Improvements in Health Status after Massachusetts Health Care Reform

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Context: Massachusetts enacted health care reform in 2006 to expand insurance coverage and improve access to health care. The objective of our study was to compare trends in health status and the use of ambulatory health services before and after the implementation of health reform in Massachusetts relative to that in other New England states.

Methods: We used a quasi-experimental design with data from the Behavioral Risk Factor Surveillance System from 2001 to 2011 to compare trends associated with health reform in Massachusetts relative to that in other New England states. We compared self-reported health and the use of preventive services using multivariate logistic regression with difference-in-differences analysis to account for temporal trends. We estimated predicted probabilities and changes in these probabilities to gauge the differential effects between Massachusetts and other New England states. Finally, we conducted subgroup analysis to assess the differential changes by income and race/ethnicity.

Findings: The sample included 345,211 adults aged eighteen to sixty-four. In comparing the periods before and after health care reform relative to those in other New England states, we found that Massachusetts residents reported greater improvements in general health (1.7%), physical health (1.3%), and mental health (1.5%). Massachusetts residents also reported significant relative increases in rates of Pap screening (2.3%), colonoscopy (5.5%), and cholesterol testing (1.4%). Adults in Massachusetts households that earned up to 300% of

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the federal poverty level gained more in health status than did those above that level, with differential changes ranging from 0.2% to 1.3%. Relative gains in health status were comparable among white, black, and Hispanic residents in Massachusetts.

Conclusions: Health care reform in Massachusetts was associated with improved health status and the greater use of some preventive services relative to those in other New England states, particularly among low-income households. These findings may stem from expanded insurance coverage as well as innovations in health care delivery that accelerated after health reform.

Keywords: health care reform, health care delivery, quality of health care, health status.

T HE KEY PROVISIONS OF MASSACHUSETTS'S 2006 HEALTH CARE reform law were an individual mandate to obtain health insurance if affordable, expanded Medicaid coverage for children and long-term unemployed adults, subsidized health insurance for low- and middle-income residents, and a health insurance exchange to help higher-income residents obtain unsubsidized insurance (Ayanian 2012). Approximately 400,000 Massachusetts residents have obtained coverage since this health care reform (Long and Stockley 2010, 2011; McDonough et al. 2008). With nearly 98% of residents now insured, Massachusetts has the highest rate of insurance of any state in the country, although the affordability of health care remains a substantial concern (Long, Stockley, and Dahlen 2012). The absolute gain in health insurance coverage was greatest for socioeconomically disadvantaged groups (Pande et al. 2011), even though racial and ethnic disparities in access to health care in Massachusetts persist (Maxwell et al. 2011; McKenna et al. 2011; Zhu et al. 2010). In addition, low-income people receive less screening for cancer and cardiovascular disease (Clark et al. 2011).

Although the initial impact of health care reform in Massachusetts on insurance coverage and access to health care has been assessed, its broader effects on health care delivery and health outcomes may become evident only over time. Accordingly, we decided to compare trends in health status and the use of ambulatory health services before and after the implementation of health reform through 2011 in Massachusetts relative to that in other New England states.

Methods

Study Design

We compared health status and the use of ambulatory services in Massachusetts relative to that in other New England states (Connecticut, Maine, New Hampshire, Rhode Island, and Vermont) before and after health care reform using a difference-in-differences analysis. This quasi-experimental approach compares outcomes among groups over two or more time periods. It can be used to assess policy changes in the absence of randomization of treatment assignment, reducing biases in simple before and after comparisons due to secular trends over time (Bertrand, Duflo, and Mullainathan 2004).

Data Source

We used data from the Behavioral Risk Factor Surveillance System (BRFSS), a state-based survey conducted by state health departments in collaboration with the Centers for Disease Control and Prevention (CDC 2006). The BRFSS tracks health behaviors, health conditions, access to care, and use of health care for adults residing in households in each U.S. state. It also collects self-reported sociodemographic data. Data are collected from a sample of adults (one per household) through a random-digit-dial telephone survey. In 2011, more than 500,000 adults were interviewed, and the median response rates in Massachusetts and other New England states ranged from 50% to 55% from 2001 through 2011 (CDC 2011a). In 2011, due to the increased percentage of cell phone–only households (~31% in 2011), the CDC started to include cell phone surveys. In addition, the CDC introduced a new technique to develop survey weights. This technique enabled the incorporation of cell phone data and additional demographic characteristics to better match sample distributions to known demographic characteristics of the population (CDC 2012).

Study Cohort

Our study cohort before and after health care reform in 2006 used yearly survey data from 2001 to 2011. We considered 2007 the first year after health care reform, since most provisions for expanded coverage took

TABLE 1
Specifications of Self-Reported Outcome Variables

Variable	Specification
Health status	
General health	Being in excellent and very good health (vs. good, fair, and poor health)
Physical health	Physical health was good for $\geq$ 28 days during past 30 days
Mental health	Mental health was good for $\geq$ 28 days during past 30 days
Health care delivery	
Cholesterol test	Female respondents aged $\geq$ 45 and male respondents aged $\geq$ 35 who had a cholesterol test within the past 5 years
Mammogram	Female respondents aged $\geq$ 40 who had a mammogram within the past 2 years
Pap test	Female respondents aged $\geq$ 18 who had a pap smear within the past 3 years
Colonoscopy	Adults aged $\geq$ 50 who have had a colonoscopy
Health care access	
Coverage by insurance	Having any kind of health care coverage, including health insurance, prepaid plans, or government plans such as Medicare
Personal doctor	Having one or more person as personal doctor or health care provider
Cost barriers	Needed to see a doctor in the past 12 months but could not because of cost

effect in late 2006. To focus on the population of nonelderly adults who were most directly affected by expanded insurance coverage under the reform, we excluded from the main analysis survey those respondents aged sixty-five or older, almost all of whom were eligible for Medicare. Because we used publicly available, de-identified data, our study was deemed exempt from review by the Harvard Medical School's Human Studies Committee.

