Minimum Wages and Healthy Diet*

R. Vincent Pohl†
University of Georgia

Kathryn L. Clark
Harvard University
and University of Georgia

Ryan C. Thomas
Allegiant Travel Company
and University of Georgia

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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. Our results indicate that higher minimum wages contribute positively but moderately to improved nutrition.

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

JEL classification: I12, J38.

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†Department of Economics, Terry School of Business, 620 S Lumpkin St, Athens, GA 30602. Email: pohl@uga.edu.

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 (Mytton, Clarke, and Rayner, 2012), 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 sub-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. 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.[1] 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 (2015) finds self-reported health improvements following a minimum

[1] In theory, a higher minimum wage also leads to a decline in labor demand and hence reduced employment. The empirical literature is still divided, however, despite a vast number of studies. See Neumark and Wascher (2006) for a review. In recent studies, Dube, Naidu, and Reich (2007), Dube, Lester, and Reich (2010), and Allegretto, Dube, and Reich (2011) find no evidence for negative employment effects, but their results are disputed by Neumark, Salas, and Wascher (2014).

wage increase in the UK while ? 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. 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.[2] Among other outcomes, Horn, Maclean, and Strain (forthcoming) and Lenhart (2016) also investigate the effect of minimum wages on fruit and vegetable consumption, and calorie intake, respectively. In related research, Meltzer and Chen (2011) and Cotti and Tefft (2013) find a decline in body weight due to higher minimum wages. They show 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 to these two studies, 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.[3]

In addition, we make a point to carefully assess the assumptions that are necessary for difference-in-differences (DD) approach to yield causal estimates. Specifically, we show that a triple-difference (DDD) approach can deal with endogenous policies in a way that DD cannot. This approach differentiates the present paper from existing studies on the health effects of minimum wages including effects on healthy diet (Lenhart, 2016; Horn, Maclean, and Strain, forthcoming).

To estimate the causal effect of income minimum wage increases on fruit and vegetable consumption, we employ a DDD strategy that accounts for unobserved heterogeneity across states, controls for common time trends, and deals with potentially endogenous minimum wage policies. In addition, the DDD estimates allow us to isolate the effect minimum wage increases among low-wage workers who are most likely to be affected by an increase of the minimum wage. We also compare our DDD results to DD estimates to show that a DDD approach removes biases that may be present in a conventional DD design. 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 2000 to 2013.

[2] In related studies, Adams, Blackburn, and Cotti (2012) and Sabia, Pitts, and Argys (2014) study alcohol-related fatalities among teens as a result of minimum wage increases.

[3] 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.

Our preferred results show an income elasticity of fruit and vegetable consumption of about 0.09. That is, a minimum wage increase or other comparable income rise leads 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. However, in order to substantially raise the fruit and vegetable consumption of low-income individuals, a modest minimum wage increase is likely insufficient.

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

While the effect of an increased minimum wage on fruit and vegetable consumption is theoretically ambiguous, we use a dynamic model of health investment and labor supply to argue that it is likely positive. Following Grossman's (1972) human capital model, we model health capital as having 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 flow 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.

Focussing on the role 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.[4] 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

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

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. Instead, individuals may opt for expensive but less time-intensive medical treatments. Realistically, the complementarity between fruit and vegetable purchases and preparation time is relatively low, so any negative effect of minimum wage raises is likely small.

A 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 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 we do not expect to find very large effects.

3 Background and Data

3.1 Minimum Wages

Nominal minimum wages have consistently increased over the past two decades with the federal minimum wage growing from $4.25 in 1996 to $5.15 in 2006 and $7.25 in 2016. In addition, many states have implemented their own minimum wage policies leading to considerable cross-sectional variation as shown in Figure 1a.[5] Over our sample period from 2000 to 2013, the mean minimum wage increased from $5.34 to $7.54 while its maximum exceeded $9 in some states.[6] In recent years, several communities have enacted their own minimum wage ordinances, but with few exceptions these policies were not in force by the end of our sample period in 2013, so we ignore sub-state variation in minimum wages.[7]

[5] We collected the prevailing federal or state minimum wage for each month from 1/2000 to 12/2012 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 1/2013 to 12/2013 from various online sources. 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, see Section 3.3.

