The influence of state minimum wage increases on health and behavior

James H Buszkiewicz

A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2020

Reading Committee:

Adam Drewnowski, Chair

Anjum Hajat

Heather D. Hill

Program Authorized to Offer Degree:

Epidemiology

University of Washington

ABSTRACT

The influence of state minimum wage increases on health and behavior

James H Buszkiewicz

Chair of the Supervisory Committee:

Adam Drewnowski

Department of Epidemiology

Low and minimum wage work, prevalent in the United States, is a key driver of both income inequality and income-driven health disparities. Cities and states have increasingly moved to adopt higher minimum wages with the goal of closing the income gap and improving the economic well-being of their residents. Over the last decade, academics and policymakers alike have been interested in the influence of higher wage policies on health and behavior. To date the emerging evidence has been mixed and varies depending on the populations or outcomes under study. Few studies have evaluated the longitudinal relation between higher minimum wages and health or changes in behavior. Moreover, no prior study has explored whether this relation is modified by individual economic circumstances.

We used the 1999 to 2017 biannual waves of the Panel Study of Income Dynamics to examine the association between minimum wage and health (obesity, hypertension, fair or poor self-reported health, and moderate psychological distress) and behavior (smoking, drinking, and physical activity) in working-age adults, both employed and unemployed. We used a difference-in-difference-in-differences model using modified Poisson regression to evaluate the association between a $1 increase in minimum wage (current and 2-year lagged) among adults with a high school education or less in the full sample and across racial/ethnic and gender strata. We also used a difference-in-differences regression restricted to those with a high school education or less to determine whether employment instability, as measured by prior-year weeks of unemployment and years of tenure the current employer, modified the influence of minimum wage on obesity and moderate psychological distress. These evaluations of potential effect

measure modification were conducted in the full sample and stratified by gender. All models were adjusted for a full set of individual and state-level covariates. We also used state and year fixed effects and cluster robust standard errors to account for within state correlations.

No association between minimum wage increases and health or health behavior was observed in the overall sample of working-age adults, employed and unemployed. Subgroup models suggested a marginal reduction in obesity risk (RR = 0.82, 95% CI = 1.03, 1.50) and a marginal increase in daily cigarette consumption (RR = 1.10, 95% CI = 1.01, 1.19) in non-Hispanic White men. Higher obesity risk was found in non-Hispanic White women (RR = 1.35, 95% CI = 1.12, 1.64) associated with 2-year lagged minimum wage. Both higher current (RR = 0.73, 95% CI = 0.54, 1.00) and 2-year lagged minimum wage (RR = 0.75, 95% CI = 0.56, 1.00) were also marginally associated with a reduced risk of moderate psychological distress in non-Hispanic White women. Higher current (RR = 1.19, 95% CI 1.02, 1.40) minimum wage was associated with an increased risk of fair or poor self-reported health in women of color. Estimates were robust to restriction to workers employed hourly at baseline. We also found imprecise but suggestive evidence that prior-year unemployment, but not duration of employment, may modify the relation between minimum wage, obesity, and moderate psychological distress with the greatest risk in those exposed to both high minimum wages and greater unemployment.

While no relation was observed between minimum wage and health or behaviors overall, these results are suggestive of potential heterogeneity across race/ethnicity and gender strata. Our findings with respect to modification by employment instability highlight the importance of considering the economic circumstances of individuals when evaluating the relation between social and income policies, such as the minimum wage, and health.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I have grown and learned so much with the help of so many during my time at the University of Washington. As a mentor likes to remind me, I started off this journey not thinking much of policy research and now it's how I frame nearly all of my research and is the focus of this dissertation. With the patience, guidance, and support of so many mentors, colleagues, family, and friends, this project and my degree was made possible.

I would like to first thank my dissertation chair, Adam Drewnowski, for always challenging me to see the bigger picture, giving me the drive to a better researcher, and being my biggest supporter and advocate. I would also like to acknowledge my committee: Anjum Hajat, for helping me discover my passion for research on the social determinants of health and social epidemiology; Heather Hill, for teaching me about econometrics, policy research, the importance of framing, and writing with intention; Jennifer Otten, for helping me understand the nuances of policies and systems in the United States, for teaching me about food and how not to waste it, and for always listening and being my academic touchstone. I would also like to recognize my Graduate Student Representative, Scott Allard, for his steadfast support and encouragement and imparting the importance of connecting the dots and thinking newly.

I am also extremely grateful for all of the University of Washington Epidemiology professors I had the opportunity to meet through coursework or shared research interests as well as the Department of Epidemiology staff, administration, and my peers for their support and guidance throughout the doctoral process. I would like to thank the interdisciplinary Seattle Minimum Wage Study team for their financial support and for teaching me so much about economics and work and for kindling my passion for the study minimum wage and health. I would also like to thank the Seattle Obesity Study and the Moving to Health Study for their financial support and for helping me understand the importance considering the built and social environments whenever I think about health. I would also like to express my sincere gratitude to my former colleagues at the Massachusetts Department of Public Health, Laura, Bonnie, Andrea, Tom L, Tom S, Sanouri, and so many others. I am also forever grateful to the faculty and staff at the Boston University School of Public Health for first sparking my interest in the field of Public Health and

to Susan Kilroy-Ames and the Cambridge Public Health Department for giving me my first real job in public health.

Words cannot express the immense well of appreciation and gratitude I have for all of the colleagues, friends, family, and friends who are family who helped me along the way to completing my PhD. There are far too many to people to acknowledge and thank than I could possibly list here but I will do my best to name a few.

First and foremost, I would like to thank my mother for her steadfast love, support, and patience and for always listening and guiding me through the most stressful aspects of this program. I would also like to thank the rest family: my godmother Joanie who always knows how to make me laugh and is one of the bravest people I know; my uncle Tony, my auntie Brenda, and cousins Leah, Aaron, and Christina, for visiting, calling, listening, talking, and laughing particularly when I needed that extra boost of encouragement. I am also deeply grateful for my longstanding friendships who, although far away, are always in my thoughts (Dylan, Kisha, Elli, Harjot, Amiel). I would especially like to thank my Epi Family (Bridget, Jamie, Jerzy, Kennedy, John, Pam, Tanya, and Tigran) for always being there to listen, talk, and laugh; for always answering my questions; and for always believing me and helping me see the importance of my work even when I cannot. I would also like to thank Laura and Archie for helping me glide into the end of my program with laughter, adventures, and great conversation – I feel incredibly lucky to have met these two before the world stood still. To all those not mentioned by name please forgive me and know that you have my sincerest gratitude and appreciation.

Finally, I would be remiss in not thanking my nearly constant companion throughout this journey, and oft described daemon, my dog Ada. While some PhD programs might feel like a lifetime, for Ada, that is quite literal. We first met when she was 4 months old about two months before I took my preliminary exam. Now, over 4 years later I cannot imagine what my life was like without her. We are both looking forward to post-dissertation life and days filled with fetch, tug, head scratches, barking at animals on the television, and belly rubs.

DEDICATION

To my mother, Pauline Buszkiewicz, and my godmother, Joanie Connerty. Thank you for being my constant touchstones and biggest advocates. Thank you for always believing in me even when I did not believe in myself. You are strongest and bravest people I know, and you taught me to be strong and brave in even in the face of seemingly insurmountable obstacles. I would not have been able to do this without your unwavering love and support. This is for you.

PROJECT INTRODUCTION

Low-wage work, prevalent in the United States (US), is a key driver of both income inequities and income-driven health disparities.[1–3] Approximately 1.6 million workers comprising 2.1% of all hourly wage workers earned the federal minimum wage of $7.25 or less.[4] More than 53 million workers earned low wages; this group included 44% of all workers between the ages of 18 to 64, with median wages of $10.22 and median annual earnings of $17,950.[5]

One-third of low-wage workers had children and were the primary earner in their household.[2,4] The majority of these workers were women, with high school education or less, who worked part time, with many working multiple jobs to make ends meet.[2,4] Non-white or Hispanic individuals also accounted for a disproportionate share of the low-wage workforce.[2,4] Importantly, adults with low income experienced higher rates of chronic disease, lower life expectancies, and greater barriers to healthcare access.[6] Additionally they were more likely to smoke,[7–9] consume alcohol more frequently or in excess,[10–12] and engaged in less frequent physical activity (PA)[13,14]

As states and localities have increasingly pushed to adopt higher minimum wages, academics and policymakers alike have become interested in the potential of these policies to serve as an indirect intervention to help close the gap on income-driven health disparities.[3] A higher minimum wage that leads to higher earnings and has no unintended consequences on employment, hours, government assistance, or prices,[15] would be expected to improve health outcomes.[16] Greater financial resources may reduce financial stress and provide the means to bolster health through increased access to healthcare or other basic needs such as affordable healthy food and safe housing.[3,17–19] Individuals may also have more time to devote to health-promoting activities should they choose to reduce their hours proportionally in response to higher wages.[3,17–19] However, unintended consequences might also occur. It is also possible that higher minimum wages could reduce employment, hours, or eligibility for health insurance and other public benefits, the net result of which could lead to a decline in income and increased stress giving rise to poor health.[3,17–20]

Many existing studies of minimum wage and health have used cross-sectional study designs as well as varied population restrictions and minimum wage exposure definitions limiting their generalizability and our ability to draw causal conclusions.[3] Few studies have longitudinally evaluated the association

between higher minimum wages and health outcomes or changes in health behavior.[3] Moreover, there has been limited evaluation of how these associations vary across race/ethnicity and gender strata.[3,17,20,21] This potential heterogeneity is important as women and persons of color are more likely to work in low-wage jobs and are at greater risk of developing chronic disease.[22] These vulnerable populations also face greater health and safety risks at work.[23,24] The minimum wage-health relation may also predominately benefit those workers who are employed and more experienced but leave behind those who are unemployed or those with less experience.[3,17] Furthermore, little is understood regarding the role that individual economic circumstances may play in modifying the minimum wage-health relation.

Using the rich socioeconomic and health data from the 1999 to 2017 Panel Study of Income Dynamics, the present project will examine the longitudinal relation between higher minimum wages, fair or poor health, hypertension, and moderate psychological distress and incident obesity (Chapter 1). This project also aims to investigate how minimum wages increases are related to changes in daily cigarette and alcohol consumption, among consumers of those products, as well as engagement in physical activity (Chapter 2). These studies of minimum wage, health, and health behavior were conducted among a population of employed and unemployed adults as well as a population of hourly wage workers. We evaluated the potential for heterogeneity by the interaction of race/ethnicity and gender strata. We additionally explored the potential role employment instability, as measured by the number of weeks spent unemployed in the prior year and current employer tenure, might play in modifying the relation between obesity as well as moderate psychological distress (Chapter 3).

Chapter 1: The association between state minimum wages and health among working-age adults, Panel Study of Income Dynamics 1999 to 2017

Abstract

Background. States have increasingly raised minimum wages to improve the economic wellbeing of their residents. Emerging work evaluating the minimum wage-health relation have been mixed, varying based on the subpopulation or health outcomes under study.

Methods. We employed a triple difference model using modified Poisson regression to evaluate the association between minimum wage and obesity, hypertension, fair or poor self-reported health, and moderate psychological distress in adults age 25 to 64 years. Data from the 1999-2017 Panel Study of Income Dynamics was linked to state policies and characteristics to estimate the risk ratio associated with a $1 increase in current and 2-year lagged minimum wage among less-educated adults overall and across racial/ethnic and gender strata.

Results. No association between minimum wage and obesity, hypertension, fair or poor self-reported health, and moderate psychological distress was observed in the overall sample of employed and unemployed working-age adults. Subgroup models suggested a modest reduction in obesity risk in non-Hispanic White men (RR = 0.82, 95% CI = 1.03, 1.50) associated with current minimum wage increases and an increased obesity risk in non-Hispanic White women (RR = 1.35, 95% CI = 1.12, 1.64) associated with 2-year lagged minimum wage. Higher current (RR = 1.19, 95% CI 1.02, 1.40) minimum wage was associated with an increased risk of fair or poor self-reported health in women of color. Higher current (RR = 0.73, 95% CI = 0.54, 1.00) and 2-year lagged minimum wage (RR = 0.75, 95% CI = 0.56, 1.00) were also marginally associated with a reduction in risk of moderate psychological distress in non-Hispanic White women. Estimates were similar when analyses were restricted to workers employed hourly at baseline.

Conclusion. While no relation was observed overall, these results are suggestive of heterogeneous associations between minimum wage and risk of obesity and moderate psychological distress across racial/ethnic and gender strata which warrants further study.

INTRODUCTION

Income and wages have long been identified as powerful social determinants of health and wellbeing in the United States (US).[1–3] Higher socioeconomic status, of which income and wages are key components, has been linked to improved access to healthy foods, healthier lifestyles, and better access to healthcare.[2,3] Deprived of these resources, many individuals with low incomes struggle to maintain optimum health.[2,3] In addition, Workers earning low wages are at higher risk of chronic disease, risky health behaviors, and premature death.[2,3] In an effort to ameliorate stagnant wage growth at the federal level and improve the economic wellbeing low wage workers and their families, states, counties, and municipalities have progressively moved to adopt higher minimum wages.[25] As a result, interest in minimum wage laws as a tool to reduce income-driven health disparities has also grown over the last decade.[3]

In the US, minimum wage laws have been in place since 1938, yet the evidence evaluating their potential influence on income-driven health disparities is only now rapidly emerging.[3] The directionality of the relation between higher minimum wages and health is theoretically equivocal and hinges upon assumptions about the policy's influence on labor markets as well as on psychosocial and behavioral responses at the individual level.[3,26,27] A higher minimum wage that leads to higher earnings with no unintended consequences on employment, hours, government assistance, or prices,[15] would be expected to improve health outcomes.[16] Greater financial resources may reduce financial stress and provide the means to bolster health through increased access to healthcare or other basic needs such as affordable food and safe housing.[3,17–19] Individuals may also have more time to devote to health-promoting activities should they choose to reduce their hours proportionally in response to higher wages.[3,17–19] Yet, is also possible that higher minimum wages could reduce employment, hours, or eligibility for health insurance and other public benefits, the net result of which could lead to a decline in resources and increased stress giving rise to poor health.[3,17–20]

The emerging literature on the relation between minimum wages and broad measures of health and mortality suggests some benefit in adults.[3,18,21,28–30] Higher minimum wages have largely been associated with better self-reported health; however, these estimates have tended to be modest ranging from 0.02 to 1.04 percentage point reductions in the reporting of fair or poor health.[3] One exception found

that higher minimum wages were associated with a 5 to 6% increase in the likelihood of reporting fair or poor health among employed men age 18 to 54 years.[17] Studies evaluating the relation between higher minimum wages and cause-specific mortality and have found a reduction in the rates of deaths due to cardiovascular disease, diabetes, and suicide ranging from 1.9 to 5.9%.[3,18,28,31]

Studies of the minimum wage and specific health conditions were more mixed. The reported association between minimum wage and obesity, or continuous body mass index (BMI) ranged from modestly negative to modestly positive.[3,20,21,32] With respect to mental health, studies from the US and United Kingdom have found suggestive evidence that higher minimum wages reduced self-reported bad mental health days by approximately 0.06 to 0.17 days and reduced scores on the General Health Questionnaire, a validated measure of mental well-being.[17,21,33] Other studies have found no evidence to support a reduction in bad mental health days [34] or any association with serious psychological distress, as measured by the Kessler 6-item scale (K-6).[20] Of the two studies to evaluate hypertension, one found that higher minimum wages led to a small increase in the odds of hypertension in women (OR = 1.12) but reduced the odds in men (OR = 0.88).[20] The other found no evidence to support an association.[33]

Many of the existing studies of minimum wage and health have used cross-sectional study designs, limiting our ability to draw causal conclusions as well as generalizability.[3] Few studies have longitudinally evaluated the association between higher minimum wages and obesity, hypertension, and fair or poor health.[3] The varied sample exclusion/inclusion criteria based on age, gender, education, or income may have contributed to the mixed findings in specific health outcomes. Studies which have directly evaluated these demographic subgroup associations have found the minimum wage-health relation to vary based on gender, age, race/ethnicity, and marital status.[3,20,21] This heterogeneity with respect to health consequences of minimum wage is perhaps unsurprising given that certain subpopulations have historically larger wage gaps or greater exposure to low- or minimum-wage work.[2,4] Women and persons of color are more likely to work in low-wage jobs and both are at greater risk of developing certain chronic diseases, such as obesity or poor mental health.[22] These same groups also face greater health and safety risks at work.[23,24] However, these heterogenous associations have been understudied to date, with few, evaluating the joint race/ethnicity-gender association.[35] Moreover there is evidence to suggest that the minimum wage-health relation may be beneficial for employed and more

experienced workers but have deleterious consequences for those who are unemployed, but seeking work, or those with less experienced.[3,17]

The present study seeks to build upon and address important limitations of prior work on minimum wage and health in adults through the application of social epidemiologic and econometric approaches. We used a difference-in-difference-differences (DDD) empirical strategy leveraging nearly two decades of state variation in minimum wage policies to examine longitudinal associations with health using the Panel Study of Income Dynamics (PSID) in a sample of employed and unemployed working age adults. Moreover, we estimated risk of obesity, hypertension, fair or poor self-reported health, and moderate psychological distress. We selected these outcomes as each have shown strong income and socioeconomic gradients in past research.[3,36–43] In addition, each of these outcomes have been linked to psychosocial factors (e.g. stress, anxiety, depression)[44–46] and health behaviors (e.g. physical activity, diet),[47–50] which have, in turn, been linked to changes in income and other socioeconomic factors.[7–14,43] These outcomes were evaluated overall and by race/ethnicity-gender strata.

METHODS

Study population and design

This study used a retrospective cohort design with data from the biannual 1999 to 2017 PSID survey waves.[51] The PSID was established in 1968 with the goal of understanding the causes and consequences of poverty in the United States. Today, the PSID remains the world's longest, continually running household panel following more than 9,000 families and 24,000 individuals. In 1999, the PSID added several health questions related to overall wellness, chronic disease, and health behaviors.[51] This individual-level PSID data set was merged to a state-level data set containing information on state minimum wages as well as other policies and characteristics thought to potentially confound the relation between minimum wage increases and health. These state characteristics and policy data were obtained from several sources.[52–58]

The study population was restricted to 25 to 64-year-old adult heads of household and their spouse/partners who were observed at least twice during the 1999 to 2017 period. The PSID defines "heads" of household as the male husband in a heterosexual married couple or the single adult of either

sex (male or female).[51] This definition conformed to the 1968 Census definition of a household head, the year in which the PSID was first implemented.[51] In 2017, the PSID replaced the term "head" with "reference person" to reflect the diversification of families over time.[51] The PSID historically defined the spouse/partner as a wife/"wife" where wife was used to describe the female in a married couple and "wife" was used to describe a cohabiting female.[51] These terms were changed to spouse and partner, respectively, to expand these definitions to encompass both heterosexual and sex same couples.[51] We limited of analysis to heads of household and spouse/partners as, even though the PSID collects information on other family members, the greatest detail with respect to economics and health is limited to these heads and spouse/partners.[51]

Sample adult heads and spouse/partners needed to be employed, or unemployed and actively seeking work, for at least half of the time they were observed and to have complete covariate information. Those who were not in the labor force for more than 50% of their observed person-years were excluded. Individuals were required to be outcome-free at baseline and were followed longitudinally until an outcome occurred or outcome information was missing and were censored thereafter.

Measures

State minimum wage policies

State minimum wage information from 1999 to 2017 was acquired from the University of Kentucky Center for Poverty Research's (UKCPR) National Welfare Data.[55] UKCPR sources these data from the Bureau of Labor Statistics' Wage and Hours Division.[52] For each state and Washington, DC, the highest effective, inflation-adjusted state minimum wage was applied using 2017 as a base year. Inflation-adjusted minimum wage is the most commonly used exposure definition in the minimum wage and health literature and allows one to account changes in the cost of living over time.[3]

State minimum wage policies were assumed to take place at the beginning of each calendar year in which the wage rate change occurred and to be in place for the full year. For years in which a state did not have a minimum wage law or had a wage rate that fell below the federal rate, the federal wage was the effective rate. We examined minimum wage rates occurring in the same year as the outcome occurred (current) as well rates two years prior (2-year lagged). The 2-year lagged minimum wage served two purposes: 1) it ensured the rate was in place for at least 13 months before the outcome measurement

since wage rate changes could occur at any time during the year, and 2) it allowed for the examination of delayed effects for health outcomes with longer onset periods.

Health outcomes

Data on all health outcomes were self-reported by the head of household. Persons with obesity were defined as those with a BMI ≥30.0 kg/m^2 based on Centers for Disease Control and Prevention guidelines using baseline self-reported height and ongoing self-reported weight data. For respondents missing self-reported height at baseline, the next available height was used. Hypertension was dichotomized as an affirmative response to a physician or healthcare provider diagnosis or not. General health status was dichotomized as "fair" or "poor" versus "good", "very good", or "excellent" self-rated health. Moderate psychological distress was measured via the K-6, which asks respondents whether and how often they experienced feelings of nervousness, hopelessness, restlessness, depression, struggle, and worthlessness in the past 30 days.[59] Responses ranged from 0 (none of the time) to 4 (all of the time), based on how frequently the participant reported experiencing the feeling or emotion[59] and were summed and dichotomized using a cut point of ≥5, which has been shown to be predictive of moderate non-specific psychological distress.[59,60] Data on psychological distress was only available for 2001, 2003, and 2007 to 2017. We therefore restricted our analysis of moderate psychological distress to the years in which psychological distress was continually measured, 2007 to 2017, to maintain evenly spaced 2-year intervals of observation for all outcomes.

Covariates

All models were adjusted for a large set of individual and state-level covariates selected based on past research on minimum wage and health.[3] Individual-level covariates included age (continuous years), gender (women, men), and race/ethnicity (persons of color versus non-Hispanic Whites, due to sample size constraints). State-level covariates included an indicator of whether the state has a refundable Earned Income Tax Credit program; state sales tax rate (continuous percentage); state Temporary Assistance for Needy Families benefit for a family of four (continuous United States Dollars (USD)), state gross product (thousands of USD) and the percentage of state residents who are union members.[53,55,58]

We also included policy index variables for Medicaid and the Supplemental Nutrition Assistance Program (SNAP), which comprised multiple aspects of each program that varied across states and time.

Both indices ranged from 0, indicating no policies to 3 indicating SNAP or Medicaid policies with greater generosity. Both measures were parameterized as ordinal, categorical covariates in all models. The Medicaid index included 1) whether state Medicaid eligibility limits for children were above median for states in a given year, 2) whether state Medicaid eligibility limits for parents were above median for states in a given year, 3) whether the state had a Medicaid program for non-citizens, and 4) whether the state expanded Medicaid under the Affordable Care Act. The SNAP index included 1) whether non-citizens in the state were fully eligible for SNAP benefits, 2) whether the state allows SNAP online applications, 3) whether state had no SNAP ban for drug felons, and 4) whether the state uses broad-based categorical eligibility to increase or eliminate the asset test and/or to increase the gross income limit for SNAP users.[57]

Statistical analysis

We estimated descriptive statistics with and without PSID survey design weights. These survey weights account for the complex survey design of the PSID as well as loss to follow-up and allows survey estimates to be nationally representative. However, only respondents who belong to families that were included in the original 1968 sample are provided longitudinal weights. Therefore, the weighted estimates are nationally representative of the 1968 US population. Since that survey weights were not available for all survey respondents and out of concern over potential bias introduced given that weighted respondents were more likely to be non-Hispanic White, we did not use survey weights to generate model estimates.