Outcome Variables

Our primary outcomes of interest were health status and the use of ambulatory health care services, as detailed in table 1. Measures of health status were self-reported general health and the number of days

in good physical or mental health during the past month. Measures of health care delivery were the receipt of preventive screening tests for cancer and cardiovascular disease recommended and published by the U.S. Preventive Services Taskforce (U.S. Preventive Services Task Force 2012). We assessed the use of screening tests for breast cancer (mammography) in women aged forty to sixty-four, cervical cancer (Pap test) in women aged eighteen to sixty-four, colorectal cancer (colonoscopy) in adults aged fifty to sixty-four, and cholesterol assessments in males aged thirty-five to sixty-four and females aged forty-five to sixty-four. Other self-reported outcomes of interest were having insurance coverage, having a personal doctor, and facing cost barriers for health care.

Independent Variables

State of residence (Massachusetts versus other New England states) was the main predictor variable for comparing outcomes before (2001 to 2006) and after (2007 to 2011) Massachusetts health care reform. Sex, age, race/ethnicity, income, employment, marital status, and education were included as covariates in adjusted analyses. In addition, we used annual unemployment rates in each state, derived from the U.S. Bureau of Labor Statistics, to adjust for differential economic conditions (U.S. Bureau of Labor Statistics 2012).

Statistical Analysis

We estimated multivariate logistic regression models for each of the dichotomized outcome variables. The interaction term for region and time period (before and after reform) was of key importance, representing trends over time in Massachusetts compared with those of other New England states. We calculated age-standardized percentages of the outcome variables per year (Klein and Schoenborn 2001). We checked for differences in linear trends between Massachusetts and other New England states before Massachusetts health care reform by comparing the slopes of linear regression models for each outcome. Odds ratios (OR) were calculated for differences between Massachusetts and other New England states during the periods before and after Massachusetts health reform. Coefficients, standard errors, and *p* values were

calculated for difference-in-differences, comparing differences in outcomes before and after reform in Massachusetts versus those in other New England states (Karaca-Mandic, Norton, and Dowd 2012). We estimated predicted probabilities for residents in Massachusetts compared with those of residents in other New England states. For each outcome we estimated the predicted probabilities using interaction plots for the conditional levels of the interacting variables. Thus, the regression specification for the difference-in-differences analysis was of the form

$$\text{logit} (p/(1\text{-}p)) = \text{ß0} + \text{ß1(region)} + \text{ß2(time period)}$$
$$+\text{ß3(region} * \text{time period)} + Bi\text{(covariates)} + \varepsilon$$

Subgroup Analysis

Households earning up to 300% of the federal poverty level (FPL) are eligible for subsidized health insurance under Massachusetts health care reform. We therefore conducted subgroup analysis for households with income less than 300% and more than 300% FPL. Annual federal poverty guidelines (U.S. DHHS 2012) were used to allocate the subgroups, based on household size and BRFSS income categories. In addition, we conducted subgroup analysis for white, black, and Hispanic residents to determine differential changes by race/ethnicity after Massachusetts health care reform. Finally, we estimated percentage changes in predicted probabilities to gauge the differential effects for each subgroup.

Analysis of BRFSS 2011 Data

The addition of cell phone data and the new weighting technique required additional analysis because the 2011 sample was not directly comparable to those of previous years. We conducted several parallel analyses to estimate the robustness of the results with respect to the new methodology. Specifically, we calculated age-adjusted percentages of the outcome variables with the combined landline and cell phone data, as well with landline data only using both the new and the previous weighting techniques. We conducted the difference-in-differences analysis by, first, estimating multivariate logistic regression models for 2001 to 2006 and 2007 to 2010. Second, we included 2011 when comparing

2001 to 2006 and 2007 to 2011 for the combined landline and cell phone data with the new weighting technique. Third, we conducted the analysis with landline data only using both the new weighting technique and the earlier weighting technique.

We also conducted a series of sensitivity analyses to estimate the robustness of the results. First, because the Massachusetts health care reform took effect in mid- to late 2006, we modified the analysis to treat 2006 as a transition year, by adding a 2006 dummy variable in the model and also by deleting 2006 data from the analysis altogether (Courtemange and Zapata 2012; Pande et al. 2011). Second, we considered alternative comparison (control) groups, including the entire United States (excluding Massachusetts), New England states other than Vermont and Maine (which expanded coverage during the study period), and comparing only Connecticut and Rhode Island, the New England states most demographically similar to Massachusetts. Finally, we conducted parallel analyses for adults aged sixty-five and older to estimate the effects on the Medicare-eligible population.

Significance was tested using two-sided tests at level 0.05. We used SAS 9.2 survey software to account for the complex survey design. Missing values of the independent variables were multiply imputed ($n = 10$) (Yuan 2011).

