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Distributional Effects of Recent Health Insurance Expansions on Weight-Related Outcomes

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ABSTRACT

We provide new evidence that weight-related outcomes improved for the severely obese following three recent health insurance expansions. Using Behavioral Risk Factor Surveillance System (BRFSS) data from 2001 through 2016, we examine the effects of Massachusetts health care reform, the Affordable Care Act (ACA) dependent coverage mandate, and the ACA Medicaid expansion on Body Mass Index (BMI) and the likelihood of obesity or severe obesity. Estimates from unconditional quantile regression show that Body Mass Index (BMI) fell among the severely obese who are at the top of the distribution of BMI following all three of these insurance expansions. We also observe a robust reduction in the likelihood of severe obesity following the ACA dependent coverage mandate, and suggestive evidence of a reduction in severe obesity following Massachusetts health care reform. Together, these results identify an important benefit arising from recent health insurance expansions: improved weight-related outcomes for those with severe obesity.

1. Introduction

Recent work has documented the striking result that both the Massachusetts health care reform and the Affordable Care Act (ACA) dependent coverage mandate led to reductions in BMI (Courtemanche and Zapata, 2014; Barbaresco et al., 2015). Specifically, Courtemanche and Zapata (2014) estimate that BMI is 0.04 standard deviations lower, approximately 1 percent, among all Massachusetts residents following Massachusetts health care reform. Barbaresco et al. (2015) examined the ACA dependent coverage mandate and found similarly sized reductions in BMI. Although these may seem to be modest impacts, these changes in BMI correspond to weight loss of between one and six pounds. This is within the range of estimated weight loss arising from weight loss programs that are tied to financial incentives (between zero and nine pounds lost, see, e.g., Cawley and Price, 2013; Volpp et al., 2008; Finkelstein et al., 2007; Kullgren et al., 2013; Cawley et al., 2007; Cawley et al., 2013; John et al., 2011; Charness and Gneezy, 2009) and is larger than the estimates of weight loss arising from taxes on sugar sweetened beverages (between zero and three pounds lost, see, e.g., Fletcher et al., 2010a; Fletcher et al., 2010b; Fletcher et al., 2013; Tosun and Skidmore, 2007; Finkelstein et al., 2013; Zhen et al., 2014).[1]

A decline in BMI at the conditional mean, however, does not inform policymakers as to which individuals along the distribution of BMI are experiencing improvements in weight-related health outcomes. Barbaresco et al. (2015) tested for the presence of distributional effects by examining whether the likelihood of obesity changed following the ACA dependent coverage mandate and found a 1.4 percentage point reduction in obesity among young adults who benefitted from the expansion, a reduction of six

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[1] The findings described above refer to the population broadly. Ouayogode (2016) examines the effect of non-financial incentives among a less healthy population: obese individuals who are required to lose weight in order to receive a kidney transplant. Ouayogode (2016) finds that obese individuals on a transplant waiting list lose on average 10.8 pounds when they face BMI eligibility criteria for the transplant.

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percent from the pre period mean of 0.2. Thus, the reductions in BMI observed following the ACA dependent coverage mandate correspond to important improvements in weight-related health among those with the worst weight-related health outcomes. It is important to understand the effect of the expansion at the top of the distribution of BMI because severe obesity is associated with substantially higher costs compared to moderate obesity; severe obesity was found to be more than twice as costly as moderate obesity in terms of annual health expenditures, compared to normal weight (an average increase of $2,264 annually vs. an average increase of $823) (Andreyeva et al., 2004).

Although previous work documented reductions in BMI following Massachusetts health care reform and the ACA dependent coverage mandate, there are no documented reductions in BMI or obesity following the 2008 Oregon Medicaid expansions (Baicker et al., 2013), the ACA in general (Courtemanche et al., 2018), and the ACA Medicaid expansions (Courtemanche et al., 2018; Simon et al., 2017). These earlier null results may reflect the fact that those expansions were different than the Massachusetts health care reform and the ACA dependent coverage mandate. For example, the composition of individuals who were treated by the expansions differ—those treated by Massachusetts health care reform and the ACA dependent coverage mandate have relatively high socioeconomic status. The expansions also have different scope—the two earlier reforms were on a smaller scale than the 2014 provisions of the ACA. Additionally, there was a different mix of public versus private provision of health insurance arising from each expansion. Alternatively, the earlier null results of the reforms on BMI at the conditional mean may have obscured effects at different points along the distribution of BMI.

Using Behavioral Risk Factor Surveillance System (BRFSS) data, we examine whether these three recent health care reforms led to changes in BMI at different points along the distribution of BMI in two ways. First, we estimate linear probability models of the likelihood a respondent is overweight or obese, obese, or severely obese separately for each of the reforms. Evidence from these linear probability models provides evidence that the reduction in BMI following the ACA dependent coverage mandate was large enough to result in a reduction in the likelihood of obesity and severe obesity; we also find suggestive evidence of a similar pattern of results in Massachusetts. Second, we estimate the effects of all three reforms on BMI throughout the distribution of BMI using unconditional quantile regression models (as in Firpo et al., 2009). We find evidence that all three insurance expansions led to statistically significant reductions in BMI among the severely obese who are at the top of the distribution of BMI. With unconditional quantile regression we also confirm our earlier findings with larger reductions in BMI for those who are obese or severely obese following Massachusetts health care reform and the ACA dependent coverage mandate.

Thus, all three insurance expansions led to reductions in BMI for the severely obese, and we find some evidence that two of the expansions—Massachusetts health care reform and the ACA dependent coverage mandate—also led to a lower likelihood that a respondent is obese or severely obese. Together, these results highlight an important benefit of recent health insurance expansions: improved weight-related health for the most vulnerable. As reductions in BMI among the severely obese may be associated with substantial cost-savings and improvements in health, it is important that policymakers consider these perhaps unintended benefits arising from the expansion of health insurance.

2. Background and Related Literature

We focus on three recent health insurance expansions, beginning with Massachusetts health care reform. Beginning in July 2006, *MassHealth*, the Massachusetts Medicaid program, raised income eligibility for children, restored coverage to groups who had lost it during the 2002-2003 recession (including the long-term unemployed), and removed caseload caps for low-income people with disabilities. The reform also began a new program called *CommCare* (Commonwealth Care). These plans were sold through the Massachusetts Connector and offered free coverage to those below 150% FPL and subsidized coverage for individuals up to 300% FPL. *CommCare* was first introduced in October 2006 for adults with family income below 100% FPL and beginning in January 2007 expanded to accommodate individuals earning between 100-300% FPL. Beginning in July 2007, the individual mandate was in place and all reforms had been implemented. The mandate is enforced by the Massachusetts Department of Revenue through tax penalties, which amount to the loss of personal exemption in 2007 and a penalty of up to 50% of the minimum to obtain coverage in each month after 2008 until the individual has enrolled in a plan.

Additionally, we study the 2010 ACA dependent coverage mandate which required that insurers must allow young adults to stay on their parents' heath insurance plan until the age of 26, regardless of the young adult's marital or financial status, and regardless of whether the young adult still lives with his or her parents. This mandate was part of the ACA which was passed in March of 2010 and became effective six months later, in late September 2010.

We also separately examine the 2014 provisions of the ACA. As early as January 2014, states began to adopt the optional Medicaid expansion to offer Medicaid to working-age adults earning up to 138% of the federal poverty guidelines. By 2016, 32 states and DC adopted this optional provision. In 2014, additional provisions of the ACA also were in place. Notably, an individual mandate which required individuals who could afford health insurance coverage to have insurance (or face a penalty) began in 2014. And, the health insurance marketplaces opened for 2014 enrollment, which included tax credit subsidies available to households under 400% of the federal poverty guidelines.[2]

Much of the prior literature has found that increased access to health insurance (or increased generosity of health insurance) *increases* BMI. For example, Bhattacharya and Sood (2011), using data from the RAND Health Insurance Experiment, and Klick and Stratmann (2007), examining the introduction of state mandates to cover diabetes care between 1981 and 2001, both find that the introduction of health insurance (or a mandate requiring that health insurance cover diabetic care) leads to an increase in BMI.
Kelly and Markowitz (2009-2010) use BRFSS data from 1993 to 2002 and address concerns about the endogeneity of health insurance coverage using the distribution of firm size in a state to instrument for the presence of health insurance. Among employed adults who did not visit the doctor in the past year, they found that gaining health insurance is associated with an increase in BMI similar in magnitude to the declines described below (following Massachusetts health care reform and the ACA dependent coverage mandate). Interestingly, Kelly and Markowitz (2009-2010) document that these increases are concentrated around the "overweight" portion of the distribution of BMI—showing an increase in the likelihood a respondent is overweight and no change in the likelihood of obesity.

In contrast, studies of more recent reforms document either modest declines in BMI or no change in BMI. Evidence from Massachusetts health care reform and the ACA dependent

[2] In states that did not expand Medicaid, these subsidies are available to households between 100-400% of the federal poverty guidelines. In Medicaid expansion states, they are available to households between 138-400% of the federal poverty guidelines.

coverage mandate shows a reduction in BMI and the likelihood of obesity after gaining health insurance. When examining the effects among all Massachusetts adults following Massachusetts health care reform, Courtemanche and Zapata (2014) document BMI reductions between -0.08 and -0.22, which correspond to weight loss reductions between 0.5-1.5 pounds for adult males and females of average weight and height. Evidence from instrumental variables analysis suggests that BMI fell among those who gained health insurance following Massachusetts health care reform. We extend their analysis by testing whether the effects were larger for individuals with higher BMI.

In addition to these documented declines in BMI following Massachusetts health care reform, evidence regarding the ACA dependent coverage mandate shows similarly sized reductions in BMI for all young adults, as well as lower likelihood of obesity. Barbaresco et al. (2015) document a 1.4 percentage point reduction in the likelihood of obesity. Given that 22.2 percent of the treatment group is obese in the pre period, this is a reduction of *nearly six percent*. This finding of dramatic reductions in the incidence of obesity provides the first evidence that the reductions in BMI arising from this private insurance expansion are concentrated among those most at risk. We extend this by testing for reductions in Class II/severe obesity (BMI> = 35) arising from all three of the expansions studied in this paper, and by presenting evidence from unconditional quantile regression to pinpoint which individuals are experiencing the reductions in BMI.

However, evidence from two other recent reforms—the Oregon Medicaid expansion and the 2014 provisions of the Affordable Care Act—shows no change in BMI or obesity. For example, Baicker et al. (2013) examine the effects of the 2008 Oregon Medicaid expansion which extended Medicaid to approximately 10,000 low-income working age adults in the state. Although the authors document that Medicaid coverage increased the use of preventive services, they find no evidence of changes in obesity.

Two recent papers examine the effects of the ACA on BMI. Though neither paper finds statistically significant evidence of the ACA leading to a reduction in BMI (or obesity) in an OLS or LPM setting, we will examine more recent years and examine additional points along the distribution of BMI. Simon et al. (2017) use BRFSS data from 2010 through 2015 to examine the effects of the ACA Medicaid expansions on access to care, preventive care, and health behaviors. Although they document robust evidence of increased access to care following these expansions, they find no evidence of changes in the weight-related health behaviors of exercise, BMI, or obesity.