[7] Among larger cities, Chicago, Washington, DC, Seattle, and San Francisco enacted minimum wage ordinances in 2014 and Los Angeles followed suit in 2015. The only city- or county-wide ordinances that were in affect at the end of our sample are in Albuquerque, NM (starting 1/1/2013), Bernalillo County, NM (starting 7/1/2013), and San Jose, CA (starting 3/11/2013). The only city that had

— Figure 1 about 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 this fruit-and-vegetable CPI. Due to a constant federal minimum wage between 2000 and 2007, the lowest deflated minimum wage is declining over this period.

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] 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 2000 to 2013 BRFSS, which is compiled by the Center for Disease Control.[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

a minimum wage higher than its surrounding state for most of our sample period is Santa Fe, NM (starting 6/24/2004), see http://laborcenter.berkeley.edu/minimum-wage-living-wage-resources/inventory-of-us-city-and-county-minimum-wage-ordinances/.

[8] We obtained the CPI data from the Federal Reserve Bank of St. Louis (see https://research.stlouisfed.org/fred2). This CPI is only available for urban consumers and is constant across the entire country. Since our sample also includes non-urban individuals and since fruit and vegetable prices vary geographically, we conduct robustness checks using an all items CPI that varies by Census region and exclude non-rural individuals.

[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.

[11] Due to the availability of our main outcome variable, we use data from the odd years and 2000 and 2002.

wage. We exclude individuals who are over the age of 65 at the time of the survey due to the likelihood that they are retired and, therefore, not affected by changes in minimum wage. Moreover, we restrict the sample to individuals with a high school degree or less because it is rare that more highly educated individuals work in minimum wage jobs. Since the BRFSS contains publicly available 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. From 2000 to 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. In 2011 and 2013, 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) conditional on various individual and household characteristics. 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 2.9 servings and the 75th percentile equals 4.2 (not shown in Table 1).[13] There is some variation in fruit and vegetable consumption by individual characteristics, with female, black, Hispanic, and married individuals consuming more. In addition, we find a positive education and income gradient and lower consumption among the unemployed.[14]

— Table 1 about here —

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. Ideally, we would randomly assign individuals to different levels of the minimum wage, which is clearly not feasible. To approximate this ideal experiment, we define a treatment and a control group such that treatment, i.e. a higher minimum wage, is as good as random conditional on observables.

[12] A very small number of individuals (919 or 0.18% 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.

[13] Most individuals therefore do not meet the recommendations of five daily servings, see also Moore and Thompson (2015).

[14] Treatment and control group at the bottom of Table 1 are defined in Section 4.3.

4.1 Difference-in-Differences

First, we exploit variation in the minimum wage across states and over time. In this DD framework, we flexibly control for state and time effects to isolate the effect of the minimum wage on healthy diet:

$$\ln\left(FV_{ismt}\right) = \alpha_1 \ln\left(MW^{FV}_{smt}\right) + X_i'\beta + f_s(t) + \nu_s + \mu_m + \epsilon_{ismt}, \tag{1}$$

where FV_{ismt} is fruit and vegetable consumption of individual i in state s, month m, and year t and MW^{FV}_{smt} is the corresponding minimum wage deflated by the fruit and vegetable CPI. X_i contains individual controls, $f_s(t)$ is a state-specific flexible time trend that we specify below, ν_s is a state fixed effect, μ_m is a month fixed effect that captures seasonality in fruit and vegetable consumption, and ϵ_{ismt} is an i.i.d. error term. The coefficient of interest is α_1, which measures the elasticity of fruit and vegetable consumption with respect to the minimum wage.

