Minimum Wages and Healthy Diet*

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Abstract

A healthy diet is often unaffordable for low-income individuals, so income-lifting policies may play an important role in not only alleviating poverty but also in improving nutrition. We investigate if higher minimum wages can contribute to an improved diet by increasing consumption of fruits and vegetables. Exploiting recent minimum wage increases in the U.S. and using individual-level data from the Behavioral Risk Factor Surveillance System we identify the causal effect of minimum wage changes on fruit and vegetable intake among low-wage individuals in a triple-differences framework. The estimated minimum wage elasticity of fruit and vegetable consumption equals 0.12.

Keywords: minimum wages; nutrition; healthy diet; fruit and vegetable consumption; obesity; triple-differences.

JEL classification: I12; I18; J38.

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1 Introduction

Low-income populations in developed countries face many difficulties in following a healthy diet. Healthy food items such as fruits and vegetables may not be available in inner city "food deserts" or may be unaffordable (Jetter and Cassady, 2006). At the same time, fast food with its high fat and sugar contents may be more convenient and cheaper (Beydoun, Powell, and Wang, 2008). To improve consumption of healthy food among the poor, policymakers have used direct measures such as subsidizing healthy food items (Powell et al., 2013), taxing unhealthy food (Fletcher, Frisvold, and Tefft, 2015), providing food stamps (Leung et al., 2012) or free school lunches (Ishdorj, Crepinsek, and Jensen, 2013), and encouraging suppliers to locate in underserved areas (Walker, Keane, and Burke, 2010).

These policies have the advantage of being targeted at populations that are potentially in greatest need of improving their diet. On the other hand, as any tax or subsidy, these policies may distort market outcomes and therefore decrease welfare. As an alternative to these targeted policies, policymakers might opt to increase income among the poor, hoping that recipients spend some of their additional resources on improving their diet. To determine if such a broad policy has the desired effect, we need to know the income elasticity for healthy food among low-income individuals.

In this paper, we exploit recent increases in state minimum wages in the U.S. to assess the effect of higher income among low-income individuals on consumption of fruits and vegetables as a proxy for a healthy diet. Fruit and vegetable consumption has important health benefits (see Van Duyn and Pivonka, 2000, for an overview) and is therefore a suitable proxy for healthy nutrition habits. Webb (1912) already recognized the importance of a minimum wage standard for workers' health, well-being, and in particular for nutrition, over a century ago. To make an argument for a binding minimum wage, he wrote "No 'intellectual' who has lived for any length of time in households of typical factory operatives or artisans in England or in the United States, can have failed to become painfully aware of their far lower standard of *nutrition*, clothing, and rest than his own, and also of their lower standard of vitality and physical and mental exertion" (Webb, 1912, p. 981, emphasis added). A higher minimum wage is only one way to increase income among poor individuals along with welfare programs and tax credits, but in contrast to these policies, higher minimum wages unambiguously increase the amount of labor supplied. On the other hand, minimum wages increases may reduce labor demand and thereby lead to disemployment. (See Section 2 for a more detailed discussion.) If we find a positive elasticity for the demand for fruits and vegetables with respect to the minimum wage, we can conclude that paying higher wages to low-income individuals may not only reduce poverty but also improve their health through a better diet.

Our study contributes to the literature in two ways. First, to our knowledge it is the first study that focuses on the effect of minimum wage increases on healthy diet. We thereby contribute to a small but growing literature on on the health effects of minimum wages. For example, Lenhart (2017) finds self-reported health improvements following a minimum wage increase in the UK while Horn, Maclean, and Strain (2017) find little evidence for better health outcomes except for small improvements in workers' mental health in the U.S. Lenhart (2016) explores the health effects of minimum wages across developed countries. Averett, Smith, and Wang (2017) find mixed results for health effects among teenagers and Averett, Smith, and Wang (2018) do not find any health effects for Hispanic women. McCarrier et al. (2011) show that higher minimum wages lead to fewer unmet medical needs. Wehby, Dave, and Kaestner (2016) find that higher minimum wages also have positive effects on infants by increasing birth weight. Among other outcomes, Horn, Maclean, and Strain (2017) and Lenhart (2016) also investigate the effect of minimum wages on fruit and vegetable consumption, and calorie intake, respectively, and do not find any significant minimum wage effects. In related research, Meltzer and Chen (2011) and Cotti and Tefft (2013) find a decline in body weight due to higher minimum wages. The latter study shows that this effect operates through higher prices in the fast food industry, which is one of the main employers of minimum wage workers, and hence affects potential consumers of fast food and not just recipients of minimum wages. In contrast, we are interested in the direct effect of minimum wage increases on the diet of low-wage workers themselves.

Second, our results are also informative more generally on the income elasticity of healthy nutrition. Therefore, our results are not only applicable to minimum wage changes, but also to policies such as welfare benefits or tax credits that lead to changes in income among low-income individuals.[1]

To estimate the causal effect of minimum wage increases on fruit and vegetable consumption, we do not only use a difference-in-differences (DD) approach, but a also employ a triple-difference (DDD) strategy that accounts for unobserved heterogeneity across states and deals with potentially endogenous minimum wage policies. To our knowledge, the only other paper in this literature to use a DDD approach is the study by Horn, Maclean, and Strain (2017) who use retired individuals as a comparison group. In contrast, we compare fruit and vegetable consumption of minimum wage earners with that of individuals earning

[1] Averett and Wang (2012) and Hoynes, Miller, and Simon (2015) analyze how the Earned Income Tax Credit affects health and Bitler and Hoynes (2006) review the literature on health effects of welfare programs, but to our knowledge no study has investigated the effect of these policies on nutrition.

above minimum wage. The DDD thereby estimates allow us to isolate the effect of minimum wage increases among low-wage workers who are most likely to be affected by an increase in the minimum wage. To implement these estimators, we use individual-level data stemming from repeated cross sections of the Behavioral Risk Factor Surveillance System (BRFSS) merged with monthly minimum wages and fruit and vegetable prices for the years 1990 to 2017.

Our preferred results show a minimum wage elasticity of fruit and vegetable consumption of about 0.12. That is, a minimum wage increase and possible another comparable income rise lead to a small but positive change in fruit and vegetable consumption. Policymakers who aim to improve the diet of low-income workers without resorting to more targeted policies may therefore employ minimum wage increases or other policies that increase income (such as the Earned Income Tax Credit). However, in order to substantially raise the fruit and vegetable consumption of low-income individuals, a modest minimum wage increase is likely insufficient. We also estimate the effect of minimum wage changes on obesity and find a significant decrease in obesity rates as minimum wage increase.