Courtemanche et al. (2018) use 2011 to 2015 BRFSS data to examine the full effects of the ACA and the effects of the Medicaid expansion separately. Although the coefficient estimates are never statistically significant, the signs are consistently negative, which would be consistent with BMI falling as a result of the ACA.[3] Their instrumental variables approach finds a BMI reduction that is not statistically significant but only slightly smaller than the estimates found in prior work for Massachusetts health care reform and the ACA dependent coverage mandate (-0.198).

Although these papers find no evidence of a statistically significant effect of the ACA on the conditional mean BMI, we will examine whether the ACA impacted BMI at different points in the distribution of BMI. We also extend the BRFSS sample an additional year—through 2016—to confirm that there is no effect in these weight-related behaviors over a longer post period.

[3] The average respondent experienced a (not statistically significant) reduction of 0.026 in BMI from the full ACA. That is, respondents who live in states with the average rate of uninsurance in the pre period (20.2%) experienced a reduction of 0.026. Respondents in states with higher uninsurance were estimated to experience larger reductions following the ACA (though not statistically significant).

3. Data and Empirical Approach

To examine whether the effect of health insurance expansions on weight related outcomes differs across the distribution of BMI, we use the Behavioral Risk Factor Surveillance System (BRFSS), an ongoing telephone health survey conducted by the Centers for Disease Control and Prevention (CDC). We examine the years 2001 through 2016. The survey consists of a core component which is asked in every state, each year, which includes key questions related to self-reported BMI and health insurance. Appendix Table A1 shows the mean values of the dependent and independent variables used in these analyses. With the BRFSS data, we estimate the distributional impact of the three health insurance expansions using the samples and specifications described in turn below.

3.1. OLS and LPM Models of the Effect of Health Care Reform on BMI and Obesity

3.1.1. 2006 Massachusetts Health Care Reform

To examine the effects of Massachusetts health care reform on BMI across the distribution, we restrict the BRFSS to the years 2001 through 2009, to end before the ACA. We exclude four states that implemented some form of health care reform or enacted a significant Medicaid expansion during this time period: California, Maine, Oregon, and Vermont (see Courtemanche and Zapata, 2014). We also restrict the sample to adults ages 18 to 64.

We estimate the following regression:

$$Y_{ist} = \gamma_0 + \gamma_1 MA_s * (Post\ \ 2006\ \ Q3_t) + \Pi X_{ist} + \theta_s + \theta_t + \varepsilon_{ist} \qquad (1)$$

where Y reflects BMI, and in linear probability models we also examine the likelihood a respondent is overweight or obese, obese, or severely obese. MA health reform first began to be implemented in July 2006, so we describe the post period as beginning in Q3 2006.[4] The early part of the reform continued from July 2006 through June 2007, which included the expansion of *MassHealth* and the subsidies for *CommCare*. Beginning in July 2007, the individual mandate is in place and all reforms have been implemented. If Massachusetts health care reform reduced BMI, we would expect to find a negative coefficient estimate for γ_1.

The vector X contains individual and demographic characteristics that impact the likelihood an individual has health insurance or receives healthcare, following the previously published literature on Massachusetts healthcare reform. This includes personal characteristics such as age (in five year categories), sex, marital status, race and ethnicity, educational attainment, household income, educational attainment, an indicator for student status, and an indicator for unemployed, indicators for the number of children in the household under the age of 18 (5 or more is the omitted category), and, for female respondents, an indicator for pregnancy. The vector X also includes the annual state unemployment rate. We also include time fixed effects to capture aggregate changes over time by quarter and year (e.g., Q3 of 2006, the first quarter of MA health reform implementation), and state fixed effects to capture permanent differences across states.

We examine whether the pre period trends differ in Massachusetts versus other states. In Fig. 1a, we present average BMI over

[4] This is similar to the approach in Sommers et al. (2014) and Kaestner (2016) who define the post period for MA health care reform to begin in 2007. There are only 11,331 MA observations in what many authors refer to as the "implementation" or "during" period (7/06-6/07). So in our preferred specification we include only one pooled post period in our analysis of MA health care reform to increase the number of observations for MA in the post period for the different quantiles of BMI. We also present robustness checks with separate "implementation" and "post" periods.

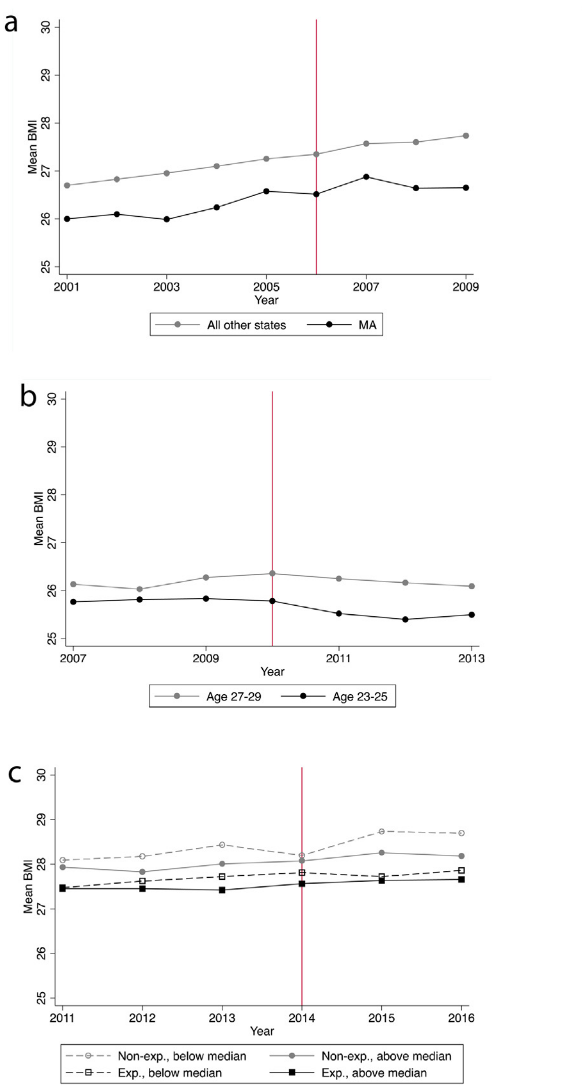

Fig. 1. (1a) Trends in BMI in Massachusetts and Comparison States (2001-2009), Adults ages 18-64.
BRFSS sample weights are used.
(1b) Trends in BMI Among Young Adults (2007-2013), Ages 23-25 & Ages 27-29.
(1c) Trends in BMI by State Medicaid Expansion Status and Local Area Pretreatment Uninsurance Rate, Ages 18-64 (2011-2016).
BRFSS sample weights are used.

time for Massachusetts residents relative to average BMI for residents in all other states and note that BMI was increasing slightly over this period in both MA and the comparison states. BMI was tracking similarly in the years prior to MA health care reform (2001 through 2005), but beginning in 2007, BMI in MA stopped rising while BMI continued to rise in the comparison states. We also formally test whether the pre trends were parallel with an event study specification, described below.

3.1.2. 2010 ACA Dependent Coverage Mandate

To estimate the effects of this mandate which allowed young adults to remain on their parent's private employer sponsored insurance until the age of 26, we use BRFSS data from 2007 through 2013. (We exclude the years 2014 and beyond, when the majority of the ACA Medicaid expansions were implemented.) We restrict the sample to young adults ages 23 through 25, who are impacted by the mandate, as well as adults ages 27 through 29, who are too old to benefit from the mandate (as in Barbaresco et al., 2015 and Antwi et al., 2013). We exclude 26 year olds since they could not be clearly assigned to the treatment or control group.

We estimate the following regression:

$$\begin{aligned} Y_{ist} &= \gamma_0 + \gamma_1 Age2325_i + \gamma_2 Post2010_t \\ &\quad + \gamma_3 Age2325_i {*} Post2010_t + \Gamma X_{ist} + \theta_s + \theta_t + \varepsilon_{ist}. \end{aligned} \tag{2}$$

The control variables in the vector X are the same as in our estimates of the effect of Massachusetts health reform described above, with three exceptions. First, we include single year of age fixed effects (in place of five year age categories). Second, beginning in 2005, the BRFSS began to publish information about whether or not the respondent lived in an MSA. So we now add controls for residence in the center city of an MSA, residence in an MSA but not in the center city, and the omitted category, which is those who do not live in an MSA. In 2011, the BRFSS began to reach respondents via cell phone, not exclusively through a landline, so we also include an indicator for cell phone respondents. This variable takes on the value of 0 for all respondents in the years 2007 to 2010. Similar to our estimates for Massachusetts health care reform, we also control for sex, race, marital status, educational attainment, household income, student status, unemployed status, indicators for number of children under 18 in the house, an indicator for pregnancy for female respondents, the state unemployment rate, as well as year by quarter fixed effects and state fixed effects.

We examine the pre period trends for BMI in Fig. 1b and note that BMI was roughly flat for the two age groups throughout the period, but there was a slight decline (0.3) among 23–25 year olds after the ACA dependent coverage mandate (from 25.8 to 25.5) whereas BMI was roughly the same in 2007 and 2013 for adults ages 27-29 (approximately 26.1). As with the Massachusetts health care reform, we also formally test whether the pre period trends were parallel with an event study approach, described below.

3.1.3. Affordable Care Act (ACA)

To examine the effects of the 2014 Affordable Care Act (ACA), we now examine the BRFSS data from 2011 through 2016 for all adults ages 18 to 64. We present results from DDD models that leverage the variation in uninsurance rates in the pre period across states (following Courtemanche et al., 2017 and 2018).[5] This approach makes the assumption that the "dose" of the ACA treatment will be higher in areas that had higher uninsurance rates in the area in the pre period year of 2013. Then the DDD model is:

$$\begin{aligned} Y_{ist} &= \alpha_0 + \alpha_1 (2013Unins_{as} \times Post_t) + \alpha_2 (Expand_s \times Post_t) \\ &\quad + \alpha_3 (2013Unins_{as} \times Expand_s \times Post_t) + \ \Gamma X_{ist} + \theta_{as} + \theta_t \\ &\quad + \varepsilon_{ist} \end{aligned} \tag{3}$$

where *2013unins* is the local uninsurance rate in 2013, the year prior to ACA implementation. With the BRFSS, we identify three areas within a state: residence in the center city of an MSA, residence in a MSA but not in the center city, and residence in the rest of the state. No sub-state location information is collected for cell phone respondents, so following Courtemanche et al. (2018), we construct a fourth area: the cell phone sample in a state. Using the BRFSS data, we then construct a measure of uninsurance in 2013 within each state for each of these four types of geography (center city MSA, rest of MSA, not MSA, and cell phone sample).

Expand takes on the value of one for all states that expanded Medicaid in 2014 or later, as shown in Appendix

[5] This approach is also similar to Duggan et al. (2019), but does not separately consider the percent uninsured at different income levels, as well as Finkelstein (2007) and Miller (2012).

Table A2. *Post* is a dummy variable equal to 1 both for sample respondents living in non-expansion states in 2014 and later and for sample respondents living in expansion states in the year of expansion or later; for all other observations, *Post* is equal to 0.[6] The vector *X* includes the same variables as in the analysis of the ACA dependent coverage mandate; however, we use five-year age categories rather than single year dummies.

Following Courtemanche et al. (2017, 2018), we provide descriptive evidence by showing time trends in BMI for four groups: whether the area is in an expansion or non-expansion state and by whether the area had uninsurance rates above or below the median in the pre period. In Fig. 1c, we see that BMI was rising for all four groups during the study period. Although there is no obvious difference in trends post-2014 in expansion states or in areas with higher uninsurance rates in the pre period, the trends for the four groups appear roughly parallel in the pre period. We will formally test this with an event study specification.