Findings

Characteristics of Study Cohort and Trend Analysis

The overall number of survey participants aged eighteen to sixty-four in Massachusetts and other New England states from 2001 through 2011 was 345,211. The participants' characteristics are presented in appendix 1. Compared with the participants from other New England states, Massachusetts's were younger, less likely to be white or married, and more likely to have higher incomes and levels of education. The age-standardized percentages for self-reported health status and health care access in Massachusetts and other New England states between 2001 and 2011 are shown in figure 1, and a detailed listing of the age-standardized percentages of all outcomes is given in appendixes 2 and 3.
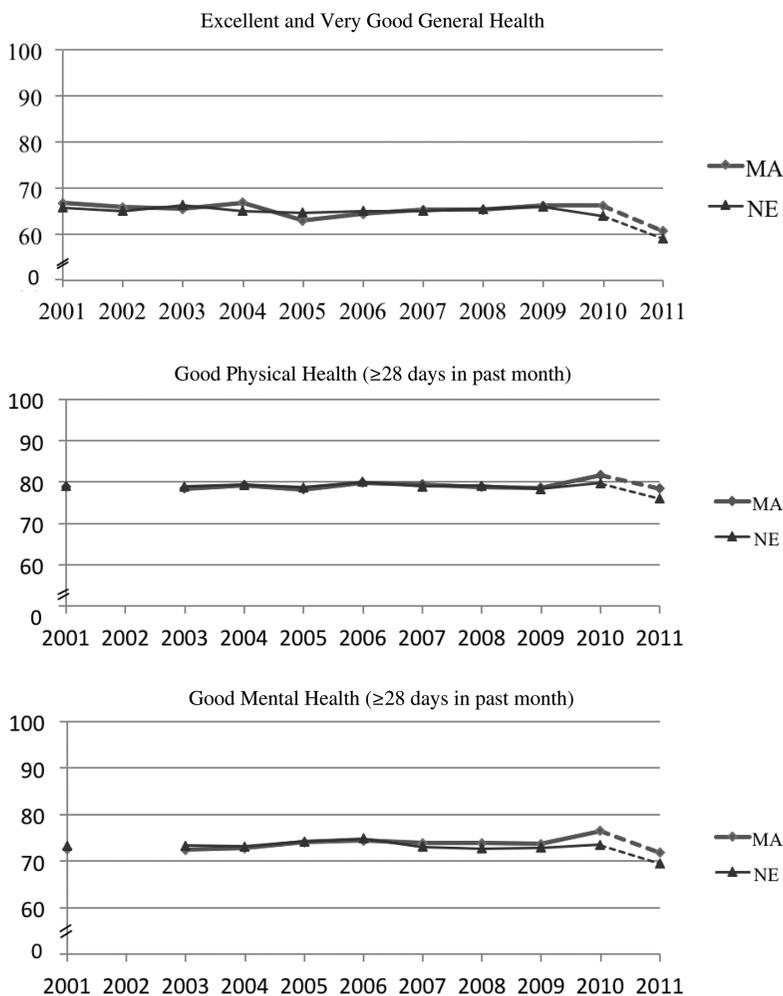
FIGURE 1. Age-adjusted outcomes (%) for self-reported health status and health care access.
Notes: MA denotes Massachusetts; NE denotes other New England states.
The dashed lines in all panels indicate the addition of cell phone data and the new weighting technique by the Centers for Disease Control and Prevention. Data for physical health and mental health were not collected in 2002, and data for cost barriers were not collected in 2001 and 2002.

FIGURE 1. *Continued.*
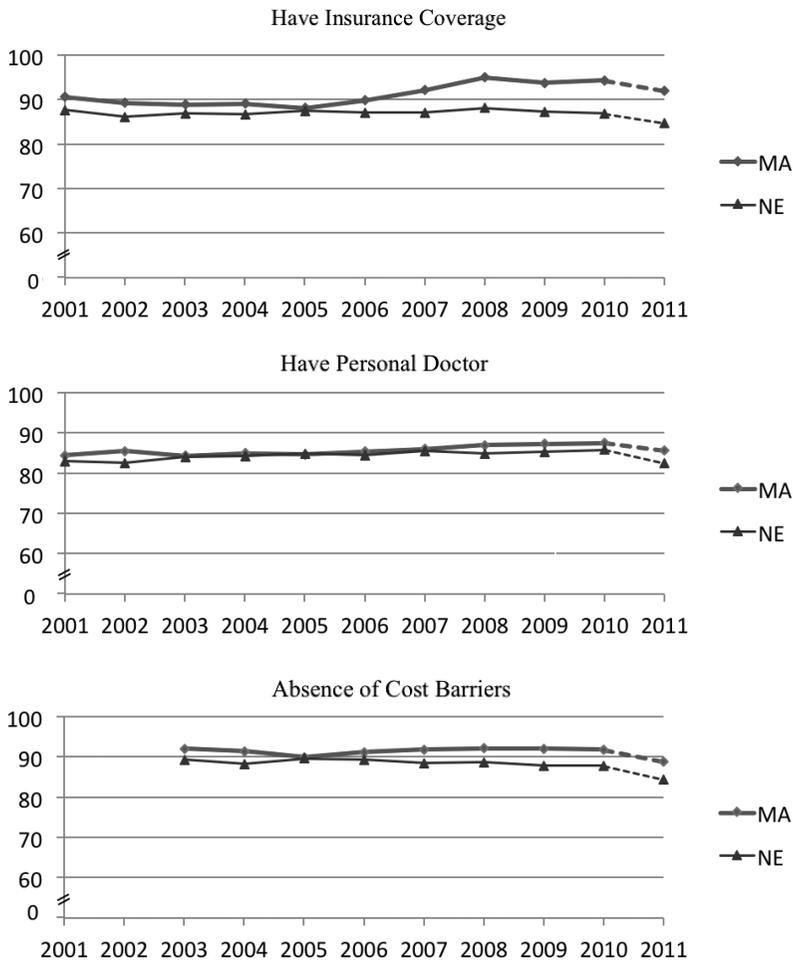
Differences between Massachusetts and Other New England States

Difference-in-differences comparing the period before (2001–2006) and after (2007–2011) health care reform are presented as odds ratios in table 2 and as predicted probabilities in table 3.

The predicted probability for Massachusetts residents being in either excellent or very good general health decreased from 66.2% before

TABLE 2
Adjusted Odds Ratios for Residents in Massachusetts versus Other New
England States Before and After Massachusetts Health Reform

	Before Reform (2001–2006)[a] OR (95% CI)[c]	After Reform (2007–2011)[a] OR (95% CI)[c]	After versus Before Reform Change[b] OR (95% CI)[c]
Health status			
General health	0.97 (0.94–1.01)	1.04 (1.00–1.08)	1.07 (1.02–1.13)
Physical health	0.97 (0.93–1.01)	1.05 (1.01–1.10)	1.08 (1.02–1.15)
Mental health	0.95 (0.91–0.98)	1.04 (1.00–1.08)	1.10 (1.04–1.16)
Health care services			
Mammogram	1.16 (1.04–1.28)	1.19 (1.07–1.32)	1.03 (0.90–1.19)
Pap test	1.07 (0.91–1.24)	1.36 (1.17–1.57)	1.28 (1.06–1.58)
Colonoscopy	0.95 (0.87–1.04)	1.14 (1.05–1.23)	1.18 (1.06–1.34)
Cholesterol check	1.14 (1.07–1.21)	1.26 (1.18–1.36)	1.17 (1.03–1.32)
Health care access			
Covered by insurance	1.26 (1.19–1.34)	2.50 (2.32–2.69)	2.03 (1.85–2.23)
Have personal doctor	1.10 (1.04–1.16)	1.27 (1.20–1.35)	1.17 (1.08–1.26)
Have cost barriers	0.79 (0.74–0.86)	0.63 (0.66–0.67)	0.80 (0.73–0.88)

Notes: Based on logistic regression with outcomes as dependent variables, and region (Massachusetts versus other New England states) as predictor variable. Adjusted for individual sex, age, race/ethnicity, income, employment, marital status, and education; and the annual unemployment rates in each state.
[a]Massachusetts versus other New England states for the periods before and after Massachusetts health reform.
[b]Difference-in-differences: comparing differences in outcomes before and after Massachusetts health reform, Massachusetts versus those in other New England states.
[c]OR = odds ratio, and CI = confidence interval.