To interpret α_1 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 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_1 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

[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.

following triple-differences (DDD) regression:

$$\ln\left(FV_{ismt}\right) = \gamma_1 \ln\left(MW^{FV}_{smt}\right) + \gamma_2 T_{ismt} + \gamma_3 \ln\left(MW^{FV}_{smt}\right) \times T_{ismt} + X_i'\beta + f_{0,s}(t) + f_{1,s}(t) \times T_{ismt} + \nu_s + \mu_m + \epsilon_{ismt}, \quad (3)$$

where T_{ismt} is a dummy variable that equals one if individual i is a member of the treatment group and zero otherwise.[16] $f_{0,s}(t)$ and $f_{1,s}(t)$ are state-specific time trends that may also vary between treatment and control group.

Hence, 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 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 minimum income earners.

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.[17]

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

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

[17] Meltzer and Chen (2011) and Cotti and Tefft (2013), in contrast, are interested in the effect of minimum wage increases on obesity that operates through higher wages for fast food restaurant employees and hence increased fast food prices. Since this mechanisms potentially applies to the entire population, they do not estimate their effects in a DDD framework.

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") as

$$Y_{ismt}^{max} = 2000 \times (N_i - \mathbf{1}\{i \text{ not employed}\}) \times MW_{smt}, \tag{4}$$

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 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.[20]

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 $2000 \times (N_i - \mathbf{1}\{i \text{ not employed}\})$ 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. We conduct several robustness checks on the implicit assumptions in the definitions in equations (4) and (5).

Most existing studies evaluate the effect of minimum wage increases on health outcomes using a DD framework (see, e.g., Wehby, Dave, and Kaestner, 2016). Since these studies

[18] We restrict the maximum number of adults to six.

[19] 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.

[20] Since the treatment group is defined based on household income being below a specific threshold, it is not surprising that fruit and vegetable consumption is lower among members of the treatment group (see Table 1.)

do not restrict the sample to minimum wage earners, they estimate an intention-to-treat effect. Therefore, analyzing the average treatment effect requires knowledge what fraction of the sample is affected by minimum wage increases. While our approach does not perfectly identify minimum wage earners, we can approximate the average treatment effect. Moreover, we provide intention-to-treat effects by estimating the DD regression (1), so we can compare our results with existing DD studies.

4.4 Time Trends

As in any DD or DDD regression, it is crucial to adequately control for time effects. The most common way to do so is simply by including a dummy variable for each time period (see, e.g., Angrist and Pischke, 2009), but other DD studies do not assume that time effects are common across treatment and control group and include, e.g., group-specific time trends (see, e.g., Page, Spetz, and Millar, 2005, Addison, Blackburn, and Cotti (2009), and Allegretto, Dube, and Reich (2011)). In the literature on the employment effects of minimum wages, recent studies conclude that linear state-specific time trends may not be sufficient to control for time variation in the data. For example, Neumark, Salas, and Wascher (2014) show that Allegretto, Dube, and Reich's (2011) results change from statistically insignificant to negative and significant when including a third-order or higher polynomial in state-specific time trends.[21]

To control for time effects in a flexible yet parsimonious way, we include quadratic state-specific time trends in our main results. Hence, we model time effects in the DD regressions (1) as

$$f_s(t) = \psi_{1,s}t + \psi_{2,s}t^2 \tag{6}$$

and in the DDD regressions (3) as

$$f_{0,s}(t) + f_{1,s}(t) \times T_{ismt} = \phi_{0,1,s}t + \phi_{0,2,s}t^2 + \phi_{1,1,s}t + \phi_{1,2,s}t^2, \tag{7}$$

where the ψs and ϕs are coefficients to be estimated. We also conduct robustness checks using linear and cubic time trends and year fixed effects to assess if our empirical results are sensitive to different ways to control for time effects.

[21] See also the discussion on state-specific time trends in Meer and West (2016).

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 Sections 4.3 and 4.4.

