source: Authors' analysis of California Office of Statewide Health Planning and Development's 2007 to 2014 Patient Discharge Data.

covariate, but the significant change from its exclusion makes the original result less robust.

Recall that a DID model assumes parallel pretreatment trends, which means that absent the UBP intervention, the hospitalization rates in San Diego County and the rest of California are expected to change at the same rate.[28] Compared with the rest of California during the pre-UBP period, the San Diego County hospitalization trend approached being higher for heart attacks and was higher for strokes (see **eAppendix Table 3**). Assuming the phenomenon driving the nonparallel trends continued into the UBP period and assuming UBP was associated with lower hospitalization rates, then San Diego County's pre-UBP higher hospitalization trend would cause the DID results to be understated. This may be the case for heart attacks; however, for strokes, the pre-UBP trend differences are primarily because of San Diego County's age-adjusted hospitalization rate in 2010 being an outlier. Its rate increased by 5.1% from 2009 to 2010, while the rest of California's rate decreased by 0.3%. Therefore, it is difficult to know whether San Diego County's 3.7% rate decrease in 2011 was because of UBP (ie, UBP reversed the pre-UBP trend difference) or if the 2011 decrease represented a regression to the mean. However, the DIDID results in **eAppendix Table 4** do not provide evidence to support that UBP was associated with a lower hospitalization rate trend for strokes during the UBP period: San Diego County's UBP hospitalization trend (OR, 0.954; P <.001) was similar to the rest of California's (OR, 0.959; P <.001), resulting in a UBP DID trend of 0.995 (P = .51) (see Model A10 in eAppendix Table 4).

TABLE 2. Number of Avoided Heart Attack Hospitalizations in California Associated With University of Best Practices in San Diego County, 2011 to 2014

Measure	Total	2011	2012	2013	2014
San Diego County					
Actual hospitalizations (with UBP)	13,849	3586	3478	3422	3363
Hospitalizations avoided (with UBP association)	2735	643	662	740	690
Total potential hospitalizations (without UBP)	16,584	4229	4140	4162	4053
Hospitalizations avoided	16.5%	15.2%	16.0%	17.8%	17.0%
Hospital costs avoided (2014$ in millions)[a]	$61	$14	$15	$17	$15
Rest of California					
Actual hospitalizations (without UBP)	174,195	43,077	43,680	44,008	43,430
Hospitalizations potentially avoided (if had UBP)	20,201	4557	5770	3309	6565
Total potential hospitalizations (if had UBP)	153,994	38,520	37,910	40,699	36,865
Hospitalizations potentially avoided	11.6%	10.6%	13.2%	7.5%	15.1%
Hospital costs potentially avoided (2014$ in millions)[a]	$453	$102	$129	$74	$147

UPB indicates University of Best Practices.
[a]Hospital costs avoided are with respect to payers' costs (or payments made to hospitals). 2014$ are inflation-adjusted 2014 dollars based on the All Items Consumer Price Index for All Urban Consumers (CPI-U) for the U.S. City Average, 1982-1984 = 100.
Source: Authors' analysis of California Office of Statewide Health Planning and Development's 2007 to 2014 Patient Discharge Data.

Because of the difficulty of interpreting the DID parameter, a ratio of ORs, **Table 2** presents the magnitude of the heart attack results from Table 1. From 2011 to 2014, there were 13,849 hospitalizations for heart attacks in San Diego County. Based on the logistic regression results in model 1, the difference between San Diego County's and the rest of California's age-adjusted hospitalization rate for heart attacks from 2007 to 2010 was 1.5 hospitalizations per 100,000 adults on average. If this difference had continued from 2011 to 2014, then there would have been 16,584 hospitalizations in San Diego County from 2011 to 2014. Therefore, this translates into the UBP being associated with 2735 hospitalizations being avoided in San Diego County (or 16.5% of the 16,584 potential) that would have cost payers $61 million (2014 dollars) in hospitalization costs from 2011 to 2014.

From 2011 to 2014, there were 174,195 hospitalizations for heart attacks in the rest of California (Table 2). Again, if the above rate difference of 1.5 had continued from 2011 to 2014, meaning that the rest of California experienced the UBP association with fewer hospitalizations for heart attacks, then there would have been only 153,994 hospitalizations in the rest of California from 2011 to 2014, a difference of 20,201 (11.6%) fewer hospitalizations at a cost of $453 million (2014 dollars).

Sensitivity Analysis

Sacramento and Los Angeles counties began less-robust UBPs in July 2012 and April 2013, respectively. If these UBPs were associated with fewer hospitalizations, then they would have attenuated our original results because they were included in the control group. When the DID regression model in equation 1 was re-estimated excluding these counties, the heart attack result did not substantively change (model 1 re-estimate: DID ratio of OR, 0.85; P <.001), but the stroke result actually became weaker (model 4 re-estimate: DID ratio of OR, 1.00; P = .79), contributing to the original stroke result's lack of robustness.

Furthermore, we conducted a falsification test and re-estimated our DID regression model in equation 1 for heart attacks (model 1 in Table 1) by treating the 8 counties with populations of more than 750,000 adults in 2014 as though they received the UBP treatment beginning in 2011. In summary, we did not find consistent evidence that any of these 8 counties experienced what San Diego County did.

Although Alameda and Orange counties' DID results were lower or similar to San Diego County's, those results were partially caused by their pre-2011 lower hospitalization rate trend compared with the rest of California (see eAppendix for details).