3.2. Unconditional quantile regression effects of health care reforms on BMI

We also examine whether there are reductions in BMI throughout the distribution by estimating unconditional quantile regressions, as introduced by Firpo et al. (2009), and used in the context of health outcomes (see, e.g., Borah and Basu, 2013; Jolliffe, 2011; Maclean et al., 2014a,b; and Slade, 2017). This tool is especially powerful for estimating the effect of state policy, as Maclean et al. (2014a) show. This is because with unconditional quantile regression, researchers can uncover the effect of the policy of interest at different points on the *unconditional* BMI distribution (rather than the effect of the policy change at a particular point on the distribution of BMI conditional on all of the covariates, as in conditional quantile regression). For example, we can identify the effect of the ACA dependent coverage mandate on young adults at the 90th percentile of the distribution of BMI (or a BMI of 34.0).

Unconditional quantile regression, as proposed by Firpo et al. (2009), uses an influence function (IF) and a recentered influence function (RIF). In general, an influence function measures the effect of an observation on a given statistic. For quantile regression, the IF for quantile τ is given by $IF(y;q_\tau) = (\tau - I\{Y \leq q_\tau\})/f_Y(q_\tau)$ where q_τ is the corresponding quantile of the unconditional distribution and $f_Y(q_\tau)$ is the probability density function of *Y* at quantile τ, and *I{.}* is the indicator function. The recentered influence function is the sum of the influence function and the statistic of interest. So, for quantile regression, the recentered influence function is given by the sum of the quantile of the unconditional distribution of Y and the influence function at that quantile: $RIF(y;q_\tau) = q_\tau + IF(y;q_\tau)$. Then as Firpo et al. (2009) show, the marginal effects of unconditional quantile regression are obtained from an OLS regression of $RIF(y;q_\tau)$ on the explanatory variables. For example, to estimate the unconditional quantile regression for Massachusetts health care reform, we estimate the following in OLS:

$$RIF(BMI,\tau) = \gamma_0^{UQR} + \gamma_1^{UQR} MA_s * (Post\ 2006\ Q3_t) + \Pi^{UQR} X_{ist} + \theta_s^{UQR} + \theta_t^{UQR} + \varepsilon_{ist} \quad (4)$$

For the other two reforms, we similarly regress the RIF of BMI at a particular quantile on the covariates described above in equations (2) and (3). We bootstrap standard errors (50 replications).

[6] For states that expanded Medicaid prior to 2014, we code *Post* to be zero in the years prior to 2014. This is because interviews with state Medicaid officials showed that early expansions built on existing state programs and thus were not as large as the 2014 (and later) Medicaid expansions (Sommers et al., 2013).

4. Results

4.1. Massachusetts health care reform

In Table 1, we present evidence of the three health care reforms on BMI. In Panel A, we present DD results describing the effect of Massachusetts health care reform. We first confirm that we match prior work examining the effect of Massachusetts health care reform. Indeed, in column (1), we show that Massachusetts health care resulted in a 4.2 percentage point increase in the likelihood of having health insurance, which is similar to Courtemanche et al. (2014). In column (2), we show that BMI in Massachusetts falls by 0.206 following the reform, which is also similar to previously published estimates. We note that this modest reduction in BMI corresponds to roughly 1.2-1.4 pounds lost for the average U.S. adult.

In columns (3) through (5) we present what we believe to be the first evidence of the effect of Massachusetts health care reform on weight-related outcomes for respondents at different points in the distribution of BMI. We present evidence from linear probability models predicting the likelihood a respondent is overweight or obese (BMI> = 25), obese (BMI> = 30), or severely obese (BMI> = 35). In each case, we find that Massachusetts health care reform resulted in approximately a one percentage point reduction in the likelihood of each of these weight-related outcomes. The effects as a percentage of the pre period means are largest at higher levels of BMI. Following Massachusetts health care reform, respondents are 1.6 percent less likely to be overweight or obese and 7 percent less likely to be obese. The largest effect is observed in column (5), for severe obesity, where we document a decline of 15 percent. In Fig. 2a, we present results from unconditional quantile regression. The solid line reflects the coefficient estimate corresponding to the 5th, 10th, 15th, through the 99th unconditional quantile regression surrounded by the 95% confidence interval. As shown in Appendix Table A3, in Massachusetts during the pre period, the percentiles in the distribution of BMI most closely corresponding to overweight, obesity, and severe obesity are the 50th percentile (BMI = 25.2, overweight), 85th percentile (BMI = 30.9, obese), and 95th percentile (BMI = 36.0, severe obesity). We note that for Massachusetts residents with BMI at or below the 50th percentile (i.e., not overweight or obese), there is no effect of the reform. But for Massachusetts residents with BMI above the median, there are statistically significant reductions in BMI, and these reductions are larger for individuals with higher BMI. At the 55th percentile of BMI, we document a statistically significant reduction of -0.1. The effects are larger for individuals with higher BMI, and at the 80th percentile, we document a statistically significant reduction of -0.22, and at the 95th percentile we document an even larger, statistically significant reduction of -0.35. These results from unconditional quantile regression show that the biggest reductions in BMI are experienced by the severely obese.

4.2. ACA Dependent Coverage Mandate

In Panel B of Table 1, we examine the effects of the ACA dependent coverage mandate. We confirm prior work in columns (2) and (4) with a reduction in BMI of 0.262 and a 1.9 percentage point decline in the likelihood the respondent is obese (an 8.6 percent reduction). We provide new evidence of dramatic reductions in severe obesity. In column (5), we find that the likelihood a respondent is severely obese falls by 1.4 percentage points, a 17.5 percent reduction in severe obesity. Thus, we show that the previously documented reductions in BMI following the ACA dependent coverage expansion correspond to meaningful

Table 1
Effect of Health Care Reform on Weight-Related Outcomes, OLS and LPM.

	= 1 if have health insurance (1)	BMI (2)	= 1 if overweight or obese (3)	= 1 if obese (4)	= 1 if severely obese (5)
Panel A: Massachusetts health care reform, 2001-2009, ages 18-64					
MA * (Post Q3 2006)	0.042***	−0.206***	−0.009***	−0.014***	−0.009***
	(0.003)	(0.018)	(0.001)	(0.001)	(0.001)
Mean DV (pre, MA)	0.90	26.33	0.55	0.19	0.06
		(5.42)			
N	1,770,643	1,710,513	1,710,513	1,710,513	1,710,513
Panel B: Effect of the dependent coverage mandate, 2007-2013, ages 23-25, 27-29					
Post 2010 x Age 23-25	0.065***	−0.262**	−0.009	−0.019**	−0.014**
	(0.009)	(0.119)	(0.009)	(0.008)	(0.006)
Mean DV (pre, 23-25)	0.68	26.42	0.53	0.22	0.08
		(5.90)			
N	123,758	117,806	117,806	117,806	117,806
Panel C: Effect of the Affordable Care Act, 2011-2016, ages 18-64					
2013 uninsurance x Post	0.238***	0.381	0.009	0.022	0.023
	(0.033)	(0.427)	(0.023)	(0.024)	(0.022)
2013 uninsurance x Post x Expansion	0.128**	0.274	0.012	0.017	0.007
	(0.052)	(0.526)	(0.033)	(0.033)	(0.027)
Implied effects of ACA (at mean uninsurance rate in 2013: 0.21)					
ACA, w/o Med. Exp.	0.050***	0.080	0.002	0.005	0.005
Medicaid expansion	0.027***	0.058	0.003	0.004	0.001
Full ACA (w/ Exp.)	0.077***	0.138	0.004	0.008	0.006
Mean DV (pre, exp.)	0.82	27.66	0.63	0.28	0.11
		(6.22)			
N	1,568,213	1,498,042	1,498,042	1,498,042	1,498,042

Sample weights used. In Panels A and B, standard errors are clustered by state. In Panel C, standard errors are clustered by state x type of area. All regressions also include controls for sex, marital status, race/ethnicity, income (<\$10,000, \$10,000-\$15,000, \$15,000-\$20,000, \$20,000-\$25,000, \$25,000-\$35,000, \$35,000-\$50,000, \$50,000-\$75,000, >\$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, and state unemployment rate. Panels A and C include controls for five year age categories and Panel B includes single year of age fixed effects. Panels B and C also include indicators for in cellphone sample (beginning 2011), residence in center city, and residence in MSA (residence outside of MSA is omitted). The regressions also include year by quarter fixed effects and Panels A and B include state fixed effects and Panel C includes state x type of area fixed effects. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

improvements in weight-related health outcomes for those with the worst weight-related health outcomes.

In Fig. 2b, we present results from quantile regression. The distribution of BMI among young adults ages 23 through 25 in the pre period is similar to that described for Massachusetts, above. The median individual is overweight (BMI = 25.1), individuals with BMI above the 80^{th} percentile (BMI = 30.6) are obese, and individuals with BMI slightly above the 90^{th} percentile (BMI = 34.0) are severely obese. Although we observe a decline in BMI at both the bottom and top of the distribution, the reductions are larger for individuals with higher BMI. We document statistically significant declines of approximately -0.13 to -0.21 between the 5^{th} and 35^{th} percentiles, as well as similar reductions at the 55^{th} through 65^{th} percentiles, but reductions of between -0.26 and -0.37 from the 70^{th} (BMI = 28.4) through the 85^{th} (BMI = 32.0) percentiles. And for adults who are severely obese (i.e., above the 90^{th} percentile), we document the largest reductions in BMI of -0.48 or larger. Thus, even though there are declines throughout the distribution of BMI following the ACA dependent coverage mandate, the largest declines are accruing to those who are severely obese.

4.3. Affordable Care Act

In Panel C of Table 1, we present results from the ACA. We consider the ACA without the Medicaid expansion, shown by the coefficient estimates in the first row of Panel A. None of the coefficient estimates corresponding to weight-related outcomes are statistically significant, and they are all positive. We find no evidence that the ACA, without the Medicaid expansion, reduced BMI or improved other weight-related outcomes. In the second row of Panel A, we examine the coefficient estimate corresponding to the effect of the Medicaid expansion. Again, none of the coefficient estimates related to weight-related outcomes are statistically significant, and they are all positive. Because we are multiplying a *Post* and an *Expansion* indicator by the 2013 uninsurance rate, to get the estimated effect we must multiply these coefficient estimates by the mean uninsurance rate in 2013 (0.21), shown at the bottom of Panel C. Even if these were statistically significant relationships, the magnitudes of these coefficient estimates are much smaller than the magnitudes presented for Massachusetts health care reform or the ACA dependent coverage mandate. The fifth row of Panel C presents the implied effect of the full ACA (which is the sum of the implied effect for the ACA without the Medicaid expansion and the implied effect for the ACA Medicaid expansion).