5.1 Main Results

Table 2 shows our main regression results from estimating DD regressions (1) and DDD regressions (3) for the whole sample. In this and all other tables, standard errors are clustered on the state level. The DD estimates in column (1) show that a one-percent raise in the minimum wage increases fruit and vegetable consumption (measured in daily servings) by 0.15 percent. This elasticity corresponds to an increase of 0.09 daily fruit and vegetable servings when the minimum wage increases by one dollar (evaluated at the respective sample means). Hence, we find that minimum wage increases lead to a modest improvement in healthy diet as proxied by fruit and vegetable consumption. When we restrict the sample to the treatment group, i.e. individuals who likely earn the minimum wage, in column (2), we find an elasticity of 0.21. When estimating our preferred specification, the DDD regression, we find the elasticity to be cut roughly in half, at 0.09 (see column (3)). On average, this estimate implies that minimum wage earners consume 0.05 more daily servings of fruits and vegetables if the minimum wage increases by one dollar. Across all three specifications, the DD and DDD effects are statistically different from zero at least at the five percent level.

— Table 2 about here —

While the DD and DDD estimates in columns (1) through (3) are not statistically significant from each other at the five percent level, the relative magnitude of the point estimates is nevertheless informative for potential biases in the DD regressions. As we discuss in Section 4.2, estimating a DD regression in this context may lead to biased estimates if there are some state and time specific factors that are correlated with minimum wage policies and fruit and vegetable consumption. Since the DDD estimate in column (3) is smaller than the DD estimate in column (1), these unobservables introduce a positive bias. In other words, our results indicate that minimum wage policies are positively correlated with other policies and factors that promote a healthy diet. When restricting the sample to potential minimum wage earners in column (2), the bias becomes larger, which is sensible if unobserved factors that positively affect fruit and vegetable consumption among these individuals are more strongly correlated with minimum wage policies. These differences across estimates highlight the importance of differencing out any unobserved factors that vary at the state and time level in our DDD regression.

The signs of coefficients on the control variables are as expected and their magnitudes are similar across specifications (1) to (3). For example, we find that men consume fewer fruits and vegetables than women and Hispanics consume more than whites and blacks. Married or cohabitation individuals and those living in larger households consume more fruits and vegetables than singles potentially due to economies of scale. High school graduates consume more than those without any degree, and self-employed individuals consume more than those working for wages while the unemployed and out-of-the-labor force consume less.

5.2 Robustness Checks

We check the robustness of our main results to four different changes: (1) the definition of the treatment group, (2) household size, (3) time controls, and (4) the deflator of the minimum wage.

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

$$T_{ismt} = \mathbf{1}\left\{b_i^{max} < Y_{ismt}^{max}\right\}. \tag{8}$$

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. The results for the same regressions as in our main results are presented in Table 3.[22] Except for column (6), we do not find any statistically or economically significant differences from the coefficients in Table 2. The DDD estimate for the employed sample in column (6) is half a large as in the main results, but both coefficients are not statistically significant. Hence, we conclude, that our results are robust to the definition of the treatment group. This finding is important because ensure that our results are meaningful despite the lack of information on individuals' actual earnings or wages.

— Table 3 about here —

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

[22]For the robustness checks, we only present the relevant DD and DDD coefficients. Full results are available from the authors.

adults work full-time. Changing the definition of the "maximum minimum wage income" to

$$Y_{ismt}^{max} = 2000 \times (1 - \mathbf{1}\{i \text{ not employed}\}) \times MW_{smt} \tag{9}$$

avoids making this assumption. Table 4 shows the results for the restricted sample. While the DD and DDD estimate do not differ significantly from the main results in Table 2, only the DD coefficients for the whole and employed one-adult samples in columns (1) and (4) are significantly different from zero.[23] The point estimates of the other DD and DDD effects are similar to our main results, however, so we can conclude that our assumption regarding the employment status of other adults in the household does not critically affect our findings.

— Table 4 about here —

Third, we assess the role of time controls. As we discuss in Section 4.4, we use quadratic state-specific time trends in our main results to control for potential differences in fruit-and-vegetable consumption trends across states. Here, we check if our findings are robust to higher or lower order polynomials of state-specific time trends and to the inclusion of year fixed effects instead of time trends. To save space, we only present results for the DDD regression for the full sample (corresponding to column (3) in Table 2).[24] Table 5 shows the results. In comparison to the main results based on quadratic time trends, repeated in column (1), both linear and cubic time trends yield smaller but not significantly different DDD estimates. However, the DDD estimates using linear or cubic time trends are less precisely estimated. In contrast, including year fixed effects instead of state-specific time trends in column (4) leads to a negative and insignificant DDD estimate. While the lack of statistical significance does not allow us to draw any strong conclusions, this results is in line with Neumark, Salas, and Wascher (2014) findings. As with labor market outcomes, it matters how to control for changes in fruit and vegetable consumption over time. Constraining these time effects to be equal across states is a strong assumption, and we prefer a flexible and state-specific specification instead.