DISCUSSION

The California RCI's UBP in San Diego County, a countywide physician organization learning collaborative, was associated with a lower level of age-adjusted adult hospitalization rates for heart attacks compared with the rest of California. The UBP was associated with 2735 (16.5%) fewer hospitalizations for heart attacks, totaling $61 million (2014 dollars). If the rest of California had experienced the same reduction in hospitalizations for heart attacks associated with UBP, then there would have been 20,201 (11.6%) fewer hospitalizations at a cost of $453 million (2014 dollars). This result is consistent with other regional collaborative efforts to improve hypertension care[7-9] and inter-organizational learning activities being associated with performance improvement.[33] However, a similar robust association between UBP and hospitalization rates for strokes was not found.

Our findings extend the current literature by providing evidence that physician organizations operating in the context of a highly competitive managed care market can collaborate and exchange best practices to achieve shared community-wide goals to decrease hospitalizations for heart attacks. Although there is limited evidence about the relative impact of various learning collaborative components, recent research has identified the core components of learning collaboratives that participants value most.[4] Collaborative faculty, solicitation of staff ideas, change package, Plan-Do-Study-Act cycles, facilitated learning sessions, and a collaborative extranet have been identified as collaborative components that provide participants with motivation, social support, and project management skills.[4] These components leverage intrinsic motivation among physicians for quality improvement.[34] The UBP collaborative incorporated these core components directly or with modification. Our findings suggest that a combination of components may be needed in collaboratives to achieve desired performance outcomes as opposed to any single component. Future research should attempt to identify the key combinations of components that have the greatest impact for a particular context. For example, the UBP's emphasis on the use of collaborative faculty (including a cardiology expert) and facilitated learning sessions warrant further study to determine if these 2 components are among the most important for achieving successful outcomes.[4]

Alternative Explanations and Limitations

Although a quasi-experimental research design using DID models is a strong design, results could be biased if another intervention or phenomenon occurred contemporaneously with the UBP that was also associated with hospitalization rates in San Diego County and/or the rest of California. Kaiser Permanente has started a number of statewide initiatives in California to improve cardiovascular and cerebrovascular care, such as the Prevent Heart Attacks and Strokes Everyday ("PHASE") program and the Aspirin, Lisinopril and Lipid-Lowering Medication ("ALL") initiative; however, we do not think these would bias our results because they began well before UBP's start in 2011.[35-38] Changes in the share of patients who experienced a heart attack, but did not survive to be admitted into the hospital, could also bias our results, but there is no reason to think this change would have occurred disproportionately in San Diego County. Also, stroke hospitalizations were more difficult to analyze because San Diego County's 2010 age-adjusted hospitalization rate for strokes was a high outlier: its rate increased by 5.1% that year, just before the start of UBP, whereas the rest of California's rate decreased by 0.3%. This could be one reason why the stroke findings were not significant and sensitive to different model specifications. Finally, we do not think hospital closures significantly contributed to lower hospitalization rates in San Diego County, because among the 16 hospitals in the county in 2007, only Fallbrook Hospital, a small, 47-bed hospital, closed during the study period, but not until November 2014. On the other hand, Palomar Medical Center, a 288-bed hospital, opened in August 2012.

CONCLUSIONS

Our study results suggest California RCI's UBP physician organization learning collaborative in San Diego County was significantly associated with—and likely at least a partial cause of—a marked decline in the number of hospitalizations for heart attacks. No robust relationship was found for hospitalizations for strokes. Although our findings are not explicitly generalizable to other physician organization learning collaboratives, they could inform similar existing or new learning collaboratives, whose numbers are increasing.[16-20] As the Medicare Access and CHIP Reauthorization Act expands value-based payment arrangements, physicians and their affiliated hospitals will have greater incentives to test different learning collaborative models to reduce hospitalizations via prevention and disease management strategies. Thus, efforts to extend learning collaborative models to other counties in California and elsewhere in the United States become especially important. ■

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eAppendix

This appendix provides more detailed methods and results for the study.

eAppendix Table 1 shows the descriptive statistics of the hospitalization data, and the age-adjusted rates that are graphically displayed in Figure 1 in the main study. During the 2007 to 2014 period, the age-adjusted hospitalization rate per 100,000 adult population for heart attacks decreased sharply in San Diego County from 180.8 to 137.4 (24.0%), but the decrease was more moderate in the rest of California from 185.5 to 160.8 (13.3%). During the same period, the age-adjusted hospitalization rate per 100,000 adult population for strokes decreased in San Diego County from 310.1 to 277.6 (10.5%), and the percentage decrease was larger in the rest of California from 323.6 to 269.5 (16.7%). In the table, the age-adjusted statistics are nearly identical to the gender-age-adjusted statistics, because the gender distribution of the population did not significantly change during this period. The bottom of the table includes the descriptive difference-in-differences (DID) statistics (i.e., not based on a regression model) comparing San Diego County to the rest of California during the UBP period (2011 to 2014) versus pre-UBP period (2007 to 2010). The DID of the age-adjusted hospitalization rate for heart attacks was negative and the rate for strokes was positive, but only the heart attack DID parameter was statistically significant at the 0.05 level in the regression model (see Table 1 in the main study).

eAppendix Table 1. Adult Hospitalizations and Hospitalization Rates for Heart Attacks and Strokes in California, 2007-2014