Even though we find no evidence of improved weight-related outcomes in the OLS or LPM context following the ACA, evidence from unconditional quantile regression in Fig. 2d suggests that there are reductions in BMI for the severely obese following the ACA Medicaid

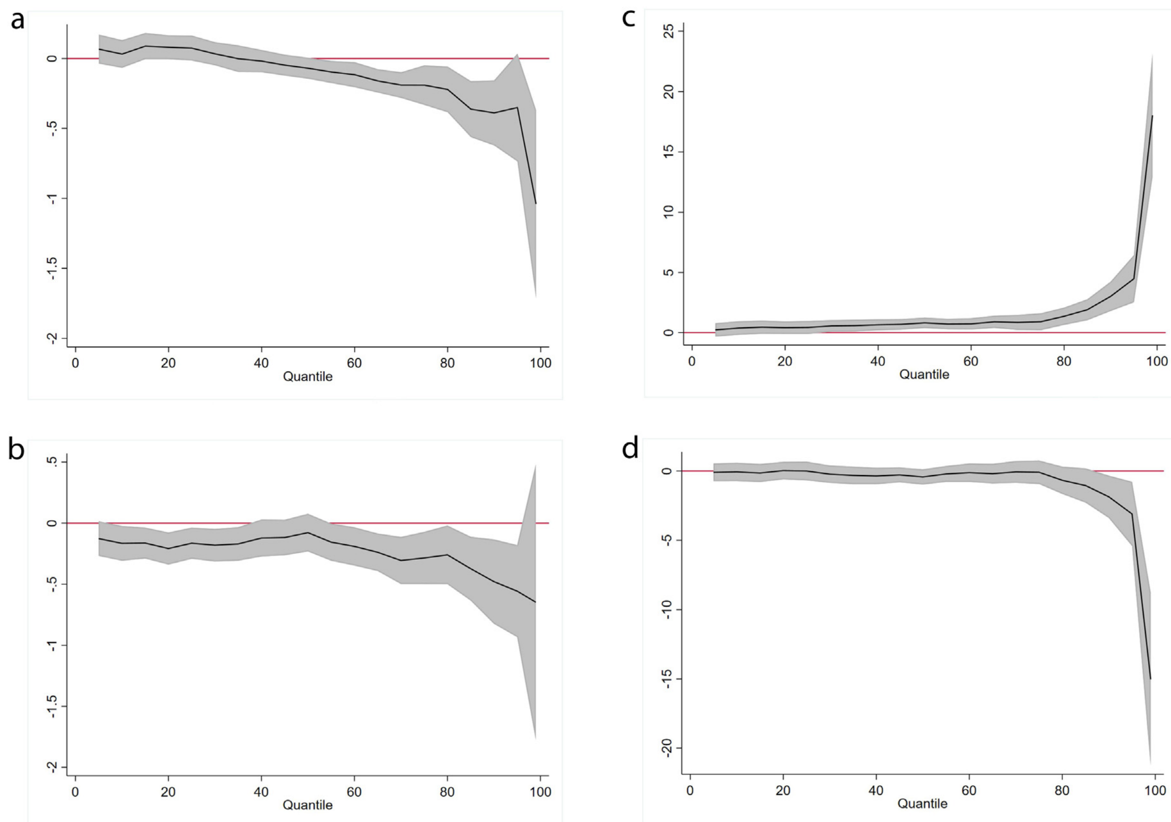

Fig. 2. (2a) Effect of Massachusetts Health Care Reform on BMI.
Coefficient estimate for MA*(Post Q3 2006) presented.
(2b) Effect of Dependent Coverage Mandate on BMI.
Coefficient estimate for Age2325*Post2010 presented.
(2c) Effect of ACA Excluding Medicaid Expansions in BMI.
Coefficient estimate for Post*Unins2013 presented.
(2d) Effect of ACA Medicaid Expansion on BMI.
Coefficient estimate for Post*Expansion*Unins13 presented.
Unconditional quantile regression results for BMI at the 5th through 99th quantiles and the 95% confidence interval with bootstrapped standard errors (50 replications).

expansions.[7] Specifically, the implied effect of the ACA Medicaid expansions is a reduction of -3.2 for those at the 99th percentile of BMI (BMI = 48.1), and a reduction of -0.39 at the 90th percentile of BMI (BMI = 35.4), which is on par with the reductions observed following Massachusetts health care reform and the ACA dependent coverage mandate. This suggests that even though the ACA Medicaid expansions did not lead to reductions in BMI at the conditional mean or in the likelihood of severe obesity, it did lead to reductions in BMI among the severely obese that are even larger than what was observed following Massachusetts health care reform and the ACA dependent coverage mandate.

Together these results show that the modest reductions in BMI previously documented following Massachusetts health care reform and the ACA dependent coverage mandate indeed correspond to weight loss for individuals with BMI at the high end of the distribution—those individuals who are overweight, obese, or severely obese. Results from the ACA show that even though there are no apparent reductions in BMI or improvements in weight related health, on average, the Medicaid expansions did result in meaningful declines in BMI for individuals who are severely obese. We now probe the parallel trends assumption by presenting results from an event study and present additional key robustness checks.

4.4. Robustness checks

We test the parallel trends assumption formally with an event study framework. For Massachusetts health care reform, we estimate the following regression:

$$Y_{ist} = \gamma_0 + \sum_{t=2001,\ t\neq 2005}^{2009} \gamma_t MA_s * (Year = t)_t + \Pi X_{ist} + \theta_s + \theta_t + \varepsilon_{ist}. \quad (5)$$

The coefficient estimates γ_t for the outcome BMI are presented in Fig. 3a, and the coefficient estimates for all other outcomes are in Appendix Table A4. The coefficient estimates presented in Fig. 3a show that the declines in BMI post-2006 were generally larger in magnitude than the declines from before 2006, but we cannot rule out that there were different pre period trends in Massachusetts versus the other states. For this reason, our preferred specification is a synthetic control analysis, described below.

[7] There is no effect on BMI for the ACA excluding the Medicaid expansion (Fig. 2c).

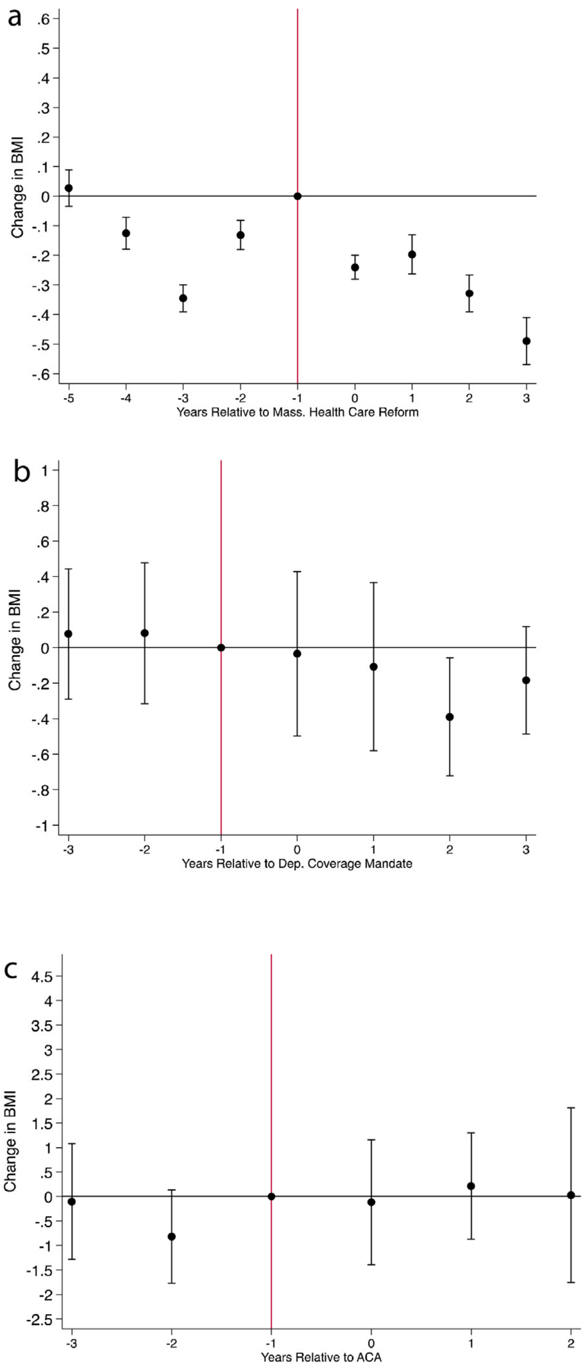

Fig. 3. (3a) Event study estimates, effect of Massachusetts health care reform on BMI, Adults ages 18-64, 2001-2009.
(3b) Event study estimates, effect of dependent coverage mandate on BMI, Ages 23-25 and 27-29, 2007-2013.
(3c) Event study estimates, effect of ACA (excluding Medicaid expansion) on BMI, Age 18-64, 2011-2016.
(3d) Event study estimates, effect of ACA Medicaid expansion on BMI, Age 18-64, 2011-2016.
Sample weights used.

For the ACA dependent coverage mandate, we estimate the following event study regression:

$$Y_{ist} = \gamma_0 + \gamma_1 Age2325_i + \sum_{t=2007,\ t\neq 2009}^{2013} \gamma_t Age2325_i * (Year = t)_t + \Gamma X_{ist} + \theta_s + \theta_t + \varepsilon_{ist}. \quad (6)$$

The event study coefficients for BMI are presented in Fig. 3b, and for all outcomes in Appendix Table A5. The event study coefficients confirm that the parallel trends assumption is satisfied; coefficient estimates are much closer to zero in the pre-2011 years.

We also present event study coefficient estimates for the 2014 provisions of the ACA by estimating the following regression:

$$\begin{aligned} Y_{ist} = \alpha_0 &+ \sum_{t=2011,\ t\neq 2013}^{2016} \alpha_t (2013Unins_{as} \times (Year = t)_t) \\ &+ \sum_{t=2011,\ t\neq 2013}^{2016} \delta_t (Expand_s \times (Year = t)_t) \\ &+ \sum_{t=2011,\ t\neq 2013}^{2016} \lambda_t (2013Unins_{as} \times Expand_s \times (Year = t)_t) \\ &+ \Gamma X_{ist} + \theta_{as} + \theta_t + \varepsilon_{ist}. \end{aligned} \quad (7)$$

We present estimates of the α coefficient estimates in Fig. 3c; these coefficient estimates reflect the effect of the ACA excluding the Medicaid expansion. And the estimates of the λ coefficient estimates are presented in Fig. 3d; these coefficient estimates reflect the effect of the ACA Medicaid expansion. In neither case do we find consistent evidence of statistically significant differences in the pre-trends. The event study coefficient estimates for all outcomes are presented in Appendix Table A6.

We also test the robustness of our findings from OLS and LPM models in Tables 2 through Table 4. We may be concerned that the effects we find at the top of the distribution of BMI are due to outliers that reflect measurement error. To address this, we examine the sensitivity of the OLS and LPM results to excluding respondents whose BMI is in the top percentile. We also present unweighted results that do not use the BRFSS sample weights in order to show that our conclusions are similar regardless of whether we use sample weights or not, which is important because the unconditional quantile regression results are unweighted. We examine the robustness of each of our findings to the inclusion of state-specific time trends, and in each case we also present some robustness checks that are especially meaningful to the particular reform, described in full below.

We begin with Massachusetts health care reform in Table 2. In Panel A, we reproduce the baseline results for this health insurance expansion. In Panel B, we show that the results are not driven by measurement error because our findings are similar even when we exclude respondents with BMI in the top percentile (BMI> = 46.4). In Panels C and D, we show that the results for BMI, obesity, and severe obesity are robust to decisions about weighting and the inclusion of state-specific time trends, though we acknowledge that the estimated reduction in the likelihood of being either overweight or obese is sensitive to these modeling decisions. However, our main conclusions of a reduction in BMI and lower likelihood of being obese or severely obese are upheld.