— Table 5 about here —

Finally, we check if our results are robust to different deflators of the minimum wage. As we describe in Section 3.2, our main results employ the going minimum wage deflated by a fruit-and-vegetable price index. While this CPI is the most relevant for our research question, it does not vary across regions, so it may mask some geographic variation in fruit and vegetable prices. The closest available CPI that varies across regions is for food at home. In addition, we deflate minimum wages by the "all items" CPI, which reflects the purchasing

[23] The loss of statistical significance is likely due to the smaller sample size due to the sample restriction.

[24] Results for the DD regressions and other samples are available from the authors.

power of minimum wage increases overall.[25] Lastly, we also run regressions with the nominal minimum wage. The results for all four minimum wage measures are presented in Table 6 for the DDD specification on the full sample.[26] As the estimates show, there are virtually no differences between the DDD coefficients, so we can conclude that our main results do not depend on the choice of the fruit-and-vegetable CPI to deflate minimum wages.

— Table 6 about here —

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. To our knowledge, no other study investigates the effect of minimum wage changes (or other income-raising policies) on healthy nutrition, so we cannot directly compare our findings. Research on other health effects of minimum wage increases has produced similar elasticities, however. 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 an birth weight elasticity of 0.03. Our results, while not directly comparable, 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 slightly. 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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[25] The "food at home" and "all items" CPIs are available from the Bureau of Labor Statistics at http://www.bls.gov/cpi/.

[26] Other DD and DDD results for different deflators are available from the authors.

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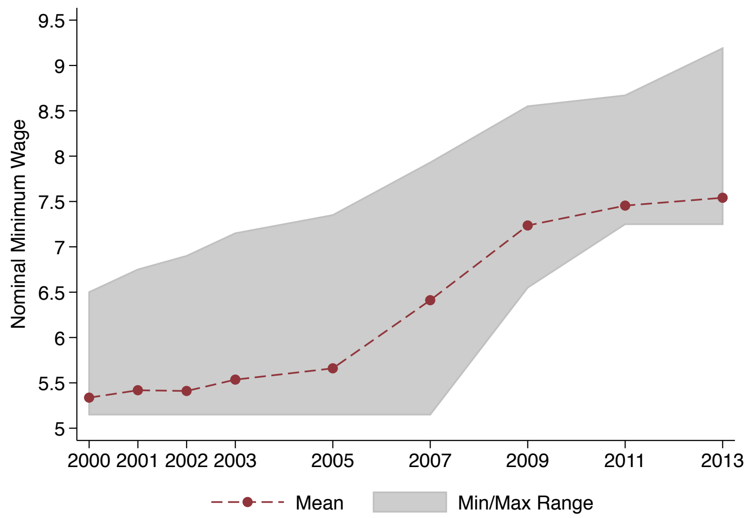
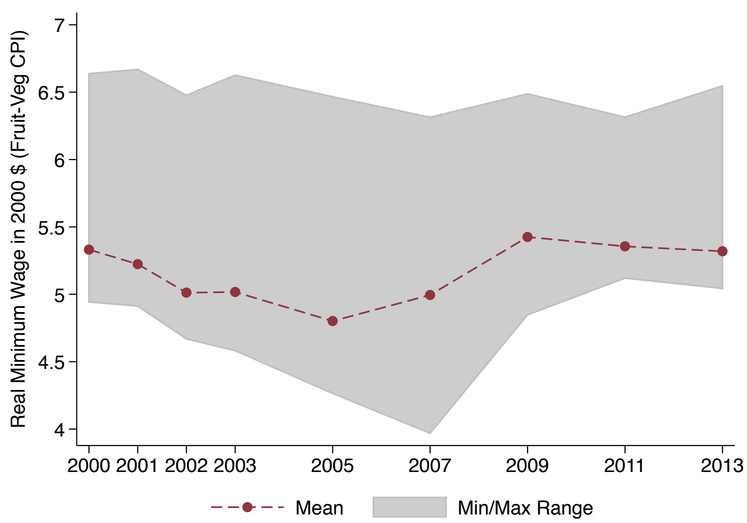