A DDD framework was used to estimate the association of an increase in minimum wage with health.[61,62] The DDD uses comparisons across states and years, but also between likely affected and likely unaffected groups, here defined by educational attainment.[63] The third comparison helps to address unobserved confounders that might vary over time differentially by state. For example, if states with increasing minimum wages also invested in infrastructure to promote biking in the period of the study, the models “control” for that factor by comparing two groups within the state both of whom benefitted from the infrastructure but only one of which benefitted from the minimum wage.[61] In this study, we defined the “likely affected” group as working-age adults with a high school education or less with the “likely unaffected” comparison group comprised of those with some college education or more.[62] The DDD modified model was defined as:

(1) $\log(Y_{itsj}) = \beta_1 MW_{ts} + \beta_2 A_{ij} + \delta_1 A_{ij} MW_{ts} + \beta_3 V_{ts} + \beta_4 S_{ts} + \varphi_t + \gamma_s + u_{ts} + e_{itsj,}$

where i, t, s, and j index individuals, years, states, treatment group respectively. The health outcomes of interest are defined as $\log(Y_{itsj})$. β_1 is the effect of the state minimum wage level for the likely unaffected group. MW_{ts} is the inflation-adjusted minimum wage (absolute or relative to state median wage) in a given state and year. β_2 is the estimated association between an individual having a high school diploma or less and their outcomes, when the minimum wage is set at the federal level. A_{ij} equals 1 if the person has a high school diploma or less.[62] The coefficient of interest, δ_1, captures the relation between minimum wage levels and the outcomes for the likely affected group and is the primary estimate of interest. The vectors V_{its} and S_t capture sets of state-level control variables. State (γ_s), and year (φ_t) fixed effects will also be included. e_{itscj} is the random error term.

Using the potential outcomes framework for causal estimation,[63] the DDD approach estimates the average intent-to-treat effect of the minimum wage. This is because not all individuals in the likely affected group are, in actuality, exposed to a minimum wage increase in their state in a given year.[63,64] Our DDD model specification was run for the overall sample and stratified by combined race/ethnicity-gender subgroups (non-Hispanic White men, non-Hispanic White women, men of color, and women of color) similar to Averett (2017).[35] As a secondary analysis, we further restricted our sample to employed, hourly wage workers, following Du and Leigh (2018)[62] to determine if association varied in this population. All regressions used a generalized linear model with Poisson distribution and log link, often referred to as a modified Poisson regression as well as robust standard errors clustered at the state level.[65] The modified Poisson model allowed us to directly estimate the risk ratio (RR). These estimates are more rigorous than those provided by a standard logistic regression model given that odds ratios are poor measures of the risk for common outcomes, such as obesity. All statistical analyses were performed using Stata Version 14[66] using a significance level 0.05.

A key assumption of DD models is that unmeasured confounders across “treated” and “untreated” groups, in this case states that increase their minimum wage and those that do not, are either time-invariant state-specific characteristics or time-varying characteristics that do not vary across states.[67] If these assumptions hold true, a time series plot of the outcome in both treated and untreated states should resemble parallel lines, that is, moving together in a fixed amount in every period.[67] This applies

for both the pre- and post-invention periods, but for the intervention in the treated states.[67] We provide graphical support for this assumption in Supplementary Figure 1 by showing the trends by whether or not the state's minimum wage was at or above the federal wage rate and by baseline educational attainment of our sample.[67]

We tested the sensitivity of our main findings to alternative pseudo treatment and control groups specifications.[3] First, to compare to prior studies, we compared our DDD approach to a difference-in-difference (DD) model using the entire sample population and a DD model restricted to the likely affected. Second, we reevaluated our education cut point by comparing those with some college education or less to college graduates or higher. Third, we redefined our treatment and control groups by comparing calculated, regular hourly wage rates, for those respondents who were employed and paid hourly, to the state minimum wage rate, both adjusted for inflation. We used a cut points of wages ≤150%, "likely affected" or >150%, "likely unaffected", of the state minimum wage rate.

In addition, we tested our findings against alternative minimum wage specifications. First, we used a nominal (not adjusted for inflation) state minimum wage. Second, we used a relative state minimum wage measure. The relative state minimum wage was calculated by dividing the inflation-adjusted state minimum wage by the median, inflation-adjusted wage for all workers age 25 to 64 years in a given state and year. This normalization serves two functions. First, relative state minimum wages better capture the value of the minimum wage to workers. If the minimum wage is high relative to the state median wages, we might expect the state minimum wage to have less of an influence on worker health.[3,68] If the minimum wage is low relative to the state minimum wage that we would expect minimum wage increases to have a greater influence of worker health. Second, relative minimum wages have been theorized to capture the potential psychosocial influences of higher minimum wage laws as individuals may judge their own societal value, in the context of the value of their labor, relative to that of their peers.[3,39]

All sensitivity analyses were run for current and 2-year lagged minimum wage for the overall sample. DD models for the full sample, DD restricted models, and non-proxy models were conducted in the overall sample of employed and unemployed adults and by race/ethnicity and gender strata. In addition, out of concern regarding the differential earnings potential associated with educational

attainment across race and gender groups, we also ran the model specification using the some college education or less treatment group by race and gender.[24] We also disaggregated persons of color into non-Hispanic Black and Hispanic and other and re-ran our primary models to acknowledge the potential for heterogeneous associations within persons of color. We ran our primary, overall models adjusting for state unemployment. We elected not to adjust for state unemployment in main models as we believed that state unemployment operates as a time-varying confounder, being both on the causal pathway between minimum wage and health as well as influencing the probability of future minimum wage increases. However, this covariate is frequently adjusted for in the literature and we therefore include this adjustment for comparison purposes. We also conducted an analysis restricting to non-movers following Du and Leigh (2018) to more rigorously control for state fixed effects. Finally, out of concern for potential misreporting of outcome measures, we restricted our analyses to non-proxy respondents, that is, examined health outcomes among adults reporting their own health outcomes. In most cases this was the head of household.

RESULTS

From 1999 to 2017 there were 362 state minimum wage increases. Of those, 63% were did not occur during the same period the federal minimum wage increased, from 2007 to 2009. The number of states with minimum wage rates above the federal rate more than doubled over the period, from 12 in 1999 to 30 in 2017 (Appendix Figure 1). Appendix Table 1 summarizes changes to changes in state policies and characteristics, included as model covariates, over the study period.

Table 1 shows both unweighted and weighted socio-demographic characteristics and prevalent outcomes of sample PSID respondents at their first observation overall and by education for the study period. The mean age of the sample was 34.7 years with an average of 13.5 years of education. Half of the sample were women and 44.1% were persons of color. Employed adults comprised 86.3% of the sample with 7.5% looking for work. Among the employed, 60.0% were paid hourly at an average hourly wage rate of $14.11 per hour. Roughly 1 in 4 (23.3%) respondents had an obese BMI at baseline. Approximately 12.2% had a self-reported physician diagnosis of hypertension. About 7.4% of respondents rated their health as fair or poor while 26.8% of respondents had K-6 scores which classified

them as having moderate psychological distress. Individuals with a high school diploma or less were comprised of fewer women (47.3%) and employed adults (82.0%) but had a greater share of persons of color (53.2%) and hourly wage earners (78.1%). Less educated adults also had a lower hourly wage rate ($12.64) compared to those with more education ($15.91) as well as a greater burden of disease across all outcomes. Weighted estimates were comparable to unweighted estimates with the exception of the percentage of the sample comprised of persons of color. This is due to the fact that only families who were included in the original 1968 sample wave received longitudinal weights and therefore these weighted estimates are nationally representative of the 1968 US population. Additionally, sociodemographic and prevalent health information for the 2007 to 2017 period in which we evaluated moderate psychological distress can be found in Supplementary Table 1.

Table 2 provides DDD estimates for the employed and unemployed respondents for current and 2-year lagged minimum wage, overall and by race/ethnicity and gender strata. Overall, there was no association between higher minimum wages and incident disease with either current or 2-year lagged minimum wage. In race/ethnicity-gender stratified models, a $1 increase in current minimum wage was associated with an 18% (RR = 0.82, 95% CI = 0.67, 0.99) reduction in risk of obesity among less educated non-Hispanic White men with a high school education or less compared to those with some college education or more, accounting for individual-level and state-level covariates. In less educated, non-Hispanic White women, a $1 increase in 2-year lagged minimum wage was associated with a 35% (RR = 1.35, 95% CI = 1.12, 1.64) higher risk of obesity compared to their higher-educated counterparts. Less educated, non-Hispanic White women also had a reduced risk of moderate psychological distress associated with both current (RR = 0.73, 95% CI = 0.54, 1.00) and 2-year lagged (RR = 0.75, 95% CI = 0.56, 1.00 minimum wage increases, compared to those with some college education or more, which were similar in magnitude. There were no associations between minimum wage increases and health in men of color. Women of color with a high school education or less had a marginal 19% (RR = 1.19, 95% CI 1.02, 1.40) increase in the risk of fair or poor health associated with current minimum wage increases compared to their higher educated women of color. Disaggregating the women of color category suggested this association was largely driven by Hispanics or other racial/ethnic groups (data not shown due to small sample sizes).

Table 3 is similar to Table 2 but restricts DDD models to those respondents who were employed and paid hourly at baseline. In general, estimates were similar to models conducted in the overall sample of employed and unemployed respondents. We observed no association between minimum wage and health in both the overall sample of employed, hourly workers. Estimates for both non-Hispanic White men and women with a high school education or less, compared to those with some college education or more, were similar but less precise. In less-educated women of color, both current and 2-year lagged minimum wage were associated with a 24 to 25% increase in the risk of fair or poor self-reported health, when compared to those with some college education or more.

Sensitivity analyses

Our main null findings, using the DDD framework, largely agreed with DD models for the full sample (Supplementary Table 2) and DD models restricted to the likely affected, those with a high school education or less (Supplementary Table 3); however, there was one notable difference. In DD models restricted to those with high school education or less, there was a marginal increase in the risk of obesity (RR = 1.19, 95% 1.01, 1.39) using 2-year lagged minimum wage. However, this modest increase in risk of obesity in the overall sample associated with 2-year lagged minimum wage was not dissimilar to the elevated risk of obesity observed in employed, less educated, hourly wage workers, which encompassed the null (RR = 1.17, 95% CI = 0.99, 1.37) (Table 3).

With respect to DD analyses by race/ethnicity and gender strata (Supplementary Table 2 and 3), our analyses are most similar to DD model restricted to the likely affected group with a few notable exceptions (Supplementary Table 3). The association between 2-lagged minimum wages and obesity for non-Hispanic White men attenuates and lacks precision (RR = 1.18, 95% CI = 0.85, 1.64). The association between current minimum wage and obesity for non-Hispanic White women reverses direction and suggests a marginally protective association (RR = 0.72, 95% CI = 0.53, 0.98). Both estimated associations between current (RR = 0.99, 95% CI = 0.58, 1.58) and 2-year lagged minimum wages (RR =0.80, 95 CI = 0.51, 1.24) are attenuated and imprecise.

Additional sensitivity analyses evaluating varying treatment and control group definitions differed little from our primary findings. Varying the education cut point from a high school education or less to some college education or less produced similar estimates compared to our main findings with the

exception of some loss or gain of precision (Supplementary Table 4). However, notable was that current minimum (RR = 1.20, 95% CI = 1.02, 1.41) and 2-year lagged minimum wage (RR = 1.24, 95% CI = 1.00, 1.55) were associated with a marginal increase in the risk of fair or poor health in less-educated, non-Hispanic White women compared to their higher educated counterparts. In addition, the association between current and 2-year lagged minimum wage and moderate psychological distress in less-educated, non-Hispanic White women was attenuated. Changing our likely affected group definition to those earning hourly wages ≤150% of the state minimum wage at baseline, using those earning hourly wages >150% of the state minimum wage as the control, also did not change our overall conclusions (Supplementary Table 5).

Our main model estimates were largely unaffected by the use of alternate minimum wage specifications – relative and nominal minimum wages (Supplementary Table 6 and 7). The only noteworthy difference was the increased risk of hypertension associated with a 10% increase in both current (RR = 1.28, 95% CI = 1.09, 1.46) and 2-year lagged (RR = 1.18, 95% = 1.03, 1.36) relative minimum wages. However, these estimates are in the same direction as estimates observed in the overall sample of employed and unemployed respondents as well as our model with the using those some college or less as the likely affected group, albeit with greater magnitude and precision.

Adjusting for state unemployment and restricting to non-movers or non-proxy respondents also had little influence of on our overall conclusions (Supplementary Table 8-10). One exception is that current minimum wage increases were associated with a 27% (RR = 1.27, 95% CI = 1.05, 1.54) higher risk of moderate psychological distress in those with a high school education or less compared to some college education or more (Supplementary Table 9). However, it should be noted movers and non-movers differed substantively on several sociodemographic characteristics (Appendix Table 2). Non-movers more likely to be persons of color, less educated, part of the labor force (employed or unemployed) and paid hourly than movers at baseline. Noteworthy is the similarity in hourly wage rates between movers and non-movers, which may partially explain the similarity to our main findings. Finally, restriction of analyses of obesity, hypertension, and fair or poor health to non-proxy respondents produced results similar to our primary findings; however, estimated associations for obesity in non-Hispanic White men and women were stronger (Supplementary Table 10).

DISCUSSION

This study, which used a longitudinal panel and nearly two decades of variation in state minimum wages, found no evidence that differences in minimum wage increases (current or 2-year lagged) had any influence on health. There were no changes in risk of obesity, hypertension, fair or poor self-rated health, or moderate psychological distress. This null finding observed with the whole sample also held for hourly wage workers. Sensitivity analyses varying the likely affected group definition and minimum wage exposure definition concurred with our primary findings. This study did, however, find suggestive evidence of heterogeneity across race/ethnicity and with a beneficial association observed between minimum wage and obesity for non-Hispanic White men and moderate psychological distress for White women. We los observed a harmful association between higher minimum wages and obesity for White women. To our knowledge these findings represent one of the first longitudinal evaluations of obesity and hypertension, which improves our ability to draw causal inference.

We believe these findings highlight the need for further investigations into the longitudinal rather than cross-sectional associations between minimum wage and health. These results also add to a growing body of recent evidence that has observed mixed or differential associations between minimum wage and health, particularly across race, gender, education, and employment strata, which suggests that these findings are not due to bias alone.[3,17,20,21,35] Our findings taken together with prior work highlight the need to examine differential associations between minimum wage and health in populations that may disproportionately make at or near minimum wage and have a higher burden of chronic disease.

Our findings with respect to race/ethnicity and gender differences between minimum wage and health show some similarities and differences with prior work evaluating race-gender heterogeneity. Contrary to prior cross-sectional work using the National Health Interview Survey, we observed an elevated risk of obesity in non-Hispanic White women as well as a marginal reduction in risk of obesity among non-Hispanic White men.[20] It should be noted however, that, similar to prior work, we did observe elevated risk of obesity in persons of color, but we had insufficient evidence to reject the null hypothesis.[20] Andreyeva et al. (2018) also observed a positive association between minimum wage and obesity in Whites.[21] Our findings suggest that this positive association may be driven primarily by non-Hispanic White women.

Fewer studies have evaluated race/ethnicity and gender differences between higher minimum wages and mental health in US adults.[3] Similar to Dow (2019), which found the largest reductions in deaths of despair among women and non-Hispanic Whites,[31] we found that higher minimum wages were associated with a lower risk of moderate psychological distress in non-Hispanic White women. Our conclusions are also broadly consistent with Horn (2017) and Andreyeva (2018) who both found reductions in the number of bad mental health days in women. However, our findings suggest these potential benefits may disproportionally accrue in less-educated, non-Hispanic White women.

There are few, if any, comparable studies which support our finding of elevated risk of fair or poor health in women of color in both our main model and among employed, hourly wage workers. These estimates are also consistent when restricted to non-proxy respondents. However, changing the likely treated group cut point to some college education or less, attenuated these estimates to the null. Therefore, we cannot rule out the potential for bias differences in the value of education, with respect to labor market outcomes, has across race/ethnicity and gender subpopulations for perceived health. The majority of studies of minimum wage and fair or poor health have observed a protective association.[3] One exception is Horn (2017),[17] however, their findings were observed in employed men. We believe this association warrants further study given that women of color are more likely to work in jobs with low or minimum wages and have a higher burden of chronic disease.[2,5,22]

The theoretical psychosocial and behavioral pathways linking minimum wage and health are multifaceted and, therefore, it is perhaps unsurprising to observe varied associations across outcomes and populations.[3,39,69] First, it is possible that minimum wage rates observed between 1999 and 2017 may not have led to a health-relevant increase in economic resources. This may be due to higher wages replacing income received through federal benefit programs such as SNAP or EITC or a failure to keep pace with local area inflation.[70] Second, some of the outcomes evaluated, such as obesity and hypertension, have complex etiologies and long onset periods.[22,36] However, in main models, estimates were similar for both current and 2-year lagged models with the exception of estimates for non-Hispanic White women. The few recent studies that evaluated the relation between minimum wage and energy balance pathways, linked to weight gain, and have shown little evidence of improvement.[17,21,71] Two out of three studies examining the association between higher minimum wages and fruit and vegetable

consumption using the Behavioral Risk Factor Surveillance System show that minimum wage increases were associated with reduced consumption.[17,21] Some have suggested that higher wages could improve purchasing power[15] ; however, this has yet to be empirically evaluated. The only study to evaluate the relation between higher minimum wages and time use examined engagement in PA.[71] They observed that a $1 increase in minimum wage was associated with a 13 minute reduction in exercise time per week which was replaced almost entirely by non-exercise-related leisure.[71] Another study found no discernable association between minimum wage and PA.[17]

The present study had several notable strengths. First, it is one of only a handful of studies that have used a longitudinal design to evaluate the association between minimum wage increases and change in individual-level health over time.[3,33,34,62,72] Second, we further leverage these longitudinal data by applying epidemiologic methods and evaluating incident outcomes to estimate risk. Third, similar to several recent studies,[3,17,20,21,62,68] this analysis employs a DDD strategy, which allows for the control of unmeasured time-varying and state-varying confounders. Fourth, we jointly evaluate the influence of both race/ethnicity and gender on the minimum wage and health relation for the general sample of employed and unemployed respondents as well as for employed, hourly wage workers. This coupled with our DDD strategy allows us to jointly evaluate the influence of race/ethnicity, gender, education, and employment status which, to our knowledge, few other studies have done.[3] We believe these intersectional evaluations are particularly important to minimum wage and health research as structural inequities with respect to wages, jobs, and educational opportunities can influence both exposure to minimum wage policies as well as physical and mental wellbeing.[2,4,22,23,73]

This study had limitations. First, small sample sizes due to restrictions, differences in or availability of health questions in the PSID over time, and PSID sampling limited the precision of our estimates. In addition, these small sample sizes may have led to violations in the positivity requirement, due to random, non-structural non-positivity, of the potential outcomes framework for causal inference. Moreover, limited representation across diverse racial/ethnic groups necessitated their aggregation to a single group of persons of color. Second, the value of education with respect to earning potential may vary across race/ethnicity and gender. Using educational attainment to identify those likely to be affected by minimum wage may introduce bias if women and/or persons of color are more likely to earn lower

wages at higher education levels relative to their White and/or male counterparts.[74] We sought to gauge the extent to which this may have influenced our results by redefining our likely affected group as those with some college education or less. While we observed somewhat similar results, our estimates for obesity for non-Hispanic White women and women of color were attenuated. Third, we cannot rule out bias due of misclassification of our minimum wage exposure. Minimum wage laws are highly complex – changing within years and often differing within states across industries among tipped versus non-tipped workers. Moreover, there a number of reasons a worker with a high school education or less may earn well over the state minimum wage such as being a trade worker or as a member of a union. We sought to address this issue by examining multiple treatment and control group definitions as well as minimum wage specifications and found little evidence that varying our treatment group definitions has an influence on our findings. Fourth, not often discussed in the minimum wage and health literature is the possibility of violating the consistency requirement of the potential outcomes framework through interference. Interference could occur when the passage of a minimum wage in a neighboring state influences the health of an individual in a state whose minimum wage is equal to the federal rate. Workers living along state borders may commute into and out of states for work and should the minimum wage in a given state lead to a loss in jobs, low-wage workers could leave that state to look for work elsewhere.[75–78] Research into these so-called geographic "spillover effects" of minimum wage policies is still an active area of research in the econometrics literature.[75–78] Evidence, to date, remains decidedly mixed and it does not appear that there is sufficient evidence to prove nor disprove the presence of interference in this minimum wage analyses.[75–78] Fifth, as with all quasi-experiential study designs, we cannot rule of the potential for unmeasured confounding.

The pathways through which minimum wage policies could act to influence health may differ across subpopulations. Although no association between minimum and health outcomes was observed in the overall sample, this analysis revealed heterogeneous associations among subgroups by gender and race/ethnicity. These subgroup associations, which warrant further study, could be related to underlying differences in disease risk, inequities with respect to labor market outcomes, or both. Even thought there were few associations between higher minimum wages and health – raising the minimum wages remains important as a societal good. It is estimated that raising the US minimum wage to $15 an hour on the

national scale could provide a pay increase to nearly half of all Americans.[5] Future studies should examine local minimum wage initiatives as well as the psychosocial and behavioral pathways through which minimum wage may operate to influence health. In addition, this study highlights the need for more diverse cohorts with sufficient representation with evaluate the combined influence of race/ethnicity and gender.

Table 1. Sample characteristics at first observation for the full sample, overall and by education, 1999 to 2017

Characteristics	Overall (unweighted)	Overall (weighted)	Educational attainment			
			≤High school diploma (unweighted)	≤High school diploma (weighted)	≥Some college (unweighted)	≥Some college (weighted)
Sample size, individuals, n	13,730	8,059	6,166	3,644	7,564	4,415
Person-years, n	165,838	104,506	75,124	48,982	90,714	55,524
Number of observations per individual, mean (SD)	6.8 (2.9)	7.5 (2.6)	6.9 (2.9)	7.7 (2.6)	6.8 (2.8)	7.3 (2.7)
Demographics						
Age (years), mean (SD)	34.7 (9.4)	35.8 (7.0)	35.1 (9.3)	36.2 (7.3)	34.4 (9.4)	35.5 (6.7)
Women, %	49.9	49.0	47.3	48.0	52.0	49.7
Persons of color, %	44.1	27.3	53.2	35.2	36.8	21.8
Race and gender, %						
Non-Hispanic White men	29.3	37.9	25.5	34.1	32.3	40.5
Non-Hispanic White women	26.6	34.8	21.3	30.7	31.0	37.7
Men of color	20.9	13.1	27.2	17.9	15.7	9.8
Women of color	23.3	14.1	26.0	17.3	21.0	12.0
Education and employment						
Average years of education (years), mean (SD)	13.5 (2.3)	13.7 (1.6)	11.5 (1.3)	11.4 (1.1)	15.1 (1.4)	15.3 (0.9)
Employment status, %						
Employed	86.3	88.5	82.0	85.1	89.8	90.9
Unemployed	7.5	6.0	11.1	8.5	4.6	4.3
Not in labor force	6.2	5.5	7.0	6.4	5.6	4.8
Paid hourly, %[a]	60.0	55.1	78.1	75.2	46.7	42.4
Hourly wage rate (USD), mean (SD)[a]	14.11 (20.42)	14.83 (16.96)	12.64 (24.52)	12.85 (20.20)	15.91 (13.62)	17.07 (12.41)
Hourly wage ≤150% of state minimum wage, (%)[a]	25.7	23.8	30.3	28.1	20.1	18.9
Health outcomes						
Obesity, %	23.3	20.9	26.4	24.5	20.7	18.4
Hypertension, %	12.2	11.4	13.6	13.2	11.0	10.3
Fair or poor self-reported health, %	7.4	6.9	10.3	9.9	5.1	4.8
Moderate psychological distress, %	26.8	24.3	30.5	27.0	24.0	22.5

SD = standard deviation; USD = United States dollars

Source: Author calculations using the Panel Study of Income Dynamics

Note: All percentages calculated using the number of unique individuals. 11 respondents were missing employment status at baseline. 1,666 individuals were missing baseline height and weight data. 51 individuals were missing information of their baseline hypertension status. 43 individuals were missing information on their baseline self-reported health status. Sample size for moderate psychological distress is 4,363 at baseline as only responses for non-proxy respondents were collected by the PSID and only responses from the 2007 to 2017 wave were included in the analysis.