We also examine some robustness checks specific to the Massachusetts expansion. First, several studies separately examine the effects of Massachusetts health care reform during the period it was implemented (Q3 2006 through Q2 2007) and once it was fully in place (beginning Q3 2007) (see, e.g., Miller, 2012; Kolstad and Kowalski, 2012; Courtemanche and Zapata, 2014). Since we rely on quantile regression and there are only 11,331 survey respondents in Massachusetts in what many authors refer to as the "implementation" or "during" period, our preferred specification includes a single pooled post period in order to increase the number of observations for MA in the post period for the different quantiles of BMI. In Panel E, we show that the results for BMI, obesity, and severe obesity are robust to modeling separate "implementation" and "post" periods.

Table 2
Robustness Checks, Effects of Massachusetts Health Care Reform on Weight-Related Outcomes, Distributional Effects, 2001-2009, ages 18-64.

	= 1 if have health insurance (1)	BMI (2)	= 1 if overweight or obese (3)	= 1 if obese (4)	= 1 if severely obese (5)
Panel A: Baseline Results					
MA * (Post Q3 2006)	0.042***	−0.206***	−0.009***	−0.014***	−0.009***
	(0.003)	(0.018)	(0.001)	(0.001)	(0.001)
N	1,770,643	1,710,513	1,710,513	1,710,513	1,710,513
Panel B: Drop Top Percentile of BMI					
MA * (Post Q3 2006)	0.042***	−0.132***	−0.008***	−0.012***	−0.006***
	(0.003)	(0.016)	(0.001)	(0.001)	(0.001)
N	1,687,953	1,690,292	1,690,292	1,690,292	1,690,292
Panel C: Unweighted DD results					
MA * (Post Q3 2006)	0.039***	−0.115***	−0.001	−0.009***	−0.007***
	(0.001)	(0.021)	(0.001)	(0.002)	(0.001)
N	1,770,643	1,710,513	1,710,513	1,710,513	1,710,513
Panel D: State-specific time trends					
MA * Post Q3 2006	0.027***	−0.081***	0.012***	−0.014***	−0.007***
	(0.003)	(0.028)	(0.002)	(0.003)	(0.002)
N	1,770,643	1,710,513	1,710,513	1,710,513	1,710,513
Panel E: Separate Implementation and Post Periods					
MA * (Q3 2006 – Q2 2007)	0.018***	−0.118***	0.002	−0.013***	−0.008***
	(0.003)	(0.029)	(0.002)	(0.002)	(0.002)
MA * (Post Q3 2007)	0.051***	−0.239***	−0.013***	−0.014***	−0.010***
	(0.003)	(0.024)	(0.002)	(0.002)	(0.001)
N	1,770,643	1,710,513	1,710,513	1,710,513	1,710,513
Panel F: Synthetic control					
MA * (Post Q3 2006)	0.040***	−0.098*	−0.007**	−0.002	−0.004
	(0.001)	(0.047)	(0.002)	(0.004)	(0.003)
N	259,099	248,683	248,683	248,683	248,683
Panel G: Randomization inference					
p-value	0.000	0.109	0.152	0.152	0.087

Sample weights are used in Panels A-B and D-G. Standard errors clustered by state in parentheses. Regressions also include controls for five year age groups, sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, and state unemployment rate. The regressions also include state fixed effects and year by quarter fixed effects. In Panel F, the synthetic inference, the following states comprise the synthetic control group: DC (13.1%), NJ (30.1%), RI (47.6%), TX (1.6%), and UT (7.7%). * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Our preferred robustness check for Massachusetts health care reform is presented in Panel F, in which we present results using a synthetic control group. We adapt the approach in Abadie et al. (2010) presented for aggregate data for individual data by collapsing our individual data to the state and quarter level and constructing a synthetic control group based on this aggregate data. We then multiply the synthetic weight by the BRFSS sampling weights as in Fitzpatrick (2008) and Courtemanche and Zapata (2014). These results are shown in Panel F. Though the estimates are noisier, the coefficient estimates are similar (for column (5), severe obesity, $p = 0.199$). Finally, because of concerns that the standard errors from our DD estimates might be too small with only one treatment state, in Panel G we present p-values from randomization inference, adapted from Kaestner (2016). To conduct this randomization inference, we assign a placebo “treatment” to each of the 46 states in our sample other than Massachusetts. For columns (2) through (5), the randomization inference p-value is the fraction of these iterations for which the effect of the placebo “treatment state” is more negative than the effect for Massachusetts.[8] We note that p < 0.10 for BMI and severe obesity, and the coefficient estimates are marginally significant for overweight/obese (p = 0.152) and obesity (p = 0.152). We interpret these robustness checks as providing support for the reduction in BMI at the conditional mean and for a lower likelihood a respondent is severely obese, and we acknowledge that the findings for the likelihood of being overweight or obese are more sensitive.

In Appendix Table A7, we present robustness checks for the quantile regression estimates. The baseline quantile regression estimates found statistically significant reductions in BMI from the 55^{th} through 99^{th} percentiles. These reductions throughout the middle of the distribution of BMI are not robust to including state specific time trends, the synthetic control approach, and randomization inference. However, the reductions in BMI we observed at the very top of the distribution (i.e., the 90^{th} percentile and above) are not sensitive to most of these checks. Thus, we interpret the results in Appendix Table A7 as supporting the finding that BMI at the top of the distribution fell following Massachusetts health care reform.

In Table 3, we examine the robustness of our results for the ACA dependent coverage mandate. As shown in Panels B, C and D, the results are robust to dropping observations with BMI above the 99^{th} percentile (45.2) as well as decisions about weighting and the inclusion of state-specific time trends. The dependent coverage mandate was announced in March 2010 and became effective in September 2010 the next time an insurance policy renewed. So in Panel E we drop 2010 from the

[8] For column (1), the likelihood of having health insurance, the p-value is the share of these iterations for which the effect for the placebo “treatment state” is larger than the effect for Massachusetts.

Table 3
Robustness Checks, Effects of Dependent Coverage Mandate, Distributional Effects, 2007-2013, ages 23-25, 27-29.

	(1) = 1 if have health insurance	(2) BMI	(3) = 1 if overweight or obese	(4) = 1 if obese	(5) = 1 if severely obese
Panel A: Baseline Results					
Post 2010 x Age 23-25	0.065***	−0.262**	−0.009	−0.019**	−0.014**
	(0.009)	(0.119)	(0.009)	(0.008)	(0.006)
N	123,758	117,806	117,806	117,806	117,806
Panel B: Drop Top Percentile of BMI					
Post 2010 x Age 23-25	0.062***	−0.237**	−0.008	−0.017**	−0.012**
	(0.009)	(0.108)	(0.009)	(0.007)	(0.005)
N	115,996	116,207	116,207	116,207	116,207
Panel C: Unweighted					
Post 2010 x Age 23-25	0.054***	−0.233***	−0.010	−0.013***	−0.009***
	(0.005)	(0.064)	(0.006)	(0.004)	(0.002)
N	123,758	117,806	117,806	117,806	117,806
Panel D: Include state-specific time trends					
Post 2010 x Age 23-25	0.064***	−0.262**	−0.009	−0.019**	−0.014**
	(0.008)	(0.120)	(0.009)	(0.008)	(0.006)
N	123,758	117,806	117,806	117,806	117,806
Panel E: Exclude 2010					
Post 2010 x Age 23-25	0.066***	−0.282**	−0.012	−0.021*	−0.014**
	(0.008)	(0.133)	(0.010)	(0.011)	(0.007)
N	111,295	105,760	105,760	105,760	105,760
Panel F: Include 19-22 year olds in treatment group					
Post 2010 x Age 19-25	0.058***	−0.324***	−0.010	−0.018**	−0.017***
	(0.008)	(0.092)	(0.008)	(0.008)	(0.004)
N	171,780	164,329	164,329	164,329	164,329
Panel G: (F) + include 18 year olds in control group					
Post 2010 x Age 19-25	0.059***	−0.371***	−0.019**	−0.019**	−0.016***
	(0.008)	(0.088)	(0.008)	(0.007)	(0.003)
N	182,647	175,261	175,261	175,261	175,261

Sample weights are used in Panels A-B and D-G. Standard errors clustered by state in parentheses. Regressions also include controls for single year of age, sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, in cellphone sample (beginning 2011), residence in center city, residence in MSA (residence outside of MSA is omitted), and state unemployment rate. The regressions also include state fixed effects and year by quarter fixed effects. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

analysis altogether and continue to find statistically significant reductions in BMI, obesity, and severe obesity. The results are also robust to expanding the treatment group to include 19 through 22 year olds (Panel F). As an additional check, we expand the comparison group to include 18 year olds, as in Antwi et al. (2013), to capture the decline of employer coverage for dependents (see Vistnes et al., 2012). In Panel G, we show that our results are robust to the inclusion of 18 year olds in the comparison group. In Appendix Table A8, we present results from robustness checks of the quantile regression results and show that the finding of large declines in BMI for those with BMI above the 60th percentile (BMI = 26.6) are robust to including state-specific time trends, excluding the year 2010 which cannot be easily assigned to the pre or post period, and expanding ages included in the treatment and comparison groups. We continue to find large, statistically significant reductions in BMI at the top of the distribution of BMI.

Our baseline findings found no effect of the ACA on weight-related outcomes in the OLS and LPM results. In Table 4 we show that we continue to find no reduction in BMI in the OLS or LPM context, including when we exclude respondents residing in expansion states that expanded Medicaid after January 2014 (Panel E)[9] or when we drop respondents who were in the cell phone sample (Panel F). When we estimated unconditional quantile regressions, however, we observed statistically significant declines in BMI following the Medicaid expansions for severely obese individuals at the top of the distribution of BMI (BMI> = 35.4, the 90th percentile). In Appendix Table A9 we present robustness checks of the unconditional quantile regressions and find that the declines in BMI at the top of the distribution are robust to including state specific time trends and dropping respondents residing in states that expanded Medicaid after 2014. This result is not robust to excluding respondents who were part of the cell phone sample. Together, we interpret these robustness checks as supporting the baseline result that the ACA Medicaid expansions led to reductions in BMI for severely obese individuals.

5. Mechanisms

It is important to understand the mechanisms driving the reductions in BMI and severe obesity we observe following these three health insurance expansions. We are especially interested in examining mechanisms that lead to weight loss among those who are severely obese. According to the American Heart Association, there are four ways in which individuals with “extreme obesity” can lose weight. These include 1) reducing caloric intake, 2) increasing physical activity (once the individual has reached 10% of the weight loss goal), 3) medication, and 4) surgery (for those who are healthy enough

[9] These states are Alaska, Indiana, Louisiana, Michigan, Montana, New Hampshire, and Pennsylvania.

Table 4
Robustness Checks, Effect of the Affordable Care Act, Distributional Effects, 2011-2016, ages 18-64.