(a) Nominal Minimum Wages



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

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

Table 1: Summary Statistics: 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	58.45	3.424	(2.194)
Male	41.55	3.006	(2.050)
Age 18 to 30	14.91	3.395	(2.395)
Age 31 to 50	43.56	3.214	(2.137)
Age 51 to 65	41.53	3.237	(2.055)
White	79.27	3.224	(2.057)
Black	11.32	3.266	(2.479)
Other race	9.41	3.451	(2.415)
Non-Hispanic	89.46	3.218	(2.105)
Hispanic	10.54	3.523	(2.441)
Single	41.71	3.127	(2.247)
Married/Cohabitating	58.29	3.339	(2.065)
1 Adult Household	28.42	3.116	(2.230)
2 Adults Household	54.00	3.293	(2.067)
3+ Adults Household	17.57	3.335	(2.229)
No High School Degree	19.95	3.163	(2.279)
High School Degree	80.05	3.272	(2.110)
Employed	53.63	3.203	(2.077)
Self-employed	9.23	3.422	(2.140)
Unemployed	7.94	3.120	(2.252)
Not in the labor force	29.21	3.318	(2.234)
Household income < 10K	9.11	3.093	(2.421)
Household income ≥ 10K & < 15K	8.08	3.079	(2.236)
Household income ≥ 15K & < 20K	10.91	3.197	(2.272)
Household income ≥ 20K & < 25K	12.77	3.221	(2.189)
Household income ≥ 25K & < 35K	15.49	3.257	(2.118)
Household income ≥ 35K & < 50K	17.26	3.273	(2.032)
Household income ≥ 50K & < 75K	14.17	3.313	(1.979)
Household income ≥ 75K	12.21	3.446	(2.056)
Control group	69.51	3.283	(2.081)
Treatment group	30.49	3.175	(2.283)

Source: Behavioral Risk Factor Surveillance System, 2000 to 2003, 2005, 2007, 2009, 2011, and 2013.

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

	Diff-in-Diff		Triple-Diff
	(1)	(2)	(3)
Log-Min. Wage	0.154***	0.214***	0.125***
	(0.0319)	(0.0468)	(0.0332)
Treatment	−0.0837***		−0.180**
	(0.00429)		(0.0713)
Treatment × Log-Min. Wage			0.0941**
			(0.0433)
Age	−0.0161***	−0.0147***	−0.0159***
	(0.00104)	(0.00141)	(0.00102)
Age squared/100	0.0202***	0.0188***	0.0200***
	(0.00125)	(0.00177)	(0.00123)
Male	−0.171***	−0.174***	−0.172***
	(0.00378)	(0.00425)	(0.00376)
Black	0.0135	0.00402	0.0147
	(0.00967)	(0.00903)	(0.00962)
Other race	0.0315**	0.0257*	0.0327**
	(0.0141)	(0.0133)	(0.0131)
Hispanic	0.0743***	0.103***	0.0698***
	(0.0163)	(0.0149)	(0.0153)
Married/cohabitating	0.0926***	0.107***	0.0924***
	(0.00343)	(0.00464)	(0.00338)
Two or more adults	0.0848***	0.0929***	0.0851***
	(0.00523)	(0.00608)	(0.00530)
High school degree	0.0894***	0.104***	0.0900***
	(0.00715)	(0.00874)	(0.00694)
Self-employed	0.0897***	0.107***	0.0900***
	(0.00468)	(0.00860)	(0.00468)
Unemployed	−0.0417***	−0.0574***	−0.0410***
	(0.00452)	(0.00695)	(0.00452)
Not in the labor force	−0.00905*	−0.0272***	−0.00870*
	(0.00490)	(0.00692)	(0.00491)
State fixed effects	Yes	Yes	Yes
State-spec. quad. time trend	Yes	Yes	Yes
Month dummies	Yes	Yes	Yes
Sample	T & C	Treat	T & C
R^2	0.0489	0.0467	0.0497
N	497,965	226,379	497,965