The remainder of this paper proceeds as follows: In Section 2, we develop a simple theoretical framework that explains why fruit and vegetable consumption is likely to rise following a minimum wage increase. Section 3 contains a detailed description of the minimum wages and fruit and vegetable prices that form our main explanatory variables. We also describe the BRFSS data and provide summary statistics in that section. In Section 4, we discuss our empirical strategy that includes DD and DDD regressions. We then discuss the results in Section 5 and conclude with Section 6.

2 Theoretical Framework

The effect of minimum wages on fruit and vegetable consumption is theoretically ambiguous. An increase in the minimum wage has two possible effects. First, it may increase the wage of workers whose wage was below the new minimum wage or even for those whose wage is above but close to it (Autor, Manning, and Smith, 2016). Second, a rise in the minimum wage may lead to disemployment due to reduced labor demand. A large literature in labor economics has investigated the employment effects of minimum wage increases and remains divided (see Neumark and Wascher, 2006, for a review). Card and Krueger (1994) famously find no evidence for employment reductions in the fast food industry. More recently, Dube, Naidu, and Reich (2007), Dube, Lester, and Reich (2010), and Allegretto, Dube, and Reich (2011) also find no evidence for negative employment effects, but Neumark, Salas, and Wascher (2014) dispute these results.

Focussing on the first possible effect, we rely on Grossman's (1972) human capital model to motivate the relationship between a minimum wage increase and fruit and vegetable consumption. In Grossman's (1972) model, health capital has two roles. First, it has an investment function and increases the number of "healthy days," i.e. the amount of time an individual can use productively (on work, leisure, and time inputs into health production). Second, health capital has a consumption function and yields a per-period utility. In this framework, individuals maximize their future discounted utility by choosing health investments, consumption levels, and hours worked each period. Investing in health capital requires both market and time inputs. For example, healthy nutrition can be thought of as a typical health investment that individuals produce by purchasing fruits and vegetables and by spending time to prepare meals.

In terms of labor supply, a minimum wage increase has three potential effects on the demand for healthy food items such as fruits and vegetables. First, higher wages increase the amount of labor supplied.[2] The resulting higher income implies that individuals demand more health, assuming that it is a normal good. To raise their health capital, individuals need to use both market and time inputs. Therefore, it is possible that they consume more healthy food (along with other market inputs such as medical care).

Second, increased labor supply may change the composition of time and market inputs into health capital due to each period's time constraint. In order to make more time available for work, individuals may choose health investments where time and market inputs are substitutes and not complements. To the extent that fruits and vegetables require preparation time to yield health improvements, this may imply a reduction in the demand for healthy food items.[3] Instead, individuals may opt for more expensive but less time-intensive medical treatments. Fruit and vegetables can also be consumed raw without much preparation, however, so realistically, the complementarity between fruit and vegetable purchases and preparation time is relatively low. Hence, any negative effect of minimum wage increases is likely small.

Grossman's (1972) dynamic model of health investments implies a third effect of higher wages. Since individuals likely believe that minimum wage increases are permanent, the expected future marginal benefit of health capital rises. In other words, individuals benefit from improving their health because each additional healthy day in the future will potentially

[2]It is a reasonable assumption that the substitution effect outweighs the income effect for wage increases in the range of typical minimum wages.

[3]Monsivais, Aggarwal, and Drewnowski (2014) estimate a negative relationship between time spent on food preparation and fruit and vegetable consumption, for instance, and Welch et al. (2009) find that time constraints are often perceived as a barrier for healthy nutrition.

earn them a higher wage. In order to reap these future benefits and to increase their health capital, they may increase their current consumption of fruits and vegetables.

Adding up these three effects, the net effect may be positive or negative. However, given the dynamic investment incentive and the fact that the degree of complementarity between fruit and vegetable consumption and related time inputs is relatively low, the overall effect is likely positive. Clearly, fruit and vegetable consumption is not the only health input that may be bought with additional income, so any effects are likely small.

On the other hand, if a minimum wage increase leads to disemployment, workers who lose their job have less disposable income. In turn, lower income likely reduces demand for fruits and vegetables for the same reasons listed above. Demand for health capital declines, so lower health investments are required. At the same time, the relaxed time constraint due to job loss will not compensate for lower income when it comes to the required time and market inputs into healthy nutrition. Finally, the dynamic incentives to improve health and productivity are reduced if the individual does not expect to return to the workforce anytime soon.

In sum, with small positive effects due to a wage increase and likely negative effects because of disemployment, we do not expect to see a substantial net impact of minimum age increases on fruit and vegetable consumption. Ideally, we would disentangle these effects by using longitudinal data. This would allow us to separate individuals whose wages increase after a minimum wage hike from those who lose their job. To our knowledge, no longitudinal data containing fruit and vegetable consumption is available, so we use repeated cross sections from the BRFSS. In this paper, we focus on the income effect of minimum wage increases and restrict the sample to employed individuals.[4] In this sample, we expect the effect of minimum wages on fruit and vegetable consumption to be positive due to the absence of disemployment effects by construction.

3 Background and Data

3.1 Minimum Wages

Nominal minimum wages have consistently increased over our study period, with the federal minimum wage growing from $3.80 in 1990 to $5.85 in 2007 and $7.25 since 2009. In addition, many states have implemented their own minimum wage policies leading to considerable

[4] We only observe the employment status of the respondent and not of other household members, so we cannot rule out disemployment effects within the household. To avoid this issue, we restrict the sample to one-person households where the respondent is employed in a robustness check.

cross-sectional variation as shown in Figure 1a.[5] The mean minimum wage increased from $3.82 in 1990 to $8.47 im 2017 while its maximum exceeded $10 in some states during the last few years of our study period.[6] In recent years, several communities have enacted their own minimum wage ordinances.[7] Since this within state variation only occurs at the very end of our study period and only affects a handful of states, we ignore it here.

3.2 Prices of Fruits and Vegetables

Whether a higher minimum wage leads to increased consumption of fruits and vegetables relative to other goods also depends on their price. Therefore we deflate nominal minimum wages by a seasonally adjusted monthly consumer price index (CPI) for fruits and vegetables.[8] Figure 1b shows annual means, minima, and maxima for minimum wages that are deflated by the fruit-and-vegetable CPI. Due to a constant federal minimum wage but increasing prices the mean deflated minimum wage is declining from 1992 to 1996 and from 2000 to 2005.