	= 1 if have health insurance (1)	BMI (2)	= 1 if overweight or obese (3)	= 1 if obese (4)	= 1 if severely obese (5)
Panel A: Baseline					
2013 uninsurance x Post	0.238***	0.381	0.009	0.022	0.023
	(0.033)	(0.427)	(0.023)	(0.024)	(0.022)
2013 uninsurance x Post x Expansion	0.128**	0.274	0.012	0.017	0.007
	(0.052)	(0.526)	(0.033)	(0.033)	(0.027)
N	1,568,213	1,498,042	1,498,042	1,498,042	1,498,042
Panel B: Drop Top Percentile of BMI					
2013 uninsurance x Post	0.243***	0.200	0.009	0.022	0.022
	(0.030)	(0.366)	(0.023)	(0.024)	(0.018)
2013 uninsurance x Post x Expansion	0.128**	0.313	0.009	0.014	0.002
	(0.051)	(0.473)	(0.033)	(0.033)	(0.024)
N	1,478,322	1,481,326	1,481,326	1,481,326	1,481,326
Panel C: Unweighted					
2013 uninsurance x Post	0.237***	1.875**	0.042**	0.045**	0.0252***
	(0.018)	(0.932)	(0.019)	(0.020)	(0.016)
2013 uninsurance x Post x Expansion	0.139***	−1.216	−0.022	−0.003	−0.025
	(0.032)	(0.952)	(0.026)	(0.026)	(0.020)
N	1,568,213	1,498,042	1,498,042	1,498,042	1,498,042
Panel D: State-Specific Time Trends					
2013 uninsurance x Post	0.241***	0.730*	−0.014	0.019	0.055***
	(0.035)	(0.416)	(0.033)	(0.028)	(0.021)
2013 uninsurance x Post x Expansion	0.040	−0.214	0.020	0.003	−0.035
	(0.037)	(0.542)	(0.042)	(0.034)	(0.027)
N	1,568,213	1,498,042	1,498,042	1,498,042	1,498,042
Panel E: Drop Late Adopters					
2013 uninsurance x Post	0.237***	0.382	0.009	0.024	0.023
	(0.032)	(0.434)	(0.023)	(0.025)	(0.022)
2013 uninsurance x Post x Expansion	0.137**	0.438	0.021	0.028	0.010
	(0.056)	(0.539)	(0.034)	(0.033)	(0.028)
N	1,375,916	1,313,469	1,313,469	1,313,469	1,313,469
Panel F: Drop Cell Phone Sample					
2013 uninsurance x Post	0.277***	1.007*	0.106***	0.064	0.017
	(0.043)	(0.522)	(0.035)	(0.040)	(0.055)
2013 uninsurance x Post x Expansion	0.120*	−0.709	−0.094	−0.055	0.019
	(0.072)	(0.798)	(0.059)	(0.059)	(0.065)
N	953,984	911,592	911,592	911,592	911,592

Sample weights are used in Panels A-B and D-F. Standard errors clustered by state x type of area in parentheses. Regressions also include controls for five year age category, sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, in cellphone sample (beginning 2011), residence in center city, residence in MSA (residence outside of MSA is omitted), and state unemployment rate. The regressions also include state x type of area fixed effects and year by quarter fixed effects. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

to undergo the procedure and have not been successful with lifestyle changes and medication). By improving access to insurance and therefore healthcare, an insurance expansion could lead to changes in all four of these mechanisms. Patients may be more likely to receive physician counseling as a result of the reform, and this could lead individuals to improve health behaviors (e.g., exercise or nutrition). Physicians may also prescribe medication to aid weight loss or refer patients who are severely obese to specialists, who provide weight-reducing medical procedures such as bariatric surgery.

With the BRFSS data, we are able to test whether the insurance expansions impacted a few health behaviors related to these mechanisms: the likelihood a respondent exercised in the past month, the likelihood a respondent consumed fruits and vegetables each day of the past month, and whether the respondent consumed any alcoholic beverages in the past month. Collectively, we do not find strong support that the health insurance expansions impacted these four health behaviors, as shown in Table 5. However, we acknowledge that these measures are imperfect proxies of both the amount of calories expended during exercise and the amount of calories consumed. Therefore, we suggest that future research examine whether the health insurance expansions reduced caloric intake using datasets that have food diaries, such as the National Health and Nutrition Examination Survey (NHANES) or the Consumer Expenditure Survey. Future work should also examine whether these health insurance expansions impacted the likelihood of bariatric surgery using discharge data such as the Healthcare Cost and Utilization Project (HCUP) State Inpatient Database (SID) and State Ambulatory Surgery and Services Database (SASD).

6. Discussion

We provide new evidence that three recent health insurance expansions led to reduced BMI for those with the highest BMI. This is an important finding for several reasons. Between 1960 and

Table 5
Linear Probability Models of Possible Mechanisms Explaining Weight Loss.

	= 1 if any exercise in past month (1)	= 1 if ate fruit each day in past month (2)	= 1 if ate vegetables each day in past month (3)	= 1 if drank any alcohol in past month (4)
Panel A: Massachusetts Health Care Reform, 2001-2009, Ages 18-64				
MA * (Post Q3 2006)	0.010***	−0.007**	−0.017***	0.004
	(0.002)	(0.003)	(0.003)	(0.003)
Mean DV (pre, MA)	0.81	0.44	0.26	0.71
N	1,772,098	1,011,972	1,003,218	1,744,603
Panel B: Dependent Coverage Mandate, 2007-2013, Ages 23-25, 27-29				
Post 2010 x Age 23-25	0.004	0.0001	0.004	−0.006
	(0.009)	(0.0153)	(0.010)	(0.010)
Mean DV (pre, 23-25)	0.81	0.36	0.16	0.62
N	121,113	71,065	70,506	122,082
Panel C: ACA, 2011-2016, Ages 18-64				
2013 uninsurance x Post	−0.023	0.010	0.066*	−0.136***
	(0.055)	(0.064)	(0.038)	(0.029)
2013 uninsurance x Post x Expansion	0.062	0.029	0.011	0.071*
	(0.060)	(0.079)	(0.056)	(0.037)
Mean DV (pre, exp.)	0.78	0.46	0.22	0.57
N	1,526,747	761,017	756,144	1,561,172

Sample weights used. In Panels A and B, standard errors are clustered by state. In Panel C, standard errors are clustered by state x residence in center city of MSA, residence in MSA but not center city, residence outside of MSA, or inclusion in the cell phone sample. All regressions also include controls for sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, and state unemployment rate. Panels A and C include controls for five year age categories and Panel B includes single year of age fixed effects. Panels B and C also include indicators for in cellphone sample (beginning 2011), residence in center city, and residence in MSA (residence outside of MSA is omitted). The regressions also include year by quarter fixed effects and Panels A and B include state fixed effects and Panel C includes state x type of area fixed effects. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

2012, the adult obesity rate nearly *tripled*, rising from 13% to 35% (Flegal et al., 1998; Ogden et al., 2014). Obesity rates have continued to rise and the associated medical costs are high. Cawley and Meyerhoefer (2012) show that the annual cost of obesity is greater than $2,700 per individual and the Centers for Disease Control and Prevention estimates that the aggregate annual medical cost of obesity is $147 billion. Compared to moderate obesity, severe obesity is associated with substantially higher costs (Andreyeva et al., 2004).

One limitation of our analysis is the reliance on self-reported height and weight to construct our measures of interest (i.e., BMI and whether a BMI reflects overweight, obesity, or severe obesity). If misreporting changes with insurance status, then we might be concerned that our results are merely capturing a decline in misreporting. This is unlikely, however, because our results show that insurance expansions lead to a decline in BMI among those who are severely obese and the pattern of misreporting for overweight individuals is to understate one's weight (see, e.g., Rowland, 1990). Thus, a decline in misreporting would make it *harder* to document a decline in weight for the most severely obese.

While we note consistent improvements in weight-related outcomes among the top of the BMI distribution across several recent insurance expansions, the mechanisms driving these improvements are unknown. Possible mechanisms include physician counseling leading to changes in nutrition and/or exercise and access to weight-reducing medical procedures and medications. Future research should investigate the mechanisms underlying these improvements in weight-related health outcomes using data that allow the researcher to pinpoint an increase in calories expended during exercise, a reduction in calories consumed, prescriptions for weight loss medications, or the incidence of bariatric surgery.

The findings of this paper have important policy implications. We have identified an important health-improving benefit of recent health insurance expansions: reduced BMI and improved weight-related outcomes among individuals who are severely obese. It is important to note that the magnitudes of these effects are similar in size to interventions that explicitly target weight loss: taxes on sugar sweetened beverages and weight loss programs that are tied to financial incentives. These reductions in BMI and severe obesity have likely not been considered in prior calculations of the financial benefits of health care expansions. Given the extraordinary costs of severe obesity in the U.S., even a modest improvement in weight-related outcomes could be associated with substantial cost savings.

CRediT authorship contribution statement

Melissa McInerney: Conceptualization, Methodology, Software, Formal analysis, Writing - original draft, Writing - review & editing. **Mark K. Meiselbach:** Conceptualization, Methodology, Software, Formal analysis, Writing - original draft, Writing - review & editing.

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Appendix.

Table A1
Means of Dependent and Independent Variables, in the Pre Period.