	Heart Attacks				Strokes			
Hospital Location and Year	Number	Crude Rate	Age-Adjusted Rate	Gender-Age Adjusted Rate	Number	Crude Rate	Age-Adjusted Rate	Gender-Age Adjusted Rate
San Diego County								
2007	3,767	165.4	180.8	181.1	6,353	278.9	310.1	310.3
2008	3,961	170.8	186.3	186.5	6,427	277.2	307.5	307.7
2009	3,857	162.8	176.0	175.9	6,619	279.3	306.4	306.4
2010	3,983	166.6	179.6	179.4	7,058	295.3	322.2	322.3
2011	3,586	148.7	158.1	157.9	6,946	288.1	310.4	310.3
2012	3,478	142.8	149.2	148.8	6,746	276.9	291.9	291.9
2013	3,422	139.2	143.4	143.0	6,812	277.2	286.8	286.7
2014	3,363	135.4	137.4	137.1	6,776	272.9	277.6	277.4
2007 to 2014 change	-10.7%	-18.1%	-24.0%	-24.3%	6.7%	-2.1%	-10.5%	-10.6%
Change since 2010								
2011	-10.0%	-10.7%	-12.0%	-12.0%	-1.6%	-2.4%	-3.7%	-3.7%
2012	-12.7%	-14.3%	-16.9%	-17.1%	-4.4%	-6.2%	-9.4%	-9.4%
2013	-14.1%	-16.4%	-20.2%	-20.3%	-3.5%	-6.1%	-11.0%	-11.1%
2014	-15.6%	-18.7%	-23.5%	-23.6%	-4.0%	-7.6%	-13.8%	-13.9%
Rest of California								
2007	42,224	170.8	185.5	186.1	72,660	293.9	323.6	323.8
2008	42,777	171.0	184.8	185.4	73,733	294.8	322.3	322.4
2009	41,262	162.5	172.6	173.1	72,882	286.9	308.1	308.2
2010	42,330	164.8	174.0	174.4	74,042	288.3	307.3	307.4
2011	43,077	165.8	173.2	173.5	75,079	288.9	304.0	304.0
2012	43,680	166.0	170.5	170.7	74,188	281.9	290.9	290.9
2013	44,008	165.2	167.2	167.3	73,349	275.3	279.2	279.2
2014	43,430	161.0	160.8	160.9	72,785	269.9	269.5	269.5
2007 to 2014 change	2.9%	-5.7%	-13.3%	-13.6%	0.2%	-8.2%	-16.7%	-16.8%
Change since 2010								
2011	1.8%	0.5%	-0.5%	-0.5%	1.4%	0.2%	-1.1%	-1.1%
2012	3.2%	0.7%	-2.0%	-2.1%	0.2%	-2.2%	-5.3%	-5.4%
2013	4.0%	0.2%	-3.9%	-4.1%	-0.9%	-4.5%	-9.1%	-9.2%
2014	2.6%	-2.3%	-7.6%	-7.8%	-1.7%	-6.4%	-12.3%	-12.3%
Difference-in-differences								
San Diego County								
2011 to 2014 (mean)	3,462	141.5	147.0	146.7	6,820	278.8	291.7	291.6
2007 to 2010 (mean)	3,892	166.4	180.7	180.7	6,614	282.7	311.6	311.7
Difference	-430	-24.8	-33.6	-34.1	206	-3.9	-19.9	-20.1
Difference (%)	-11.0%	-14.9%	-18.6%	-18.8%	3.1%	-1.4%	-6.4%	-6.4%
Rest of California								
2011 to 2014 (mean)	43,549	164.5	167.9	168.1	73,850	279.0	285.9	285.9
2007 to 2010 (mean)	42,148	167.3	179.2	179.8	73,329	291.0	315.3	315.4
Difference	1,401	-2.8	-11.3	-11.6	521	-12.0	-29.4	-29.5
Difference (%)	3.3%	-1.7%	-6.3%	-6.5%	0.7%	-4.1%	-9.3%	-9.4%
Difference-in-differences	-1,830	-22.1	-22.4	-22.4	-315	8.1	9.5	9.4

Note: Rates are hospitalizations per 100,000 adult population
Source: Authors' analysis of California Office of Statewide Health Planning and Development's 2007 to 2014 Patient Discharge Data

eAppendix Table 2 shows the population-level characteristics for adults in San Diego County and the rest of California from 2007 to 2014, including the percentage of the adult population that was uninsured, did not have a usual place to go to when sick or needing health advice, and had an income from 0% to 199% of the federal poverty level. The table shows how these percentages changed from 2007 to 2014, but also from 2010 to 2014, because the UBP began in 2011. From 2010 to 2014, the uninsured rate among adults decreased by similar percentages in San Diego County (19.8%) and the rest of California (21.6%); however, San Diego County's adult population improved more than the rest of California on the other two measures. Thus, it was important to control for these factors, because they may influence hospitalization rates for heart attacks and strokes. From 2010 to 2014, the percentage of the adult population that did not have a usual place to go for care decreased in San Diego County (4.5%), yet dramatically increased in the rest of California (43.2%). Furthermore, the percentage of the adult population with incomes less than 200% of the federal poverty level increased less in San Diego County (9.1%) compared with the rest of California (30.5%). For the models that use subsets of the data (e.g., by gender) or analyze different counties in our sensitivity analyses, the three population measures were based on those population subsets.

eAppendix Table 2. Population-Level Characteristics for Adults in San Diego County and the Rest of California, 2007-2014