[a]Only calculated for those individuals who were employed, and those individuals paid hourly with tips or commission were excluded

Table 2. DDD risk ratio associated with a $1 increase in minimum wage on health among adults age 25 to 64 years with a high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
Subgroup MW specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall								
Current minimum wage	1.05	(0.95, 1.15)	1.08	(0.98, 1.19)	1.02	(0.95, 1.10)	0.97	(0.84, 1.12)
2-year lagged minimum wage	1.07	(0.97, 1.17)	1.04	(0.95, 1.15)	1.06	(0.96, 1.17)	0.90	(0.77, 1.06)
Person-years		*92,956*		*115,220*		*127,334*		*33,194*
Non-Hispanic White men								
Current minimum wage	0.86	(0.72, 1.01)	1.03	(0.89, 1.18)	0.92	(0.78, 1.08)	0.89	(0.64, 1.23)
2-year lagged minimum wage	0.82*	(0.67, 0.99)	0.98	(0.86, 1.13)	1.04	(0.86, 1.27)	0.79	(0.54, 1.16)
Person-years		*28,530*		*33,832*		*39,920*		*8,400*
Non-Hispanic White women								
Current minimum wage	1.11	(0.93, 1.32)	1.14	(0.95, 1.37)	1.00	(0.83, 1.22)	0.73*	(0.54, 1.00)
2-year lagged minimum wage	1.35**	(1.12, 1.64)	1.14	(0.90, 1.44)	0.99	(0.80, 1.23)	0.75*	(0.56, 1.00)
Person-years		*28,668*		*34,572*		*36,712*		*9,540*
Men of color								
Current minimum wage	1.07	(0.89, 1.29)	1.02	(0.86, 1.21)	0.95	(0.82, 1.11)	1.08	(0.70, 1.67)
2-year lagged minimum wage	1.23	(0.91, 1.67)	1.07	(0.92, 1.24)	0.98	(0.83, 1.17)	1.10	(0.72, 1.68)
Person-years		*16,792*		*21,104*		*23,020*		*5,618*
Women of color								
Current minimum wage	1.20	(0.98, 1.47)	1.21	(0.99, 1.49)	1.19*	(1.02, 1.40)	1.12	(0.94, 1.34)
2-year lagged minimum wage	1.08	(0.95, 1.22)	1.04	(0.86, 1.27)	1.19	(1.00, 1.41)	1.06	(0.88, 1.26)
Person-years		*18,966*		*25,712*		*27,682*		*9,636*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, as well as state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 3. DDD risk ratio associated with a $1 increase in minimum wage on health among adults age 25 to 64 years employed and paid hourly at baseline with a high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
Subgroup MW specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall								
Current minimum wage	1.12	(0.98, 1.29)	1.01	(0.90, 1.14)	1.05	(0.95, 1.14)	0.96	(0.81, 1.13)
2-year lagged minimum wage	1.17	(0.99, 1.37)	0.96	(0.86, 1.08)	1.10	(0.96, 1.26)	0.95	(0.80, 1.12)
Person-years		*52,128*		*66,886*		*72,216*		*19,332*
Non-Hispanic White men								
Current minimum wage	0.93	(0.67, 1.28)	1.06	(0.89, 1.27)	0.98	(0.77, 1.25)	0.79	(0.51, 1.20)
2-year lagged minimum wage	0.83	(0.58, 1.17)	0.99	(0.82, 1.19)	1.16	(0.85, 1.16)	0.80	(0.48, 1.32)
Person-years		*12,944*		*15,602*		*18,142*		*3,830*
Non-Hispanic White women								
Current minimum wage	1.14	(0.92, 1.41)	0.96	(0.78, 1.17)	0.91	(0.70, 1.18)	0.61	(0.35, 1.04)
2-year lagged minimum wage	1.46**	(1.13, 1.89)	0.99	(0.78, 1.27)	1.03	(0.78, 1.35)	0.73	(0.46, 1.16)
Person-years		*15,124*		*18,836*		*19,822*		*5,212*
Men of color								
Current minimum wage	1.20	(0.98, 1.47)	0.97	(0.79, 1.18)	0.89	(0.74, 1.08)	1.20	(0.76, 1.90)
2-year lagged minimum wage	1.41	(0.95, 2.10)	1.00	(0.82, 1.22)	0.86	(0.69, 1.09)	1.21	(0.83, 1.77)
Person-years		*11,262*		*14,520*		*15,338*		*3,712*
Women of color								
Current minimum wage	1.26	(0.92, 1.73)	1.09	(0.86, 1.39)	1.24*	(1.05, 1.49)	1.08	(0.85, 1.38)
2-year lagged minimum wage	1.11	(0.93, 1.32)	0.90	(0.74, 1.09)	1.25*	(1.01, 1.54)	1.07	(0.90, 129)
Person-years		*12,798*		*17,928*		*18,914*		*6,578*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

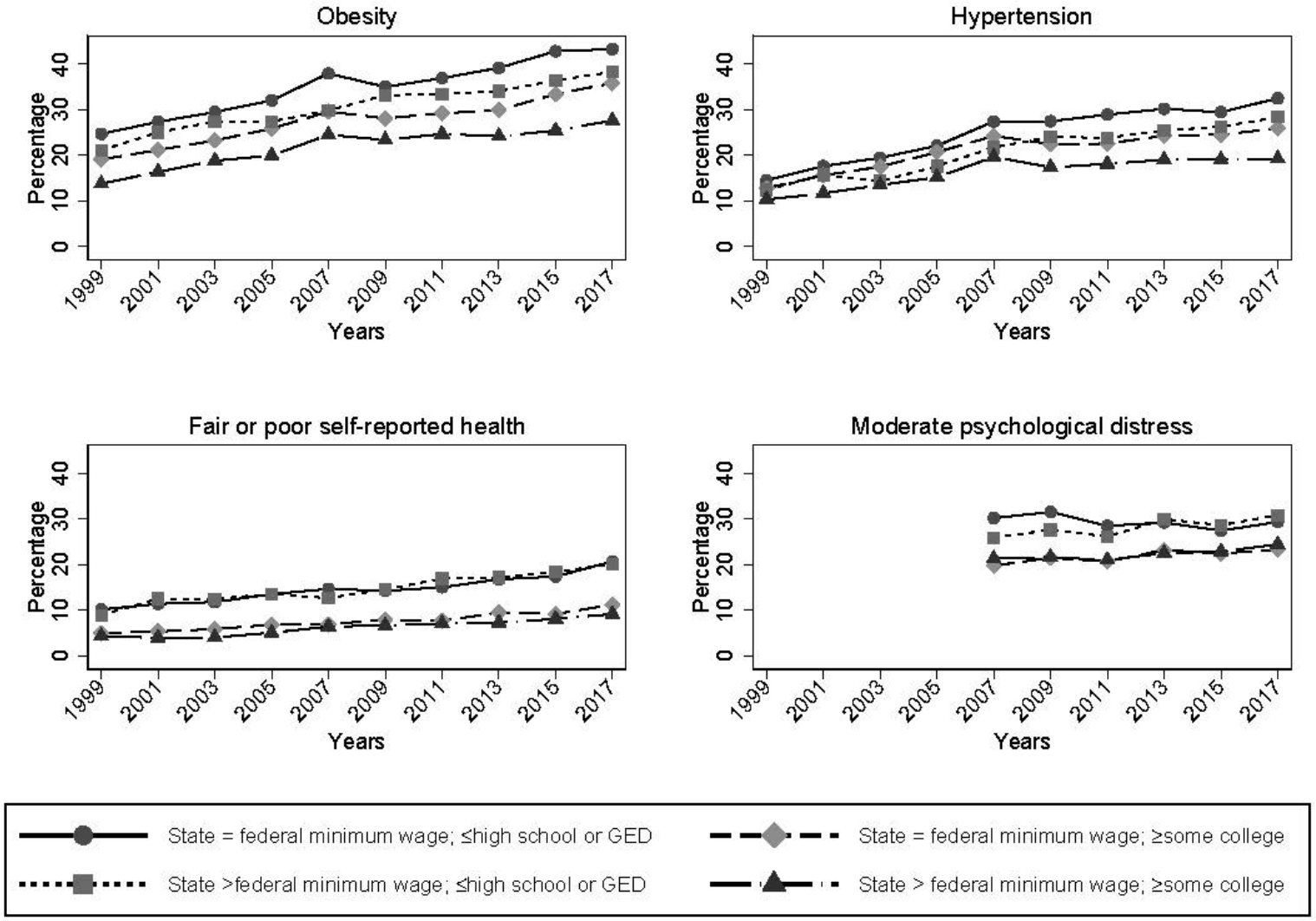
Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, as well as state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Figure 1. Prevalence of obesity, hypertension, fair or poor self-reported health, and moderate psychological distress



Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics
Note: Prevalence estimates are unweighted. The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

Supplementary Table 1. Sample characteristics at first observation for the full sample, overall and by education, 2007 to 2017

Characteristics	Overall (unweighted)	Overall (weighted)	Educational attainment			
			≤High school diploma (unweighted)	≤High school diploma (weighted)	≥Some college (unweighted)	≥Some college (weighted)
Sample size, individuals, n	11,459	7,047	4,944	3,094	6,515	3,953
Person-years, n	103,660	66,196	45,080	29,826	58,580	36,370
Number of observations per individual, mean (SD)	5.0 (1.3)	5.1 (1.2)	5.1 (1.3)	5.2 (1.2)	5.0 (1.3)	5.1 (1.2)
Demographics						
Age (years), mean (SD)	37.3 (10.7)	39.3 (7.6)	38.0 (10.6)	40.0 (7.7)	36.7 (10.8)	38.8 (7.5)
Women, %	50.7	49.5	48.4	48.4	52.5	49.7
Persons of color, %	45.1	28.3	55.3	37.1	37.4	22.4
Race and gender, %						
Non-Hispanic White men	28.5	36.9	24.2	32.9	31.8	40.1
Non-Hispanic White women	26.4	34.8	20.5	30.0	30.9	37.5
Men of color	20.8	13.5	27.4	18.7	15.7	10.3
Women of color	24.3	14.8	27.8	18.4	21.6	12.1
Education and employment						
Average years of education (years), mean (SD)	13.6 (2.2)	37.8 (1.6)	11.6 (1.4)	11.5 (1.1)	15.2 (1.4)	15.3 (0.9)
Employment status, %						
Employed	87.5	88.6	83.0	86.1	90.9	91.2
Unemployed	8.0	6.6	11.9	9.5	5.0	4.8
Not in labor force	4.6	4.7	5.1	4.5	4.2	4.0
Paid hourly, %[a]	59.6	55.6	77.8	74.7	47.2	43.6
Hourly wage rate (USD), mean (SD)[a]	16.3 (18.0)	17.1 (9.2)	14.0 (9.2)	14.5 (6.2)	18.8 (24.1)	20.0 (11.2)
Hourly wage <150% of state minimum wage, (%)[a]	28.2	25.9	32.9	30.5	22.8	21.1
Health outcomes						
Obesity, %	16.8	12.0	18.7	14.3	15.5	11.0
Hypertension, %	9.2	7.7	10.3	8.5	8.5	7.1
Fair or poor self-reported health, %	5.6	5.0	7.7	7.8	4.1	3.1
Moderate psychological distress, %	26.8	24.3	30.5	27.0	24.0	22.5

SD = standard deviation; USD = United States dollars

Source: Author calculations using the Panel Study of Income Dynamics

Note: All percentages calculated using the number of unique individuals.

[a]Only calculated for those individuals who were employed, and those individuals paid hourly with tips or commission were excluded

Supplementary Table 2. DD relative risk associated with a $1 increase in minimum wage on health among adults age 25 to 64 years, overall and overall and by race/ethnicity and gender strata

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
MW specification Model specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall								
Current minimum wage	0.99	(0.89, 1.11)	0.99	(0.91, 1.08)	1.01	(0.92, 1.11)	1.13	(0.99, 1.30)
2-year lagged minimum wage	1.10	(0.96, 1.26)	0.95	(0.84, 1.09)	0.94	(0.86, 1.04)	1.05	(0.89, 1.23)
Person-years		*92,956*		*115,220*		*127,334*		*33,194*
Non-Hispanic White men								
Current minimum wage	0.90	(0.72, 1.14)	1.03	(0.89, 1.20)	1.00	(0.80, 1.25)	1.35*	(1.00, 1.83)
2-year lagged minimum wage	1.31*	(1.03, 1.65)	1.01	(0.85, 1.19)	1.10	(0.84, 1.43)	1.56*	(1.09, 2.23)
Person-years		*28,530*		*33,832*		*39,920*		*8,400*
Non-Hispanic White women								
Current minimum wage	1.00	(0.79, 1.29)	0.93	(0.77, 1.13)	1.05	(0.81, 1.35)	1.02	(0.79, 1.32)
2-year lagged minimum wage	0.88	(0.68, 1.14)	0.96	(0.75, 1.22)	1.04	(0.83, 1.31)	0.82	(0.64, 1.05)
Person-years		*28,668*		*34,572*		*36,712*		*9,540*
Men of color								
Current minimum wage	1.18	(0.89, 1.58)	0.96	(0.78, 1.18)	1.10	(0.86, 1.40)	1.23	(0.90, 1.69)
2-year lagged minimum wage	1.19	(0.86, 1.63)	0.95	(0.68, 1.31)	0.75**	(0.61, 0.93)	1.06	(0.67, 1.66)
Person-years		*16,792*		*21,104*		*23,020*		*5,618*
Women of color								
Current minimum wage	0.96	(0.82, 1.14)	0.97	(0.78, 1.21)	0.93	(0.77, 1.13)	1.08	(0.82, 1.43)
2-year lagged minimum wage	1.01	(0.83, 1.23)	0.86	(0.68, 1.09)	0.87	(0.68, 1.12)	1.09	(0.82,1.46)
Person-years		*18,966*		*25,712*		*27,682*		*9,636*

DD = difference-in-differences; PSID = Panel Study of Income Dynamics; RR = relative risk; CI = confidence interval

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 3. DD relative risk associated with a $1 increase in minimum wage on health among adults age 25 to 64 years with ≤high school education, overall and by race/ethnicity and gender strata

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
MW specification Model specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall								
Current minimum wage	0.89	(0.76, 1.03)	1.05	(0.92, 1.20)	1.03	(0.91, 1.16)	1.10	(0.87 1.41)
2-year lagged minimum wage	1.19*	(1.01, 1.39)	1.00	(0.86, 1.16)	1.02	(0.87, 1.19)	1.05	(0.81, 1.37)
Person-years		*39,442*		*49,888*		*53,134*		*13,092*
Non-Hispanic White men								
Current minimum wage	0.77	(0.52, 1.13)	1.24	(0.99, 1.55)	0.91	(0.68, 1.21)	0.99	(0.58, 1.69)
2-year lagged minimum wage	1.18	(0.85, 1.64)	1.02	(0.76, 1.36)	1.15	(0.85, 1.56)	1.29	(0.66, 2.53)
Person-years		*10,460*		*12,416*		*14,454*		*2,616*
Non-Hispanic White women								
Current minimum wage	0.72*	(0.53, 0.98)	0.87	(0.62, 1.23)	1.04	(0.74, 1.47)	0.99	(0.58, 1.58)
2-year lagged minimum wage	1.20	(0.86, 1.69)	1.12	(0.81, 1.55)	1.23	(0.95, 1.59)	0.80	(0.51, 1.24)
Person-years		*9,392*		*11,974*		*12,280*		*3,058*
Men of color								
Current minimum wage	0.94	(0.69, 1.30)	0.95	(0.75, 1.22)	1.14	(0.90, 1.45)	1.50	(1.00, 2.25)
2-year lagged minimum wage	1.23	(0.88, 1.71)	1.05	(0.78, 1.43)	0.89	(0.66, 1.21)	1.14	(0.59, 2.21)
Person-years		*9,902*		*12,408*		*12,748*		*2,850*
Women of color								
Current minimum wage	1.09	(0.90, 1.33)	1.04	(0.79, 1.36)	1.00	(0.81, 1.23)	1.10	(0.66, 1.50)
2-year lagged minimum wage	1.14	(0.95, 1.38)	0.86	(0.62, 1.20)	0.87	(0.66, 1.15)	1.09	(0.63, 1.86)
Person-years		*9,688*		*13,090*		*13,652*		*4,568*

DD = difference-in-differences; PSID = Panel Study of Income Dynamics; RR = relative risk; CI = confidence interval

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 4. DDD risk ratio associated with a $1 increase in minimum wage on health among adults age 25 to 64 years with some college education or less compared to those with a college degree or more, overall and by race/ethnicity and gender strata

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
Subgroup MW specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall								
Current minimum wage	1.07	(1.00, 1.15)	1.10*	(1.02, 1.18)	1.09	(0.97, 1.23)	0.93	(0.85, 1.03)
2-year lagged minimum wage	1.07	(0.98, 1.18)	1.03	(0.95, 1.12)	1.12	(0.98, 1.29)	0.90	(0.81, 1.01)
Person-years		*92,956*		*115,220*		*127,334*		*33,194*
Non-Hispanic White men								
Current minimum wage	0.95	(0.77, 1.18)	0.99	(0.86, 1.15)	1.03	(0.89, 1.20)	0.88	(0.66, 1.18)
2-year lagged minimum wage	1.01	(0.80, 1.27)	0.99	(0.87, 1.12)	1.10	(0.94, 1.32)	0.75*	(0.57, 0.99)
Person-years		*28,530*		*33,832*		*39,920*		*8,400*
Non-Hispanic White women								
Current minimum wage	1.09	(0.90, 1.32)	1.19*	(1.01, 1.40)	1.20*	(1.02, 1.41)	0.90	(0.71, 1.15)
2-year lagged minimum wage	1.09	(0.89, 1.33)	1.03	(0.86, 1.22)	1.24*	(1.00, 1.55)	1.00	(0.79, 1.27)
Person-years		*28,668*		*34,572*		*36,712*		*9,540*
Men of color								
Current minimum wage	1.25	(0.99, 1.56)	1.12	(0.90, 1.39)	1.09	(0.83, 1.43)	1.16	(0.74, 1.83)
2-year lagged minimum wage	1.18	(0.86, 1.61)	1.07	(0.85, 1.36)	1.03	(0.79, 1.33)	1.24	(0.82, 1.87)
Person-years		*16,792*		*21,104*		*23,020*		*5,618*
Women of color								
Current minimum wage	1.10	(0.93, 1.29)	1.24*	(1.03, 1.49)	1.11	(0.87, 1.42)	0.90	(0.69, 1.17)
2-year lagged minimum wage	1.07	(0.84, 1.36)	1.12	(0.89, 1.42)	1.02	(0.79, 1.32)	0.88	(0.59, 1.33)
Person-years		*18,966*		*25,712*		*27,682*		*9,636*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, as well as state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 5. DDD risk ratio associated with a $1 increase in minimum wage among employed workers earning wages ≤150% versus >150% of the state minimum wage at baseline, overall

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
Minimum wage specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Current minimum wage	0.95	(0.85, 1.05)	1.09	(0.96, 1.25)	0.96	(0.76, 1.21)	1.00	(0.81, 1.23)
Person-years		*41,104*		*52,738*		*57,862*		*9,452*
2-year lagged minimum wage	0.93	(0.76, 1.14)	1.06	(0.91, 1.23)	1.19	(0.96, 1.47)	1.23	(0.98, 1.54)
Person-years		*29,340*		*37,280*		*41,426*		*5,786*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, as well as state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 6. DDD risk ratio associated with a 10% increase in relative minimum wage on health among adults age 25 to 64 years with a high school education or less compared to those with some college or more, overall

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
Minimum wage specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Current minimum	0.98	(0.81, 1.18)	1.28**	(1.10, 1.48)	1.02	(0.83, 1.25)	0.95	(0.76, 1.17)
2-year lagged minimum wage	1.00	(0.82, 1.21)	1.19*	(1.03, 1.37)	1.06	(0.88, 1.28)	0.87	(0.69, 1.11)
Person-years	*92,956*		*115,220*		*127,334*		*33,194*	

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, as well as state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 7. DDD risk ratio associated with a $1 increase in nominal minimum wage on health among adults age 25 to 64 years with a high school education or less compared to those with some college or more, overall

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
Minimum wage specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Current minimum wage	1.04	(0.98, 1.11)	1.07	(1.00, 1.14)	1.01	(0.95, 1.07)	0.92	(0.81, 1.05)
2-year lagged minimum wage	1.06	(0.99, 1.13)	1.06	(0.99, 1.13)	1.02	(0.95, 1.09)	0.88	(0.77, 1.01)
Person-years	*92,956*		*115,220*		*127,334*		*33,194*	

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, as well as state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 8. DDD risk ratio associated with a $1 increase in minimum wage among those with high school education or less compared to those with some college or more, overall sample, adjusting for state unemployment

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
Minimum wage specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Current minimum wage	1.05	(0.96, 1.14)	1.08*	(1.00, 1.17)	1.00	(0.94, 1.07)	0.95	(0.79, 1.13)
2-year lagged minimum wage	1.08	(0.99, 1.19)	1.06	(0.97, 1.15)	1.02	(0.92, 1.12)	0.91	(0.79, 1.04)
Person-years	*92,956*		*115,220*		*127,334*		*33,194*	

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, state unemployment, as well as state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 9. DDD risk ratio associated with a $1 increase in minimum wage on health among adults age 25 to 64 years, who did not move during the study period, with high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

Health outcome	Obesity		Hypertension		Fair or poor health		Moderate psychological distress[a]	
Subgroup MW specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall								
Current minimum wage	0.98	(0.89, 1.10)	1.07	(0.97, 1.18)	1.05	(0.97, 1.14)	1.02	(0.88, 1.18)
2-year lagged minimum wage	0.98	(0.88, 1.10)	1.04	(0.94, 1.14)	1.07	(0.97, 1.19)	0.93	(0.79, 1.09)
Person-years		*71,214*		*88,564*		*98,606*		*24,766*
Non-Hispanic White men								
Current minimum wage	0.82*	(0.68, 0.97)	1.02	(0.87, 1.19)	1.00	(0.83, 1.21)	0.95	(0.63, 1.44)
2-year lagged minimum wage	0.77*	(0.63, 0.95)	0.98	(0.84, 1.15)	1.08	(0.87, 1.33)	0.82	(0.56, 1.21)
Person-years		*21,186*		*25,168*		*29,936*		*5,884*
Non-Hispanic White women								
Current minimum wage	1.03	(0.83, 1.27)	1.12	(0.92, 1.35)	0.99	(0.76, 1.28)	0.68*	(0.48, 0.96)
2-year lagged minimum wage	1.22	(0.98, 1.52)	1.12	(0.89, 1.40)	0.98	(0.75, 1.29)	0.69*	(0.51, 0.94)
Person-years		*21,776*		*26,388*		*28,404*		*7,008*
Men of color								
Current minimum wage	1.10	(0.87, 1.38)	1.00	(0.83, 1.20)	0.94	(0.79, 1.12)	1.19	(0.75, 1.87)
2-year lagged minimum wage	1.20	(0.81, 1.78)	1.04	(0.89, 1.23)	1.03	(0.86, 1.23)	1.14	(0.68, 1.93)
Person-years		*13,182*		*16,514*		*17,984*		*4,218*
Women of color								
Current minimum wage	1.16	(0.92, 1.47)	1.20	(0.94, 1.54)	1.22**	(1.06, 1.41)	1.27*	(1.05, 1.54)
2-year lagged minimum wage	1.04	(0.90, 1.21)	1.05	(0.83, 1.33)	1.16	(0.97, 1.39)	1.14	(0.94, 1.37)
Person-years		*15,070*		*20,494*		*22,282*		*7,656*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, as well as state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 10. DDD relative risk associated with a $1 increase in minimum wage on health among adults age 25 to 64 years, restricted to non-proxy respondents, with high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

Health outcome	Obesity		Hypertension		Fair or poor health	
Subgroup MW specification	RR	95% CI	RR	95% CI	RR	95% CI
Overall						
Current minimum wage	1.05	(0.91, 1.21)	1.11	(0.98, 1.27)	1.06	(0.97, 1.17)
2-year lagged minimum wage	1.10	(0.95, 1.26)	1.09	(0.96, 1.23)	1.09	(0.98, 1.21)
Person-years		*59,314*		*74,170*		*81,344*
Non-Hispanic White men						
Current minimum wage	0.71**	(0.55, 0.91)	0.93	(0.76, 1.15)	0.98	(0.74, 1.29)
2-year lagged minimum wage	0.75*	(0.56, 1.00)	0.95	(0.77, 1.18)	1.15	(0.84, 1.58)
Person-years		*15,724*		*18,584*		*21,740*
Non-Hispanic White women						
Current minimum wage	1.17	(0.98, 1.40)	1.25	(0.98, 1.59)	1.12	(0.86, 1.45)
2-year lagged minimum wage	1.44***	(1.18, 1.74)	1.28	(0.96, 1.72)	1.03	(0.78, 1.37)
Person-years		*19,336*		*23,278*		*24,692*
Men of color						
Current minimum wage	1.05	(0.74, 1.49)	1.06	(0.80, 1.41)	0.94	(0.81, 1.10)
2-year lagged minimum wage	1.30	(0.78, 2.15)	1.14	(0.91, 1.42)	1.00	(0.80, 1.26)
Person-years		*9,194*		*11,564*		*12,344*
Women of color						
Current minimum wage	1.23	(0.97, 1.57)	1.25	(0.98, 1.60)	1.17	(0.95, 1.43)
2-year lagged minimum wage	1.07	(0.92, 1.24)	1.06	(0.85, 1.32)	1.16	(0.96, 1.40)
Person-years		*15,060*		*20,744*		*22,568*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Author calculations using the 1999 to 2017 Panel Study of Income Dynamics

Note: Moderate psychological distress not included as only non-proxy respondents are asked to respond to Kessler 6-item questions and the analyses of this outcome have been previously shown. Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, as well as state and year fixed effects.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Chapter 2: The association between state minimum wages and health behaviors among working-age adults Panel Study of Income Dynamics 1999 to 2017

Abstract

Background. As more states move to adopt higher minimum wages, evidence regarding the influence of these increases on smoking, drinking, and physical activity remains unclear and may depend on how these goods and individual time use are valued.