Massachusetts health care reform to 65.5% after the health care reform, while the predicted probabilities for good physical health and mental health increased from 79.8% to 80.4% and from 75.1% to 75.2%, respectively. For residents in other New England states, the predicted probabilities before and after Massachusetts health care reform dropped from 66.6% to 64.2% for being in either excellent or very good health, from 80.1% to 79.4% for being in good physical health, and from 75.6% to 74.2% for being in good mental health. The changes in predicted probabilities were statistically significant in favor of Massachusetts residents

TABLE 3
Predicted Probabilities Before and After Massachusetts Health Reform

	Massachusetts[a]		Other New England States[a]		Difference-in-Differences[b]	
	Before (%)	After (%)	Before (%)	After (%)	Difference[c] (%)	P Value
Health status						
General health	66.2	65.5	66.6	64.2	1.7	0.01
Physical health	79.8	80.4	80.1	79.4	1.3	0.02
Mental health	75.1	75.2	75.6	74.2	1.5	< 0.01
Health care services						
Mammogram	85.3	85.6	83.2	83.6	− 0.1	0.64
Pap test	93.8	93.3	93.5	90.7	2.3	0.02
Colonoscopy	59.7	71.2	61.8	67.8	5.5	< 0.01
Cholesterol check	90.7	92.6	90.2	90.7	1.4	0.01
Health care access						
Covered by insurance	94.4	96.8	92.9	91.7	3.6	< 0.0001
Have personal doctor	89.7	90.7	88.4	87.8	2.4	< 0.0001
Have cost barriers	5.9	5.8	7.5	9.4	− 2.0	< 0.0001

Notes: [a]Massachusetts and other New England states before and after Massachusetts health reform. [b]Difference-in-differences: comparing differences in outcomes before and after Massachusetts health reform, Massachusetts versus those in other New England states. Adjusted for individual sex, age, race/ethnicity, income, employment, marital status, and education; and the annual unemployment rates in each state. [c]Percentage-point differences in predicted probabilities between Massachusetts and other New England states.

for being in either excellent or very good general health (1.7%; $p = 0.01$), good physical health (1.3%; $p = 0.02$), good mental health (1.5%; $p < 0.01$); and having had a Pap test (2.3%; $p = 0.02$), a colonoscopy (5.5%; $p < 0.01$), and a cholesterol test (1.4%; $p = 0.01$). The outcomes were consistent for the different estimation methods of the BRFSS 2011 data when using combined landline and cell phone data, landline data only, and with new and old weighting techniques.

Massachusetts residents were more likely to report improved access to health care relative to residents in other New England states, with statistically significant changes in predicted probabilities for having

TABLE 4
Difference-in-Differences by Poverty Level and by Race/Ethnicity Between
Massachusetts and Other New England States

	Poverty Level[a]		Race/Ethnicity		
	≤ 300% FPL[b] (%)[c]	> 300% FPL[b] (%)[c]	White (%)[c]	Black (%)[c]	Hispanic (%)[c]
Health status					
General health	1.7	1.0	1.8	2.0	2.2
Physical health	2.1	0.8	1.3	1.1	1.2
Mental health	1.6	1.4	1.7	1.6	1.3
Health care services					
Mammogram	− 0.1	0.0	0.1	0.1	0.1
Pap test	3.1	1.6	1.2	0.8	1.4
Colonoscopy	4.0	5.6	3.7	3.9	3.8
Cholesterol check	1.2	1.4	1.4	1.2	2.1
Health care access					
Covered by insurance	6.1	2.6	2.8	3.8	5.0
Have personal doctor	2.4	1.3	1.8	2.2	2.4
Have cost barriers	− 3.9	− 1.0	− 1.6	− 1.9	− 1.7

Notes: Difference-in-differences: comparing differences in outcomes before and after Massachusetts health reform, Massachusetts versus those in other New England states, for poverty and race/ethnicity. Adjusted for individual sex, age, race/ethnicity, income, employment, marital status, and education; and the annual unemployment rates in each state.
[a]Poverty level by income ≤ 300% versus > 300% of the federal poverty level.
[b]FPL = federal poverty level.
[c]Percentage-point differences in predicted probabilities between Massachusetts and other New England states.

health insurance (3.6%; $p < 0.0001$), having a personal doctor (2.4%; $p < 0.0001$), and having fewer cost barriers (-2.0%; $p < 0.0001$).

Subgroup Analysis

The results of the analysis by poverty and race/ethnicity are shown in table 4. The predicted probability for insurance coverage in Massachusetts, compared with that in other New England states, increased by 6.1% for households with earnings less than 300% FPL and by 2.6% for those above that line. Massachusetts residents in the less than 300% FPL group also reported greater increases in the health status outcomes, with differential changes of 0.7%, 1.3%, and 0.2% for general health, physical health, and mental health, respectively. For receiving a Pap test, the differential change was in favor of the less than 300% FPL group