Location and Year	Uninsured	No Usual Place for Care	Poverty
San Diego County			
2007	16.0%	21.6%	31.5%
2008	17.1%	19.3%	33.1%
2009	18.2%	17.0%	34.7%
2010	18.2%	16.7%	34.8%
2011	18.2%	16.3%	34.8%
2012	17.7%	16.5%	37.5%
2013	17.2%	14.7%	35.7%
2014	14.6%	15.9%	37.9%
2007 to 2014 change (%)	-8.8%	-26.4%	20.3%
2010 to 2014 change (%)	-19.8%	-4.5%	9.1%
Rest of California			
2007	15.3%	18.9%	24.5%
2008	15.3%	15.3%	25.5%
2009	15.2%	11.7%	26.5%
2010	16.2%	12.2%	26.9%
2011	17.2%	12.6%	27.3%
2012	18.8%	14.9%	33.5%
2013	18.0%	16.1%	28.5%
2014	12.7%	17.4%	35.1%
2007 to 2014 change (%)	-17.0%	-7.9%	43.3%
2010 to 2014 change (%)	-21.6%	43.2%	30.5%

No Usual Place for Care: did not have a usual place to go to when sick or needing health advice
Poverty: income from 0% to 199% of the federal poverty level
Note: The 2008 and 2010 values are based on interpolating the two years adjacent to these years.
Source: California Health Interview Survey

A DID model assumes parallel pre-treatment trends, which means that absent the UBP intervention, the hospitalization rates in San Diego County and the rest of California are expected to change at the same rate.[1] If San Diego County's pre-UBP hospitalization trend was higher (or

lower) than the rest of California's, then the DID results would be understated (or overstated), assuming the phenomenon driving the non-parallel trends continued into the UBP period and assuming UBP was associated with lower hospitalization rates. To test pre-UBP hospitalization trends between San Diego County and the rest of California, we used a DID logistic regression model based on Eq. (1) in the main study with the following exceptions: only included 2007 to 2010, the pre-UBP period; replaced *year11_14* with *year*, a continuous variable that equaled the calendar year minus 2007; and dropped the variable percentage of the adult population that had an income from 0% to 199% of the federal poverty level, because it was collinear with the uninsured percentage during the pre-UBP period. As in the main study, we estimated six models, including three for heart attacks and three for strokes, for the full sample, males and females.

eAppendix Table 3 shows the DID logistic regression trend results for heart attacks (models A1- A3) and strokes (models A4-A6) during the pre-UBP period from 2007 to 2010. The top portions of the heart attack and stroke sections show the summary DID results based on the logistic regression models: They report each odds ratio that makes up the DID trend parameter, which is a ratio of two odds ratios. The summary DID result from Eq. (1) in the main study (as modified above) for San Diego County is $\beta 2 + \beta 3$, for the rest of California is $\beta 2$, and for the DID ratio of the odds ratios is $\beta 3$. Below the summary DID results, the table reports the regression parameter estimates for each model. Compared with the rest of California during the pre-UBP period, the San Diego County hospitalization trend for heart attacks approached being higher for the full sample, was not higher for males, and was higher for females: full sample (model A1: DID trend=1.02, p=0.11); males (model A2: DID trend=1.00, p=0.74); and females (model A3: DID trend=1.04, p<0.01). In spite of the pre-UBP hospitalization trend being higher in San Diego County compared with the rest of California for females (and nearly so for the full sample), the DID estimates were still below 1.00 (see Table 1 in main study). These DID estimates may have been even further below 1.00 without these pre-UBP trend differences.

San Diego County's pre-UBP hospitalization trend for strokes was higher than the rest of California's (model A4: DID trend: 1.04, p<0.001), in large part because San Diego County's age-adjusted hospitalization rate increased by 5.1% from 2009 to 2010, while the rest of California's rate decreased by 0.3%. If this trend was persistent, this may have contributed to the null finding that in the UBP versus pre-UBP period, the odds of adults being hospitalized for a stroke in San Diego County decreased (OR=0.95) about the same as for adults in the rest of California

(OR=0.97): DID ratio of OR=0.98 (p=0.08) (Table 1, model A4 in main study). Further study is needed to determine why the 2010 age-adjusted hospitalization rate for strokes was a high outlier in San Diego County.

eAppendix Table 3. Logistic Regression Results for Age-Adjusted Hospitalizations for the Full Sample and by Gender for Heart Attacks and Strokes in California during the Pre-University of Best Practices Period, 2007-2010