To get an idea about the food prices in relation to going minimum wages, we use data compiled by the U.S. Department of Agriculture on the "Cost of Food at Home."[9] The USDA defines a "thrifty plan," for example, that is designed to feed a family a nutritious and healthy diet at a minimum cost. It includes 18 pounds of fruits and vegetables per week for men and 13 pounds for women. In 2015, the weekly cost of food at home for a family of four (adult male, adult female, and two children) was $149 under the thrifty plan and $197 under the low-cost plan. At the federal minimum wage of $7.25 and with both parents working full-time, this family's weekly income would be $580, so it would have to devote 25 to 35% of its income for food under the thrifty and low-cost plans, respectively. Under this scenario, it is likely that families may not have enough resources to afford a healthy diet.[10]

[5]We collected the prevailing federal or state minimum wage for each month from the Bureau of Labor Statistics Monthly Labor Review (see http://www.bls.gov/opub/mlr/author/nelson-richard-r.htm and http://www.bls.gov/opub/mlr/author/fitzpatrick-john-j-jr.htm) and from Vaghul and Zipperer (2016) (see https://github.com/equitablegrowth/VZ_historicalminwage). In addition, we cross-checked these minimum wages with independently collected data from Gittings and Schmutte (2016). We are grateful to Ian Schmutte for providing their minimum wage data.

[6]We only show minima, maxima, and means for our sample years in Figure 1a. The mean minimum wage is weighted by the number of BRFSS respondents in each year and state.

[7]Among larger cities, Chicago, Washington, Seattle, and San Francisco enacted minimum wage ordinances in 2014 and Los Angeles followed suit in 2015. See http://laborcenter.berkeley.edu/minimum-wage-living-wage-resources/inventory-of-us-city-and-county-minimum-wage-ordinances/.

[8]See https://research.stlouisfed.org/fred2/series/CUSR0000SAF113.

[9]Annual reports are available at http://www.cnpp.usda.gov/USDAFoodPlansCostofFood/reports.

[10]In a related study, Johnson, Anderson, and Chenhall (2006) also find that minimum wage earners in Nova Scotia cannot afford a nutritious diet.

Therefore, it is important to investigate the potential effects of increasing income and other policies on the nutrition of low-income individuals and households.

3.3 Data Description and Summary Statistics

We use repeated cross sections of the 1990 to 2017 BRFSS, which is compiled by the Centers for Disease Control and Prevention.[11] The BRFSS is a representative, annual phone survey that collects health behaviors and characteristics of the adult population of the U.S. While some variables are on the household level (e.g., income), the focus is on the individual respondent. Therefore, we will analyze individuals' fruit and vegetable consumption as a function of the minimum wage. Our sample consists of employed individuals aged 65 and younger. In our main results, we analyze the relationship between minimum wages and fruit and vegetable consumption in both the full sample (1,314,302 individuals) and those with a high school degree or less (416,990 individuals). Since the BRFSS contains state identifiers and month of interview, we can merge the individual-level data to state-and month-specific real minimum wages.

The outcome variable of interest, daily fruit and vegetable consumption (in servings) is derived from various interview questions concerning dietary habits. Until 2009, respondents were asked how often they consumed fruit juices, fruit, green salad, potatoes, carrots, other vegetables (per day, week, or month). Based on their responses, the BRFSS contains a variable that measures daily servings of fruits and vegetables. From 2011 onwards, the underlying questions were more detailed (consumption of pure fruit juices, fruit, beans or lentils, dark green vegetables, orange colored vegetables, other vegetables), but the derived daily servings variable is consistent with the earlier years.[12]

In Table 1, we provide summary statistics on fruit and vegetable consumption (measured in daily servings and weighted by BRFSS survey weights) conditional on various individual and household characteristics for our main estimation sample (alpa education levels). We also report the distribution of these characteristics in the estimation sample. Overall, individuals consume 3.25 servings of fruits and vegetables per day. Median daily consumption is 2.8 servings and the 75th percentile equals 4.1 (not shown in Table 1). Most individuals therefore do not meet the recommendations of five daily servings, (see also Moore and Thompson, 2015). There is some variation in fruit and vegetable consumption by individual characteristics, with female, black, Hispanic, and married individuals consuming more. In

[11] Information on fruit and vegetable consumption is only available for odd years after 2002, so we do not include even years from 2004 to 2016.

[12] A very small number of individuals (1,937 or 0.09% of our sample) indicated no consumption of fruits or vegetables. To allow use of the logarithm in our regressions, we code these responses to 0.01, the minimum average number of daily servings among those with strictly positive consumption levels.

addition, we find a positive education and income gradient. Finally, we observe a slight decline in fruit in vegetable consumption over our study period. This is consistent with the findings in Casagrande et al. (2007) for an earlier but overlapping time period.

4 Empirical Methodology

In this section, we discuss how we identify and estimate the causal effect of minimum wage increases on fruit and vegetable consumption.

4.1 Difference-in-Differences

First, we exploit variation in the minimum wage across states and within states over time in a DD framework:

$$\ln\left(FV_{ismt}\right) = \alpha \ln\left(MW_{smt}^{FV}\right) + X_i'\beta + \nu_t + \mu_m + \rho_s + \epsilon_{ismt}, \tag{1}$$

where FV_{ismt} is fruit and vegetable consumption (in daily servings) of individual i in state s, month m, and year t and MW_{smt}^{FV} is the corresponding minimum wage deflated by the fruit and vegetable CPI. X_i contains individual controls, ν_t is a year fixed effect, μ_m is a calendar month fixed effect that captures seasonality in fruit and vegetable consumption, ρ_s is a state fixed effect, and ϵ_{ismt} is an i.i.d. error term. State and year fixed effects control for systematic differences in fruit and vegetable consumption between states and changes over time that are common across states.[13] The latter captures federal policies aimed at low-income populations, such as the Earned Income Tax Credit and food stamps.[14] The coefficient of interest is α, which measures the elasticity of fruit and vegetable consumption with respect to the minimum wage. We weight all regressions by BRFFS sampling weights and cluster standard errors on the state level.

To interpret α as a causal estimate, we require that any variation in ϵ_{ismt} within states and time periods be uncorrelated with the minimum wage. This assumption holds if the unobserved and idiosyncratic determinants of fruit and vegetable consumption captured by ϵ_{ismt} are unrelated to the minimum wage set by policymakers on the state or federal level. While it is common for DD studies to make this assumption, it is possible that it is violated

[13] We add state specific time trends in a robustness check.