Table 3: Difference-in-Differences and Triple-Differences Regressions for the Effect of Minimum Wages on Log-Fruit and Vegetable Servings per Day (Strict Definition of the Treatment Group)

	Diff-in-Diff		Triple-Diff
	(1)	(2)	(3)
Log-Min. Wage	0.146***	0.227***	0.128***
	(0.0319)	(0.0507)	(0.0333)
Treatment	−0.0703***		−0.275***
	(0.00574)		(0.0948)
Treatment × Log-Min. Wage			0.110*
			(0.0578)
Individual controls	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes
State-spec. quad. time trend	Yes	Yes	Yes
Month dummies	Yes	Yes	Yes
Sample	T & C	Treat	T & C
R^2	0.0478	0.0474	0.0484
N	497,965	154,617	497,965

Table 4: Difference-in-Differences and Triple-Differences Regressions for the Effect of Minimum Wages on Log-Fruit and Vegetable Servings per Day (One Adult Households)

	Diff-in-Diff		Triple-Diff
	(1)	(2)	(3)
Log-Min. Wage	0.106**	0.184	0.103**
	(0.0474)	(0.156)	(0.0481)
Treatment	−0.0884***		0.157
	(0.0165)		(0.528)
Treatment × Log-Min. Wage			0.0840
			(0.319)
Individual controls	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes
State-spec. quad. time trend	Yes	Yes	Yes
Month dummies	Yes	Yes	Yes
Sample	T & C	Treat	T & C
R^2	0.0420	0.0552	0.0436
N	141,540	22,975	141,540

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

	(1)	(2)	(3)	(4)
Log-Min. Wage	0.125***	−0.0945**	0.0794*	−0.0219
	(0.0332)	(0.0413)	(0.0452)	(0.0463)
Treatment	−0.180**	−0.0950	−0.242	0.134
	(0.0713)	(0.0658)	(0.158)	(0.173)
Treatment × Log-Min. Wage	0.0941**	0.0724	0.0729	−0.102
	(0.0433)	(0.0442)	(0.0886)	(0.109)
Individual controls	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
State-spec. quad. time trend	Yes	No	No	No
State-spec. lin. time trend	No	Yes	No	No
State-spec. cubic time trend	No	No	Yes	No
Year fixed effects	No	No	No	Yes
Month dummies	Yes	Yes	Yes	Yes
Sample	T & C	T & C	T & C	T & C
R^2	0.0497	0.0465	0.0488	0.0482
N	497,965	497,965	497,965	497,965

Table 6: Triple-Differences Regressions for the Effect of Minimum Wages on Log-Fruit and Vegetable Servings per Day (Robustness to Different CPIs)

	(1)	(2)	(3)	(4)
Log-Min. Wage	0.125***			
	(0.0332)			
Log-Min. Wage		0.162***		
		(0.0333)		
Log-Min. Wage			0.155***	
			(0.0310)	
Log-Min. Wage				0.152***
				(0.0306)
Treatment	−0.180**	−0.257**	−0.280***	−0.248***
	(0.0713)	(0.0976)	(0.0889)	(0.0827)
Treatment × Log-Min. Wage	0.0941**			
	(0.0433)			
Treatment × Log-Min. Wage		0.100		
		(0.0600)		
Treatment × Log-Min. Wage			0.115**	
			(0.0548)	
Treatment × Log-Min. Wage				0.0969*
				(0.0520)
Individual controls	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
State-spec. quad. time trend	Yes	Yes	Yes	Yes
Month dummies	Yes	Yes	Yes	Yes
Sample	T & C	T & C	T & C	T & C
R^2	0.0497	0.0485	0.0485	0.0485
N	497,965	497,965	497,965	497,965