	Model A1: Full Sample		Model A2: Males		Model A3: Females	
Variables	OR	CI	OR	CI	OR	CI
Heart Attacks						
Summary Difference-in-Differences Results from Regression Models						
San Diego County pre-UBP period year trend	1.02	(0.99 - 1.04)	1.01	(0.97 - 1.04)	1.01	(0.98 - 1.04)
Rest of California pre-UBP period year trend	1.00	(0.99 - 1.01)	1.01	(0.99 - 1.04)	0.97**	(0.96 - 0.99)
Ratio of odds ratios (DID of trends) (1)	1.02	(1.00 - 1.04)	1.00	(0.97 - 1.02)	1.04**	(1.01 - 1.07)
Regression Results						
San Diego County	0.99	(0.94 - 1.05)	1.01	(0.94 - 1.09)	0.97	(0.88 - 1.06)
Pre-UBP period year trend	1.00	(0.99 - 1.01)	1.01	(0.99 - 1.04)	0.97**	(0.96 - 0.99)
San Diego County x Pre-UBP period year trend (1)	1.02	(1.00 - 1.04)	1.00	(0.97 - 1.02)	1.04**	(1.01 - 1.07)
Uninsured (percentage)	0.99	(0.97 - 1.01)	0.97**	(0.96 - 0.99)	1.01	(0.97 - 1.05)
No usual place for care (percentage)	1.01	(1.00 - 1.02)	1.00	(0.99 - 1.02)	1.01	(1.00 - 1.02)
Constant	0.00***	(0.00 - 0.00)	0.00***	(0.00 - 0.01)	0.00***	(0.00 - 0.00)
Model chi-squared likelihood ratio p-value	<0.001		<0.001		<0.001	
N	110,171,352		54,254,197		55,917,155	
	Model A4: Full Sample		Model A5: Males		Model A6: Females	
	OR	CI	OR	CI	OR	CI
Strokes						
Summary Difference-in-Differences Results from Regression Models						
San Diego County pre-UBP period year trend	1.04***	(1.02 - 1.06)	1.06***	(1.03 - 1.09)	1.02*	(1.00 - 1.04)
Rest of California pre-UBP period year trend	0.99	(0.98 - 1.01)	1.02*	(1.00 - 1.04)	0.98***	(0.97 - 0.99)
Ratio of odds ratios (DID of trends) (1)	1.04***	(1.03 - 1.06)	1.03**	(1.01 - 1.05)	1.05***	(1.03 - 1.07)
Regression Results						
San Diego County	0.99	(0.95 - 1.03)	1.05	(0.99 - 1.12)	0.95	(0.89 - 1.01)
Pre-UBP period year trend	0.99	(0.98 - 1.01)	1.02*	(1.00 - 1.04)	0.98***	(0.97 - 0.99)
San Diego County x Pre-UBP period year trend (1)	1.04***	(1.03 - 1.06)	1.03**	(1.01 - 1.05)	1.05***	(1.03 - 1.07)
Uninsured (percentage)	1.01	(0.99 - 1.02)	1.00	(0.98 - 1.01)	1.01	(0.99 - 1.04)
No usual place for care (percentage)	1.01**	(1.00 - 1.02)	1.02**	(1.01 - 1.03)	1.00	(1.00 - 1.01)
Constant	0.00***	(0.00 - 0.00)	0.00***	(0.00 - 0.00)	0.00***	(0.00 - 0.00)
Model chi-squared likelihood ratio p-value	<0.001		<0.001		<0.001	
N	110,171,352		54,254,197		55,917,155	

*p<0.05, **p<0.01, ***p<0.001

(1) In each model, *San Diego County x Pre-UBP Period year trend* is the difference-in-differences (DID) trend parameter. The DID trend parameter is the ratio of the San Diego County's year-trend odds ratio to the rest of California's year-trend odds ratio, all which are reported in the summary results sections of the table.

Notes: UBP: University of Best Practices; Heart attacks (ICD-9-CM 410); Strokes (ICD-9-CM 430-438); OR: odds ratio (for interaction terms, it is the ratio of two odds ratios); CI: 95% confidence interval

Source: Authors' analysis of California Office of Statewide Health Planning and Development's 2007 to 2014 Patient Discharge Data

In addition to analyzing pre-UBP age-adjusted hospitalization *level* differences between San Diego County and the rest of California using the DID model in the main paper (Eq. 1), we analyzed pre-UBP versus UBP age-adjusted hospitalization *trend* differences between San Diego County and the rest of California using a piecewise linear regression difference-in-differences-in-differences (DIDID) model in Eq. (A1) below. These DIDID models were a supplemental analysis, because there are only two four-year periods to estimate trend differences. The variables in Eq. (A1) have the same definitions as in Eq. (1) in the main study, except the variable for year ($year_t$) is now a continuous variable centered at the first year of the UBP intervention (i.e., $year_t$ is 0 in 2011). The model allows the intercepts and slopes (or trends) for San Diego County and the rest of California to be different in the 2007-to-2010 (pre-UBP) period versus the 2011-to-2014 (UBP) period, because I_t is an indicator variable that is 1 when $year_t \geq 2011$ (0 otherwise). The key parameter estimate, β_6, can be interpreted as a DIDID, because it compares a pre-UBP DID term to a UBP DID term, that is, it compares the differences in the *trend* in hospitalizations before and after the UBP treatment for San Diego County versus the rest of California. As in the main study, we estimated six models, including three for heart attacks and three for strokes, for the full sample, males and females. A1:

$$ln\left(\frac{p(hosp_{i,c,t}=1}{1-p(hosp_{i,c,t}=1)}\right)$$
$$= \beta_0 + \beta_1 SD_c + \beta_2 year_t + \beta_3 SD_c \times year_t + \beta_4 I_t + \beta_5 year_t \times I_t + \beta_6 SD_c \times year_t \times I_t + \beta_7 X_{c,t}$$

eAppendix Table 4 shows the DIDID logistic regression results for heart attacks (models A7-A9) and strokes (models A10-A12). The top portion of the heart attack and stroke sections show the summary DIDID results based on the logistic regression models: They report each odds ratio that makes up the DID parameter (which is a ratio of two odds ratios), and report each DID parameter that makes up the DIDID parameter (which is the ratio of the DID parameters). These summary DID results are either parameters directly estimated by the model or linear combinations of the parameters. The summary DIDID results from Eq. (A1) for San Diego County trend (post-UBP initiation) is $\beta_2 + \beta_3 + \beta_5 + \beta_6$, for rest of California trend (post-UBP initiation) is $\beta_2 + \beta_5$, for the DID trend (post-UBP initiation) is $\beta_3 + \beta_6$; for San Diego County trend (pre-UBP) is $\beta_2 + \beta_3$, for the rest of California trend (pre-UBP) is β_2, for the DID trend (pre-UBP) is β_3; and for the DIDID trend is β_6. Below the summary DIDID results, the table reports the regression parameter estimates.