TABLE 5

Adjusted Odds Ratios by Poverty Level and Race/Ethnicity of Massachusetts Residents After Health Reform

| | Poverty Level | Race/Ethnicity | |
	≤ 300% vs. > 300% FPL OR (95% CI)	Black vs. White OR (95% CI)	Hispanic vs. White OR (95% CI)
Health status			
General health	0.61 (0.57–0.66)	0.75 (0.65–0.86)	0.69 (0.62–0.77)
Physical health	0.78 (0.71–0.85)	1.25 (1.08–1.45)	1.15 (1.01–1.30)
Mental health	0.82 (0.76–0.89)	1.23 (1.08–1.41)	1.46 (1.29–1.66)
Health care services			
Mammogram	0.72 (0.57–0.93)	1.75 (1.14–2.68)	1.34 (0.91–1.97)
Pap test	0.56 (0.41–0.78)	1.19 (0.81–1.75)	0.97 (0.65–1.45)
Colonoscopy	0.64 (0.53–0.76)	0.92 (0.67–1.26)	1.02 (0.74–1.42)
Cholesterol check	0.52 (0.43–0.64)	1.21 (0.89–1.63)	0.57 (0.45–0.72)
Health care access			
Covered by insurance	0.32 (0.27–0.37)	0.72 (0.59–0.88)	0.52 (0.43–0.63)
Have personal doctor	0.58 (0.51–0.63)	0.71 (0.59–0.84)	0.64 (0.55–0.74)
Cost barriers	2.78 (2.43–3.17)	1.28 (1.08–1.52)	1.30 (1.13–1.52)

Notes: Subgroup analysis for Massachusetts residents after Massachusetts health reform (2007–2011). Based on logistic regression with outcomes as dependent variable; poverty level (≤ 300% versus > 300% of the federal poverty level), and race (black versus white, Hispanic versus white) as predictor variables. Adjusted for individual sex, age, race/ethnicity, income, employment, marital status, and education and the annual unemployment rates in each state.
OR = odds ratio; CI = confidence interval; and FPL = federal poverty level.

(1.5%), while for receiving a colonoscopy, it leaned toward the more than 300% FPL group (1.6%).

The subgroup analysis by race/ethnicity for Massachusetts residents, relative to residents in other New England states, showed the largest increase in predicted probability of insurance coverage for Hispanic residents (5.0%), followed by black (3.8%) and white residents (2.8%). Smaller differential changes were noted in health status outcomes among white, black, and Hispanic residents, ranging from 0.1% to 0.4%. For health care services, cholesterol testing showed a greater increase in predicted probability for Hispanic residents (2.1%), compared with an increase of 1.4% and 1.2% for white and black residents in Massachusetts, respectively.

Table 5 shows the results of subgroup analysis within Massachusetts after health care reform. Massachusetts residents who earned less than

300% FPL were less likely to report good health status outcomes, less likely to receive ambulatory health services, and less likely to have access to health care, compared with residents who earned more than 300% FPL. Black and Hispanic residents in Massachusetts were less likely than white residents to report good general health after health care reform, and black and Hispanic residents were more likely to report good physical and mental health. Hispanic residents in Massachusetts were less likely to report having received a cholesterol test, but black residents were more likely to report having received mammography screening. We found no differences for Pap testing and colonoscopy among white, black, and Hispanic residents in Massachusetts after health care reform.

Sensitivity Analyses

Using 2006 as the intermediate year of health care reform, using U.S. states as a parallel analysis, and dropping Maine and Vermont from the analysis, followed by New Hampshire, resulted in similar outcomes for the difference-in-differences analysis. The results of the sensitivity analysis for comparisons with Maine and Vermont excluded are presented in appendix 4. Analysis of the population aged sixty-five and older showed no statistically significant differences between Massachusetts and the New England states for any of the measures of health status or preventive services. Massachusetts residents aged sixty-five and older were, however, more likely to have insurance coverage ($p = 0.02$) and to have no cost barriers ($p = 0.03$).

Discussion

Our study demonstrated that after health care reform, Massachusetts residents reported better general health, physical health, and mental health compared with that of residents in neighboring states. In addition, health care reform in Massachusetts was associated with an increased use of preventive screening tests for cervical cancer, colorectal cancer, and cholesterol. In addition to these new findings on health status, our results confirm findings of prior studies that estimated the impact of health reform on having insurance coverage, having a personal doctor, and facing cost barriers for the overall population in Massachusetts (Long, Stockley, and Dahlen 2012; Pande et al. 2011).

The subgroup analysis showed that those households in Massachusetts earning up to 300% of the federal poverty level gained more from health care reform in regard to insurance coverage than did those above the 300% level. Earlier studies also showed increased insurance coverage for all income levels, with higher gains for lower-income groups (Long and Masi 2009; Zhu et al. 2010). The subgroup analysis also showed that relative to other New England states, the health status outcomes of low-income residents in Massachusetts increased more than those of higher-income residents. Despite these relative gains for low-income residents, disparities between low- and higher-income residents in Massachusetts after health care reform still exist for all outcomes of health status, preventive services, and health care access. The relative gains in health status were comparable for white, black, and Hispanic residents in Massachusetts. Racial and ethnic disparities for Massachusetts residents after health care reform show a mixed picture for health status and preventive services, while disparities in health care access persist.

The increase in self-reported health status of Massachusetts residents relative to that in other New England states was consistent for general health, physical health, and mental health. But the estimated predicted probability for general health of Massachusetts residents after health care reform was lower than before the reform. Our parallel analysis confirmed that this decrease was caused by a drop in 2011 due to the BRFSS's new weighting technique. The differential changes were similar for all estimations with the new and old weighting techniques as well as for landline data only (data not shown). Although we hypothesized that the potential effect of expanded insurance coverage on health outcomes would rise over time, additional comparable longitudinal data are needed to determine whether our findings represent a transient improvement or a consistent trend.

A recent working paper indicates improvements for several determinants of overall health, including functional limitations, joint disorders, body mass index, and moderate physical activity when comparing Massachusetts with all U.S. states through 2010 (Courtemange and Zapata 2012). Our article adds to these findings by comparing Massachusetts with other New England states using data though 2011 across both health outcomes and use of ambulatory health services. Although the self-reported outcomes for health status in the BRFSS survey are subjective, previous studies have shown that the self-reported index for general health is correlated with objective measures of health, such as

risk of mortality (DeSalvo et al. 2006) and that the index is a global measure that captures the full range of a person's health conditions and functional limitations (Courtemange and Zapata 2012). In addition, insurance coverage itself may provide a general sense of well-being and financial security, which may have a positive effect on self-reported health, as was demonstrated with a randomized expansion of Medicaid in Oregon (Baicker and Finkelstein 2011; Finkelstein et al. 2011). Medicaid coverage in the Oregon study decreased the probability of a positive screening for depression, increased the use of many preventive services, and generated no statistically significant changes in the prevalence or control of hypertension or high cholesterol in the first two years after implementation (Baicker et al. 2013). Our study showed a delayed effect in self-reported health status improvement, as opposed to the immediate impact of Medicaid coverage shown in the Oregon study. The Oregon study compared low-income residents, almost all of whom obtained coverage within a short time period, so these effects were more immediate and pronounced. In contrast, we compared the health of all nonelderly adult state residents before and after health reform, so the effects were dampened by the broader study population and the slower gains in coverage with the implementation of Massachusetts health reform.