Methods. We employed a triple difference model using modified Poisson regression to evaluate the association between minimum wage and daily cigarette and alcohol consumption. The association between minimum wage and light or moderate and heavy physical activity, measured in times per week, in adults age 25 to 64 years was also examined. Data from the 1999 to 2017 waves of the Panel Study of Income Dynamics was linked to state policies and characteristics to estimate the risk ratio associated with a $1 increase in current minimum wage among less-educated adults overall and across racial/ethnic and gender strata.

Results. No association between minimum wage increases and smoking, drinking, and physical activity was observed in the overall sample of working age adults, employed and unemployed. Subgroup models suggested a modest increase in daily cigarette consumption in non-Hispanic White men (RR = 1.10, 95% CI = 1.01, 1.19). Estimates were consistent when restricted to workers employed hourly at baseline.

Conclusion. In theory, health behaviors represent a major pathway through which higher minimum wages should operate to influence short and long-term health. However, we found little evidence that higher minimum wages influence drinking, smoking, and engagement in physical activity. We also found little evidence of heterogeneity across race/ethnicity-gender strata. More work is needed to elucidate what influence, if any, higher minimum wage laws have on health behavior over time.

INTRODUCTION

With their residents facing widening income inequality, states and localities have increasingly pushed to adopt higher minimum wages which, at the federal level have not kept pace with inflation, remaining at $7.25 since 2009.[25] The primary goal of these higher minimum wage laws has been to improve the economic wellbeing of low wage workers and their families. However, policy makers and academics alike have become interested in the potential for minimum wage laws to serve as an indirect intervention to help close the gap on income-driven health disparities.[3]

In general, United States (US) adults with low income smoke more,[7–9] consume alcohol more frequently, or in excess,[10–12] and engage in less frequent physical activity (PA)[13,14] than US adults with higher incomes. It stands to reason that a higher minimum wage, which leads to higher earnings with no unintended consequences on employment, hours, or government assistance,[15] would result in a higher net income leading to better health.[2,16] Greater financial resources may reduce financial stress which might result in reduced reliance on alcohol and cigarettes as a coping strategy.[3,17–19] Moreover, higher incomes would provide the means to bolster health through increased access to healthcare or other basic needs such as affordable food, safe housing, and more.[3,17–19] Individuals could also have more time to devote to health-promoting activities such as exercise should they choose to reduce their hours proportionally in response to higher wages.[3,17–19,71]

Alternatively, higher minimum wages could reduce employment, hours, or eligibility for health insurance and other public benefits, the net result of which could lead to a decline in financial resources and increased stress, which might give rise to poor health.[3,17–20] Chronic economic hardship and struggles with financial decision-making can lead to a cognitive overload potentially leading to exacerbation of unhealthy behaviors, such as physical inactivity, or behaviors that relieve present stressors to the determinant of health, such as smoking and drinking alcohol.[39,79]

Adding further complexity, consumption of goods such as cigarettes and alcohol, are also dependent on how these products are valued or their “elasticity of demand” as this concept is commonly referred to in the economics literature.[39,79–81] Goods such as cigarettes and alcohol can fall into two broad categories: “normal” and “inferior.”[39,79–81] A normal good is a product or service whose consumption rises

along with a rise in incomes.[39,79–81] Conversely, an “inferior” good is one whose consumption falls as incomes rise.[39,79–81]

Cigarettes generally operate as inferior goods, displaying an inverse relation between consumption and income.[82] Higher incomes, and higher socioeconomic position more generally, has also been associated with a greater likelihood of successful smoking cessation.[83] However, in some circumstances, such as when large boluses of cash are received from policies such as the Earned Income Tax Credit, lottery winnings, or inheritance, this additional disposable income is positively associated with cigarette consumption.[80,81] Alcohol is generally considered a normal good, with individuals with higher incomes generally consuming more alcohol.[84,85] Yet, the relation between income and alcohol consumption can become unmoored in turbulent economic conditions such as the Great Reccession.[86]

Other health behaviors, such leisure time PA, can also exhibit differences in demand across income levels, although not goods in the traditional sense. Engagement in PA can be thought of as an “investment” in one’s health and; therefore, we should expect a positive gradient between engagement in PA and higher incomes.[39,71] However, it is also possible that higher wages may place more value on time at work drawing workers away from leisure time PA and toward more time spent at work.[39,71]

The current body of evidence evaluating the relations between minimum wage and drinking, smoking, and PA in adults remains largely inconclusive.[17,19,21,33,68,71,87] There appeared to be some consistent evidence, in cross-sectional evaluations, that higher minimum wages were associated with a lower probability of being a current smoker of approximately 1.6-7.4% in less educated women .[17,68,87] However, no such relation has been observed in men[17] or in combined samples of less-educated men and women.[21] Two longitudinal studies showed that the introduction of the National Minimum Wage in the United Kingdom reduced the probability of being a current smoker by 8.0%[19] but had no impact on daily cigarette consumption in smokers.[33]

The influence of minimum wage on alcohol intake depended on the drinking habit under study.[17,21,88] One study found that higher minimum wage increases were associated with a 0.6-3.3% reduction in the probability of binge drinking (consuming ≥5 drinks in one session for men or ≥4 for women), but a 2.4-3.7% increase in the probability of heavy drinking (>1 alcoholic beverage daily for

women and >2 for men) in less educated adults ages 18-54 years.[17] However, another study found that higher minimum wages increased the probability of alcohol abuse among less educated adults ages 21-64 years.[21] Both had insufficient evidence to reject the null hypothesis.[17,21]

To date only two studies have evaluated the relation between minimum wage increases and PA.[17,71] One study found that a $1 increase in minimum wage was associated with a 13 minute reduction in exercise time per week which was replaced almost entirely by non-exercise-related leisure.[71] The other study found suggestive, but statistically imprecise, evidence that higher minimum wages reduced engagement in PA outside of work.[17]

The present study used social epidemiologic and econometric approaches to evaluate the effects of minimum wage on smoking, drinking, and PA in adults. To date, all but two studies evaluating these health behaviors have relied on cross-sectional study designs hindering the ability to evaluate dynamic engagement in these behavior over time and limiting causal inference.[3] Moreover, while there has been some work evaluating potential heterogeneity with the minimum wage-health behavior relation by gender and employment status, to our knowledge, no studies have jointly evaluated the joint role that race/ethnicity and gender may play in modifying these relations in adults. We used a triple difference-in-differences empirical strategy leveraging nearly two decades of state variation in minimum wage to examine longitudinal associations with smoking, drinking, and PA using the Panel Study of Income Dynamics (PSID) in a sample of employed and unemployed working age adults. These outcomes were evaluated in the overall population and by race/ethnicity-gender interaction.

METHODS

Study population and design

The present study utilizes a data from the 1999 to 2017 biannual waves of the PSID and implements a retrospective cohort study design.[51] The PSID was established in 1968, recruiting a nationally representative sample of families to study how fluid economic circumstances in US households and to examine the etiology of economic hardship.[51] The PSID interviews adult heads of households, who are predominantly male, and their spouses or domestic partners. The PSID is one of the world's longest, continually running longitudinal studies and follows more than 9,000 families and 24,000 individuals.

Seeking to better understand how economic circumstances influence health and health behaviors, the PSID added several questions related to overall wellness, chronic disease, and health behaviors in 1999.[51]

The study population was restricted to 25 to 64-year-old adult heads of household and their spouse/partners who were observed at least twice during the 1999 to 2017 period. The PSID defines "heads" of household as the male husband in a heterosexual married couple or the single adult of either sex (male or female).[51] This definition conformed to the 1968 Census definition of a household head, the year in which the PSID was first implemented.[51] In 2017, the PSID replaced the term "head" with "reference person" to reflect the diversification of families over time.[51] The PSID historically defined the spouse/partner as a wife/"wife" where wife was used to describe the female in a married couple and "wife" was used to describe a cohabiting female.[51] These terms were changed to spouse and partner, respectively, to expand these definitions to encompass both heterosexual and sex same couples.[51] We limited of analysis to heads of household and spouse/partners as, even though the PSID collects information on other family members, the greatest detail with respect to economics and health is limited to these family members.[51]

Sample adults need be observed at least twice needed to be employed, or unemployed and actively seeking work, for at least half of the time they were observed and have complete covariate information during the study period. For all smoking outcomes this study period was defined between 1999 and 2017 and from 2005 to 2017 for alcohol consumption and PA. Our individual-level PSID data set was merged to a state-level data set containing information on state minimum wages as well as other policies and characteristics thought to potentially confound the relation between minimum wage increases and smoking, drinking, PA. These state characteristics and policy data were obtained from several sources.[52–58]

Measures

State minimum wage policies

Data on state minimum policies from 1999 to 2017 was acquired from the University of Kentucky Center for Poverty Research's (UKCPR) National Welfare Data.[55] UKCPR sources these data from the Bureau of Labor Statistics' Wage and Hours Division.[52] For each state and Washington, DC, the highest

effective, inflation-adjusted state minimum wage was applied using 2017 as a base year. Federal law stipulates that those states which do not have a minimum wage law or have a minimum wage which falls below the federal rate, the federal wage is the effective rate. Inflation-adjusted minimum wages allow one to account changes in the purchasing power of each dollar due to changes in the cost of living and is the most commonly used exposure definition in the minimum wage-health literature.[3]

State minimum wage policies were assumed to take place at the beginning of each calendar year in which the wage rate change occurred and to be in place for the full year. We examined minimum wage rates occurring in the same year as the outcome occurred. However, since respondents were asked to report on prior year alcohol consumption, we used a 1-year lagged minimum wage rate for our evaluation of alcohol consumption to be temporarily in sync with reported behaviors.

Health behaviors

All health behaviors were self-reported by the head of household, who reported both for themselves and their spouse/domestic partner, if one was present. We assessed daily cigarettes smoked among respondents who were current smokers at their baseline observation. We defined current smokers as those who responded yes to the question “Do you smoke cigarettes?” We also examined daily alcoholic beverages consumed, on days respondents drank, among those who drank alcohol in the past year. We defined those who drank alcohol in the past year as those who said yes to “Do you ever drink any alcoholic beverages such as beer, wine, or liquor?” and said that they consumed at least 1 to 11 or more alcoholic beverages in the past year based on a categorical assessment of alcohol consumption frequency. We assessed alcohol consumption only for the 2005 to 2017 survey years as alcohol consumption was only assessed categorically in 1999, 2001, and 2003. Cigarette counts were top coded to 60 cigarettes per day (3 packs) and alcohol consumption was top coded to 10 drinks, representing the 99.9th and 99th percentiles, respectively, to limit the influence of extreme values on model estimates. We only examined smoking and drinking among those who smoked and drank at baseline as smoking and drinking behaviors are usually set by early adulthood and we did not expect many individuals to initiate smoking and drinking for the first time between the ages of 25 to 64 years.[89,90] Moreover, we had no prior hypothesize that increases in the minimum wage would lead nonsmokers and nondrinkers to initiate these behaviors.

We accessed PA by evaluating the frequency of weekly light or moderate and heavy PA. To assess light or moderate PA, respondents were asked "*How often do you do light or moderate activities for at least 10 minutes that cause only light sweating or slight to moderate increases in breathing or heart rate*." To assess heavy PA, respondents were asked "*How often do you do vigorous physical activities for at least 10 minutes that cause heavy sweating or large increases in breathing or heart rate?"* For both light or moderate PA and heavy PA, respondents could provide a frequency, ranging from 0, indicating "never", and 200. They were then asked to select a unit of time for this corresponding frequency: per week, per month, or per year. Using these responses, we calculated the frequency of weekly light or moderate or heavy PA. Only responses for the 2005 to 2017 survey years for light or moderate and heavy PA were assessed as the survey question was changed substantively in 2005 by no longer referring to specific activity types and adding a specific minimum time interval – 10 minutes. In addition, due to the presence of extreme outlier values, we top-coded both PA metrics to 28 times per week which corresponded to the 99th percentile for light or moderate PA and the 99.5th percentile for heavy PA.

As a secondary analysis we also examined the association between minimum wage increases and smoking cessation as well as frequency of binge drinking episodes in the past year. We defined smoking cessation as respondents who reported that they were a current smoker at baseline and reported no longer smoking in a subsequent wave. Individuals were followed until they reported they were no longer a current smoker or had missing outcome and were censored thereafter. Based on the definition for binge drinking from the National Institute for Alcohol Abuse and Alcoholism,[91] a binge drinking episode was defined as consuming 4 or more alcoholic beverages in a single day for women. For men, a binge drinking episode was defined as heavy consumed 5 or more beverages in a single day.

Covariates

All models were adjusted for a large set of individual and state-level covariates selected based on past research on minimum wage and health.[3] Individual-level covariates included age (continuous years), gender (women, men), and race/ethnicity (persons of color versus non-Hispanic Whites). State-level covariates included an indicator of whether the state has a refundable Earned Income Tax Credit program; state sales tax rate (continuous percentage); state Temporary Assistance for Needy Families

benefit for a family of four (continuous United States Dollars (USD)), state gross product (thousands of USD) and the percentage of state residents who are union members.[53,55,58]

We also included policy index variables for Medicaid and the Supplemental Nutrition Assistance Program (SNAP), which comprised multiple aspects of each program that varied across states and time. Both indices ranged from 0, indicating no policies to 3 indicating SNAP or Medicaid policies with greater generosity. Both measures were parameterized as ordinal, categorical covariates in all models. The Medicaid index included 1) whether state Medicaid eligibility limits for children were above median for states in a given year, 2) whether state Medicaid eligibility limits for parents were above median for states in a given year, 3) whether the state had a Medicaid program for non-citizens, and 4) whether the state expanded Medicaid under the Affordable Care Act. The SNAP index included 1) whether non-citizens in the state were fully eligible for SNAP benefits, 2) whether the state allows SNAP online applications, 3) whether state had no SNAP ban for drug felons, and 4) whether the state uses broad-based categorical eligibility to increase or eliminate the asset test and/or to increase the gross income limit for SNAP users.[57]

Statistical analysis

A difference-in-difference-differences (DDD) framework was used to estimate the association of an increase in minimum wage and health behaviors.[61,62] The DDD uses comparisons across states and years, but also between likely affected and likely unaffected group, here defined by educational attainment.[63] The third comparison helps to address unobserved confounders that might vary over time differentially by state.[61] In this study, we defined the "likely affected" group as working-age adults with a high school education or less with the "likely unaffected" comparison group comprised of those with some college education or more.[62] The DDD modified model was defined as:

$$(1)\ \log(Y_{itsj}) = \beta_1 MW_{ts} + \beta_2 A_{ij} + \delta_1 A_{ij} MW_{ts} + \beta_3 V_{ts} + \beta_4 S_{ts} + \varphi_t + \gamma_s + u_{ts} + e_{itsj,}$$

where i, t, s, and j index individuals, years, states, treatment group respectively. The health behaviors of interest, smoking, drinking, or PA are defined as $\log(Y_{itsj})$. β_1 is the effect of the state minimum wage level for the likely unaffected group. MW_{ts} is the inflation-adjusted minimum wage in a given state and year. β_2 is the estimated association between an individual having a high school diploma or less and their outcomes, when the minimum wage is set at the federal level. A_{ij} equals 1 if the person has a high school

diploma or less.[62] The coefficient of interest, δ_1, captures the relation between minimum wage levels and the outcomes for the likely affected group and is the primary estimate of interest. The vectors V_{its} and S_t capture sets of state-level control variables. State (γ_s), and year (φ_t) fixed effects will also be included. e_{itscj} is the random error term. Using the potential outcomes framework for causal estimation,[63] the DDD approach estimates the average intent-to-treat effect of the minimum wage. This is because not all individuals in the likely affected group are, in actuality, exposed to a minimum wage increase in their state in a given year.[63,64]

We examined associations in the full sample of employed and unemployed adult respondents. We then restricted our sample to employed, hourly wage workers, following Du and Leigh (2018)[62] to determine if the associations between the minimum wage and our primary health outcomes of interest were different in this population. In addition, we examined associations within race/ethnicity-gender strata (non-Hispanic White men, non-Hispanic White women, men of color, and women of color) similar to Averett (2017).[35] Secondary analyses of smoking cessation and binge drinking episodes in the past year were only conducted in the full sample and the subsample of employed, hourly wage workers due to the small number of outcomes across race/ethnicity and gender strata. All regressions used a generalized linear model with Poisson distribution and log link, which allowed us to directly estimate the risk ratio (RR).[65] All statistical analyses were performed using Stata Version 14[66] using a significance level 0.05.

A key assumption of DD models is that unmeasured confounders across "treated" and "untreated" groups, in this case states that increase their minimum wage and those that do not, are either time-invariant state-specific characteristics or time-varying characteristics that do not vary across states.[67] If these assumptions hold true, a time series plot of the outcome in both treated and untreated states should resemble parallel lines, that is, moving together in a fixed amount in every period.[67] This applies for both the pre- and post-invention periods, but for the intervention in the treated states.[67] We provide graphical support for this assumption in Supplementary Figure 1 by showing the trends by whether or not the state's minimum wage was at or above the federal wage rate and by baseline educational attainment of our sample.[67]

We tested the sensitivity of our main findings to alternative pseudo treatment and control groups specifications.[3] First, to compare to prior studies, we compared our DDD approach to a difference-in-

difference (DD) model using the entire sample population and a DD model restricted to the likely affected. Second, we reevaluated our education cut point by comparing those with some college education or less to college graduates or higher. Third, we redefined our treatment and control groups by comparing calculated, regular hourly wage rates, for those respondents who were employed and paid hourly, to the state minimum wage rate, both adjusted for inflation. We used a cut point of wages ≤150%, "likely affected" or >150%, "likely unaffected", of the state minimum wage rate. Note that the PSID asks about wage rates at the time of the survey, therefore, since alcohol consumption was assessed in the prior year, we used wages and state minimum wage rates from the prior survey wave. In addition, we tested our findings against an alternative minimum wage specification – the nominal, non-inflation adjusted minimum wage. All sensitivity analyses were run for the overall sample only. In addition, we ran our primary, overall models adjusting for state unemployment. We elected not to adjust for state unemployment in main models as we believed that state unemployment operates as a time-varying confounder, being both on the causal pathway between minimum wage and health as well as influencing the probability of future minimum wage increases. However, this covariate is frequently adjusted for in the literature and we therefore include this adjustment for comparison purposes. We also restricted our sample to respondents who did not moved to a different state during the period of observation following Du and Leigh (2018) to more rigorously control for state fixed effects. Finally, out of concern for potential misreporting of health behaviors, we restricted our analyses to non-proxy respondents, that is, we examined health behaviors among adults reporting only for themselves. In most cases this was the head of household.

RESULTS

During the period of observation, from 1999 to 2017, states increased their minimum wage rates a combined total of 362 times. About three-fifths (63%) of these increases did not occur during the same period the federal minimum wage increased, from 2007 to 2009. The number of states with minimum wage rates above the federal rate more than doubled over the period, from 12 in 1999 to 30 in 2017 (Appendix Figure 1). Appendix Table 1 summarizes changes to changes in other state policies and state characteristics that were included as model covariates between the 1999 to 2017 period.

Table 1 shows both unweighted and weighted socio-demographic characteristics, prevalent health behaviors, consumption, and PA engagement in sample PSID respondents at their first observation overall and by education for the 1999 to 2017 study period and between 2005 to 2017 for alcohol consumption and PA. The mean age of the sample was 34.7 years with an average of 13.5 years of education. Half of the sample were women and 44.1% were persons of color. Most of the sample was employed (86.3%) with 7.5% looking for work and 6.2% not in the labor force. Among the employed, 60.0% were paid hourly at an average hourly wage rate of $14.11 per hour.

Approximately one-fourth of the sample (24.0%) were current smokers. Among current smokers, the mean number of cigarettes consumed per day was 13.2, or just under a pack and a half a day. About 67.1% of respondents said that they ever drank alcohol and consumed at least 1 to 11 alcoholic beverages in the past year. On average, respondents engaged in light or moderate PA of ≥10 minutes in duration 4.4 times per week. In comparison, respondents engaged in slightly less frequent heavy PA of ≥10 minutes in duration – around 3.3 times per week. Additional descriptive statistics for the sample restricted to the 2005 to 2017 PSID waves can be found in Supplementary Table 1. Sociodemographic characteristics of respondents in both survey periods were comparable.