Before reporting the DIDID results for each model, the following explains how the DIDID results are calculated and interpreted for one model, the heart attack results for the full sample (model A7). In the pre-UBP period, the odds of adults being hospitalized for a heart attack in San Diego County decreased (OR=0.970, $p<0.001$) more each year than for adults in the rest of California (OR=0.984, $p<0.01$): ratio of OR (pre-UBP DID)=0. 985 ($p<0.01$).[a] However, this relative trend difference slightly accelerated in the UBP period. In that period, the odds of adults being hospitalized for a heart attack in San Diego County decreased (OR=0.940, $p<0.001$) more each year than for adults in the rest of California (OR=0.973, $p<0.001$): ratio of OR (UBP DID)=0.966 ($p<0.001$). However, the change in trend of adults being hospitalized for a heart attack in San Diego County versus the rest of California did not sufficiently decrease more in the UBP period (DID=0.966) compared with the pre-UBP period (DID=0.985) to be significant at the 0.05 level, because the ratio of these DID parameters (0.966/0.985) equaled 0.981 ($p=0.11$), which is the DIDID parameter estimate.

The DIDID parameter estimates for heart attacks for males was significant at the 0.05 level (model A8: 0.958, $p<0.01$) but was not for females (model A9: 1.003, $p=0.87$). This means that the change in trend of adult males being hospitalized for a heart attack in San Diego County versus the rest of California decreased more in the UBP period (DID=0.948) compared with the pre-UBP period (DID=0.990), resulting in the DIDID to be 0.958 ($p<0.01$).

[a] The pre-UBP DID results in eAppendix Table 4 are different that the DID results in eAppendix Table 3. This is because the models in eAppendix Table 4 have fewer degrees of freedom, because the UBP period is included in these models to enable the UBP period's relative hospitalization trends between San Diego County and the rest of California to be compared to the pre-UBP period's relative hospitalization trends. Therefore, the DID results in eAppendix Table 3 are more appropriate when only analyzing pre-UBP relative hospitalization trends.

Turning to the stroke DIDID results, the result for the full sample is significant (model A10: DIDID=0.975, $p<0.01$). This means that the change in trend of adults being hospitalized for a stroke in San Diego County versus the rest of California decreased more in the UBP period (DID=0.995) compared with the pre-UBP period when it had increased (DID=1.021), resulting in the DIDID to be 0.975 ($p<0.01$). However, as stated above, this result is at least partially due to San Diego County's age-adjusted hospitalization rate for strokes increasing by 5.1% from 2009 to 2010, while the rest of California's rate decreased by 0.3%. Hence, because San Diego County's downward hospitalization trend (OR: 0.954) during the UPB period was similar to the rest of California's (OR: 0.959), resulting in the DID=0.995 ($p=0.51$), it may have been partially due to a regression to the mean.

eAppendix Table 4. Logistic Regression Difference-in-Differences-in-Differences Results for Age-Adjusted Hospitalizations for the Full Sample and by Gender for Heart Attacks and Strokes in California, 2007-2014

Variables	Model A7: Full Sample OR	Model A7: Full Sample CI	Model A8: Males OR	Model A8: Males CI	Model A9: Females OR	Model A9: Females CI
Heart Attacks						
Summary Difference-in-Differences-in-Differences Results from Regression Models						
San Diego County trend (UBP)	0.940***	(0.924 - 0.956)	0.923***	(0.902 - 0.944)	0.945***	(0.920 - 0.971)
Rest of California trend (UBP)	0.973***	(0.964 - 0.982)	0.973***	(0.965 - 0.981)	0.962***	(0.945 - 0.979)
Ratio of odds ratios trend (UBP DID)	0.966***	(0.948 - 0.984)	0.948***	(0.928 - 0.969)	0.983	(0.954 - 1.012)
San Diego County trend (pre-UBP)	0.970***	(0.955 - 0.985)	0.984	(0.965 - 1.004)	0.953***	(0.933 - 0.973)
Rest of California trend (pre-UBP)	0.984**	(0.973 - 0.996)	0.994	(0.977 - 1.011)	0.973***	(0.959 - 0.987)
Ratio of odds ratios trend (pre-UBP DID)	0.985**	(0.976 - 0.995)	0.990	(0.979 - 1.002)	0.979*	(0.964 - 0.995)
DIDID trend: Ratio of UBP DID ratio to pre-UBP DID ratio (1)	0.981	(0.957 - 1.005)	0.958**	(0.931 - 0.986)	1.003	(0.965 - 1.044)
Regression Results						
San Diego County	0.911***	(0.875 - 0.948)	0.939**	(0.897 - 0.984)	0.873***	(0.819 - 0.930)
UBP Period (2011 to 2014) year trend	0.989	(0.977 - 1.001)	0.979*	(0.960 - 0.998)	0.989	(0.974 - 1.004)
San Diego County x UBP Period (2011 to 2014) year trend (1)	0.981	(0.957 - 1.005)	0.958**	(0.931 - 0.986)	1.003	(0.965 - 1.044)
Pre UBP Period (2007 to 2010) trend	0.984**	(0.973 - 0.996)	0.994	(0.977 - 1.011)	0.973***	(0.959 - 0.987)
San Diego County x Pre UBP Period (2007 to 2010) trend	0.985**	(0.976 - 0.995)	0.990	(0.979 - 1.002)	0.979*	(0.964 - 0.995)
Year 2011 constant	1.020*	(1.001 - 1.039)	0.998	(0.974 - 1.022)	1.036*	(1.006 - 1.067)
Uninsured (percentage)	0.994*	(0.988 - 0.999)	0.985***	(0.977 - 0.993)	0.995	(0.989 - 1.002)
No usual place for care (percentage)	0.999	(0.993 - 1.004)	0.998	(0.991 - 1.005)	0.998	(0.990 - 1.006)
Income 0% to 199% of FPL (percentage)	0.996*	(0.992 - 0.999)	0.997	(0.992 - 1.001)	0.997	(0.991 - 1.003)
Constant	0.002***	(0.002 - 0.003)	0.004***	(0.003 - 0.005)	0.002***	(0.001 - 0.002)
Model chi-squared likelihood ratio p-value	<0.001		<0.001		<0.001	
N (2)	225,871,212		111,324,852		114,546,357	