The results of our study must be viewed in light of the uncertain specific effects of health care reform in Massachusetts. Other changes in Massachusetts may have accounted for the improved health status and preventive services. Although health care reform in Massachusetts initially focused on expanding insurance coverage, it also was associated with numerous efforts in the public and private sector to improve quality and contain costs (Ayanian and Van der Wees 2012; Song et al. 2012). These innovations were directed to large segments of the population and may contribute to broader effects over time. Although the actual contribution of such innovations is unclear, the combined efforts within Massachusetts to improve quality may be reflected in our findings. Despite our adjustment for annual state unemployment rates, differences in recent economic developments between Massachusetts and other New England states also may have influenced our results. Unemployment rates in Massachusetts dropped 1.2 percentage points, from 8.6% in 2009 to 7.4% in 2011, while the average unemployment rates in other New England states dropped 0.6 percentage point, from 8.3% to 7.8% (U.S. Bureau of Labor Statistics

2012). Other unmeasured economic factors in Massachusetts relative to those in other New England states may therefore have added to our findings.

We found no improvements in mammography rates in Massachusetts after health reform. Keating and colleagues (2013) also found no improvements in mammography rates after health reform in Massachusetts compared with those in California, possibly because screening rates in Massachusetts were already high before health reform. Another explanation might be the change of screening recommendations over time. In 2009 the U.S. Preventive Services Task Force recommended raising the initial age for routine screening mammography from forty to fifty (U.S. Preventive Services Task Force 2009). The U.S. Department of Health and Human Services, though, still endorses the 2002 recommendation for breast cancer screening (U.S. Preventive Services Task Force 2012). In addition, a recent study showed that mammography rates in the United States did not fall among women aged forty to forty-nine after publication of the 2009 U.S. Preventive Services Task Force recommendations (Pace, He, and Keating 2013). Thus, we expect that the effect of this new recommendation still is limited.

Although screening rates for cervical cancer showed a relative change in favor of Massachusetts, the absolute screening rates were lower in both Massachusetts and other New England states. In 2012 the U.S. Preventive Services Task Force changed the recommended age for starting routine screening from eighteen to twenty-one (U.S. Preventive Services Task Force 2012). The states may have anticipated these new recommendations in their policy during previous years. However, in analyzing data for women aged twenty-one and older, we found a similar decline (data not shown). This unfavorable trend also is seen at the national level in the United States, as the proportion of women aged twenty-two to thirty who report never having been screened rose from 6.6% in 2002 to 9% in 2010 (CDC 2013).

Our analysis showed that the rate of colorectal cancer screening went up in Massachusetts and other New England states, with a relatively greater increase in Massachusetts. Publications of national screening rates by the Centers for Disease Control and Prevention showed a sharp increase in screening rates in the United States, from 52.3% in 2002 to 65.4% in 2010, with the rates in Massachusetts among the highest in the country (CDC 2011b). Physicians' recommendations and health insurance are important facilitators of screening, and further monitoring

of preventive services will be a core component of evaluations of national health care reform (Koh and Sebelius 2010).

One notable finding of the sensitivity analysis of adults aged sixty-five and older was the positive effect on insurance coverage and cost barriers for Massachusetts compared with other New England states. Courtemange and Zapata (2012) confirmed these results, although Pande and colleagues (Pande et al. 2011) found a difference only for insurance coverage and not for cost barriers. A possible explanation is the increased proportion of seniors reporting Medicaid rather than Medicare as their primary source of insurance, suggesting that health care reform resulted in some seniors obtaining more comprehensive coverage (Courtemange and Zapata 2012; Kolstad and Kowalski 2010). For example, immigrant seniors who are legal citizens but have not worked long enough in the United States to become eligible for Medicare were helped to enroll in Medicaid as part of the outreach efforts by the hospitals and health centers where they were seeking care.

Our sensitivity analysis presents the comparisons, with Maine and Vermont excluded from the main analysis. In 2003, Maine passed the Dirigo Health Reform Act, which was aimed at covering uninsured and underinsured residents, improving health care quality, and lowering health costs (Rosenthal and Pernice 2004). The Vermont Blueprint for Health was launched in 2003 with expanded health coverage and delivery system reform (Department of Vermont Health Access 2013). These reforms could have biased our results, so we offer alternative comparisons that exclude these states from the analysis. The sensitivity analysis shows results similar to those of the main analysis, which may be because the reforms in Maine and Vermont were introduced several years before the Massachusetts health reform and thus had little impact on our overall comparisons. We decided to maintain the comparisons with Maine and Vermont included, which provided more power, especially in the subgroup analysis.