In comparing respondents by level of educational attainment, those with a high school diploma or less were comprised of fewer women (47.3%) and employed adults (82.0%) but had a greater share of persons of color (53.2%) and hourly wage earners (78.1%) (Table 1). Less educated adults also had a lower hourly wage rate ($12.64) compared to those with more education ($15.91). Less educated respondents were more likely to be smokers and less educated smokers smoked more cigarettes per day compared to their higher educated counterparts. Less educated respondents were less likely to report having drank in the past year; however, those that did drink consumed more alcoholic beverages per day in the past year, on days they drink compared to those with some college education or more. Weekly engagement in light or moderate and heavy PA was similar between those with a high school education or less and those with some college education or more (Table 1). Weighted estimates were comparable to unweighted estimates with the exception of the percentage of the sample comprised of persons of color. This is due to the fact that only families who were included in the original 1968 sample wave

received longitudinal weights and therefore these weighted estimates are nationally representative of the 1968 US population.

Estimated DDD risk ratios associated with minimum wage increases and cigarette consumption for employed and unemployed respondents, overall and by race/ethnicity and gender strata can be found in Table 2. Overall, there was no association between higher minimum wages and daily consumption of cigarettes. However, there was null but suggestive evidence of a marginally elevated daily consumption of cigarettes of 6% (RR = 1.06, 95% CI = 0.99, 1.13) associated with a $1 increase in minimum wage among baseline smokers with a high school education or less compared to those some college education or more. However, we had insufficient precision to reject the null hypothesis. In race/ethnicity and gender stratified models, higher minimum wages were modestly associated a 10% higher daily consumption of cigarettes among non-Hispanic White men with high school education or less compared to those some college education or more who smoked at baseline.

Also found in Table 2 is the estimated risk associated with minimum wage increases and alcohol consumption for employed and unemployed respondents, overall and by race/ethnicity and gender strata. Overall, there was no association between higher minimum wages and daily consumption of alcohol, on days that respondents reported drinking. In addition, there was no association between minimum wage increases and alcohol consumption across race/ethnicity and gender strata.

Table 2 additionally displays the estimated risk associated with higher minimum wage and weekly engagement in light or moderate or heavy PA. Overall, there was no association between higher minimum wages and the number of times respondents reported engaging in light or moderate PA or heavy PA per week. In race/ethnicity and gender stratified models, men of color with a high school education or less there had a marginal 5% reduction (RR = 0.95, 95% CI = 0.90, 1.00) in weekly engagement in heavy PA. There was no other evidence of associations between minimum wage increases and PA in any other race/ethnicity and gender group.

Further analyses (Table 3) restricted the sample population to those respondents who were employed and paid hourly at baseline. Similar to our models conducted in the full population of employed and unemployed respondents, we observed no association between higher minimum wages and smoking, drinking, or PA in the overall sample of employed hourly wage workers. Estimates for daily

cigarette consumption among non-Hispanic White men were attenuated to non-significance in this subsample. However, in employed, hourly wage men of color with a less than a high school education we also observed a 5% reduction in weekly heavy PA but not light PA relative to their higher educated counterparts. No associations between minimum wage and any of the four health behaviors examined were present across race/ethnicity and gender strata.

Table 4 provides DDD risk ratios associated with minimum wage increases and our secondary analytic outcomes: smoking cessation and binge drinking episodes in the past year for the full sample of employed and unemployed respondents as well as the subsample of employed, hourly wage workers. There was little evidence that higher minimum wages were associated with greater smoking cessation or a higher or lower rate of days of binge drinking in the past year. There was some suggestive evidence that higher minimum wages were associated with higher (RR = 1.15, 95% CI = 0.93, 1.43) smoking cessation among employed, hourly wage workers with a high school education or less; however, this estimate was imprecise and failed to reject the null hypothesis.

Sensitivity analyses

DD models conducted in the full sample and restricted to our likely affected group supported our primary findings using DDD models (Supplementary Table 2) There was no association between higher minimum wages and smoking, drinking, or PA in DD models in the full sample. Likewise, no such association was observed in DD models restricted to respondents with high school education or less.

We also conducted several other sensitivity tests varying our likely affected and unaffected group definition, minimum wage specification, covariate adjustment, and population (Supplementary Table 3). Our primary model findings were robust to defining our likely affected group as those earning hourly wages $\leq$150% of the state minimum wage at baseline, using those earning hourly wages >150% of the state minimum wage as controls. In addition, our findings were robust to adjusting for state unemployment and restricting to those respondents who did not move to a new state from 1999 to 2017. However, our estimate for daily cigarette consumption was sensitivity to varying our likely affected educational attainment cut point to some college education or less compared to a college degree or more, finding a 17% (RR = 1.17, 95% CI = 1.08, 1.26) increase in daily consumption of cigarettes associated with higher minimum wages. All other health behavior estimates for this treatment group specification

were comparable to primary models. In addition, our estimates were similar when using the nominal minimum wage instead of the inflation-adjusted minimum wage; however, our estimate for daily cigarette consumption had somewhat better precision (RR = 1.06, 95% CI = 1.03, 1.09). Restriction of analyses to non-proxy respondents produced results similar to our primary findings; however, the estimated reduction in engagement in heavy PA in men of color was attenuated (Supplementary Table 4). In addition, we observe a reduction in weekly engagement in light PA in less educated non-Hispanic White men compared to their higher educated counterparts.

Finally, out of concern over a potential violation of the parallel trends assumption for cigarette consumption from 1999 to 2005 (Supplementary Figure 1) we ran cigarette consumption models for the full sample and those employed and paid hourly at baseline for the years in which we have better support for parallel trends for smoking – 2007 to 2017 (Supplementary Table 5). The elevated risk of cigarette consumption for non-Hispanic Whites was attenuated and highly imprecise. All other estimates null in line with our primary findings.

DISCUSSION

The present study found little evidence that minimum wage increases had any influence on cigarette consumption among baseline smokers, alcohol consumption in baseline drinkers, or engagement in either light or moderate or heavy PA. These findings did not change when restricted to the subpopulation of employed, hourly wage workers. Moreover, our findings were robust to changes in the method used to define our likely affected and unaffected group specifications, using the nominal rather than inflation-adjusted minimum wage, adjusting for state unemployment, and restriction to non-movers. We also found little evidence of heterogeneity in these associations across race/ethnicity and gender.

Our null overall findings for daily cigarette smoking differ from the majority of cross-sectional studies which have found that minimum wage increases reduce the probability of being a current smoker.[3] However, it is worth noting that in secondary analyses we do observe a positive but imprecise association between higher minimum wages and smoking cessation among employed, hourly wage workers, which is in line with this prior body of work and deserves further study. This present study is

perhaps most comparable to the longitudinal study conducted by Reeves (2017)[33] who found no evidence of a change in cigarette smoking in smokers.

Horn (2017) also found, in secondary analysis, that minimum wage increases were positively associated with smoking in men; however, they had insufficient evidence to show this estimate was statistically different from 0. While smoking is generally considered an inferior good by much of the economics literature,[82] there is some evidence from the evaluation of other income policies, such as the EITC, that smoking increases with higher income.[81] Moreover, there is evidence to suggest that the relation between income and smoking varies by the economic development of the country in which a person lives and the economic state – expanding or in decline.[81,92,93]

With respect to the influence of minimum wage on alcohol consumption, our findings are unable to further elucidate the nature of this relation, if one exists at all.[3] To date, most the studies evaluating this relation have specifically focused on problem drinking – typically binge drinking or heavy drinking with one studying examining alcohol-related traffic fatalities in youth.[17,21,88,94] Our main findings differ from these studies in that we use a continuous measure of alcohol consumption rather than a specific cut point. However, secondary analyses examining the influence of minimum wage increases on the number of days respondents reported binge drinking also found no relation. As with smoking, there is some evidence to suggest that alcohol consumption varies with larger macroeconomic trends.[92,93] Regular alcohol consumption is expensive; however, excessive alcohol consumption itself is a chronic condition that does likely persists beyond financial constraints. We believe the study of the minimum wage's influence on alcohol consumption should remain an active area of research.

While our overall results showed no relation between minimum wage increases and PA, we did observe a reduction in participation in heavy PA, but not light or moderate PA, among men of color. Our findings are in line with both Horn (2017) who found higher minimum wages lead to a nonsignificant decline in participation in PA.[17] Lenhart provides a more holistic picture by showing that higher minimum wages lead to a decline in time devoted to health-promoting activities, such a PA, in favor of non-health promoting leisure.[71] We believe understanding the relation between higher minimum wages and PA is particularly important given the interest in the influence on minimum wages on obesity risk.[3] If minimum wage increases influence risk of obesity, either positively or negatively, it stands to reason that higher

minimum wages should be associated with energy balance behaviors, but, to date, no conclusive evidence has been found.[3]

Although our findings were largely null, we believe these results nonetheless represent an important contribution to the growing literature evaluating the influence of minimum wage increases on health behavior and had several major strengths. First, to our knowledge, it is one of two studies that have used a longitudinal design to evaluate the association between minimum wage increases and smoking and the first to examine longitudinal changes in alcohol consumption and PA.[3,72] Second, we further leverage these longitudinal data by applying econometric and social epidemiologic methods to estimate risk. Third, similar to several recent studies,[3,17,20,21,62,68] this analysis employs a DDD strategy, which allows for the control of unmeasured time-varying and state-varying confounders. Fourth, we jointly evaluate the influence of both race/ethnicity and gender on the minimum wage and health behavior relation for the general sample of employed and unemployed respondents as well as for employed, hourly wage workers. This coupled with our DDD strategy allows us to jointly evaluate the influence of race/ethnicity, gender, education, and employment status which, to our knowledge, few other studies have done.[3]

Despite these strengths, this study also had several key limitations. First, small sample sizes due to restrictions, differences in or availability of health questions in the PSID over time, and PSID sampling limited the precision of our estimates and may have led to violations in the positivity requirement of the potential outcomes framework for causal inference. However, these violations, were they present, were random and not structural in nature. Moreover, limited representation across racial/ethnic identities necessitated the aggregation of several categories to a singular persons of color category. Second, the value of education with respect to earning potential may vary across race/ethnicity and gender and therefore using educational attainment as a strategy to identify those likely affected by minimum wage may introduce bias if women and/or persons of color are more likely to earn lower wages at higher education levels relative to their White and/or male counterparts.[74] We sought to gauge the extent to which this may have influenced our results by redefining our likely affected group as those with some college education or less. While we observed similar results overall, our estimates for daily cigarette consumption for non-Hispanic White men strengthened when using some college or less education as

our education cut point. Third, we cannot rule out bias due of misclassification of our minimum wage exposure. Minimum wage laws are highly complex – changing within years and often differing within states across industries among tipped versus non-tipped workers. Moreover, there a number of reasons a worker with a high school education or less may earn well over the state minimum wage such as being a trade worker or as a member of a union. We sought to address this issue by examining multiple treatment and control group definitions as well as minimum wage specifications. Fourth, not often discussed in the minimum wage and health literature is the possibility of violating the consistency requirement of the potential outcomes framework through interference. Interference could occur when the passage of a minimum wage in a neighboring state influences the health of an individual in a state whose minimum wage is equal to the federal rate. Workers living along state borders may commute into and out of states for work and should the minimum wage in a given state lead to a loss in jobs, low-wage workers could leave that state to look for work elsewhere.[75–78] Research into these so-called geographic "spillover effects" of minimum wage policies is still an active area of research in the econometrics literature.[75–78] Evidence, to date, remains decidedly mixed and it does not appear that there is sufficient evidence to prove nor disprove the presence of interference in this minimum wage analyses.[75–78] Fifth, our measure of PA was relatively crude given that we only had information on the frequency of participation in PA and the minimum, but not actual duration. Future work should evaluate whether minimum wage increases have any influence on the minutes engaged in moderate to vigorous PA and whether or not it is associated with meeting US guidelines for PA for adults.[95] Sixth, cigarette consumption in treated and control states across our likely affected and unaffected groups may violate the parallel trends assumption for the first half of the observation period. We sought directly evaluate the potential impact this had on findings by restricting our analysis to 2007 to 2017 when we have better support for parallel trends. Seventh, our analysis of secondary outcomes, smoking cessation and binge drinking was limited, given the small number of events, and we were unable to examine differences within race/ethnicity and gender strata. Moreover, we did not have information on the number quit attempts for the entire period of observation. Eighth, as with all quasi-experiential study designs, we cannot rule of the potential for unmeasured confounding.

Our findings contribute to the growing body of work that has examined the association between higher minimum wages and health behavior. Health behaviors such as drinking, smoking, and PA represent a key pathway through which minimum wage can influence long-term health. We found no evidence of a relation higher minimum wages and smoking, drinking, and PA in either a combined sample of employed and unemployed working-age adults nor an employed sample of hourly wage workers. We further found little evidence of heterogeneity across race/ethnicity-gender strata. Future studies should examine local minimum wage initiatives and the extent to work macroeconomic conditions, such as state unemployment, minimum wage may jointly operate to influence health behavior. In addition, studies should continue to examine the influence that minimum wage has smoking cessation, both the number of quit attempts and successful quits, as well as binge drinking and evaluate these relations by race/ethnicity and gender strata.

Table 1. Sample characteristics at first observation for the full sample, overall and by education, 1999 to 2017

Characteristics	Overall (unweighted)	Overall (weighted)	Educational attainment			
			≤High school diploma (unweighted)	≤High school diploma (weighted)	≥Some college (unweighted)	≥Some college (weighted)
Sample size, individuals, n	13,730	8,059	6,166	3,644	7,564	4,415
Person-years, n	165,838	104,506	75,124	48,982	90,714	55,524
Number of observations per individual, mean (SD)	6.8 (2.9)	7.5 (2.6)	6.9 (2.9)	7.7 (2.6)	6.8 (2.8)	7.3 (2.7)
Demographics						
Age (years), mean (SD)	34.7 (9.4)	35.8 (7.0)	35.1 (9.3)	36.2 (7.3)	34.4 (9.4)	35.5 (6.7)
Women, %	49.9	49.0	47.3	48.0	52.0	49.7
Persons of color, %	44.1	27.3	53.2	35.2	36.8	21.8
Race and gender, %						
Non-Hispanic White men	29.3	37.9	25.5	34.1	32.3	40.5
Non-Hispanic White women	26.6	34.8	21.3	30.7	31.0	37.7
Men of color	20.9	13.1	27.2	17.9	15.7	9.8
Women of color	23.3	14.1	26.0	17.3	21.0	12.0
Education and employment						
Years of education, mean (SD)	13.5 (2.3)	13.7 (1.6)	11.5 (1.3)	11.4 (1.1)	15.1 (1.4)	15.3 (0.9)
Employment status, %						
Employed	86.3	88.5	82.0	85.1	89.8	90.9
Unemployed	7.5	6.0	11.1	8.5	4.6	4.3
Not in labor force	6.2	5.5	7.0	6.4	5.6	4.8
Paid hourly, %[a]	60.0	55.1	78.1	75.2	46.7	42.4
Hourly wage rate (USD 2017), mean (SD)[a]	14.11 (20.42)	14.83 (16.96)	12.64 (24.52)	12.85 (20.20)	15.91 (13.62)	17.07 (12.41)
Hourly wage ≤150% of state minimum wage, (%)[a]	25.7	23.8	30.3	28.1	20.1	18.9
Health behaviors						
Current smoker, %	24.0	23.3	35.1	34.9	14.9	15.1
Daily cigarette consumption, mean (SD)[b]	13.2 (9.4)	14.4 (6.9)	14.2 (9.7)	15.6 (7.3)	11.4 (8.5)	12.6 (6.1)
Drank alcohol, %[c,d]	67.1	71.3	60.3	64.4	72.4	76.2
Alcoholic beverages consumed, mean (SD)[c,e]	2.5 (1.7)	2.5 (1.2)	2.8 (1.9)	2.9 (1.5)	2.3 (1.4)	2.3 (1.0)
Weekly instances of light physical activity, mean (SD)[c]	4.3 (3.9)	4.5 (2.7)	4.3 (4.3)	4.4 (3.1)	4.3 (3.6)	4.5 (2.4)
Weekly instances of heavy physical activity, mean (SD)[c]	3.0 (3.4)	3.1 (2.3)	2.9 (3.7)	2.9 (2.7)	3.1 (3.1)	3.2 (2.1)

SD = standard deviation; USD = United States dollars

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Note: All percentages calculated using the number of unique individuals.

[a]Only calculated for those individuals who were employed, and those individuals paid hourly with tips or commission were excluded

[b] Only calculated for current smokers

[c] Based on consumption during past year. Data only from survey waves 2005 to 2017.

[d] Defined as those who responded yes to having ever drank alcohol and that they consumed at least 1 to 11 alcoholic beverages in the past year

[e]Only calculated for current drinkers on days reported drinking

Table 2. DDD risk ratio associated with a $1 increase in current minimum wage on health behaviors among employed and unemployed adults age 25 to 64 years with a high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

Health behavior	Daily cigarette consumption		Alcoholic beverages consumed on days drank		Weekly instances of light or moderate physical activity		Weekly instances of heavy physical activity	
Subgroup MW specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall	1.06	(0.99, 1.13)	1.01	(0.99, 1.04)	1.00	(0.96, 1.00)	1.00	(0.95, 1.01)
Person-years		*37,660*		*70,530*		*111,044*		*104,248*
Non-Hispanic White men	1.10*	(1.01, 1.19)	1.00	(0.96, 1.03)	0.97	(0.93, 1.01)	1.00	(0.92, 1.05)
Person-years		*12,146*		*23,742*		*33,864*		*33,890*
Non-Hispanic White women	1.01	(0.89, 1.14)	1.00	(0.97, 1.03)	1.00	(0.95, 1.01)	0.98	(0.93, 1.03)
Person-years		*9,372*		*21,576*		*28,942*		*24,332*
Men of color	1.01	(0.91, 1.12)	1.03	(0.97, 1.11)	0.98	(0.94, 1.03)	0.95*	(0.90, 1.00)
Person-years		*8,510*		*12,556*		*22,712*		*22,786*
Women of color	1.02	(0.90,1.17)	1.01	(0.96, 1.07)	1.00	(0.96, 1.03)	1.00	(0.96, 1.05)
Person-years		*7,632*		*12,656*		*25,526*		*23,240*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Note: Smoking and alcohol consumption evaluated only among those individuals who said they consumed these products at their baseline observation. The evaluation of alcoholic beverages consumed on days drank, weekly light or moderate physical activity, and weekly physical activity occurred during the 2005 to 2017 waves of the PSID due to prior year question or response option incompatibility. Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 3. DDD risk ratio associated with a $1 increase in current minimum wage on health behaviors among employed, hourly wage adults age 25 to 64 years with high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

Health behavior	Daily cigarette consumption		Alcoholic beverages consumed on days drank		Weekly instances of light or moderate physical activity		Weekly instances of heavy physical activity	
Subgroup MW specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall	1.00	(0.93, 1.07)	1.02	(0.99, 1.06)	0.98	(0.96, 1.01)	0.97	(0.93, 1.01)
Person-years		*26,538*		*38,490*		*65,404*		*61,724*
Non-Hispanic White men	1.03	(0.96, 1.11)	1.00	(0.96, 1.05)	0.98	(0.93, 1.03)	0.98	(0.90, 1.08)
Person-years		*7,998*		*10,422*		*15,944*		*15,950*
Non-Hispanic White women	0.96	(0.85, 1.09)	1.01	(0.97, 1.06)	0.98	(0.94, 1.02)	0.95	(0.89, 1.02)
Person-years		*6,272*		*11,286*		*15,966*		*13,314*
Men of color	0.93	(0.82, 1.06)	1.04	(0.97, 1.11)	1.00	(0.94, 1.05)	0.95*	(0.90, 1.00)
Person-years		*6,530*		*8,440*		*15,546*		*16,036*
Women of color	1.01	(0.88, 1.15)	1.02	(0.94, 1.09)	0.99	(0.94, 1.05)	0.98	(0.94, 1.02)
Person-years		*5,738*		*8,342*		*17,948*		*16,424*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Note: Smoking and alcohol consumption evaluated only among those individuals who said they consumed these products at their baseline observation. The evaluation of alcoholic beverages consumed on days drank, weekly light or moderate physical activity, and weekly physical activity occurred during the 2005 to 2017 waves of the PSID due to prior year question or response option incompatibility. Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 4. DDD risk ratio associated with a $1 increase in current minimum wage on smoking cessation and binge drinking among adults age 25 to 64 years with high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

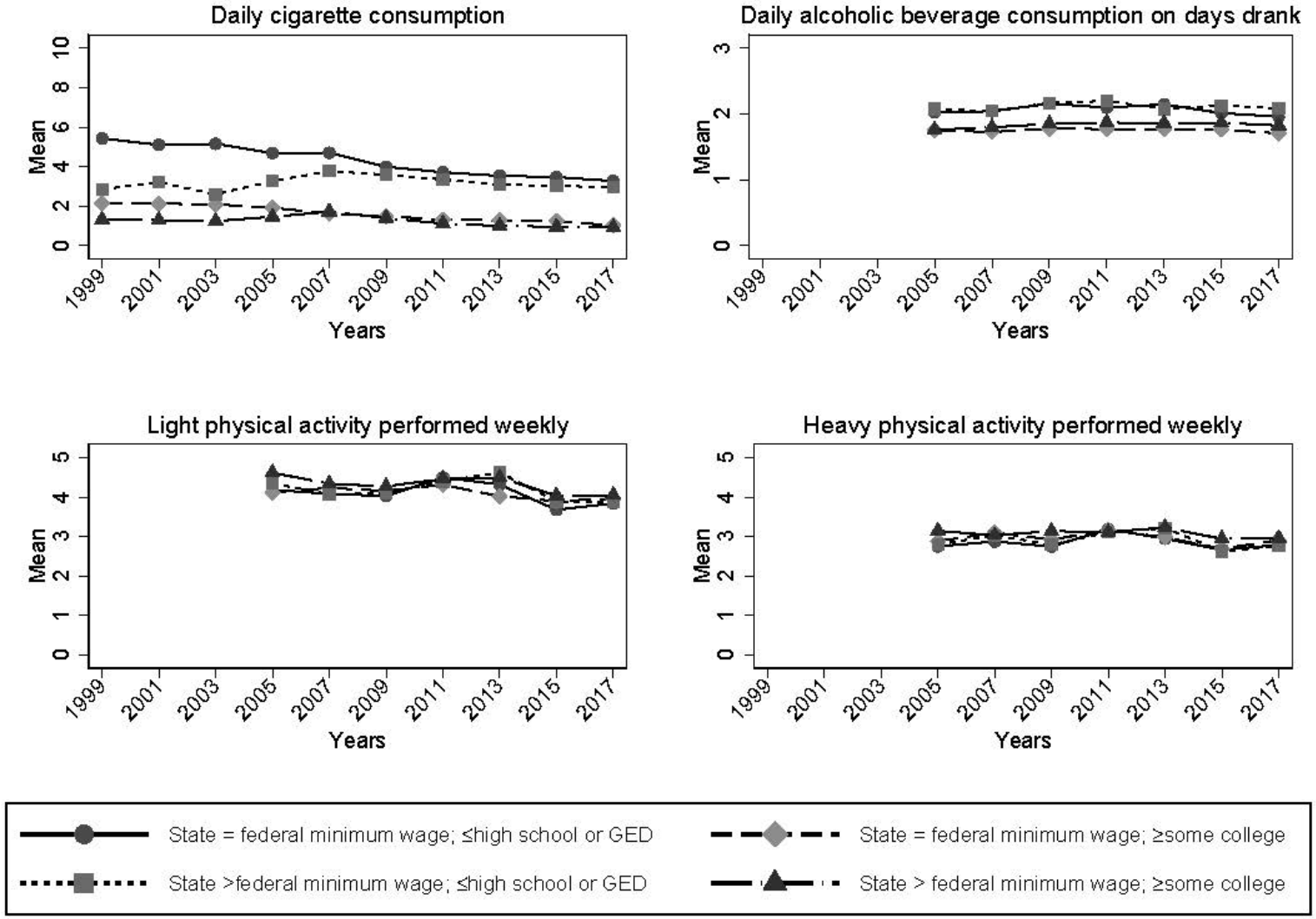
Health behavior	Smoking cessation		Binge drinking episodes in past year	
Subgroup MW specification	RR	95% CI	RR	95% CI
Full sample	1.01	(0.85, 1.21)	0.97	(0.87, 1.07)
Person-years		*25,588*		*74,826*
Employed, hourly wage workers	1.15	(0.93, 1.43)	0.98	(0.87, 1.10)
Person-years		*18,310*		*42,766*

Source: Authors' calculation using the 1999-2017 Panel Study of Income Dynamics

Note: Smoking and alcohol consumption evaluated only among those individuals who said they consumed these products at their baseline observation. The evaluation of alcoholic beverages consumed on days drank, weekly light or moderate physical activity, and weekly physical activity occurred during the 2005 to 2017 waves of the PSID due to prior year question or response option incompatibility. Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.00$

Supplementary Figure 1. Daily cigarette and daily alcohol beverage consumption and engagement in light or moderate and heavy physical activity by state relative to federal minimum wage and individual-level education



Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics
Note: Prevalence estimates are unweighted.