	Model A10: Full Sample OR	Model A10: Full Sample CI	Model A11: Males OR	Model A11: Males CI	Model A12: Females OR	Model A12: Females CI
Strokes						
Summary Difference-in-Differences-in-Differences Results from Regression Models						
San Diego County trend (UBP)	0.954***	(0.943 - 0.966)	0.953***	(0.935 - 0.971)	0.953***	(0.937 - 0.969)
Rest of California trend (UBP)	0.959***	(0.952 - 0.965)	0.962***	(0.955 - 0.969)	0.957***	(0.947 - 0.968)
Ratio of odds ratios trend (UBP DID)	0.995	(0.982 - 1.009)	0.990	(0.973 - 1.008)	0.995	(0.977 - 1.013)
San Diego County trend (pre-UBP)	1.015*	(1.003 - 1.026)	1.023**	(1.005 - 1.040)	1.007	(0.993 - 1.021)
Rest of California trend (pre-UBP)	0.994	(0.985 - 1.003)	1.006	(0.991 - 1.020)	0.983***	(0.974 - 0.992)
Ratio of odds ratios trend (pre-UBP DID)	1.021***	(1.014 - 1.028)	1.017***	(1.007 - 1.027)	1.025***	(1.014 - 1.036)
DIDID trend: Ratio of UBP DID ratio to pre-UBP DID ratio (1)	0.975**	(0.958 - 0.992)	0.974*	(0.951 - 0.997)	0.971*	(0.947 - 0.995)
Regression Results						
San Diego County	1.015	(0.985 - 1.046)	1.023	(0.985 - 1.063)	1.016	(0.976 - 1.057)
UBP Period (2011 to 2014) year trend	0.965***	(0.956 - 0.974)	0.957***	(0.941 - 0.972)	0.974***	(0.965 - 0.984)
San Diego County x UBP Period (2011 to 2014) year trend (1)	0.975**	(0.958 - 0.992)	0.974*	(0.951 - 0.997)	0.971*	(0.947 - 0.995)
Pre UBP Period (2007 to 2010) trend	0.994	(0.985 - 1.003)	1.006	(0.991 - 1.020)	0.983***	(0.974 - 0.992)
San Diego County x Pre UBP Period (2007 to 2010) trend	1.021***	(1.014 - 1.028)	1.017***	(1.007 - 1.027)	1.025***	(1.014 - 1.036)
Year 2011 constant	0.995	(0.982 - 1.009)	0.973**	(0.953 - 0.993)	1.009	(0.990 - 1.028)
Uninsured (percentage)	0.995*	(0.991 - 0.999)	0.992*	(0.986 - 0.999)	0.999	(0.995 - 1.003)
No usual place for care (percentage)	1.003	(0.999 - 1.007)	1.004	(0.998 - 1.009)	1.002	(0.996 - 1.007)
Income 0% to 199% of FPL (percentage)	0.997*	(0.994 - 1.000)	0.995**	(0.992 - 0.999)	0.998	(0.994 - 1.002)
Constant	0.004***	(0.003 - 0.004)	0.004***	(0.003 - 0.005)	0.003***	(0.003 - 0.004)
Model chi-squared likelihood ratio p-value	<0.001		<0.001		<0.001	
N (2)	225,871,213		111,324,852		114,546,357	

*p<0.05, **p<0.01, ***p<0.001

(1) In each model, *San Diego County x UBP Period (2011 to 2014) year trend* is the difference-in-differences-in-differences (DIDID) parameter. The DIDID parameter is the ratio of the UBP difference-in-differences (DID) ratio to the pre-UBP DID ratio. The DID ratios, including the odds ratios that make up the DID ratios, are reported in the summary results sections of the table.
(2) The number of observations for the full sample does not equal the sum of the number of observations in the sub-samples, because California Department of Finance population estimates were not integers, but had to be rounded to integers for the blogit model.
Notes: UBP: University of Best Practices; Heart attacks (ICD-9-CM 410); Strokes (ICD-9-CM 430-438); OR: odds ratio (for interaction terms, it is the ratio of two or four odds ratios); CI: 95% confidence interval; FPL: federal poverty level
Source: Authors' analysis of California Office of Statewide Health Planning and Development's 2007 to 2014 Patient Discharge Data