[14] See, for instance, Hoynes and Schanzenbach (2016) and Nichols and Rothstein (2016) for a description of these federal policies.

in the present case. Writing the error term in equation (1) as

$$\epsilon_{ismt} = \eta_{smt} + \tilde{\epsilon}_{ismt}, \tag{2}$$

we can find reasons why η_{smt} may be correlated with the minimum wage even conditional on state and time. In particular, if $\text{cov}(MW^{FV}_{smt}, \eta_{smt}) > 0$, the DD estimate α is upward biased. For example, due to some unobserved event such as an upcoming election, policymakers may want to increase their popularity with low-income workers and farmers at the same time by increasing the minimum wage and subsidizing fruits and vegetables.[15] Although this example is somewhat contrived it illustrates the possibility that the typical DD identifying assumption is not valid when then a state's minimum wage policy is endogenous.

4.2 Triple-Differences

In order to avoid the bias described in the previous section, we take a third difference to identify the effect of minimum wage increase on fruit and vegetable consumption. In particular, we divide the sample into individuals who are affected by a minimum wage increase ("treatment group") and those who are not affected ("control group"). We then estimate the following triple-differences (DDD) regression:

$$\begin{aligned} \ln\left(FV_{ismt}\right) = \gamma_1 \ln\left(MW^{FV}_{smt}\right) + \gamma_2 T_{ismt} + \gamma_3 \ln\left(MW^{FV}_{smt}\right) \times T_{ismt} + X_i'\beta \\ + \nu_t + \mu_m + \rho_s + \theta_{st} + \epsilon_{ismt}, \end{aligned} \tag{3}$$

where T_{ismt} is a dummy variable that equals one if individual i is a member of the treatment group and zero otherwise.[16] In addition, we include state-by-year fixed effects θ_{st} in some specifications. These fixed effects flexibly control for unobserved factors and policies that vary on the state-by-year level, such as welfare policies and Medicaid eligibility rule that may affect low-income individuals' income and hence fruit and vegetable consumption.[17] Note that we can estimate the effect of the minimum wage, γ_1, even when we include θ_{st}, because the minimum wage varies on the state and month level.

The crucial assumption to identify the causal effect of minimum wage increases on fruit and vegetable consumption, γ_3 in equation (3), is independence between the minimum wage

[15] Note that we do not have data on state-specific fruit and vegetable prices. Hence, measurement error in MW^{FV}_{smt} may lead to the type of endogeneity described here.

[16] As we discuss below, the definition of the treatment and control groups depends on factors that vary with state and time.

[17] See, for instance. Ziliak (2016), Buchmueller, Ham, and Shore-Sheppard (2016), and Pohl (2018) for a description of these state-level policies.

in state s and time period t, m and the *difference* in unobservable factors affecting fruit and vegetable consumption between the treatment and control group. In other words, the state- and time-specific error term component η_{smt} in equation (2) is differenced out by taking the third difference. To continue the above example, this assumption would only be violated if policymakers were somehow able to increase the minimum wage and subsidize fruits and vegetables only for the treatment group (i.e., minimum income earners). One identification challenge that the DDD approach cannot solve is due to the fact that individuals may move to states with higher minimum wages (see Boffy-Ramirez, 2013, for example). Any migration effects are likely small, so we follow the literature on minimum wages and health and ignore this issue here.

Aside from providing a better identification strategy, the DDD approach has important implications for the interpretation of our results. In particular, the DDD effect γ_3 in equation (3) measures the causal effect of minimum wage increases on the fruit and vegetable consumption among members of the treatment group, i.e. those individuals who actually earn the minimum wage. In contrast, the DD effect in equation (1), α_1, measures the same effect among the entire sample. Since we are interested in how minimum wage increases affect the healthy diet of minimum wage earners, the appropriate coefficient is γ_3.

4.3 Definition of the Treatment Group

If the BRFSS data contained hourly wages, it would be straightforward to define the treatment group consisting of individuals who earn (close to) the minimum wage. Unfortunately, this information is not available, so we have to construct the treatment and control group using the only related variable, which is annual household income.

BRFSS respondents indicate in which of a number of brackets their annual household income falls. These brackets have the upper thresholds $b_i^{max} = \{10000, 15000, 20000, 25000, 35000, 50000, 75000, \infty\}$. The lower threshold for each income bracket is the next smaller value with the lower threshold for the first bracket being zero. Using the going minimum wage in state s and time period t, m, we can calculate the maximum earned income that i's household can make per year when working minimum wage jobs ("maximum minimum wage income," MMWI) as

$$Y_{ismt}^{max} = 2000 \times N_i \times MW_{smt}, \quad (4)$$

where N_i is the number of adults in i's household.[18] We assume that individuals do not work more than 40 hours per week (2000 hours per year) and only adults work. Since we only have information about individual i's employment status, we can only assume that all other

[18] We drop households with more than six adults.

adult household members work to obtain the highest possible household income.[19] Using the definition in equation (4), we can define the treatment group using the following inequality:

$$T_{ismt} = \mathbf{1}\left\{b_i^{max} \leq Y_{ismt}^{max}\right\}. \tag{5}$$

That is, an individual is allocated to the treatment group if her reported highest possible household income b_i^{max} is no larger than what her household can earn when each adult member works full-time minimum wage jobs. In other words, if at least one household member worked a full-time job that pays above minimum wage, annual income could not be in the bracket defined by b_i^{max} or any lower bracket.

The treatment group definition in equation (5) has several limitations that may lead to misclassification of individuals into the treatment or control group. First, it is possible that the household works more than $2000 \times N_i$ hours per year because some household members work more than 40 hours per week or non-adult household members are employed. In this case, we would falsely assign some minimum wage earners to the control group. Second, it is possible that an individual earns more than the minimum wage, but her income falls below Y_{ismt}^{max} because she works fewer hours at a higher wage. In this case, individuals with higher wages may be falsely assigned to the treatment group. Finally, unearned income could lead to households having earnings that are much lower than b_i^{max}, but in that case could be consistent with earning the minimum wage or earning a higher wage and working few hours. Overall, the misclassification bias may be positive or negative. To deal with these issues, we conduct several robustness checks on the implicit assumptions in the definitions in equations (4) and (5).