Supplementary Table 1. Sample characteristics at first observation for full sample, overall and by education, 2005 to 2017

Characteristics	Overall (unweighted)	Overall (weighted)	Educational attainment			
			≤High school diploma (unweighted)	≤High school diploma (weighted)	≥Some college (unweighted)	≥Some college (weighted)
Sample size, individuals, n	11,979	7,267	5,220	3,210	6,759	4,057
Person-years, n	118,588	75,368	52,042	34,268	66,546	41,100
Number of observations per individual, mean (SD)	5.6 (1.6)	5.8 (1.5)	5.7 (1.6)	5.9 (1.5)	5.6 (1.6)	5.7 (1.5)
Demographics						
Age (years), mean (SD)	36.5 (10.3)	38.2 (7.6)	37.1 (10.2)	38.7 (7.7)	36.0 (10.4)	37.8 (7.4)
Women, %	50.3	48.7	47.6	47.6	52.3	49.2
Persons of color, %	45.1	28.1	55.2	36.9	37.2	22.1
Race and gender, %						
Non-Hispanic White men	28.8	37.7	24.6	33.5	32.1	40.8
Non-Hispanic White women	26.2	34.1	20.3	29.6	30.7	37.1
Men of color	20.9	13.5	27.8	18.9	15.6	10.0
Women of color	24.1	14.6	27.3	18.0	21.6	12.1
Education and employment						
Years of education, mean (SD)	13.6 (2.3)	13.8 (1.6)	11.6 (1.4)	11.5 (1.1)	15.1 (1.4)	15.3 (0.9)
Employment status, %						
Employed	87.3	89.2	82.9	86.2	90.8	91.6
Unemployed	7.8	6.0	11.7	8.6	4.8	4.3
Not in labor force	4.9	4.8	5.5	5.2	4.5	4.1
Paid hourly, %[a]	60.0	55.7	78.9	76.4	47.1	43.0
Hourly wage rate (USD 2017), mean (SD)[a]	15.1 (15.2)	15.8 (8.0)	13.1 (6.3)	13.4 (4.6)	17.4 (20.9)	18.4 (10.1)
Hourly wage ≤150% of state minimum wage, (%)[a]	26.9	25.2	31.6	29.5	21.6	20.4
Health behaviors						
Current smoker, %	23.3	22.5	34.6	34.3	14.5	14.7
Daily cigarette consumption, mean (SD)[b]	11.1 (9.1)	12.0 (6.7)	12.0 (9.4)	12.9 (7.0)	9.5 (8.1)	10.5 (6.0)
Drank alcohol, %[c,d]	67.1	71.3	60.3	64.4	72.4	76.2
Alcoholic beverages consumed on days drank, mean (SD)[c,e]	2.5 (1.7)	2.5 (1.2)	2.8 (1.9)	2.9 (1.5)	2.3 (1.4)	2.3 (1.0)
Weekly light physical activity, mean (SD)[c]	4.3 (3.9)	4.5 (2.7)	4.3 (4.3)	4.4 (3.1)	4.3 (3.6)	4.5 (2.4)
Weekly heavy physical activity, mean (SD)[c]	3.0 (3.4)	3.1 (2.3)	2.9 (3.7)	2.9 (2.7)	3.1 (3.1)	3.2 (2.1)

SD = standard deviation; USD = United States dollars

Source: Authors' calculation using the Panel Study of Income Dynamics

Note: All percentages calculated using the number of unique individuals.

[a]Only calculated for those individuals who were employed, and those individuals paid hourly with tips or commission were excluded

[b] Only calculated for current smokers

[c] Based on consumption during past year. Data only from survey waves 2005 to 2017.

[d] We defined drinking alcohol in the past year as those who responded yes to having ever drank alcohol and consuming at least 1 to 11 beverages in the past year

[e]Only calculated for current drinkers

Supplementary Table 2. DD risk ratio associated with a $1 increase in minimum wage on health among adults age 25 to 64 years, overall and by race/ethnicity and gender strata

Health behavior	Daily cigarette consumption		Alcoholic beverages consumed on days drank		Weekly instances of light or moderate physical activity		Weekly instances of heavy physical activity	
MW specification Model specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
DD full population								
Overall	1.00	(0.96, 1.03)	0.99	(0.98, 1.01)	1.01	(0.99, 1.03)	1.00	(0.97, 1.03)
Person-years		*37,660*		*70,530*		*111,044*		*104,248*
Non-Hispanic White men	1.02	(0.97, 1.06)	1.00	(0.98, 1.02)	1.00	(0.97, 1.03)	1.01	(0.96, 1.06)
Person-years		*12,146*		*23,742*		*33,864*		*33,890*
Non-Hispanic White women	1.02	(0.95, 1.09)	0.99	(0.96, 1.01)	1.05**	(1.02, 1.08)	1.04	(0.99, 1.08)
Person-years		*9,336*		*21,576*		*28,942*		*24,332*
Men of color	1.01	(0.96, 1.07)	0.97	(0.94, 1.00)	0.97	(0.92, 1.02)	0.94*	(0.89, 1.00)
Person-years		*8,510*		*12,556*		*22,712*		*22,786*
Women of color	0.92	(0.83, 1.01)	1.02	(0.98, 1.05)	1.00	(0.96, 1.03)	1.01	(0.97, 1.05)
Person-years		*7,632*		*12,656*		*25,526*		*23,240*
DD ≤ HS ed. only								
Overall	1.01	(0.97, 1.05)	1.00	(0.97, 1.04)	0.99	(0.96, 1.02)	0.99	(0.95, 1.04)
Person-years		*24,626*		*23,814*		*47,922*		*45,154*
Non-Hispanic White men	1.04	(0.99, 1.09)	0.99	(0.95, 1.03)	0.99	(0.94, 1.04)	1.02	(0.95, 1.11)
Person-years		*7,508*		*7,796*		*12,468*		*12,464*
Non-Hispanic White women	1.06	(0.98, 1.13)	1.00	(0.95, 1.06)	1.02	(0.98, 1.07)	1.03	(0.96, 1.11)
Person-years		*5,458*		*6,416*		*9,530*		*7,792*
Men of color	1.01	(0.95, 1.07)	0.99	(0.94, 1.04)	0.92*	(0.86, 0.98)	0.90**	(0.83, 0.97)
Person-years		*6,272*		*6,596*		*13,182*		*13,234*
Women of color	0.92	(0.84, 1.01)	1.00	(0.93, 1.08)	1.00	(0.96, 1.05)	0.99	(0.92, 1.07)
Person-years		*5,388*		*5,392*		*12,742*		*11,664*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Note: Smoking and alcohol consumption evaluated only among those individuals who said they consumed these products at their baseline observation. The evaluation of alcoholic beverages consumed on days drank, weekly light or moderate physical activity, and weekly physical activity occurred during the 2005 to 2017 waves of the PSID due to prior year question or response option incompatibility. Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 3. Sensitivity analyses for main model DDD risk ratio for the relation between minimum wage and health behaviors, overall

Health behavior	Daily cigarette consumption		Alcoholic beverages consumed on days drank		Weekly instances of light or moderate physical activity		Weekly instances of heavy physical activity	
Alternate model specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Some college education or less (college grad or more ref.	1.17***	(1.08, 1.26)	1.01	(0.99, 1.04)	0.99	(0.96, 1.01)	0.99	(0.94, 1.03)
Person-years	*37,660*		*70,530*		*111,044*		*104,248*	
Earning wage <= 150% of the SMW (>150% SMW ref.)	1.00	(0.92, 1.09)	1.02	(0.99, 1.06)	1.00	(0.97, 1.03)	0.98	(0.94, 1.03)
Person-years	*20,212*		*20,732*		*51,452*		*48,294*	
Nominal minimum wage	1.06***	(1.03, 1.09)	1.01	(0.99, 1.03)	1.00	(0.98, 1.01)	1.00	(0.98, 1.03)
Person-years	*37,660*		*70,530*		*111,044*		*104,248*	
Adjusting for state unemployment	1.06	(0.99, 1.13)	1.01	(0.99, 1.04)	1.00	(0.97, 1.00)	0.98	(0.95, 1.01)
Person-years	*37,660*		*70,530*		*111,044*		*104,248*	
Restricted to those who did not moved to a new state	1.03	(0.95, 1.10)	1.01	(0.98, 1.03)	1.00	(0.96, 1.01)	0.97	(0.94, 1.00)
Person-years	*29,558*		*52,540*		*82,568*		*79,390*	

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Note: Smoking and alcohol consumption evaluated only among those individuals who said they consumed these products at their baseline observation. The evaluation of alcoholic beverages consumed on days drank, weekly light or moderate physical activity, and weekly physical activity occurred during the 2005 to 2017 waves of the PSID due to prior year question or response option incompatibility. Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 4. DDD relative risk associated with a $1 increase in minimum wage on health behaviors among adults age 25-64 years, restricted to non-proxy respondents, with a high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

Health behavior	Daily cigarette consumption		Alcoholic beverages consumed on days drank		Weekly instances of light or moderate physical activity		Weekly instances of heavy physical activity	
Subgroup MW specification	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Overall	1.04	(0.96, 1.13)	1.00	(0.98, 1.02)	0.98	(0.96, 1.01)	0.98	(0.95, 1.02)
Person-years		*25,644*		*45,828*		*73,420*		*68,990*
Non-Hispanic White men	1.09	(0.97, 1.23)	0.98	(0.94, 1.03)	0.95*	(0.92, 0.99)	0.96	(0.89, 1.04)
Person-years		*6,672*		*13,310*		*18,368*		*18,374*
Non-Hispanic White women	1.00	(0.89, 1.13)	0.99	(0.95, 1.03)	0.99	(0.95, 1.02)	0.97	(0.91, 1.04)
Person-years		*7,018*		*14,584*		*20,360*		*17,540*
Men of color	0.99	(0.86, 1.15)	1.03	(0.95, 1.10)	1.03	(0.98, 1.10)	0.99	(0.91, 1.09)
Person-years		*5,206*		*9,430*		*12,684*		*12,688*
Women of color	0.97	(0.83, 1.14)	1.00	(0.96, 1.04)	0.99	(0.95, 1.03)	1.01	(0.96, 1.06)
Person-years		*6,748*		*10,504*		*22,008*		*20,388*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Note: Smoking and alcohol consumption evaluated only among those individuals who said they consumed these products at their baseline observation. The evaluation of alcoholic beverages consumed on days drank, weekly light or moderate physical activity, and weekly physical activity occurred during the 2005 to 2017 waves of the PSID due to prior year question or response option incompatibility. Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Supplementary Table 5. DDD risk ratio associated with a $1 increase in current minimum wage on health behaviors among adults age 25 to 64 years with a high school education or less compared to those with some college or more, overall and by race/ethnicity and gender strata

	Full sample (employed and unemployed)		Employed, hourly wage workers	
Subgroup MW specification	RR	95% CI	RR	95% CI
Overall	0.98	(0.89, 1.08)	0.92	(0.84, 1.01)
Person-years		*20,074*		*14,426*
Non-Hispanic White men	0.96	(0.83, 1.12)	0.93	(0.81, 1.07)
Person-years		*6,086*		*4,108*
Non-Hispanic White women	0.84	(0.68, 1.05)	0.82	(0.63, 1.08)
Person-years		*4,854*		*3,348*
Men of color	1.01	(0.84, 1.21)	0.94	(0.79, 1.13)
Person-years		*4,966*		*3,820*
Women of color	1.00	(0.82, 1.23)	0.97	(0.79, 1.19)
Person-years		*7,632*		*3,150*

DDD = difference-in-difference-in-differences; RR = risk ratio; CI = confidence interval

Source: Authors' calculation using the 2007 to 2017 Panel Study of Income Dynamics

Note: Smoking and alcohol consumption evaluated only among those individuals who said they consumed these products at their baseline observation. The evaluation of alcoholic beverages consumed on days drank, weekly light or moderate physical activity, and weekly physical activity occurred during the 2005 to 2017 waves of the PSID due to prior year question or response option incompatibility. Models are adjusted for age, gender, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, and the percentage of residents who are union members, and state and fixed effects.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Chapter 3: The influence of prior-year employment instability on the relation between state minimum wage policies, obesity, and mental wellbeing

ABSTRACT

Background. Low and minimum wage workers experience greater movement into and out of employment than their higher-earning counterparts. This instability has ramifications for health and may influence the potential benefits or unintended harms of social and income policies, such as the minimum wage on risk of obesity and poor mental health.

Methods. Individual-level health data on adults from the 1999 to 2017 Panel Study of Income Dynamics was linked to state policies and characteristics. We used modified Poisson, difference-in-differences regression restricted to those likely affected by the minimum wage – individuals with a high school education or less. We estimated the risk associated with a $1 increase in minimum wage, interacted with employment instability, on obesity and moderate psychological distress, overall and stratified by gender. Employment instability was captured using two measures: 1) the number of weeks spent unemployed in the prior year and 2) tenure, in years, at their current employer. A body mass index of $\geq$30.0kg/m^2 defined obesity while a Kessler-6 score of $\geq$5 defined moderate psychological distress.

Results. We found limited but suggestive evidence that prior unemployment, but not employer tenure, may modify the relation between minimum wage, obesity, and moderate psychological distress. Among those with a high school education or less, we found that the greatest risk of obesity and moderate psychological distress was in individuals who experienced full year unemployment when the state minimum wage was $3 higher than the federal rate.

Conclusion. Although we were unable to provide conclusive, causal evidence of effect modification by employment instability, we believe these findings highlight the importance of examining the economic circumstances of individuals when evaluating the relation between social and income policies, such as the minimum wage, and health. This is particularly timely as governments worldwide seek to ameliorate the long-term health and economic impacts ushered in by the current public health crisis through innovative income policies targeted at individuals.

INTRODUCTION

The lives of many individuals earning low or minimum wages are ones marked instability and uncertainty.[2,96] Low and minimum wage workers experience greater movement into and out of employment than their higher-earning counterparts.[97,98] Evidence from work evaluating unstable or precarious employment, perceived job insecurity, and economic insecurity suggests that employment instability is linked to higher stress, anxiety, and depression.[38,45,98–106] These chronic financial and job-related stressors coupled with material depravation of basic needs, such as healthy food, and a paucity of time for health-promoting behaviors may also increase the likelihood of obesity.[99,104,107] Compounding the issue, individuals earning low or minimum wages are often less educated which exposes them to greater employment instability and is itself a risk factor for obesity and poor mental health.[4,36,38,102] As cities and states increasingly adopt higher minimum wages to improve the economic well-being of their residents there is concern that the most vulnerable low or minimum wage workers with less stable attachment to employment may not be in a position to benefit.[2,25,98,108,109]

Individual-level, employment instability could be related to the minimum wage in one of several ways. First, should employers need to need to make changes to staffing or hours in response to increases in labor costs associated with higher minimum wage, they may base their decisions on the level of experience of the employee as well as their time under their employment. Work by Seattle researchers found that the more experienced and stably employed workers were more likely to see higher earnings while those who were less experienced were more likely to experience a loss in hours.[109] Second, unemployment spells can lead to instability in other aspects of life such as material instability for basic needs like housing, health care, and child care[97,110] or family instability, such as placing strain on marriages or domestic partnerships.[97] These multiplicative or additive influences across multiple domains of instability could influence to likelihood of finding employment as well as the type and quality of that employment, such as low-paying jobs with erratic scheduling and few benefits. These factors all relate to the likelihood of individuals being in jobs that stand to benefit or be harmed by minimum wage increases.

To date, there is a lack of clear evidence on the nature of the relation between minimum wage increases, obesity, and mental wellbeing. Evidence evaluating the association between minimum wage and obesity, or body mass index (BMI) range from somewhat negative to somewhat positive with a recent

review deeming the minimum wage-obesity relation inconclusive.[3,20,21,32] With respect to mental well-being, studies from the United States and United Kingdom have found some evidence that minimum wage increases reduce self-reported bad mental health days by approximately 0.06-0.17 days and reduce scores on the General Health Questionnaire, a validated measure of mental wellbeing.[17,21,33] Other studies have found no evidence to support a reduction in bad mental health days[34] or any association with serious psychological distress, as measured by the Kessler 6-item scale (K-6).[20] However, there is fairly consistent recent evidence that higher minimum wages reduce the number of deaths from suicide.[29–31]

The goal of the present study is address key limitations in the minimum wage and health by seeking to understand how employment instability modifies the relation between minimum wage and both physical and mental health. For our physical and mental health outcomes we examined obesity and moderate psychological distress. We selected these outcomes as both have demonstrated a strong associations with income[36,111–113] and can be influenced by material depravation,[98,114,115] job and financial stressors,[98] positive or negative affect,[39,69] as well as behavior,[39,69] and have displayed some mixed associations with social and income policies, including the minimum wage.[3,20,116–118] Moreover, much of the existing work on minimum wage and health has been cross-sectional which does not allow for the examination of dynamic changes in individual economic circumstances on risk of obesity and poor mental health. We used the rich economic and health data from the Panel Study of Income Dynamics (PSID) to explore changes in state minimum wage over nearly two decades. We used two measures of employment stability. First, we measured the extent of unemployment experienced by a worker in the past year using continuous reported weeks of unemployment in the past year. Second, we measured job tenure, in years, at the respondent's current employer. We hypothesized that any beneficial influences of the minimum wage on obesity and mental well-being would accrue primarily among those with stable employment, while such benefits would be attenuated or reversed in persons with employment instability.

METHODS

We used data from the 1999 to 2017 PSID[51] to conduct a retrospective cohort study restricted to working-age, adult, heads of household and their spouses or domestic partners. The PSID is the world's

longest, continually operating panel study following 9,000 families comprised of 24,000 individuals since 1968 contacted via telephone. The original goal of the PSID was to understand the causes and consequences of poverty in the US and in 1999 they expanded outcomes to include physical and mental health.[51] Since 1999, the PSID has collected data biannually giving us 10 waves of data between 1999 and 2017.

The study population was restricted to 25 to 64-year-old adult heads of household and their spouse/partners who were observed at least twice during the 1999 to 2017 period. The PSID defines "heads" of household as the male husband in a heterosexual married couple or the single adult of either sex (male or female).[51] This definition conformed to the 1968 Census definition of a household head, the year in which the PSID was first implemented.[51] In 2017, the PSID replaced the term "head" with "reference person" to reflect the diversification of families over time.[51] The PSID historically defined the spouse/partner as a wife/"wife" where wife was used to describe the female in a married couple and "wife" was used to describe a cohabiting female.[51] These terms were changed to spouse and partner, respectively, to expand these definitions to encompass both heterosexual and sex same couples.[51] We limited of analysis to heads of household and spouse/partners as, even though the PSID collects information on other family members, the greatest detail with respect to economics and health is limited to these family members.[51]

Adults ages 25 to 64 years, who have been attached to the labor force (either employed or unemployed) at least once during the study period and have been observed at least twice during the years 1999 to 2017 were included in for the evaluation of obesity. For mental well-being, we restricted our analysis to 2007 to 2017, years in which questions regarding psychological distress were asked, and applied these same restrictions to this study period. All respondents included in the analysis needed to be free of prevalent disease at baseline for both obesity and moderate psychological distress; that is, they were not obese and were not experiencing moderate psychological distress at the time they met entry criteria and were first observed. Our analysis followed each individual until their last non-missing outcome measurement or until they developed the outcome, at which point they were censored. We merged this individual-level PSID data was to state-level file containing information on minimum wages as well as

other policies and characteristics thought to potentially confound the relation between minimum wage and health based on prior literature.[3] These state-level data were obtained from multiple sources.[52–58]

State minimum wage policies

Information on state minimum wage policies over the period was acquired from the University of Kentucky Center for Poverty Research's National Welfare Data[55] and the Bureau of Labor Statistics.[52] The highest effective minimum wage was used for each state and for Washington, DC. Rates were adjusted for inflation using 2017 as a base year. It was assumed that each state minimum wage increase was realized at the first of the year and in place for the entire year. Some states have minimum wage laws that fall below the federal rate or have no minimum wage law at all. In these cases, federal law dictates that the federal minimum wage rate is the effective rate. In states that did not have a minimum wage law in place in a given year or had a rate that fell below the federally mandated minimum, the federal wage rate was the effective rate. We further centered the minimum wage by taking the difference between the state minimum wage and the federal minimum wage. This meant that a state that had a minimum wage rate that was equal to the federal rate would be assigned a value 0. We evaluated only contemporaneous increases in the minimum wage, that is, minimum wage increases that occurred in the same year as reported health outcomes. We did this as we hypothesized that the potential moderating influence of employment instability on the minimum wage-health relation would be immediate and potentially transitory.

Obesity and moderate psychological distress

Data on the height and weight of the head of household and their spouse/partner was self-reported by the head of household. BMI was calculated using these self-reported data based on the standard formula BMI = weight (kg)/height $(m)^2$. Persons with obesity were defined as those with BMI at or exceeding 30.0 kg/m^2 based on Centers for Disease Control and Prevention guidelines.

Moderate psychological distress was measured via the Kessler 6-item scale (K-6), which asks respondents whether and how often they experienced feelings of nervousness, hopelessness, restlessness, depression, struggle, and worthlessness in the past 30 days.[59] Responses ranged from 0 (none of the time) to 4 (all of the time), based on the frequency with which participants reported each item[59] and were summed and dichotomized using a cut point of ≥ 5, which is predictive of moderate

psychological distress.[59,60] The PSID did not administer the K-6 in either 1999 or 2005 and only administered the questionnaire to non-proxy respondents, that is, respondents only provided information on their own psychological distress. We restricted our analysis of mental well-being only to the period when the K-6 was continuously administered, from 2007 to 2017.

Employment Instability

Information on employment instability was based on data self-reported by head of household on their and their spouse/partner's experience. We used two measures of employment stability. First, we measured the extent of unemployment experienced by a worker in the past year using continuous reported weeks in which the head or their spouse/domestic was unemployed but looking for work the past year. Second, we measured employer tenure at the head of household's or spouse/partner's employer for whom they reported currently working using the question: "*How many years' experience do you have altogether with your present employer?"* Respondents could answer in weeks, months, and years. Standardized and summed these responses to obtain a measure of employer in years.