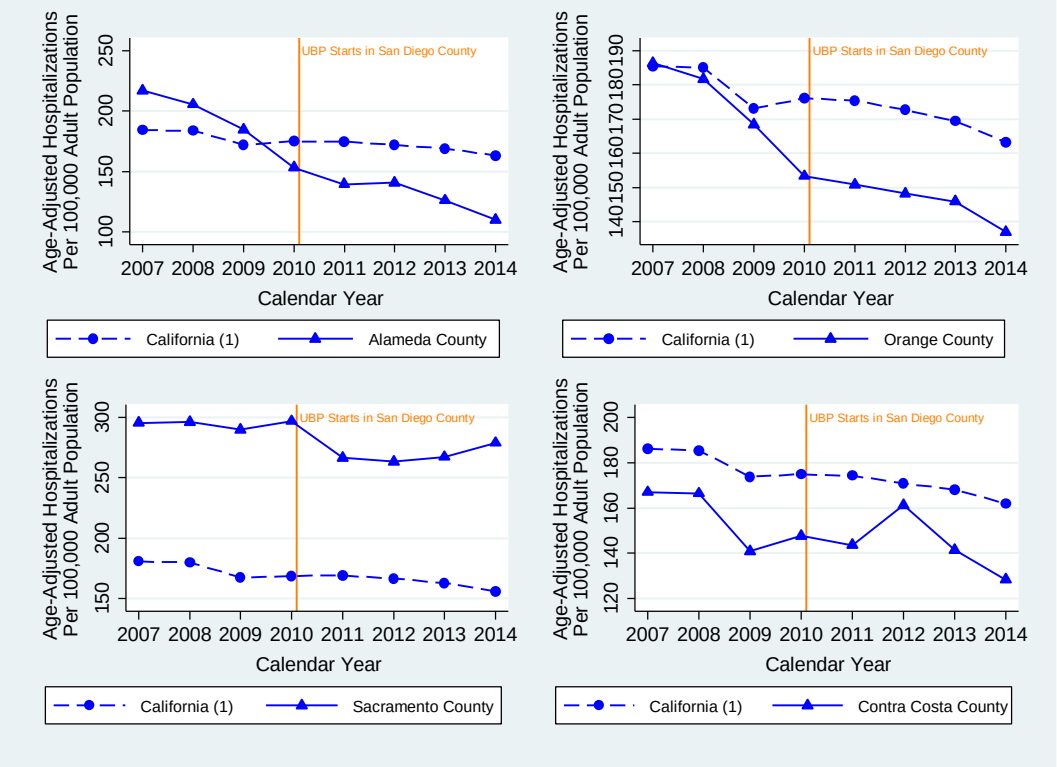
We used a falsification test and re-estimated our regression model in Eq. (1) in the main study for heart attack hospitalization rates by treating the eight counties with populations over 750,000 adults in 2014 as though they received the UBP treatment beginning in 2011. For each model, the remaining 56 counties served as control counties; San Diego County was excluded from these models. Their DID ratio of odds ratios from Eq. (1) were as follows: Alameda (0.69, $p<0.001$), Orange (0.88, $p<0.001$), Sacramento (0.95, $p<0.01$), Contra Costa (0.95, $p<0.05$), Los Angeles (1.05, $p<0.001$), Santa Clara (1.06, $p<0.001$), San Bernardino (1.10, $p<0.001$) and Riverside (1.18, $p<0.001$). Compared with San Diego County's DID ratio of odds ratio of 0.84 ($p<0.001$) (see model 1 in Table 1 in the main study), Alameda County's DID estimate was lower and Orange County's DID estimate was similar, and both counties' estimates were significant at the 0.001 level. Sacramento and Contra Costa counties DID estimates were higher, but still significant at the 0.01 and 0.05 levels, respectively. Another intervention or phenomenon—other than UBP—caused these decreases, thereby raising a concern that it may have also contributed to the decrease found in San Diego County.

Therefore, we plotted these four counties' pre-2011 and post-2011 age-adjusted hospitalization rates in **eAppendix Figure 1**. Unlike San Diego County, these results may be attributable to steeper pre-2011 downward trends in these counties relative to the rest of California. We tested the pre-2011 hospitalization trends between each of these counties and the rest of California (excluding San Diego County) using the same model we used to test pre-UBP hospitalization trends between San Diego County and the rest of California. Indeed, Alameda and Orange counties' pre-2011 hospitalization trends were decreasing more rapidly than the rest of California: Alameda County DID trend=0.86 ($p<0.001$) and Orange County DID trend=0.96

(p<0.001). These pre-2011 trend differences may be based on systemic factors that continued into the post-2011 period, which may be why their rates continued to decrease more rapidly than in the rest of California from 2011 to 2014. We do not have sufficient information to determine the degree that systemic factors played this role.

On the other hand, Sacramento and Contra Costa counties' pre-2011 hospitalization trends were not decreasing more rapidly than the rest of California: Sacramento County DID trend=1.01 (p=0.73) and Contra Costa County DID trend=1.01 (p=0.78). But as stated above, Sacramento and Contra Costa counties' DID estimates were higher (DID ratio of odds ratios = 0.95) than San Diego County's (DID ratio of odds ratios = 0.84). A DID ratio of odds ratio of 0.95 may have been attributable to an intervention or phenomenon that was also present in San Diego County, thus contributing to the San Diego County result; however, it does not fully explain the lower DID estimates found in San Diego County. Note, as stated in the main study, Sacramento County began a less-robust UBP in April 2013, but it does not appear that the UBP explains its 0.95 DID estimate, because the key hospitalization rate relative decrease occurred between 2010 and 2011 (see eAppendix Figure 1).

eAppendix Figure 1. Age-Adjusted Hospitalizations per 100,000 Adult Population for Heart Attacks for Select Counties in California, 2007-2014



(1) California is the remainder of California except for the subject county and San Diego County
Notes: Heart Attacks (ICD-9-CM 410); UBP: University of Best Practices. UBP started in San Diego County in February 2011, just after the 2010 data points. Percentages are percent changes since 2010.
Source: Authors' analysis of California Office of Statewide Health Planning and Development's 2007 to 2014 Patient Discharge Data.

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