In general, the challenge in assessing the effect of minimum wage changes on health outcomes arises from the fact that it is difficult to identify individuals who are actually affected by the change, especially in the absence of precise wage and earnings data. Therefore, most existing studies in this area that use a DD framework estimate intent-to-treat (ITT) effects (see, for example, Wehby, Dave, and Kaestner, 2016; Averett, Smith, and Wang, 2017). These studies typically restrict the sample to individuals who are likely affected by minimum wage changes, such as teenagers and those with low levels of education. The study by Horn, Maclean, and Strain (2017) is a notable exception in that it uses a DDD approach in addition to excluding more educated individuals. In contrast to our third difference, they compare working age adults to retired individuals who are 70 and older. This is a valid placebo group

[19] We conduct a robustness check with one-adult households where we know the employment status of all adult household members. We do not account for unearned income because we do not have any information on how the household income reported in BRFSS is composed. It seems likely, however, that most income reported by low-income individuals consists of earnings.

since these individuals are not affected by the minimum wage. We believe, however, that our comparison group consisting of individuals who earn just above the minimum wage is equally valid and subject to the same dynamics as same-age minimum wage earners. We do concede, however, that our approach still estimates ITT effects since we cannot perfectly identify minimum wage earners due to the coarse income measure in the BRFSS.

5 Results

In this section, we first present our main results from estimating the DD regression (1) and the DDD regression (3). Then we provide several robustness checks to assess the role of some of the assumptions that are discussed in Section 4.3 and provide results using different minimum wage measures. We also present regression results with obesity as the outcome.

5.1 Main Results

Table 2 shows our main regression results from estimating DD regressions (1) and DDD regressions (3) (with and without state-year fixed effects) for the whole sample, i.e. for employed individuals with any education level. The DD regression in column (1) does not yield a statistically significant effect of the minimum wage on fruit and vegetable consumption. In the DDD regressions, however, we estimate a statistically significant elasticity of 0.11 to 0.12 for individuals whose income makes it likely that they are affected by minimum wage changes. The effects do not vary significantly by whether we include state-by-year fixed effects in addition to state and year fixed effects. They are signifiant at the 5% level without state-by-year fixed effects and at the 10% level when we include these fixed effects. The elasticities correspond to an increase of about 0.08 daily fruit and vegetable servings when the minimum wage increases by one dollar (evaluated at the respective sample means).

We briefly describe the effects of control variables on fruit and vegetable consumption. Men consume fewer daily servings than women. African Americans consume the least fruits and vegetables among all racial groups, which is consistent with the literature (Centers for Disease Control and Prevention, 2015). Moreover, we find higher consumption among married individuals and a positive education gradient. These findings confirm existing evidence on the relationship between education and marital status and health investments (see, for example, Cutler and Lleras-Muney, 2010; Wilson and Oswald, 2005).

Most of the existing literature on the health effects of minimum wages focuses on individuals with low education levels since they are more likely to be employed in minimum wage jobs. We follow this approach in Table 3 where we restrict the sample to individuals who have at most a high school degree. Compared to the full sample results in Table 2, the effect of the minimum wage is smaller and not statistically significant. These results are consistent with the finding in Horn, Maclean, and Strain (2017) who also use a sample of individuals with low education levels but a different DDD comparison group.

Tables 2 and 3 and provide somewhat conflicting estimates for the effect of minimum wages on fruit and vegetable consumption. In a sample of all employed individuals, we find positive and significant effects, but when we restrict the sample to individuals with at most a high school degree, the effects become insignificant (with point estimates still positive). The restriction to a low eduction sample is sensible in the existing literature that mostly relies on a DD approach. The rationale for only including individuals with at most a high school degree is that they are most likely to earn a minimum wage. In our DDD approach, however, we explicitly compare individuals whose income makes it likely to earn minimum wages with those reporting a higher income. Therefore, the additional limitation to a low education sample is not necessary. Given this argument and the fact that the estimates in Tables 2 and 3 do not differ significantly from each other, we conclude that the effect of a minimum wage increase on fruit and vegetable consumption is likely positive.

5.2 Robustness Checks

We check the robustness of our main results to different assumptions regarding the treatment group and time trends as well as alternative minimum wage measures. For each robustness check, we only report results for the DDD specifications with state-by-year fixed effects.

First, we replace the weak inequality in the definition of treatment group in equation (5) with a strict inequality, so the treatment group is now defined as $T_{ismt} = \mathbf{1}\left\{b_i^{max} < Y_{ismt}^{max}\right\}$. Hence, we now only count those individuals as potential minimum wage earners whose household income category is strictly below the maximum income that is possible given the going minimum wage and the number of adults in the household. With this stricter definition, we account for the possibility that minimum wage earners may not work full-time and therefore have lower income levels. Column (1) of Table 4 shows that the estimated elasticity of fruit and vegetable consumption with respect to the minimum wage among individuals who satisfy the strict inequality above equals 0.146. It is slightly larger but not statistically different from the elasticity in column (3) of Table 2. Hence, our findings are not sensitive to the exact definition of the treatment group. This is reassuring especially because we have to rely on the coarse income measurement available in the BRFSS.

Second, we restrict the sample to individuals who are the only adult member in their respective households. In the definition of the highest possible household income given the going minimum wage in equation (4), we assume that all adult household members other than the interviewed individual are employed. This assumption is necessary because we only observe the employment status of the respondent, but it is clearly possible that not all other adults work full-time. Changing the definition of the "maximum minimum wage income" to $Y^{max}_{ismt} = 2000 \times MW_{smt}$ and restricting the sample to one-adult households avoids making this assumption. The regression results in column (2) of Table 4 show that the point estimate for the effect of the minimum wage among the treatment group is very similar to the effect in our main specification in Table 2. The coefficient is not statistically significant in the one-adult sample, however, most likely due to the smaller sample size. We therefore find that the assumption that all non-respondent adults are employed underlying our main specification is not crucial for our overall results.

A common concern in DD studies is the possibility that the necessary parallel trends assumption is violated. To avoid this issue, researchers often include group specific time trends in their DD regressions. In our main DDD specification , any non-parallel trends likely disappear from taking the third difference. Moreover, Sabia and Nielsen (2015) note that including state specific time trends in minimum wage studies removes too much variation. Nevertheless, we include linear state specific time trends in a robustness check in column (3) of Table 4. We find that the minimum wage effect among individuals likely affected by minimum wage changes is statistically significant at the 10% level and slightly smaller than in our main specification. Our results are therefore robust to the inclusion of time trends and it appears that they do not absorb too much variation in this case.