Covariates

Several individual and state-level covariates were selected for adjustment based on their potential to confound the relation between state minimum wage increases and health.[3] At the individual-level we adjusted for age (continuous years), gender (women, men), and race/ethnicity (persons of color, non-Hispanic Whites), marital status (married, not married). Our list of individual-level covariates was limited as, although there are many individual socioeconomic and demographic characteristics that are related to obesity and moderate psychological distress, we did not believe that individual characteristics were likely to be related to state minimum wage increasing and would therefore not be considered confounders. At the state-level, covariates included whether the state has a refundable Earned Income Tax Credit program (EITC), the state sales tax rate (continuous percentage), the state Temporary Assistance for Needy Families benefit for a family of four (continuous United States Dollars (USD)), the state gross product (thousands of USD) and the percentage of state residents who are union members.[53,55,58]

Two ordinal policy index variables related to Medicaid and the Supplemental Nutrition Assistance Program were also included to encompass multiple aspects of safety net or benefit generosity, which varied across states over time. The Medicaid index included whether state Medicaid eligibility limits for 1)

children or 2) adults were above median for states in a given year, 3) whether the state had a Medicaid program for non-citizens, and 4) whether the state expanded Medicaid under the Affordable Care Act. The SNAP index included 1) whether non-citizens in the state were fully eligible for SNAP benefits, 2) whether the state allows SNAP online applications, 3) whether state had no SNAP ban for drug felons, and 4) whether the state uses broad-based categorical eligibility to increase or eliminate the asset test and/or to increase the gross income limit for SNAP users.[57] Both indices ranged from 0, indicating no policies, to 3 indicating 3 or 4 of the aforementioned SNAP or Medicaid policies had been implemented in a given state and year. We chose to parameterize these variables as ordinal, categorical variables as we believed greater implementation of these policies would be associated with greater state generosity for these programs. We selected these programs as states have been given increasingly more leeway, over the study period, in how they administer these programs to their residents. In addition, both programs are used individuals earning low or minimum wages and both are related to health by increasing access to affordable healthcare and subsiding food costs.

Statistical analysis

We estimated descriptive statistics with and without PSID survey design weights. These survey weights account for the complex survey design of the PSID as well as loss to follow-up and allow survey estimates to be nationally representative. However, only respondents who belong to families that were included in the original 1968 sample are provided longitudinal weights. Therefore, the weighted estimates are nationally representative of the 1968 US population. Since that survey weights were not available for all survey respondents and out of concern over potential bias introduced given that weighted respondents were more likely to be non-Hispanic White, we did not use survey weights to generate model estimates.

We used a difference-in-differences (DD) strategy using a modified Poisson model to estimate the risk ratios (and 95% confidence intervals) associated with a $1 increase in minimum wage associated with obesity or moderate psychological distress. A DD strategy is a common, quasi-experimental approach that evaluates groups exposed to a policy change or some other environmental factor at different points in time.[67] The simplest design compares outcomes across two groups, one exposed to a given policy or intervention, and one not, the control, between two points in time: pre-policy/intervention

and post-policy/intervention.[67] We restricted our analysis to respondents most likely affected by the minimum wage law based on educational attainment – those with a high school degree or less.

$$(1)\ \log(Y_{itse}) = \beta_1 MW_{ts} + \beta_2 A_{ij} + \delta_1 A_{ie} MW_{ts} + \beta_3 V_{ts} + \beta_4 S_{ts} + \varphi_t + \gamma_s + u_{ts} + e_{itse},$$

where i, t, s, and e index individuals, years, states, exposure to any weeks of unemployment in the past year. Incident obesity or moderate psychological distress are defined as $\log(Y_{itsj})$. β_1 is the effect of the state minimum wage level for those who did not experience any weeks of unemployment in the prior year or whose employer tenure is <1 year. MW_{ts} is the inflation-adjusted difference between the state minimum wage and federal minimum wage in a given state and year. β_2 is the estimated risk associated with every 1 week increase in prior year unemployment or 1-year increase in employer tenure for individuals living in state with minimum wage rates equal to the federal rate. A_{ij} is the number of weeks in unemployment or years of tenure. The coefficient of interest, δ_1, captures the excess joint influence of higher minimum wage rates and weeks of unemployment in the prior year or years of tenure. The vectors V_{its} and S_t capture sets of state-level control variables. State (γ_s), and year (φ_t) fixed effects will also be included. e_{itscj} is the random error term. All DD models also included cluster robust standard errors at the state level to account for within state correlation. All models were run for the full sample of employed and unemployed respondents as well as stratified by gender.[119] We ran models by gender to account for known differences in the internalization of work by men. Men may be more likely to consider stable employment their normative role in society than women.[119] This stratification also accounts for known differences in the proportion of women working in low and minimum wage jobs.[5,119] All analyses were conducted using Stata 15.[66] For further ease of interpretation of the continuous by continuous interaction, risk ratios were generated for selected combinations of state and federal minimum wage differences ($1, $2, and $3 differences between state and federal minimum wage) and our employment stability metrics using Stata's *lincom* function. For unemployment, estimates were generated for 0, 26, and 52 weeks of unemployment in the prior year. For job tenure, we estimate risk at 1, 5, and 10 years of employment. For these calculations, states with no difference between their state minimum wage rate and the federal minimum wage rate ($0) were the reference group. Contour plots for main, full sample models were also generated to more fully examine the full spectrum of risk across a wider range of value for these two continuous metrics.

A key assumption of DD models is that unmeasured confounders across "treated" and "untreated" groups, in this case states that increase their minimum wage and those that do not, are either time-invariant state-specific characteristics or time-varying characteristics that do not vary across states.[67] If these assumptions hold true, a time series plot of the outcome in both treated and untreated states should resemble parallel lines, that is, moving together in a fixed amount in every period.[67] This applies for both the pre- and post-invention periods, but for the intervention in the treated states.[67] We provide graphical support for this assumption in Supplementary Figure 1-3 by showing the trends in both our outcomes and modifiers by whether or not the state's minimum wage was at or above the federal wage rate and by baseline educational attainment of our likely affected group and unaffected group, for our sensitivity tests described in what follows. Out of concern for a potential violation of this parallel trends assumption for moderate psychological distress, we additionally run our primary models only for those years in which we have better support for parallel trends, 2011-2017.

Sensitivity tests

We tested the robustness of our results using several sensitivity tests. First, we rerun our DD Poisson model described in equation (1) in those respondents with some college education to estimate placebo effects. Second, we ran a difference-in-difference-in-differences model to directly compare of likely affected population to our likely unaffected population.[61,62] The DDD model leverages not only comparisons across states and years but between likely affected and likely unaffected adults, in this case – those with a high school education or less compared to those with some college education or more. This third comparison is particularly useful in addressing potential unobserved, time-varying confounders that vary differentially across state. The DDD model accounts for that unobserved factor by comparing two groups within the state both of whom benefitted from the unobserved policy implementation but only one of which benefitted from the minimum wage.[61] We further interacted this third difference with our employment instability measure. Third, capturing the correct timing of employer instability using employer tenure is somewhat complicated given that respondents may change employers as a consequence of a state minimum wage increase, due to job loss or a loss or benefits or hours. To address this issue, we ran additional models excluding those respondents who reported that the start date at their current employer was within the same year as the survey. Fourth, out of concern for potential misclassification of

spouse/partner heights and weights that were reported by the head of household, we ran our primary models restricted to non-proxy respondents, i.e. those respondents who self-reported their own height and weight values. Fifth, as previously described, we additionally run our primary models for moderate psychological distress only for those years in which we have better support for parallel trends, 2011-2017.

RESULTS

During the period of observation, from 1999 to 2017, states increased their minimum wage rates a combined total of 362 times with three-fourths (270) occurring between 2007 to 2017. About three-fifths (63%) of these increases did not occur during the same period the federal minimum wage increased, from 2007 to 2009. The number of states with minimum wage rates above the federal rate more than doubled over the period, from 12 in 1999 to 30 in 2017 (Appendix Figure 1). Appendix Table 1 summarizes changes to changes in other state policies and state characteristics that were included as model covariates between the 1999 to 2017 period.

Table 1 provides a description of the demographic and socioeconomic characteristics of PSID participants with a high school education or less included in the analytic sample at their first observation. Sample characteristics are presented both unweighted and weighted, to account for the complex survey design of the PSID, from 1999 to 2017. The total sample included 7,017 individuals with an average of 6 observations per individual (out of a maximum of 10) and a total of 86,220 person-years of observation. The average age of participants was 35.9 years. Half of participants were women (50.3%) and half were (53.2%) were persons of color. The average duration of education was 11.4 years. Approximately 77.9% of participants were employed at baseline while 11.0% were unemployed but actively seeking work and the remaining 11.0% were not in the labor force. Roughly 15.3% of participants experienced one or more weeks of unemployment, in the prior year, with an average of 20.7 weeks spent unemployed. Among those participants who were employed at baseline, the average tenure at that employer was 6.5 years. Supplementary Table 1 provides more information on participants included in the 2007-2017 sample for the evaluation of moderate psychological distress. Across demographic, socioeconomic, characteristics the 1999 to 2017 and 2007 to 2017 samples were comparable. Weighted and unweighted characteristics were similar with the exception of the proportion of participants who were persons of color. This is likely

due to the fact that PSID participant families who were added to the panel after 1968 do not receive longitudinal weights. Therefore, weighted characteristics are nationally representative of the 1968 US population.

Obesity

Table 2 provides select estimates of risk of obesity by minimum wage and weeks of prior year employment for the full sample of respondents with a high school education or less and by gender strata. At all levels of minimum wage and prior year unemployment, estimates were imprecise, and we did not have sufficient evidence to reject the null hypothesis, therefore estimates must be interpreted with extreme caution. There were, however, some suggestive findings. Among respondents who did not experience any weeks of unemployment in the prior year, higher minimum wages led to lower obesity risk. The estimate for a $1 increase in inflation-adjusted minimum wage was a 13% (RR = 0.87, 95% CI = 0.75, 1.01) reduction in obesity risk. The estimate for a $3 increase in minimum wage was a 34% (RR = 0.66, 95% CI = 0.42, 1.03) reduction in obesity risk. However, the positive associations with higher minimum age were dependent on the number of weeks of unemployment experienced in the prior years. Following a full year of unemployment, a $1 increase in inflation-adjusted minimum wage was associated with a 11% (RR = 1.11, 95% CI = 0.83, 1.48) higher obesity risk. Similarly, a $3 increase in inflation-adjusted minimum wage was associated with a 37% (RR= 1.37, 95% CI = 0.57, 3.26) higher obesity risk. Figure 1 provides a visual representation of the continuum obesity risk by minimum wage, increased at $0.50 intervals, and weeks of prior year unemployment, in 4-week intervals, for those with a high school education or less. In gender-stratified models, this relation seemed to be largely driven by men with the aforementioned obesity risk gradient observed in men, but no in women (Table 2).

Table 3 shows the risk of obesity by minimum wage and years of tenure in the full sample of workers with a high school education or less and by gender strata. At all levels of minimum wage and years of tenure, estimates were imprecise, and there was little difference in obesity risk within or across greater years of tenure. Higher minimum wages were associated with lower risk of obesity regardless of the number of years of tenure. Among those with 1 year of tenure, a $1 increase in minimum wage was associated with a 19% (RR = 0.81, 95% = 0.64, 1.01) lower risk of obesity. In those with 10 years of tenure, a $1 increase in minimum wage was associated with a 16% (RR = 0.84, 95% CI = 0.71, 1.00)

lower risk of obesity. A visual of the representation of the continuum obesity risk by minimum wage, increased at $0.50 intervals, and years of job tenure, at 1-year intervals, for those with a high school education or less can be found in Supplementary Figure 4. This relation was similar for both men and women (Table 3).

Moderate psychological distress

Table 4 provides select estimates of risk of moderate psychological distress by minimum wage and weeks of prior year employment for the full sample of respondents with a high school education or less and by gender strata. Estimates were imprecise but nevertheless, some patterns emerged. Higher minimum wage values were associated with higher risk of moderate psychological distress among respondents who did not experience any weeks of unemployment in the prior year. The estimate for a $1 higher minimum wage was a 16% (RR = 1.16, 95% CI = 0.89, 1.50) increase in risk of moderate psychological distress. The estimate for a $3 higher minimum wage was a 54% (RR = 0.71, 95% CI = 0.71, 3.36) increase in risk of psychological distress. This higher risk of moderate psychological distress appeared to increase with greater number of weeks spent unemployed. When experiencing a full year of unemployment, a $1 higher minimum wage was associated with a 54% (RR = 1.54, 95% CI = 1.11, 2.14) higher risk of psychological distress. A $3 higher minimum wage was associated with 3.65 times the risk of psychological distress (RR= 3.65, 95% CI = 1.36, 9.83). Figure 2 provides a visual representation of risk of moderate psychological distress by minimum wage, increased at $0.50 intervals, and weeks of prior year unemployment, in 4-week intervals, for those with a high school education or less. As with obesity, this relation was largely driven by men with risk appearing somewhat similar and less precise across levels of minimum wage and unemployment for women (Table 4).

Table 5 provides the risk of moderate psychological distress by minimum wage and years of tenure in the full sample of workers with a high school education or less and by gender strata. At all levels of minimum wage and years of tenure, estimates were imprecise, and there was little difference in risk of moderate psychological distress within or across greater years of tenure. Among those with 1 year of tenure, a $1 increase in minimum wage was associated with a 5% (RR = 1.05, 95% = 0.70 1.57) higher risk of moderate psychological distress. In those with 10 years of tenure, a $1 increase in minimum wage had no measurable influence on risk of moderate psychological distress (RR = 1.00, 95% CI = 0.71,

1.42). A visual of the representation of the continuum risk of risk of moderate psychological distress by minimum wage, increased at $0.50 intervals, and years of job tenure, at 1-year intervals, for those with a high school education or less can be found in Supplementary Figure 5. As with obesity, this relation was similar for both men and women.

Sensitivity analyses

Supplementary Table 2 shows the risk of obesity and moderate psychological distress by minimum wage and weeks of unemployment among those respondents with some college education or more. Risk of obesity was somewhat elevated among those who had not experienced unemployment in the prior year; however, these estimates encompassed the null. There was little difference in risk of obesity associated with more weeks spent out of work among the higher educated. With respect to moderate psychological distress, risk was higher within but not across weeks of unemployment.

Supplementary Table 3 shows the risk of obesity and moderate psychological distress by minimum wage and years of tenure among those workers with some college education or more. Risk of obesity was somewhat elevated among those who had not experienced unemployment in the prior year; however, these estimates encompassed the null. Estimated risk of obesity was identical across weeks spent out of work. With respect to moderate psychological distress, there was evidence of elevated risk of moderate psychological distress at baseline which decline somewhat with weeks spent out of work. Among those with 1 year of tenure, a $1 increase in minimum wage was associated with a 29% (RR = 1.29, 95% = 1.07, 1.57) higher risk of moderate psychological distress while those experiencing a full year of employment had a 17% (RR = 1.17, 95% CI = 0.97, 1.42) lower risk of moderate psychological distress. Note that Supplementary Tables 4 and 5 provide information demographic and socioeconomic characteristics for respondents with some college education or more, both unweighted and weighted, for the 1999-2017 and 2007-2017 periods, respectively

Supplementary Table 6 shows the risk of obesity and moderate psychological distress by minimum wage and weeks of unemployment directly comparing respondents with a high school education or less to those with some college education or more – DDD estimates. As with our primary models, risk of obesity declined with higher minimum wage values and increased with greater number of weeks spent unemployed. Among those experiencing no unemployment in the prior year, a $1 increase was

associated with a 5% (RR = 0.95, 95% CI = 0.87, 1.03) lower risk of obesity in those with a high school education or less compared to those with some college education or more. Among those experiencing unemployment for a full year, a $1 increase was associated with a 49% (RR = 1.49, 95% CI = 0.82, 2.71) higher risk of obesity in those with a high school education or less compared to those with some college education or more. For moderate psychological distress, risk also decreased with increasing minimum wage and increased with a greater number of weeks spent unemployed. Among those experiencing no unemployment in the prior year, a $1 increase was associated with a 11% (RR = 0.89, 95% CI = 0.77, 1.03) lower risk of moderate psychological distress in those with a high school education or less compared to those with some college education or more. Among those experiencing unemployment for a full year, a $1 increase was associated with a 37% (RR = 1.37, 95% CI = 1.02, 1.83) increase in risk of moderate psychological distress in those with a high school education or less compared to those with some college education or more.

Supplementary Table 7 shows the risk of obesity and moderate psychological distress by minimum wage and years of tenure at current employer directly comparing respondents with a high school education or less to those with some college education or more. As with our primary models we found no evidence of variation in risk of obesity across years of tenure. Likewise, we found no evidence of variation in risk of moderate psychological distress across greater tenure.

Supplementary Table 8 and 9 provide estimates for obesity risk by minimum wage and unemployment and minimum wage and tenure, respectively, excluding proxy respondents. Estimates were comparable to our primary models. We again find evidence of a variation in risk of obesity across weeks of unemployment but not years of tenure.

Supplementary Table 10 displays estimates for risk obesity and moderate psychological distress by tenure excluding those workers with less educated who started their jobs the same year the survey was administered. Estimates for both obesity risk and moderate psychological distress concurred with our primary findings. There was no evidence of variation in risk in either outcome across year of tenure.

Finally, out of concern over a potential violation of the parallel trends assumption for moderate psychological distress in 2007 and 2009 (Supplementary Figure 1) we ran moderate psychological distress models for the full sample and by gender for the years in which we have better support for

parallel trends for moderate psychological distress – 2011 to 2017. We ran models for both unemployment (Supplementary Table 11) and job tenure (Supplementary Table 12). In both sensitivity analyses estimates were in agreement with our primary models.

DISCUSSION

The present study found limited but suggestive evidence that prior unemployment, but not employer tenure, may modify the relation between minimum wage and obesity risk. In all models evaluating these relations in a population with a high school education or less we found the suggestive benefit of minimum wage on obesity was reversed by greater duration of unemployment in the prior year. Among persons who had experienced full year unemployment, higher minimum wage led to higher obesity risk. Highest risk was found when the state minimum wage was $3 higher than the federal rate.

Similar patterns were observed for moderate psychological distress. However, unlike obesity, there was suggestive evidence that higher minimum wages lead to higher risk of moderate psychological distress even when employed for the full, prior year. Among persons who had experienced full year unemployment, higher minimum wage led to higher risk of psychological distress. Highest risk of distress was found when the state minimum wage was $3 higher than the federal rate.

Although we were unable to provide conclusive, causal evidence of effect modification by employment instability, we nevertheless believe our findings to be hypothesis generating. Evaluations of the influence of minimum wage increases on physical and mental health across individual or household economic circumstance may represent a fruitful avenue for research. Although there is little evidence that the relation between minimum wage, obesity, and moderate psychological distress is modified by employer tenure, we believe the modifying role or prior unemployment remains an open question. This avenue of research is particularly timely as governments worldwide seek to improve the long-term health and economic impacts ushered in by the present public health crisis through innovative policies targeted at individuals and households.

Our lack of definitive findings with respect to the relation between minimum wage, employment instability, and obesity is in line with the current body of evidence evaluating minimum wage and obesity which finds inconclusive evidence to support a consistent relation.[3,20] The uncertainty surrounding the

association between minimum wage and obesity may stem from the complex etiology of the disease, which is influenced not only by socioeconomic factors, but demographics, genetics, behavior, the environment, and more.[120] There is also no existing evidence, at present, to support that higher minimum wages improve energy balance pathways, such as increasing fruit and vegetable consumption or physical activity levels.[17,21,71]

In addition, there is a body of work that finds income-obesity relation differs across gender and education, which warrants further investigation into the implications for minimum wage research.[36] One could also argue that the risk imposed by socioeconomic factors on obesity is may not be primarily a function of income but may be more influenced by socioeconomic position, which that is better captured by assets and access to resources. Indeed, some studies no longer use income as the principal measure of socioeconomic status.[47,121]

Finally, the influence of macroeconomic conditions, such as the high unemployment rate observed during the COVID-19 pandemic, on health outcomes, such as obesity, remains unclear, with some studies finding no association,[122,123] while others find, counterintuitively, some health benefit.[124] Should our suggestive finding of modification of the minimum wage-obesity relation by unemployment be confirmed, it would concordant with work conducted by researchers in Seattle who found that the labor market benefits of a city-wide minimum wage increase accrued primarily among more experienced, stably employed workers.[109]

Our results with respect to the influence of employment instability on the relation between minimum wage and moderate psychological distress are in line with broader work evaluating the influence of employment instability, macroeconomic conditions, precarity, and economic insecurity on mental well-being.[38,45,106,98–105] However, we observed higher risk of moderate psychological distress across all levels of unemployment in both the less and higher educated. It is worth noting that the period encompassing our evaluation of moderate psychological distress is limited, spanning 6 waves of data between 2007-2017, which encapsulate the first 2 years of the Great Recession and the period immediately after. The evaluations of the Great Recession have noted that it has had a profound influence on mental health.[125] Those with higher educational attainment may be particularly impacted should they feel a loss of control and work-related stressors in jobs they feel are below their educational or experience level.[125] However,

our DDD model comparison provides suggestive evidence that, relative to the higher educated, those with a high school degree or less had lower risk of moderate psychological distress.

The overall finding of increasing risk of moderate psychological distress across greater unemployment experience was in line with our hypothesis and are driven by less-educated men and who experienced unemployment. This relation may be reflective of the decline in job opportunities for less-educated men over the last decade.[98] These results may also be partially explained by the importance of work in terms of male identity and the need to provide for others that men may feel more acutely than women.[119] Moreover, men may be more likely to consider stable employment their normative role.[119] There is also evidence to suggest that instability in one aspect of life begets further instability.[97,98] For example, less-educated men experiencing employment instability are less likely to find or maintain romantic partnerships, which may have implications for their mental wellbeing as well as future household earning potential.[98]

This study had several key strengths. First, to our knowledge, this study represents one of the first to investigate how the association between minimum wage and physical and mental health is influence by individual-level economic circumstances. We build off prior work which has examined the influence of state-level economic circumstances on the minimum wage-health relation.[29] Second, we leveraged a retrospective cohort design which, along with Poisson models, allowed us to longitudinally evaluate dynamic changes in economic factors as well as estimate risk of obesity and moderate psychological distress. Third, similar to several recent studies,[3,20] we employed both a DD and DDD strategy to further account for any unobserved time- and state-varying confounding.

This study also had several notable limitations. First, our precision was limited by several factors: limitations in the years the K-6 module was asked to participants, sample restrictions, interactions, and the number of subgroup models employed. Second, all health outcome and employment are self-reported with heads of household reporting on behalf their spouse/domestic partner. While we were able to determine that proxy responses for height and weight had relatively little impact on our obesity estimates, employment and mental health are highly sensitive topics and personal topics. Therefore, we cannot completely rule out bias due to poor recall or social desirability bias. Third, we were unable to investigate differences among married and unmarried men and women due to sample size limitations; however, we

believe this warrants further study given the associations between economic insecurity and family dynamics.[98] Married women are also the one of the only groups to experience improvements in job tenure over the last decade.[97] Fourth, we were unable to examine tenure at a specific job or role which may be more unstable than time at a specific employer. Moreover, our measure of tenure captures the full extent of the time spent at a given employer during a respondent's lifetime and is sensitivity to timing. As an example, a seasonal worker spends 4 months of each year at a given job over a period of a 3 years could be classified the same as a worker who spent 1 continuous year at an employer. Fifth, as with all quasi-experiential study designs, we cannot rule out the potential for unmeasured confounding. Sixth, while we took care to test the parallel trends assumption with respect to our employment stability variables and to make sure that they temporally preceded minimum wage increases, we cannot rule out the influence of minimum wage policies on employment and health in prior periods. Lastly, it should be noted that our findings with respect to obesity may have limited generalizability outside the US population or developed nations. There is suggestive evidence that the relation between income and obesity resembles a U-shaped Kuznets curve which show that as per capita income or gross domestic product rises obesity rises until a certain level of economic development where it then levels off or falls.[112] However, evaluations of minimum wage increases in low- and middle-income countries have found that higher wage policies were an effective strategy in reducing obesity in women.[32,126]

The present study found suggestive and imprecise evidence that higher minimum wage rates coupled with greater duration of prior year unemployment were associated with the greater risk of obesity and moderate psychological distress. Although we were unable to provide conclusive, causal evidence of effect modification by employment instability, we believe these findings highlight the importance of examining the economic circumstances of individuals when evaluating the relation between social and income policies and health. These conclusions are particularly timely as the US debates a federal minimum wage increase and as governments worldwide seek to ameliorate the long-term health and economic impacts ushered in by the current public health crisis through innovative policies targeted at individuals, households, and businesses. Future work should examine how other aspects of, as well as cumulative exposure to, employment instability and, to a greater extent, economic insecurity influences

the relation between minimum wage and incident as was as recurrent physical and mental health outcomes.