MA health care reform (2001-2006)			Dependent Coverage Mandate (2007-2010)			Affordable Care Act (2011-2013)		
	MA	All other states		Age 23-25	Age 27-29		Expansion states	Non-expansion states
Has health insurance	0.90	0.83	Has health insurance	0.68	0.76	Has health insurance	0.82	0.75
BMI	26.33	27.09	BMI	26.42	27.24	BMI	27.66	28.09
	(5.42)	(5.74)		(5.90)	(6.03)		(6.22)	(6.43)
Overweight or obese	0.55	0.61	Overweight or obese	0.53	0.61	Overweight or obese	0.63	0.66
Obese	0.19	0.24	Obese	0.22	0.26	Obese	0.28	0.31
Severe obesity	0.06	0.09	Severe obesity	0.08	0.10	Severe obesity	0.11	0.12
Five year age group:			Age:			Five year age group:		
Age 18-24	0.13	0.14	23	0.33	0	Age 18-24	0.14	0.13
Age 25-29	0.10	0.10	24	0.35	0	Age 25-29	0.10	0.10
Age 30-34	0.13	0.12	25	0.32	0	Age 30-34	0.11	0.11
Age 35-39	0.13	0.12				Age 35-39	0.10	0.10
Age 40-44	0.14	0.13	27	0	0.31	Age 40-44	0.11	0.12
Age 45-49	0.12	0.12	28	0	0.34	Age 45-49	0.11	0.11
Age 50-54	0.11	0.11	29	0	0.35	Age 50-54	0.13	0.13
Age 55-59	0.09	0.09				Age 55-59	0.11	0.10
Age 60-64	0.07	0.07				Age 60-64	0.10	0.10
Female	0.49	0.48	Female	0.50	0.50	Female	0.48	0.48
Married	0.58	0.61	Married	0.30	0.56	Married	0.51	0.53
Race/ethnicity:			Race/ethnicity:			Race/ethnicity:		
Non-Hispanic White	0.83	0.73	Non-Hispanic White	0.59	0.62	Non-Hispanic White	0.66	0.64
Non-Hispanic black	0.04	0.11	Non-Hispanic black	0.11	0.12	Non-Hispanic black	0.10	0.17
Hispanic	0.08	0.10	Hispanic	0.20	0.19	Hispanic	0.15	0.14
Other race/ethnicity	0.05	0.06	Other race/ethnicity	0.09	0.08	Other race/ethnicity	0.09	0.06
Income:			Income:			Income:		
< $10,000	0.03	0.04	< $10,000	0.07	0.05	< $10,000	0.07	0.07
$10,000-$15,000	0.03	0.04	$10,000-$15,000	0.07	0.05	$10,000-$15,000	0.05	0.06
$15,000-$20,000	0.04	0.07	$15,000-$20,000	0.10	0.07	$15,000-$20,000	0.07	0.09
$20,000-$25,000	0.06	0.09	$20,000-$25,000	0.12	0.09	$20,000-$25,000	0.08	0.10
$25,000-$35,000	0.09	0.13	$25,000-$35,000	0.14	0.13	$25,000-$35,000	0.10	0.11
$35,000-$50,000	0.14	0.18	$35,000-$50,000	0.17	0.17	$35,000-$50,000	0.13	0.14
$50,000-$75,000	0.20	0.19	$50,000-$75,000	0.14	0.19	$50,000-$75,000	0.16	0.15
>$75,000	0.40	0.25	>$75,000	0.19	0.25	>$75,000	0.33	0.28
Education:			Education:			Education:		
Less than high school	0.06	0.09	Less than high school	0.10	0.10	Less than high school	0.12	0.13
High school degree	0.23	0.30	High school degree	0.28	0.25	High school degree	0.27	0.28
Some college	0.25	0.28	Some college	0.31	0.28	Some college	0.32	0.33
College or more	0.46	0.33	College or more	0.31	0.37	College or more	0.29	0.27
Pregnant	0.01	0.01	Pregnant	0.04	0.04	Pregnant	0.00	0.00
Number of children under 18 in house:			Number of children under 18 in house:			Number of children under 18 in house:		
0	0.53	0.51	0	0.54	0.37	0	0.55	0.55
1	0.19	0.20	1	0.23	0.23	1	0.18	0.18
2	0.19	0.18	2	0.15	0.23	2	0.16	0.16
3	0.07	0.08	3	0.05	0.11	3	0.07	0.07
4	0.02	0.02	4	0.02	0.04	4	0.02	0.03
5+	0.01	0.01	5+	0.01	0.01	5+	0.01	0.01
Student	0.05	0.05	Student	0.11	0.06	Student	0.07	0.06
Unemployed	0.06	0.06	Unemployed	0.11	0.09	Unemployed	0.09	0.09
State unemployment rate	4.92	5.28	State unemployment rate	7.17	7.29	State unemployment rate	8.32	7.67
	(0.64)	(0.93)		(2.56)	(2.59)		(1.64)	(1.55)
Cellphone sample (2011-)	–	–	Cellphone sample (2011-)	–	–	Cellphone sample (2011-)	0.39	0.45
In MSA (not center city) (2005-)	–	–	In MSA (not center city) (2005-)	0.42	0.42	In MSA (not center city) (2005-)	0.29	0.22
In center city (2005-)	–	–	In center city (2005-)	0.40	0.41	In center city (2005-)	0.22	0.21
Not in MSA (2005-)	–	–	Not in MSA (2005-)	0.18	0.18	Not in MSA (2005-)	0.10	0.13
N	30,474	891,223	N	22,006	35,763	N	532,052	304,180

Sample weights are used.

Table A2
Expansion and Non-expansion States.

Expansion States	Expansion Date	Non-Expansion States
Alaska	9/2015	Alabama
Arizona	1/2014	Florida
Arkansas	1/2014	Georgia
California	1/2014	Idaho
Colorado	1/2014	Kansas
Connecticut	1/2014	Maine[a]
Delaware	1/2014	Mississippi
District of Columbia	1/2014	Missouri
Hawaii	1/2014	Nebraska
Illinois	1/2014	North Carolina
Indiana	2/2015	Oklahoma
Iowa	1/2014	South Carolina
Kentucky	1/2014	South Dakota
Louisiana	7/2016	Tennessee
Maryland	1/2014	Texas
Massachusetts	1/2014	Utah
Michigan	4/2014	Virginia
Minnesota	1/2014	Wisconsin
Montana	1/2016	Wyoming
Nevada	1/2014	
New Hampshire	8/2014	
New Jersey	1/2014	
New Mexico	1/2014	
New York	1/2014	
North Dakota	1/2014	
Ohio	1/2014	
Oregon	1/2014	
Pennsylvania	1/2015	
Rhode Island	1/2014	
Vermont	1/2014	
Washington	1/2014	
West Virginia	1/2014	

SOURCE: Kaiser Family Foundation. 2018. “Status of State Action on the Medicaid Expansion.” Available at: https://www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D; viewed March 9, 2018.

[a] As of January 2018, Maine has adopted the Medicaid expansion but does not yet have a date of implementation.

Table A3
BMI at the 5th through 99th quantiles.

	Massachusetts Residents Ages 18-64, 2001- 2006	Young Adults Ages 23-25, 2007-2010	Expansion State Residents Ages 18-64, 2011-2013
5	19.6	19.2	19.8
10	20.6	20.2	21.0
15	21.3	21.0	21.9
20	22.0	21.8	22.7
25	22.6	22.4	23.4
30	23.1	22.9	24.1
35	23.7	23.5	24.7
40	24.3	24.0	25.2
45	24.9	24.5	25.8
50	25.2	25.1	26.6
55	25.9	25.9	27.3
60	26.6	26.6	28.0
65	27.2	27.5	28.7
70	27.9	28.4	29.5
75	28.7	29.4	30.6
80	29.7	30.6	31.8
85	30.9	32.0	33.3
90	32.8	34.0	35.4
95	36.0	37.8	39.1
99	44.5	45.7	48.1

Table A4
Event Study Estimates of the Effect of Massachusetts Health Care Reform on Weight-Related Outcomes, Distributional Effects, 2001-2009, ages 18-64.

	=1 if have health insurance (1)	BMI (2)	=1 if overweight or obese (3)	=1 if obese (4)	=1 if severely obese (5)
Panel A: DD results					
MA * (Post Q3 2006)	0.042***	−0.206***	−0.009***	−0.014***	−0.009***
	(0.003)	(0.018)	(0.001)	(0.001)	(0.001)
Panel B: Event study results					
MA * 2001	−0.001	0.027	0.019***	−0.011***	−0.001
	(0.005)	(0.031)	(0.003)	(0.002)	(0.002)
MA * 2002	0.006*	−0.125***	0.011***	−0.015***	−0.005***
	(0.003)	(0.027)	(0.002)	(0.002)	(0.001)
MA * 2003	−0.002	−0.345***	−0.013***	−0.038***	−0.016***
	(0.003)	(0.023)	(0.003)	(0.003)	(0.001)
MA * 2004	−0.003	−0.131***	0.005**	−0.022***	−0.007***
	(0.003)	(0.024)	(0.002)	(0.002)	(0.002)
MA * 2005	–	–	–	–	–
MA * 2006	0.013***	−0.240***	−0.006**	−0.029***	−0.009***
	(0.002)	(0.020)	(0.003)	(0.002)	(0.001)
MA * 2007	0.034***	−0.197***	0.001	−0.024***	−0.008***
	(0.003)	(0.033)	(0.003)	(0.003)	(0.002)
MA * 2008	0.062***	−0.329***	−0.001	−0.031***	−0.019***
	(0.004)	(0.031)	(0.003)	(0.003)	(0.001)
MA * 2009	0.050***	−0.489***	−0.021***	−0.037***	−0.017***
	(0.003)	(0.040)	(0.003)	(0.003)	(0.002)
p-value, F-test	<0.001	<0.001	<0.001	<0.001	<0.001
Mean DV (pre, MA)	0.90	26.33	0.55	0.19	0.06
		(5.42)			
N	1,770,643	1,710,513	1,710,513	1,710,513	1,710,513

Sample weights are used. Standard errors are clustered by state. Regressions also include controls for five year age groups, sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, and state unemployment rate. The regressions also include state fixed effects and year by quarter fixed effects. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Table A5
Event Study Estimates of the Effect of the Dependent Coverage Mandate on Weight-Related Outcomes, Distributional Effects, 2007-2013, Ages 23-25, 27-29.

	(1) =1 if have health insurance	(2) BMI	(3) =1 if overweight or obese	(4) =1 if obese	(5) =1 if severely obese
Panel A: DD					
Post 2010 x Age 23-25	0.065***	−0.262**	−0.009	−0.019**	−0.014**
	(0.009)	(0.119)	(0.009)	(0.008)	(0.006)
Panel B: Event Study					
2007 x Age 23-25	0.004	0.077	0.017	0.010	−0.005
	(0.022)	(0.183)	(0.019)	(0.021)	(0.009)
2008 x Age 23-25	0.002	0.081	0.004	0.026	0.002
	(0.023)	(0.198)	(0.020)	(0.015)	(0.010)
2009 x Age 23-25	–	–	–	–	–
2010 x Age 23-25	0.009	−0.034	−0.008	−0.001	−0.003
	(0.026)	(0.230)	(0.016)	(0.021)	(0.012)
2011 x Age 23-25	0.072***	−0.107	0.007	−0.006	−0.018*
	(0.020)	(0.236)	(0.021)	(0.013)	(0.011)
2012 x Age 23-25	0.073***	−0.390**	−0.015	−0.010	−0.016
	(0.017)	(0.165)	(0.015)	(0.010)	(0.010)
2013 x Age 23-25	0.060***	−0.184	−0.007	−0.010	−0.011
	(0.021)	(0.151)	(0.017)	(0.012)	(0.009)
p-value, F test pre-pd.	0.98	0.88	0.67	0.17	0.50
Mean DV (pre, 23-25)	0.68	26.42	0.53	0.22	0.08
		(5.90)			
N	123,758	117,806	117,806	117,806	117,806

Sample weights are used. Standard errors are clustered by state. Regressions also include controls for single year of age, sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, in cellphone sample (beginning 2011), residence in center city, residence in MSA (residence outside of MSA is omitted), and state unemployment rate. The regressions also include state fixed effects and year by quarter fixed effects. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Table A6
Event Study Estimates of the Effect of the Affordable Care Act on Weight-Related Outcomes, Distributional Effects, 2011-2016, ages 18-64.