Finally, we consider different minimum wage measures. In column (1) of Table 5, we replace the logarithm of the deflated minimum wage that we use in our main specification with the logarithm of the nominal minimum wage to check whether our findings are sensitive to the use of the fruit and vegetable CPI deflator. We find that the effect of the nominal minimum wage on fruit and vegetable consumption among individuals who earn close to the minimum wage is an order of magnitude smaller than in our main results and statistically insignificant. The difference in estimated coefficients is not surprising because the minimum wage measures follow different trajectories over time. The average nominal minimum wage was always increasing whereas the deflated minimum wage exhibited periods of decline (see Figure 1). Especially when analyzing fruit and vegetable consumption over an almost 30-year period, it is important to account for changes in purchasing power, so we find the main results using deflated minimum wages more credible.

In column (2) of Table 5, we replace the logarithms of fruit and vegetable servings and the minimum wage (deflated by the fruit and vegetable CPI) with their respective absolute values. We estimate that a one-dollar increase in the minimum wage increases the number of daily fruit and vegetable servings by about 0.06. This effect is not statistically significant but roughly similar to the effect implied by the estimated elasticity of 0.08. Hence, our findings do not depend on functional form assumptions. We prefer to base any conclusions about the effect of minimum wage increases on fruit and vegetable consumption on the estimated elasticity due to its higher precision.

It is possible that individuals do not make decisions based on their wage per se but rather based on how much they earn relative to the average worker. To capture this idea, we replace the minimum wage by its ratio to the year and state specific median hourly wage in column (3) of Table 5 (where the outcome variables is number of daily fruit and vegetable servings).[20] We find that a one-unit increase in the minimum wage to median hourly wage ratio increases fruit and vegetable consumption by about 0.23 daily servings implying that a one standard deviation increase in this ratio leads to a 0.01 servings increase in fruit and vegetable consumption. However, this effect is not statistically significant.

5.3 Results for Obesity

While fruit and vegetable consumption is an important part of healthy nutrition in its own right, we ultimately care about the effect of nutrition on body mass and obesity as the latter can lead to health conditions such as diabetes. Therefore, we estimate our main DD and DDD specifications with an obesity indicator as the outcome variable. We use self-reported height and weight to construct the body mass index (BMI) of BRFSS respondents and then define obesity as a BMI above 30.[21] About 24% of our sample are obese.

Table 6 shows the results for the DD regression in column (1) and for DDD regressions without and with state-by-year fixed effects in columns (2) and (3), respectively. Across all three specifications, we find that the relevant effect of a 100% increase in the minimum wage leads to a decline in obesity by about 3.6 to 4.4 percentage points. This finding is consistent with Meltzer and Chen (2011) who find that a one dollar increase in the minimum wage reduces BMI by 0.06. Cotti and Tefft (2013) also investigate the indirect relationship between the minimum wage and obesity that operates through fast food prices in a two-stage least squares analysis. They do not find a significant relationship between minimum wages and BMI or obesity in their reduced form, but this may be due to the fact that they include county specific time trends which absorb too much variation (see above). In contrast, our results suggest a robust relationship between minimum wages, implying that

[20] We are grateful to an anonymous referee for making this suggestion. Hourly median wages stem from the Bureau of Labor Statistics's Occupational Employment Statistics (https://www.bls.gov/oes/tables.htm) and are only available starting in 2001. The mean ration of the minimum wage to the median hourly wage equals 0.44 with a standard deviation of 0.05 across all states and the years 2001 to 2017.

[21] BMI is defined as weight (in kilograms) divided by height (in meters) squared.

higher minimum wages do not only lead to more fruit and vegetable consumption but also to healthier diet in general, thereby reducing obesity.

6 Conclusion

This paper uses recent increases in the minimum wage the effect of increased income among low-income individuals on their consumption of fruits and vegetables. Using DD and DDD approaches, we find small but significantly positive effects that are confirmed by various robustness checks. Research on the effect of minimum wage on other health outcomes has produced similar elasticities. Meltzer and Chen's (2011) results correspond to an elasticity of body mass index with respect to the minimum wage of -0.25 (which translates into a health improvement), and Wehby, Dave, and Kaestner (2016) find a birth weight elasticity of 0.03. Our results, with an estimated elasticity of 0.12, therefore fit into the emerging literature on health effects of minimum wage policies.

Hence, our results imply that low-income individuals use most of their increased earnings due to higher minimum wages for other consumption goods, but they nevertheless improve their nutrition. Hence, raising income through higher minimum wages or other means is a feasible option for policymakers whose aim is to moderately improve nutrition among low-income populations. However, a minimum wage increase within the existing range is unlikely to have a large effect on healthy diet. Further research is necessary to assess if more targeted approaches, such as subsidies for healthy food items, have a larger impact when compared to an increase in income.

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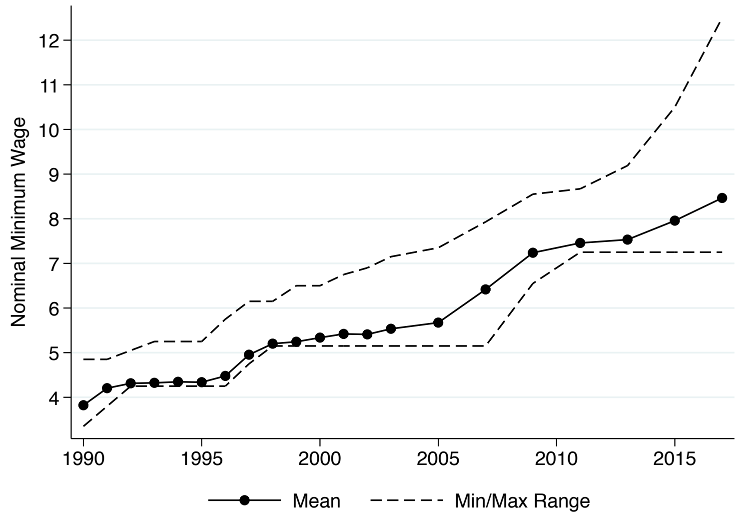
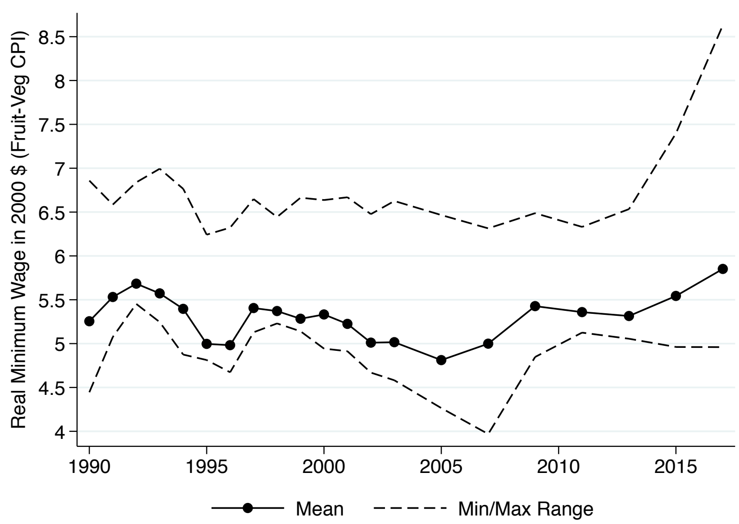