Several limitations of our study should be noted. Although the cooperation rate of BRFSS respondents over the study years was high (ranging from 72% to 77%), the actual response ranged from 50% to 55% (CDC 2011a). The interviewers' inability to contact some eligible households may affect the generalizability of the survey data (Johnson and Wislar 2012). Another limitation is the lack of coverage of persons residing in households without a telephone. Those households without a telephone have, on average, a lower income, which may limit the generalizability

of the survey. The addition of cell phone interviews in the 2011 BRFSS survey provided a more representative sample. But the cell phone data and the new weighting technique also limited comparability with previous years and the trend analysis over time. To address these potential limitations, we estimated outcomes with and without the 2011 data, as well as by using the previous weighting technique provided by the Centers for Disease Control and Prevention. Although the difference-in-difference analysis allowed for a quasi-experimental design in the absence of a controlled intervention, this approach also has limitations, especially related to the difficulty of interpreting the interaction terms in logistic regression models. To optimize interpretation of the data, we presented the results as predicted probabilities for the differences-in-differences (Bertrand, Duflo, and Mullainathan 2004; Karaca-Mandic, Norton, and Dowd 2012). Another limitation of difference-in-differences analysis is the underestimation of standard errors due to the serial correlation of outcomes over time. We corrected this by aggregating the data into two periods: before and after Massachusetts health reform. However, the clustering of data with a small number of clusters may lead to a higher rate of false positive outcomes (Bertrand, Duflo and Mullainathan 2004). Our sensitivity analysis that dropped some New England states from the sample was stable using the full cohort but sacrificed considerable power in subgroup analyses. Although subjective self-reported health status provides valid and valuable outcomes, the BRFSS data lack objective measures such as reductions in blood pressure or cholesterol levels. Finally, it would have been interesting to estimate the impact by type of insurance coverage (public versus private insurance), but these data are not collected in the BRFSS survey.

Our study found that Massachusetts's 2006 health reform law was associated with increased access to health care, improved health status, and greater use of some preventive services relative to those in other New England states. Households in Massachusetts that earned up to 300% of the federal poverty level gained more in health status outcomes than did those with incomes above that level. The relative gains in health status were comparable for white, black, and Hispanic residents in Massachusetts. Nonetheless, disparities in health status and the use of preventive services for low-income residents in Massachusetts still exist. Additional data are needed to determine whether our findings represent a consistent trend, which may stem from expanded insurance coverage as well as innovations in health care delivery that accelerated

after health reform. Our results demonstrate the potential benefits of health care reform in Massachusetts that may also be achieved through the implementation of the federal Affordable Care Act.

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APPENDIX 1

Characteristics of Study Population Based
on BRFSS Survey Data, 2001–2011

	Massachusetts	Other New England States
Sample size	112,011	233,200
Age (mean)*	40.6	41.0
Male (%)	49.1	49.4
*Race/ethnicity (%)**		
White	79.0	85.2
Black	4.5	3.2
Other	5.5	3.5
Multiracial	0.9	0.8
Hispanic	9.0	6.2
Missing	1.2	1.1
*Employment status (%)***		
Employed	73.9	74.0
Unemployed	6.8	6.5
Other	18.9	19.2
Missing	0.4	0.3
*Marital status (%)**		
Married	57.8	59.9
Divorced	8.2	9.6
Widowed	1.6	1.7
Separated	2.2	1.5
Never married	24.3	21.8
Member of unmarried couple	5.3	5.2
Missing	0.6	0.4

APPENDIX 1—*Continued*

	Massachusetts	Other New England States
*Annual household income (%)**		
<$10,000	2.8	2.9
$10,000–$15,000	2.6	2.8
$15,000–$20,000	4.0	4.1
$20,000–$25,000	5.4	5.4
$25,000–$35,000	7.4	8.3
$35,000–$50,000	11.3	13.1
$50,000–$75,000	15.6	17.2
> $75,000	37.9	33.9
Missing	13.0	12.4
*Education (%)**		
None	0.2	0.1
Grade 1–8	2.2	1.6
Grade 9–11	4.7	4.8
Grade 12 or GED	23.4	27.3
College yr 1–3	24.1	25.8
College yr ≥ 4	45.1	40.2
Missing	0.4	0.2

Note: BRFSS = Behavioral Risk Factor Surveillance System.
*$p < 0.0001$; **$p < 0.01$; based on weighted, unadjusted Rao–Scott chi–square statistics.

APPENDIX 2

Mean Outcomes in Massachusetts for Self-Reported Health Status and Health Care Access

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Health status											
General health	66.7 (65.4–68.0)	65.8 (64.2–67.3)	65.4 (63.9–67.9)	66.8 (65.2–68.4)	62.8 (61.1–64.4)	64.4 (62.9–66.2)	65.3 (64.0–66.6)	65.2 (63.9–66.6)	66.2 (64.6–67.9)	66.1 (64.4–67.9)	60.7 (59.4–62.0)
Physical health	78.7 (77.5–79.6)		78.3 (77.0–79.7)	79.2 (77.9–80.5)	78.2 (76.8–79.6)	79.8 (78.5–81.1)	79.3 (78.2–80.4)	78.8 (77.7–79.9)	78.5 (77.1–79.8)	81.7 (80.4–83.1)	78.4 (77.3–79.5)
Mental health	72.5 (71.2–73.8)		72.3 (70.9–73.8)	72.7 (71.2–74.2)	74.0 (72.5–75.6)	74.3 (72.9–75.8)	73.7 (72.5–75.0)	73.8 (72.5–75.0)	73.6 (72.1–75.1)	76.4 (74.9–78.0)	71.6 (70.4–72.9)
High cholesterol	24.1 (22.8–25.4)		25.1 (23.7–26.6)		29.2 (27.3–31.1)		27.5 (26.3–28.7)		28.4 (26.7–30.1)		25.7 (24.5–26.9)
High blood pressure					17.3 (16.2–18.6)		17.8 (17.9–18.6)		17.5 (16.5–18.5)		20.8 (19.8–21.8)
Health care services											
Mammogram		83.3 (82.1–84.5)		82.6 (81.0–83.9)		84 (82.5–85.9)		84.5 (83.7–85.5)		83.7 (82.8–84.9)	
Pap smear				92.9 (91.4–94.4)		91.5 (90.0–93.0)		92.3 (91.0–93.5)		92.1 (90.3–94.1)	
Colonoscopy				56.3 (53.6–59.0)		60.3 (58.0–62.6)		69.1 (67.4–70.8)		72.7 (70.9–74.5)	
Cholesterol check	88.9 (87.7–90.2)		89.2 (87.9–90.5)		88.2 (86.9–89.5)		91.1 (90.2–92.0)		91.8 (90.9–92.7)		91.4 (90.4–92.3)
Health care access											
Insurance	90.7 (89.9–91.6)	89.3 (88.3–90.4)	88.9 (87.8–90.0)	89.1 (87.9–89.4)	88.2 (87.0–89.4)	89.9 (88.8–91.0)	92.2 (91.4–93.0)	95.1 (94.4–95.7)	93.8 (92.5–94.7)	94.4 (93.5–95.3)	92.1 (91.3–92.9)
Personal doctor	84.5 (83.5–85.6)	85.5 (84.3–86.6)	84.4 (83.2–85.7)	85 (83.6–86.3)	84.7 (83.4–86.1)	85.4 (84.0–86.7)	86.0 (85.0–87.1)	87.0 (85.9–88.0)	87.3 (86.5–88.6)	87.6 (86.2–89.1)	85.6 (84.5–86.6)
Have cost barriers			8.0 (71.–8.9)	8.6 (7.6–9.6)	10.1 (9.1–11.2)	8.8 (7.8–9.8)	8.2 (7.5–9.0)	7.1 (6.4–7.8)	8.0 (7.1–8.9)	8.2 (7.2–9.2)	11.1 (10.2–12.0)