	=1 if have health insurance (1)	BMI (2)	=1 if overweight or obese (3)	=1 if obese (4)	=1 if severely obese (5)
		Panel A: DDD			
2013 uninsurance x Post	0.238***	0.381	0.009	0.022	0.023
	(0.033)	(0.427)	(0.023)	(0.024)	(0.022)
2013 uninsurance x Post x Expansion	0.128**	0.274	0.012	0.017	0.007
	(0.052)	(0.526)	(0.033)	(0.033)	(0.027)
Implied effects of ACA (at mean uninsurance rate in 2013: 0.21)					
ACA, w/o Med. Exp.	0.050***	0.080	0.002	0.005	0.005
Medicaid expansion	0.027***	0.058	0.003	0.004	0.001
Full ACA (w/Med. Exp.)	0.077***	0.138	0.004	0.008	0.006
		Panel B: Event Study			
2013 uninsurance x Year = 2011	−0.126***	−0.102	0.021	0.009	0.010
	(0.037)	(0.600)	(0.066)	(0.053)	(0.028)
2013 uninsurance x Year = 2012	−0.046	−0.817*	−0.080	−0.037	−0.032
	(0.087)	(0.482)	(0.041)	(0.034)	(0.020)
2013 uninsurance x Year = 2014	0.112**	−0.115	−0.054	−0.011	0.035
	(0.055)	(0.646)	(0.042)	(0.055)	(0.033)
2013 uninsurance x Year = 2015	0.185**	0.215	0.047	−0.007	−0.032**
	(0.090)	(0.551)	(0.043)	(0.030)	(0.015)
2013 uninsurance x Year = 2016	0.280***	0.028	−0.029	0.038	0.035
	(0.038)	(0.904)	(0.064)	(0.030)	(0.032)
2013 uninsurance x Exp. X Year=2011	0.016	−0.220	−0.066	−0.026	−0.035
	(0.086)	(0.812)	(0.087)	(0.069)	(0.041)
2013 uninsurance x Exp. X Year=2012	0.006	1.235*	0.060	0.081	0.048
	(0.103)	(0.672)	(0.055)	(0.057)	(0.030)
2013 uninsurance x Exp. X Year=2014	0.077	0.258	0.041	0.031	−0.048
	(0.068)	(0.774)	(0.052)	(0.063)	(0.041)
2013 uninsurance x Exp. X Year=2015	0.200*	1.012	0.019	0.075	0.082***
	(0.101)	(0.792)	(0.075)	(0.048)	(0.030)
2013 uninsurance x Exp. X Year=2016	0.140**	1.009	−0.003	0.057	0.027
	(0.067)	(1.033)	(0.079)	(0.049)	(0.038)
p-value, F test, pre pd. Int.	<0.001	0.24	0.11	0.27	0.43
Mean DV (pre, exp.)	0.82	27.66	0.63	0.28	0.11
		(6.22)			
N	1,568,213	1,498,042	1,498,042	1,498,042	1,498,042

Sample weights are used. The implied effect of the ACA at the 2013 mean uninsurance rate is given by the coefficient estimate on (2013 uninsurance x Post) multiplied by the 2013 uninsurance rate. The implied effect of the Medicaid expansion is given by the 2013 uninsurance rate multiplied by the coefficient estimate on (2013 uninsurance x Post x Expansion). The implied effect of the Full ACA (with the Medicaid expansion) is the sum of these two effects. We determine statistical significance of the full ACA with an F-test. Standard errors clustered by state x type of area in parentheses. Regressions also include controls for five year age category, sex, marital status, race/ethnicity, income (< $10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, in cellphone sample (beginning 2011), residence in center city, residence in MSA (residence outside of MSA is omitted), and state unemployment rate. The regressions also include state x type of area fixed effects and year by quarter fixed effects. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Table A7
Robustness Checks of the Quantile Regression Results, Massachusetts Health Care Reform, 2001-2009, ages 18-64, Coefficient on Post x MA.

		State-Specific Time Trend	Separate Implementation and Post Periods		Synthetic Control	Randomization Inference
	Baseline (1)	Post Q3 2006 x MA (2)	(2006 Q3 – 2007 Q2) x MA (3)	Post Q3 2007 x MA (4)	Post Q3 2006 x MA (5)	p-value (6)
10^{th} Percentile	0.032	0.017	0.100	0.009	0.088	0.70
	(0.052)	(0.092)	(0.067)	(0.047)	(0.056)	
20^{th} Percentile	0.080	0.134*	0.221***	0.035	0.087	0.85
	(0.056)	(0.076)	(0.073)	(0.036)	(0.055)	
30^{th} Percentile	0.033	0.127	0.169**	−0.011	0.072	0.65
	(0.047)	(0.079)	(0.071)	(0.049)	(0.058)	
40^{th} Percentile	−0.019	0.080	0.129*	−0.066*	−0.003	0.33
	(0.051)	(0.088)	(0.075)	(0.037)	(0.058)	
50^{th} Percentile	−0.070	0.042	0.099	−0.124***	−0.027	0.24
	(0.051)	(0.076)	(0.063)	(0.045)	(0.044)	
60^{th} Percentile	−0.116*	−0.119	0.026	−0.162**	−0.036	0.24
	(0.060)	(0.116)	(0.100)	(0.067)	(0.055)	

Table A7 (*Continued*)

	Baseline	State-Specific Time Trend	Separate Implementation and Post Periods		Synthetic Control	Randomization Inference
		Post Q3 2006 x MA	(2006 Q3 – 2007 Q2) x MA	Post Q3 2007 x MA	Post Q3 2006 x MA	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
70th Percentile	−0.190***	−0.170*	−0.044	−0.237***	−0.065	0.15
	(0.054)	(0.099)	(0.082)	(0.064)	(0.086)	
80th Percentile	−0.221***	−0.157	−0.066	−0.272***	−0.042	0.15
	(0.080)	(0.139)	(0.114)	(0.088)	(0.089)	
90th Percentile	−0.389***	−0.201	−0.143	−0.468***	−0.259*	0.09f4
	(0.103)	(0.220)	(0.226)	(0.133)	(0.151)	
N	1,710,513	1,710,513	1,710,513		248,683	

Unconditional quantile regression results for BMI at the 10th through the 90th quantiles with bootstrapped standard errors (50 replications). In columns (1), (2), (5), and (6), the coefficient estimate for MA*(Post Q3 2006) is presented. Columns (3) and (4) present the coefficient estimates from a single regression that separates the post period into the implementation period (Q3 2006 – Q2 2007) and post period (Q3 2007 – Q4 2009). In column (5), the synthetic inference, the following states comprise the synthetic control group: DC (13.1%), NJ (30.1%), RI (47.6%), TX (1.6%), and UT (7.7%). All models include controls for five year age groups, sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, state unemployment rate, state fixed effects, and year by quarter fixed effects.

Table A8

Robustness Checks of the Quantile Regression Results, Dependent Coverage Mandate, 2007-2013, ages 23-25, 27-29, Coefficient on Post 2010 x Treat Age.

	Baseline	State-Specific Time Trend	Exclude 2010	Include 19-22 Year olds in Treatment Group	Column (3) + Include 18 Year Olds in Comparison Group
		Post 2010 x Age 23-25	Post 2010 x Age 23-25	Post 2010 x Age 19-25	Post 2010 x Age 19-25
	(1)	(2)	(3)	(4)	(5)
10th Percentile	−0.166**	−0.167**	−0.186***	−0.133***	−0.123***
	(0.073)	(0.072)	(0.064)	(0.046)	(0.043)
20th Percentile	−0.208***	−0.208***	−0.216***	−0.195***	−0.206***
	(0.067)	(0.067)	(0.061)	(0.051)	(0.046)
30th Percentile	−0.181***	−0.178***	−0.190***	−0.155***	−0.193***
	(0.068)	(0.068)	(0.060)	(0.050)	(0.047)
40th Percentile	−0.122	−0.118	−0.132*	−0.182***	−0.219***
	(0.077)	(0.078)	(0.068)	(0.054)	(0.053)
50th Percentile	−0.078	−0.074	−0.055	−0.169***	−0.209***
	(0.079)	(0.079)	(0.071)	(0.058)	(0.062)
60th Percentile	−0.191**	−0.184**	−0.239***	−0.210***	−0.235***
	(0.062)	(0.080)	(0.079)	(0.076)	(0.073)
70th Percentile	−0.306***	−0.297***	−0.384***	−0.321***	−0.330****
	(0.098)	(0.098)	(0.102)	(0.086)	(0.100)
80th Percentile	−0.260**	−0.246**	−0.297**	−0.403***	−0.376***
	(0.122)	(0.123)	(0.138	(0.092)	(0.121)
90th Percentile	−0.479***	−0.464***	−0.388**	−0.576***	−0.618***
	(0.176)	(0.175)	(0.193)	(0.154)	(0.156)
N	117,806	117,806	105,760	164,329	175,261

Unconditional quantile regression results for BMI at the 10th through the 90th quantiles with bootstrapped standard errors (50 replications). All models include controls for single year of age, sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, state unemployment rate, state fixed effects, residence in center city of MSA, residence in rest of MSA, inclusion in the cell phone sample (beginning in 2011) (the omitted category is residence outside of MSA), and year by quarter fixed effects.

Table A9
Robustness Checks of the Quantile Regression Results, Affordable Care Act Medicaid Expansions, 2011-2016, ages 18-64, Coefficients on 2013 Uninsurance x Post and 2013 Uninsurance x Post x Expansion.

	Baseline		State-Specific Time Trend		Drop Late Adopters		Drop Cell Phone Sample	
	2013 Uninsurance x Post (1)	2013 Uninsurance x Post x Expansion (2)	2013 Uninsurance x Post (3)	2013 Uninsurance x Post x Expansion (4)	2013 Uninsurance x Post (5)	2013 Uninsurance x Post x Expansion (6)	2013 Uninsurance x Post (7)	2013 Uninsurance x Post x Expansion (8)
10th Percentile	0.376 (0.289)	−0.066 (0.339)	0.418 (0.354)	−0.159 (0.416)	0.390 (0.266)	0.035 (0.342)	−0.482 (0.466)	0.817 (0.561)
20th Percentile	0.409 (0.265)	0.028 (0.323)	0.455 (0.338)	0.168 (0.403)	0.418 (0.269)	0.122 (0.324)	−0.199 (0.379)	0.286 (0.568)
30th Percentile	0.555** (0.246)	−0.229 (0.320)	0.450 (0.343)	0.088 (0.424)	0.547** (0.261)	−0.170 (0.312)	0.141 (0.419)	−0.244 (0.501)
40th Percentile	0.651*** (0.233)	−0.360 (0.302)	0.600* (0.309)	−0.105 (0.392)	0.665*** (0.243)	−0.271 (0.278)	0.226 (0.395)	−0.549 (0.536)
50th Percentile	0.812*** (0.219)	−0.428 (0.280)	0.620** (0.290)	−0.030 (0.332)	0.813*** (0.268)	−0.257 (0.366)	0.497 (0.392)	−0.996* (0.572)
60th Percentile	0.725*** (0.241)	−0.120 (0.338)	0.652** (0.293)	0.069 (0.400)	0.742** (0.291)	−0.057 (0.433)	0.368 (0.493)	−0.433 (0.752)
70th Percentile	0.849*** (0.319)	−0.066 (0.402)	0.913** (0.389)	−0.074 (0.499)	0.873** (0.349)	−0.004 (0.505)	−0.458 (0.625)	0.367 (0.815)
80th Percentile	1.360*** (0.367)	−0.670 (0.503)	1.616*** (0.470)	−0.728 (0.610)	1.306*** (0.443)	−0.411 (0.601)	−0.034 (0.935)	−0.541 (1.210)
90th Percentile	3.020*** (0.625)	−1.861** (0.778)	3.998*** (0.699)	−2.495** (0.864)	3.095*** (0.595)	−1.783* (0.785)	0.632 (1.109)	−0.343 (1.572)
N	1,498,042		1,498,042		1,313,469		911,592	

Unconditional quantile regression results for BMI at the 10th through the 90th quantiles with bootstrapped standard errors (50 replications). All models include controls for five year age groups, sex, marital status, race/ethnicity, income (<$10,000, $10,000-$15,000, $15,000-$20,000, $20,000-$25,000, $25,000-$35,000, $35,000-$50,000, $50,000-$75,000, >$75,000), educational attainment, pregnant, number of children under the age of 18 in the home, student, unemployed, state unemployment rate, residence in center city of MSA, residence in rest of MSA, inclusion in the cell phone sample (beginning in 2011) (the omitted category is residence outside of MSA), state by type of area fixed effects, and year by quarter fixed effects.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:10.1016/j.ehb.2020.100870.

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