(a) Nominal Minimum Wages



(b) Minimum Wages Deflated by the Fruit-and-Vegetable CPI

Figure 1: Means, Minima, and Maxima of Minimum Wages Over Time

Table 1: Distribution of Control Variables and Mean/Standard Deviations of Fruit and Vegetable Consumption (Daily Servings) by Control Variables

	Percent	Fruit/Vegetable	
		Mean	Std.dev.
Female	57.18	3.760	(1.940)
Male	42.82	3.353	(1.845)
Age 18 to 30	16.11	3.384	(1.956)
Age 31 to 50	52.69	3.550	(1.871)
Age 51 to 65	31.20	3.726	(1.889)
White	84.10	3.547	(1.876)
Black	8.79	3.462	(2.002)
Other race	7.12	3.609	(1.997)
Non-Hispanic	93.90	3.555	(1.888)
Hispanic	6.10	3.453	(1.996)
Single	36.59	3.408	(1.964)
Married/Cohabitating	63.41	3.611	(1.865)
No High School Degree	4.86	3.206	(1.932)
High School Degree	26.87	3.250	(1.848)
Some College	28.10	3.524	(1.884)
College Degree or More	40.18	3.874	(1.895)
Household income < 10K	1.88	3.380	(2.107)
Household income ≥ 10K & < 15K	2.82	3.268	(2.000)
Household income ≥ 15K & < 20K	5.03	3.309	(1.978)
Household income ≥ 20K & < 25K	7.48	3.349	(1.928)
Household income ≥ 25K & < 35K	13.03	3.397	(1.887)
Household income ≥ 35K & < 50K	18.66	3.514	(1.863)
Household income ≥ 50K & < 75K	20.90	3.614	(1.855)
Household income ≥ 75K	30.19	3.756	(1.881)
Year 1990	0.85	3.637	(2.065)
Year 1991	0.93	3.611	(1.903)
Year 1992	0.84	3.646	(1.896)
Year 1993	0.39	3.632	(1.883)
Year 1994	3.71	3.719	(2.014)
Year 1995	0.88	3.680	(1.997)
Year 1996	4.22	3.601	(1.783)
Year 1997	0.91	3.610	(1.721)
Year 1998	5.23	3.555	(1.794)
Year 1999	0.67	3.522	(1.885)
Year 2000	6.44	3.539	(1.817)
Year 2001	1.38	3.590	(1.833)
Year 2002	7.93	3.520	(1.859)
Year 2003	8.31	3.484	(1.846)
Year 2005	10.65	3.504	(1.873)
Year 2007	11.81	3.563	(1.885)
Year 2009	10.75	3.593	(1.875)
Year 2011	9.91	3.324	(2.054)
Year 2013	7.05	3.368	(2.089)
Year 2015	4.24	3.322	(2.100)
Year 2017	2.89	3.462	(2.169)

Source: Behavioral Risk Factor Surveillance System, 1990 to 2017.
Note: Means weighted by BRFSS survey weights.

Table 2: Difference-in-Differences and Triple-Differences Regressions for the Effect of Minimum Wages on Log-Fruit and Vegetable Servings per Day (All Education Levels)

	(1)	(2)	(3)
Log-MW	−0.00105	−0.0195	0.0344
	(0.0420)	(0.0542)	(0.0449)
Inc.≤MMWI		−0.224**	−0.216**
		(0.0846)	(0.0883)
Inc.≤MMWI × Log-MW		0.118**	0.112*
		(0.0541)	(0.0564)
Age	−0.00367***	−0.00458***	−0.00452***
	(0.000706)	(0.000834)	(0.000831)
Age squared/100	0.00943***	0.0104***	0.0103***
	(0.000928)	(0.00107)	(0.00106)
Male	−0.131***	−0.132***	−0.132***
	(0.00318)	(0.00328)	(0.00324)
Black	−0.0286***	−0.0255***	−0.0261***
	(0.00674)	(0.00676)	(0.00670)
Other race	0.0167	0.0197	0.0184
	(0.0122)	(0.0124)	(0.0130)
Hispanic	0.00648	0.0110	0.0101
	(0.0119)	(0.0106)	(0.0106)
Married/cohabitating	0.0869***	0.0842***	0.0841***
	(0.00286)	(0.00278)	(0.00254)
High school graduate	0.0462***	0.0395***	0.0404***
	(0.0137)	(0.0121)	(0.0115)
Some college	0.151***	0.141***	0.143***
	(0.0166)	(0.0143)	(0.0135)
College degree or more	0.263***	0.251***	0.251***
	(0.0154)	(0.0128)	(0.0125)
State fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
State×year FE	No	No	Yes
Month dummies	Yes	Yes	Yes
R^2	0.0555	0.0558	0.0615
N	1,314,302	1,314,302	1,314,302

Notes: The dependent variable is the logarithm of daily fruit and vegetable servings. MW = minimum wage; MMWI = maximum minimum wage income (see equation (4) in the text). The minimum wage is deflated by the fruit-and-vegetable CPI. The sample consists of employed individuals from the 1990 to 2017 BRFSS. Regressions are weighted by BRFSS survey weights. Standard errors are clustered on the state level. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 3: Difference-in-Differences and Triple-Differences Regressions for the Effect of Minimum Wages on Log-Fruit and Vegetable Servings per Day (High School Degree and Less Education)