Note: Age-adjusted means and 95% confidence intervals using logistic regression.

APPENDIX 3

Mean Outcomes in Other New England States for Self-Reported Health Status and Health Care Access

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Health status											
General health	65.8 (64.9–66.7)	65.0 (64.0–66.0)	66.4 (65.4–67.3)	65.0 (64.1–66.0)	64.6 (63.5–65.7)	65 (64.1–66.0)	65.0 (64.0–66.1)	65.5 (64.3–66.6)	65.9 (64.7–67.0)	63.9 (62.8–65.1)	59.1 (58.0–60.2)
Physical health	78.9 (78.1–79.7)		78.8 (78.0–79.6)	79.1 (78.3–80.0)	78.5 (77.6–79.4)	79.9 (79.1–80.7)	78.7 (77.8–79.7)	78.9 (77.9–78.8)	78.1 (77.1–79.1)	79.5 (78.5–80.4)	76.0 (75.0–76.9)
Mental health	73.3 (72.5–74.1)		73.3 (72.4–74.3)	73.1 (72.1–74.0)	74.2 (73.1–75.3)	74.9 (74.1–75.8)	73.0 (72.0–74.0)	72.7 (71.6–73.8)	72.9 (71.8–74.0)	73.5 (72.4–74.6)	69.4 (69.1–70.4)
High cholesterol	24.7 (23.9–25.5)		24.8 (23.9–25.7)		26.2 (25.1–27.3)		30 (28.7–31.2)		29.1 (27.8–30.4)		27.7 (26.7–28.8)
High blood pressure					16.7 (16.0–17.4)		18.4 (17.7–19.1)		19.4 (18.5–20.2)		21.3 (20.5–22.0)
Health care services											
Mammogram		81.9 (81.2–82.6)		80.3 (79.4–81.2)		80.9 (80.7–81.1)		82.8 (82.6–82.9)		79.4 (79.2–79.6)	
Pap smear				92.6 (91.8–93.3)		91.9 (91.0–92.8)		89.6 (84.2–90.9)		90.5 (89.3–91.7)	
Colonoscopy				55.5 (54.0–57.0)		61.8 (60.5–63.2)		66 (64.4–67.3)		71.4 (70.1–72.6)	
Cholesterol check	87.2 (86.3–87.9)		87.5 (86.7–88.3)		87.3 (86.5–88.2)		89.3 (88.6–90.0)		89.3 (88.6–90.1)		87.4 (86.4–88.3)
Health care access											
Insurance	87.7 (87.0–88.4)	86.1 (85.3–86.9)	86.8 (86.1–87.6)	86.6 (85.9–87.4)	87.5 (86.7–88.3)	87.1 (86.4–87.8)	87.1 (86.3–88.0)	88.1 (87.3–89.0)	87.3 (86.4–88.2)	86.8 (85.9–87.8)	84.7 (83.9–85.6)
Personal doctor	83 (82.2–83.7)	82.6 (81.7–83.5)	83.9 (83.1–84.8)	84.2 (83.4–85.0)	84.9 (84.0–85.8)	84.5 (83.7–85.3)	85.5 (82.6–84.5)	84.8 (83.8–85.8)	85.3 (83.3–86.3)	85.8 (84.8–86.8)	82.4 (81.4–83.2)
Have cost barriers			10.7 (10.0–11.4)	11.7 (11.0–12.4)	11.4 (10.6–12.2)	10.8 (10.2–11.4)	11.6 (10.8–12.3)	11.4 (10.7–12.1)	12.2 (11.4–13.0)	12.2 (11.3–13.1)	15.6 (14.8–16.4)

Note: Age-adjusted means and 95% confidence intervals using logistic regression.

APPENDIX 4

Sensitivity Analysis: Massachusetts versus New Hampshire, Connecticut, and Rhode Island (Maine and Vermont excluded)

	Massachusetts[a]		Other New England States[a]		Difference-in-Difference[b]	
	Before (%)	After (%)	Before (%)	After (%)	Probability[b] (%)	*p* Value
Health status						
General health	66.8	65.9	67.2	64.6	1.7	< 0.01
Physical health	80.1	80.8	80.4	79.9	1.2	0.03
Mental health	75.3	75.6	75.9	74.7	1.5	0.01
Health care services						
Mammogram	86.7	85.4	83.8	83.2	0.3	0.86
Pap test	93.8	93.6	93.3	91.3	1.8	0.03
Colonoscopy	59.2	72.4	60.7	69.6	4.3	< 0.01
Cholesterol check	90.7	92.8	90	91.1	1.0	0.03
Health care access						
Covered by insurance	94.4	96.9	93.1	92.3	3.3	< 0.0001
Have personal doctor	89.6	90.9	88.2	88.3	1.2	< 0.001
Have cost barriers	5.8	5.6	7.3	9.1	−2.0	< 0.0001

Notes: Massachusetts and other New England states before and after Massachusetts health reform.
[a]Difference-in-differences: comparing differences in outcomes before and after Massachusetts health reform, Massachusetts versus those in other New England states, with Maine and Vermont deleted.
[b]Percentage-point differences in predicted probabilities between Massachusetts and other New England states, with Maine and Vermont deleted.