	(1)	(2)	(3)
Log-MW	0.0173	−0.00553	0.0975
	(0.0491)	(0.0648)	(0.0699)
Inc.≤MMWI		−0.189	−0.121
		(0.114)	(0.102)
Inc.≤MMWI × Log-MW		0.0933	0.0512
		(0.0711)	(0.0631)
Age	−0.00789***	−0.00888***	−0.00903***
	(0.00108)	(0.00122)	(0.00121)
Age squared/100	0.0137***	0.0147***	0.0149***
	(0.00147)	(0.00162)	(0.00159)
Male	−0.114***	−0.116***	−0.117***
	(0.00491)	(0.00520)	(0.00517)
Black	−0.0201*	−0.0146	−0.0154
	(0.0112)	(0.0110)	(0.0107)
Other race	0.0230	0.0265	0.0271*
	(0.0161)	(0.0163)	(0.0159)
Hispanic	0.0414**	0.0495***	0.0449***
	(0.0175)	(0.0161)	(0.0151)
Married/cohabitating	0.0983***	0.0952***	0.0946***
	(0.00373)	(0.00362)	(0.00338)
High school degree	0.0602***	0.0528***	0.0557***
	(0.0107)	(0.00936)	(0.00858)
State fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
State×year FE	No	No	Yes
Month dummies	Yes	Yes	Yes
R^2	0.0285	0.0290	0.0393
N	416,990	416,990	416,990

Notes: The dependent variable is the logarithm of daily fruit and vegetable servings. MW = minimum wage; MMWI = maximum minimum wage income (see equation (4) in the text). The minimum wage is deflated by the fruit-and-vegetable CPI. The sample consists of employed individuals with a high school degree or less education from the 1990 to 2017 BRFSS. Regressions are weighted by BRFSS survey weights. Standard errors are clustered on the state level. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 4: Triple-Differences Regressions for the Effect of Minimum Wages on Log-Fruit and Vegetable Servings per Day (Robustness to Alternative Assumptions)

	(1) Strict Treatment	(2) One-Adult	(3) State Trends
Log-MW	0.0387	−0.0533	−0.137*
	(0.0469)	(0.0709)	(0.0763)
Income<MMWI	−0.267***		
	(0.0939)		
Income<MMWI × Log-MW	0.146**		
	(0.0592)		
Inc.≤MMWI		−0.286	−0.195**
		(0.319)	(0.0776)
Inc.≤MMWI × Log-MW		0.138	0.0999*
		(0.201)	(0.0498)
Controls	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
State×year FE	Yes	Yes	No
State trends	No	No	Yes
Month dummies	Yes	Yes	Yes
R^2	0.0614	0.0604	0.0572
N	1,314,302	356,310	1,314,302

Notes: The dependent variable is the logarithm of daily fruit and vegetable servings. MW = minimum wage; MMWI = maximum minimum wage income (see equation (4) in the text). The minimum wage is deflated by the fruit-and-vegetable CPI. The included control variables are listed in Table 2. The sample consists of employed individuals from the 1990 to 2017 BRFSS; in column (2), the sample is restricted to individuals who are the only adult in their household. Regressions are weighted by BRFSS survey weights. Standard errors are clustered on the state level. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 5: Triple-Differences Regressions for the Effect of Minimum Wages on Log-Fruit and Vegetable Servings per Day (Robustness to Alternative Minimum Wage Measures)

	(1) Nominal	(2) Absolute	(3) Relative
Log-MW (nom.)	0.0691		
	(0.0543)		
Inc.≤MMWI	−0.0555*	−0.359*	−0.139
	(0.0325)	(0.197)	(0.102)
Inc.≤MMWI × Log-MW (nom.)	0.0149		
	(0.0221)		
MW		0.00381	
		(0.0279)	
Inc.≤MMWI × MW		0.0615	
		(0.0407)	
Relative MW			−0.315
			(0.379)
Inc.≤MMWI × Relative MW			0.226
			(0.265)
Controls	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
State×year FE	Yes	Yes	Yes
Month dummies	Yes	Yes	Yes
R^2	0.0615	0.0523	0.0528
N	1,314,302	1,314,302	984,739

Notes: The dependent variable is the logarithm of daily fruit and vegetable servings in column (1) and daily fruit and vegetable servings in columns (2) and (3). MW = minimum wage; MMWI = maximum minimum wage income (see equation (4) in the text). The minimum wage is nominal in column (1) and deflated by the fruit-and-vegetable CPI in column (2). In column (3), the nominal minimum wage is divided by the median hourly wage to yield the relative minimum wage. The included control variables are listed in Table 2. The sample consists of employed individuals from the 1990 to 2017 BRFSS. Regressions are weighted by BRFSS survey weights. Standard errors are clustered on the state level. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 6: Difference-in-Differences and Triple-Differences Regressions for the Effect of Minimum Wages on Obesity (All Education Levels)

	(1)	(2)	(3)
Log-MW	−0.0422***	−0.0417***	0.00138
	(0.0143)	(0.0121)	(0.0156)
Inc.≤MMWI		0.104***	0.0903***
		(0.0242)	(0.0228)
Inc.≤MMWI × Log-MW		−0.0441***	−0.0358**
		(0.0147)	(0.0138)
Age	0.0149***	0.0159***	0.0159***
	(0.000435)	(0.000416)	(0.000416)
Age squared/100	−0.0144***	−0.0155***	−0.0155***
	(0.000537)	(0.000512)	(0.000509)
Male	0.0179***	0.0188***	0.0187***
	(0.00205)	(0.00209)	(0.00209)
Black	0.0912***	0.0880***	0.0879***
	(0.00348)	(0.00340)	(0.00342)
Other race	−0.0351***	−0.0377***	−0.0374***
	(0.00672)	(0.00657)	(0.00645)
Hispanic	0.0375***	0.0321***	0.0323***
	(0.00688)	(0.00667)	(0.00667)
Married/cohabitating	−0.00113	0.00161	0.00176
	(0.00122)	(0.00126)	(0.00125)
High school graduate	−0.0112***	−0.00434	−0.00466
	(0.00340)	(0.00350)	(0.00328)
Some college	−0.0174***	−0.00739*	−0.00782**
	(0.00387)	(0.00395)	(0.00368)
College degree or more	−0.0826***	−0.0696***	−0.0699***
	(0.00266)	(0.00277)	(0.00262)
State fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
State×year FE	No	No	Yes
Month dummies	Yes	Yes	Yes
R^2	0.0485	0.0493	0.0509
N	1,645,414	1,645,414	1,645,414

Notes: The dependent variable is in indicator that equals one if the individual is obese (BMI above 30). MW = minimum wage; MMWI = maximum minimum wage income (see equation (4) in the text). The minimum wage is deflated by the fruit-and-vegetable CPI. The sample consists of employed individuals from the 1990 to 2017 BRFSS. Regressions are weighted by BRFSS survey weights. Standard errors are clustered on the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.