Table 1. Sample characteristics at first observation for the full sample for those with a high school education or less, 1999 to 2017

Characteristics	Unweighted	Weighted
Sample size, individuals	7,017	4,214
Person-years, n	86,220	56,700
Number of observations per individual, mean (SD)	6.1 (2.9)	7.9 (2.4)
Demographics		
Age (years), mean (SD)	35.9 (9.8)	37.4 (7.7)
Women, %	50.3	51.4
Persons of color, %	53.2	35.2
Married, %	55.2	55.4
Education and employment		
Average years of education (years), mean (SD)	11.4 (1.4)	11.4 (1.1)
Current employment status, %[a]		
Employed	77.9	80.5
Unemployed[b]	11.0	8.8
Not in labor force	11.0	10.8
Experienced any weeks unemployed, past year, %	15.3	13.5
Number of weeks unemployed, past year, mean (SD)[a]	20.7 (16.6)	17.9 (12.2)
Tenure at current employer (years), mean (SD)[b]	6.5 (7.2)	7.3 (5.6)
Health outcomes		
Obesity	26.8	24.7
Moderate psychological distress[c]	32.7	29.7

n = sample size, SD = standard deviation
Source: Authors' calculation using the Panel Study of Income Dynamics
Note: All percentages calculated using the number of unique individuals.
[a]Only calculated for those who experienced any weeks of unemployment in the past year
[b]Only calculated for those currently employed
[c]Calculated using only the 2007-2017 PSID survey waves

Table 2. Risk of obesity by minimum wage and prior year unemployment in those with a high school education or less

	Weeks of unemployment, past year					
	0 weeks		24 weeks		52 weeks	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Overall						
$1.00	0.87	(0.75, 1.01)	0.97	(0.81, 1.18)	1.11	(0.83, 1.48)
$2.00	0.76	(0.56,1.02)	0.95	(0.65, 1.39)	1.23	(0.69, 2.20)
$3.00	0.66	(0.42, 1.04)	0.93	(0.53, 1.63)	1.37	(0.57, 3.26)
By gender						
Women						
$1.00	0.93	(0.79, 1.10)	0.94	(0.75, 1.19)	0.96	(0.62, 1.47)
$2.00	0.87	(0.62, 1.22)	0.89	(0.56, 1.42)	0.92	(0.39, 2.16)
$3.00	0.81	(0.49, 1.35)	0.84	(0.42, 1.68)	0.88	(0.24, 3.18)
Men						
$1.00	0.80	(0.63, 1.01)	0.99	(0.76, 1.29)	1.27	(0.85, 1.92)
$2.00	0.64	(0.40, 1.01)	0.98	(0.58, 1.67)	1.62	(0.72, 3.67)
$3.00	0.51	(0.26, 1.02)	0.97	(0.44, 2.16)	2.07	(0.61, 7.04)

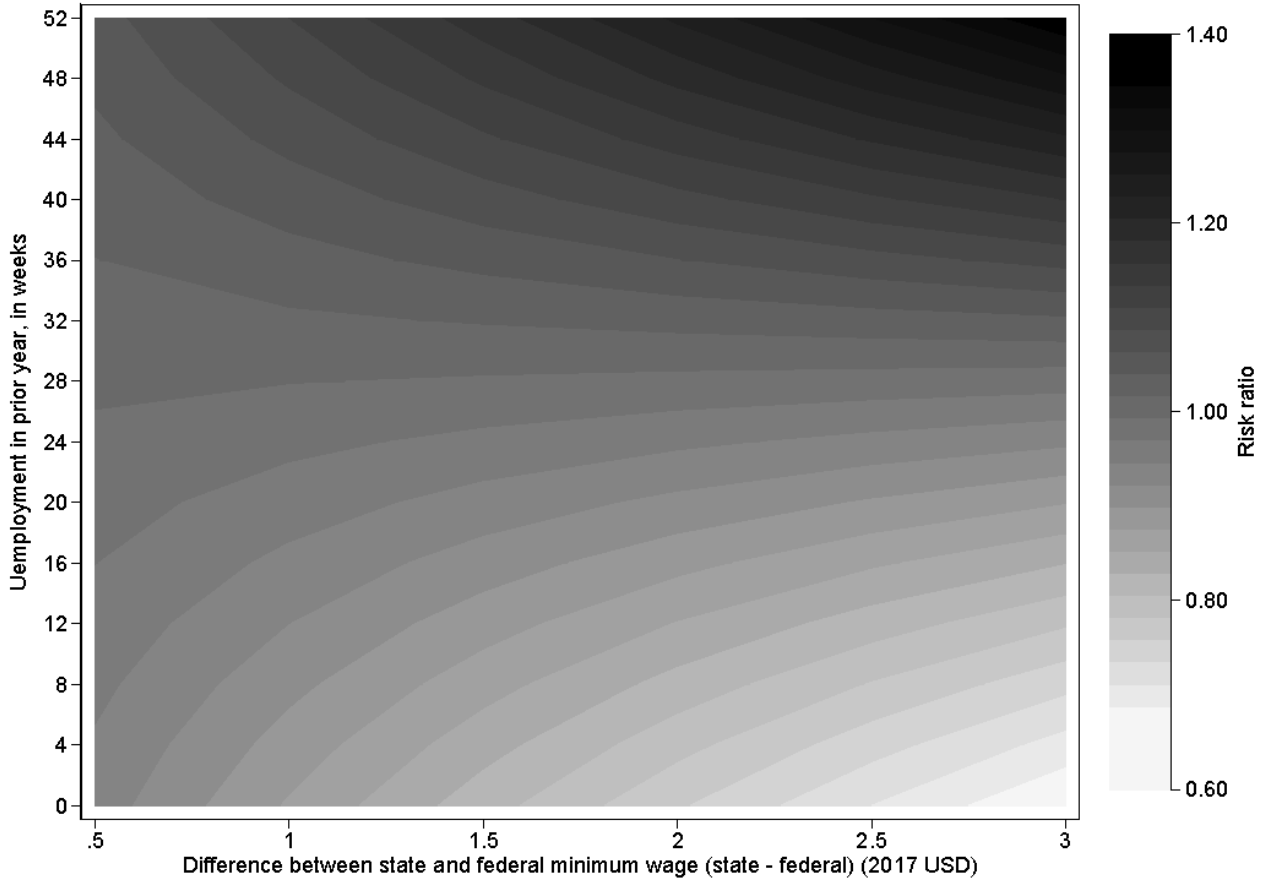
RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 44,608 person-years for the full sample, 22,798 person-years for women and 21,810 person-years for men. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

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

Figure 1. Risk of obesity by minimum wage and prior year unemployment in those with high school education or less



Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics
Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 44,608 person years and spans the biannual PSID survey waves from 1999 to 2017. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

Table 3. Risk of obesity by minimum wage and years of tenure at current employer in workers with a high school education or less

	Years of tenure, current employer					
	1 year		5 years		10 years	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Overall						
$1.00	0.81	(0.64, 1.01)	0.82	(0.68, 1.00)	0.84	(0.71, 1.00)
$2.00	0.65	(0.42, 1.01)	0.68	(0.46, 1.00)	0.71	(0.50, 1.00)
$3.00	0.52	(0.27, 1.02)	0.56	(0.31, 1.00)	0.60	(0.36, 1.01)
By gender						
Women						
$1.00	0.86	(0.66, 1.12)	0.84	(0.66, 1.07)	0.82	(0.65, 1.04)
$2.00	0.74	(0.44, 1.24)	0.71	(0.44, 1.14)	0.68	(0.43, 1.07)
$3.00	0.63	(0.29, 1.39)	0.60	(0.29, 1.21)	0.56	(0.28, 1.11)
Men						
$1.00	0.76	(0.55, 1.04)	0.79	(0.59, 1.06)	0.82	(0.63, 1.08)
$2.00	0.57	(0.30, 1.08)	0.62	(0.34, 1.11)	0.68	(0.40, 1.16)
$3.00	0.43	(0.17, 1.13)	0.49	(0.20, 1.17)	0.56	(0.25, 1.25)

RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 29,804 person-years for the full sample, 14,632 person-years for women and 15,172 person-years for men. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

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

Table 4. Risk of moderate psychological distress by minimum wage and prior year unemployment in those with high school education or less

	Weeks of unemployment, past year					
	0 weeks		24 weeks		52 weeks	
Minimum wage (State – Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Overall						
$1.00	1.16	(0.89, 1.50)	1.32*	(1.02, 1.71)	1.54*	(1.11, 2.14)
$2.00	1.34	(0.80, 2.24)	1.74*	(1.04, 2.93)	2.37*	(1.23, 4.59)
$3.00	1.54	(0.71, 3.36)	2.30*	(1.06, 5.00)	3.65*	(1.36, 9.83)
By gender						
Women						
$1.00	1.14	(0.84, 1.56)	1.19	(0.80, 1.77)	1.24	(0.65, 2.38)
$2.00	1.31	(0.70, 2.44)	1.41	(0.63, 3.13)	1.54	(0.42, 5.67)
$3.00	1.50	(0.59, 3.82)	1.68	(0.51, 5.55)	1.91	(0.27, 13.50)
Men						
$1.00	1.17	(0.83, 1.65)	1.37	(0.99, 1.89)	1.64**	(1.16, 2.34)
$2.00	1.38	(0.69, 2.73)	1.88	(0.99, 3.57)	2.70**	(1.34, 5.47)
$3.00	1.61	(0.58, 4.51)	2.57	(0.98, 6.73)	4.44**	(1.54, 12.8)

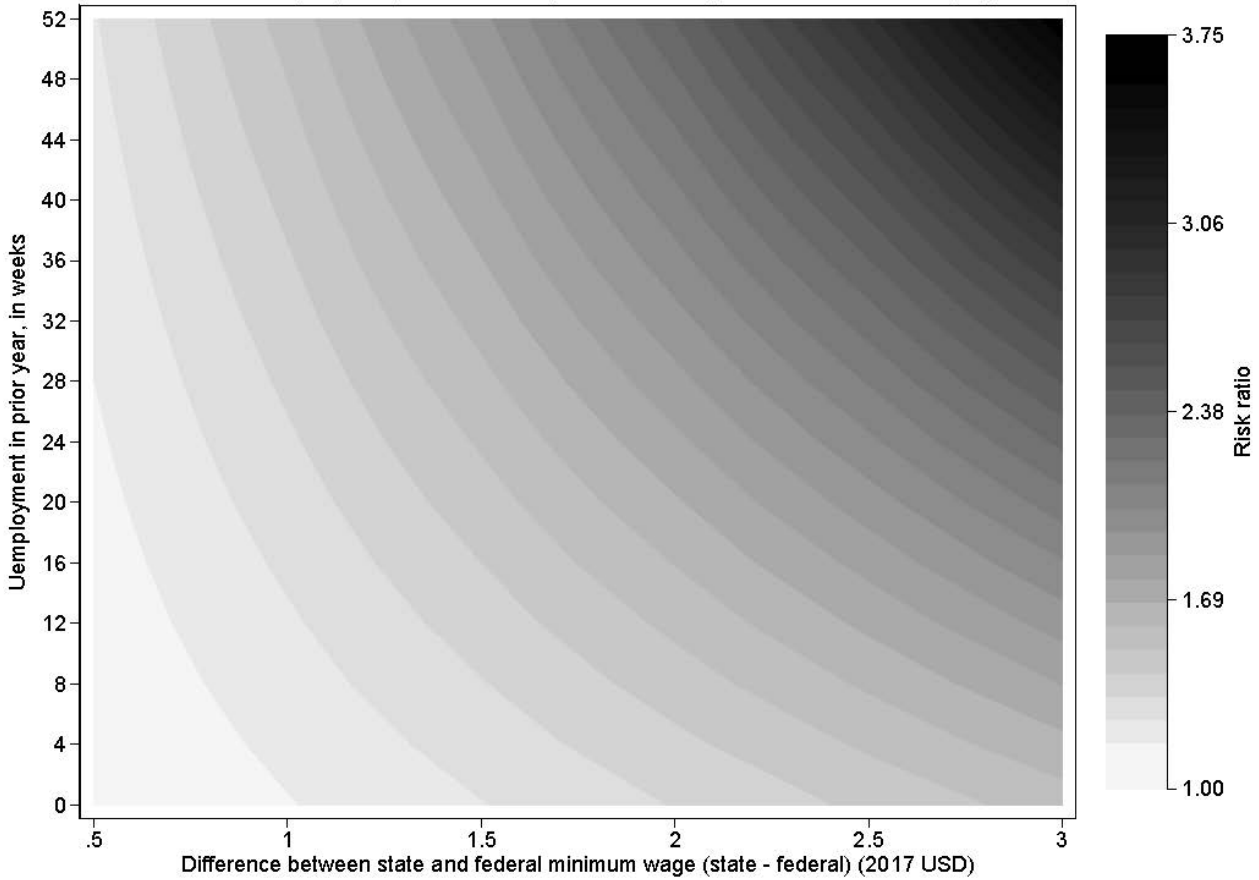
RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 2007 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 14,726 person-years for the full sample, 9,898 person-years for women and 8,902 person-years for men. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

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

Figure 2. Risk of moderate psychological distress by minimum wage and prior year unemployment in those with a high school education or less



Source: Authors' calculation using the 2007 to 2017 Panel Study of Income Dynamics
Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 14,726 person years and spans the biannual PSID survey waves from 2007-2017. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who in a union, and state and year fixed effects.

Table 5. Risk of moderate psychological distress by minimum wage and tenure at current employer in workers with a high school education or less

	Years of tenure, current employer					
	1 year		5 years		10 years	
Minimum wage (State – Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Overall						
$1.00	1.05	(0.70, 1.57)	1.03	(0.71, 1.49)	1.00	(0.71, 1.42)
$2.00	1.10	(0.49, 2.45)	1.06	(0.50, 2.22)	1.01	(0.51, 2.02)
$3.00	1.15	(0.34, 3.85)	1.09	(0.36, 3.30)	1.01	(0.36, 2.87)
By gender						
Women						
$1.00	0.94	(0.61, 1.46)	0.94	(0.63, 1.40)	0.93	(0.64, 1.34)
$2.00	0.89	(0.37, 2.13)	0.88	(0.39, 1.95)	0.86	(0.41, 1.80)
$3.00	0.84	(0.23, 3.12)	0.82	(0.25, 2.72)	0.80	(0.26, 2.41)
Men						
$1.00	1.13	(0.66, 1.95)	1.12	(0.68, 1.86)	1.11	(0.68, 1.80)
$2.00	1.28	(0.43, 3.79)	1.26	(0.46, 3.45)	1.22	(0.46, 3.23)
$3.00	1.45	(0.29, 7.38)	1.41	(0.31, 6.41)	1.35	(0.31, 5.81)

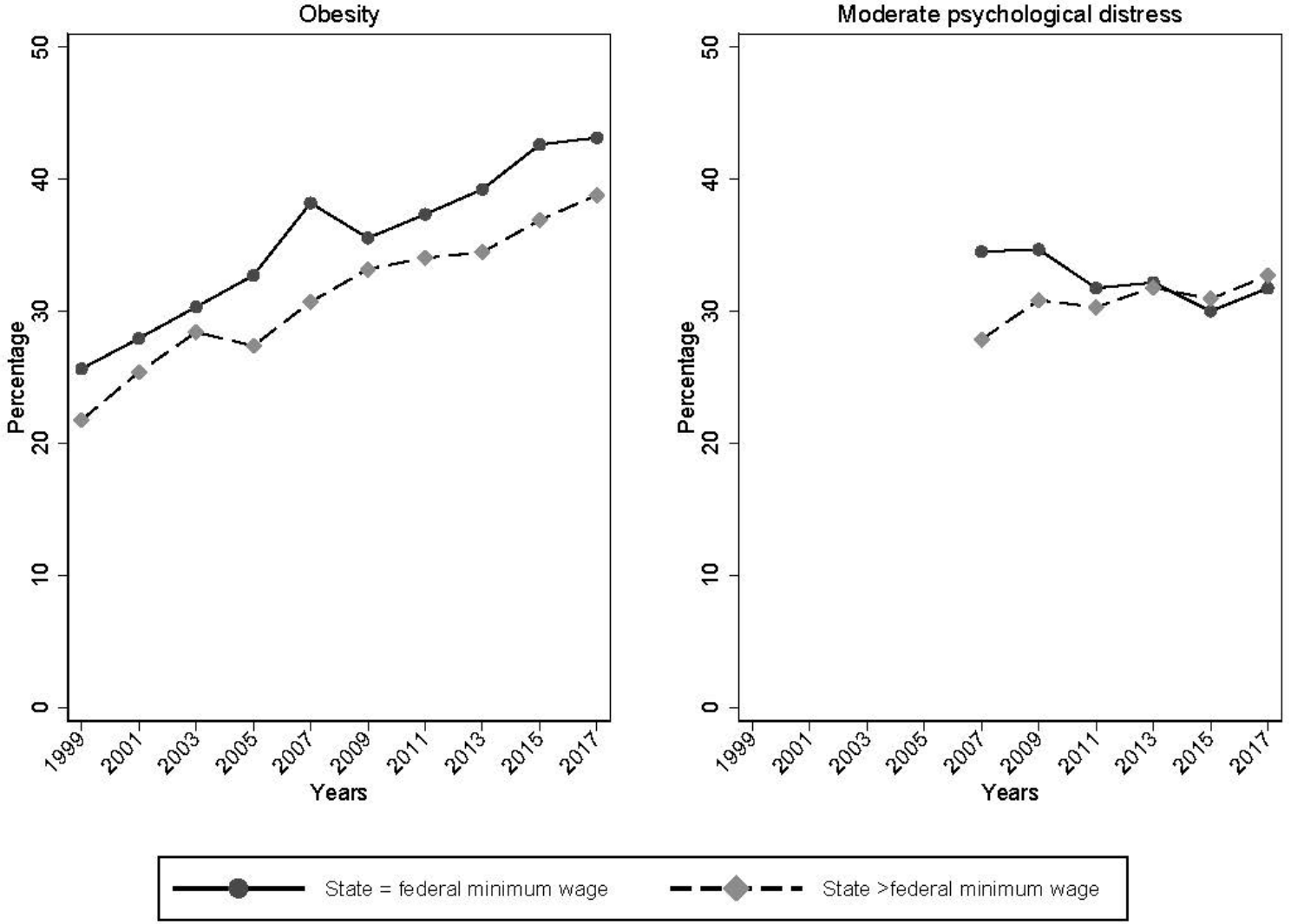
RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 9,898 person-years for the full sample, 5,962 person-years for women and 3,936 person-years for men. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

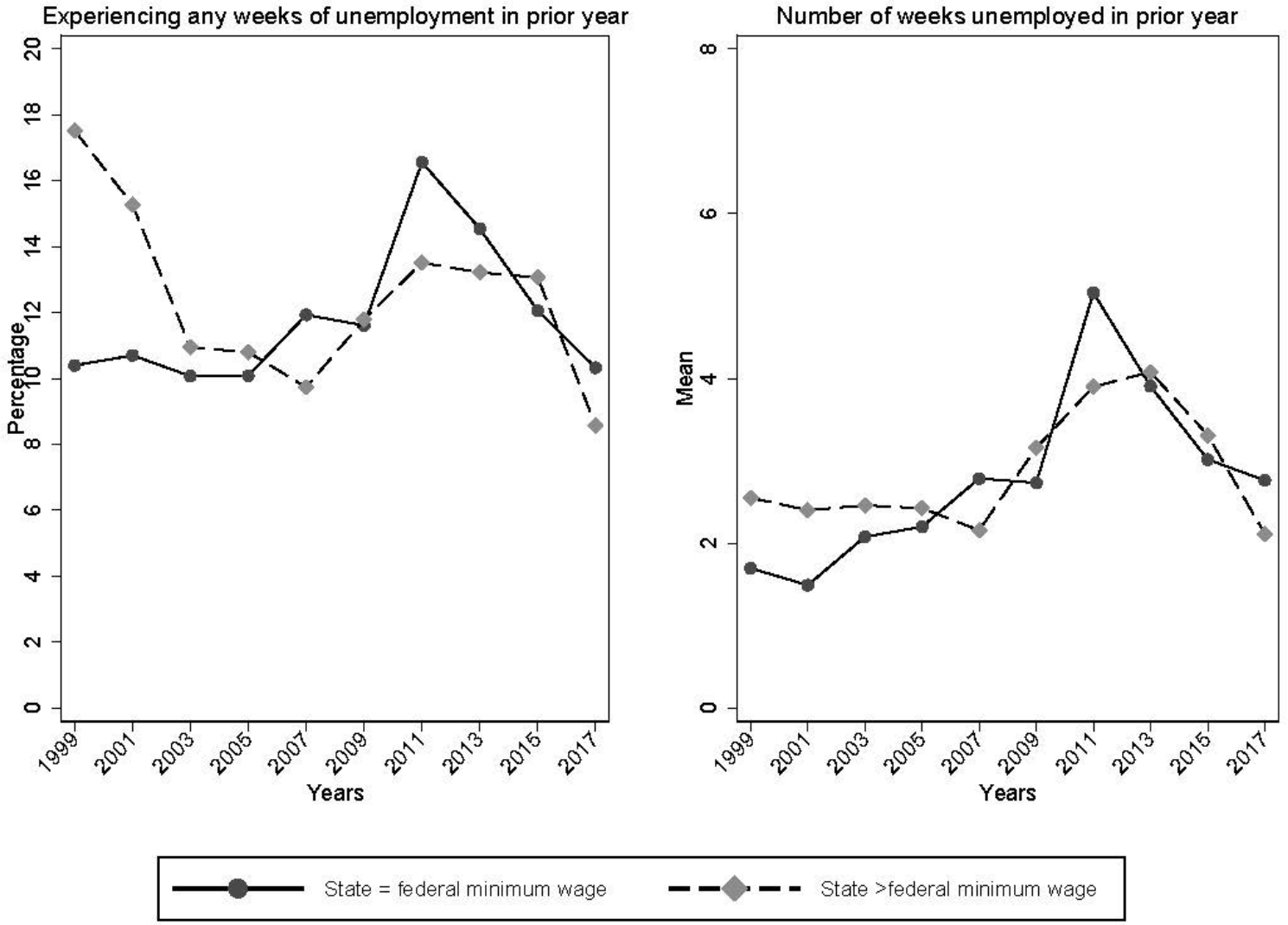
* p <0.05, ** p <0.01, *** p <0.001

Supplementary Figure 1. Prevalent obesity and moderate psychological distress by minimum wage for those with a high school education or less



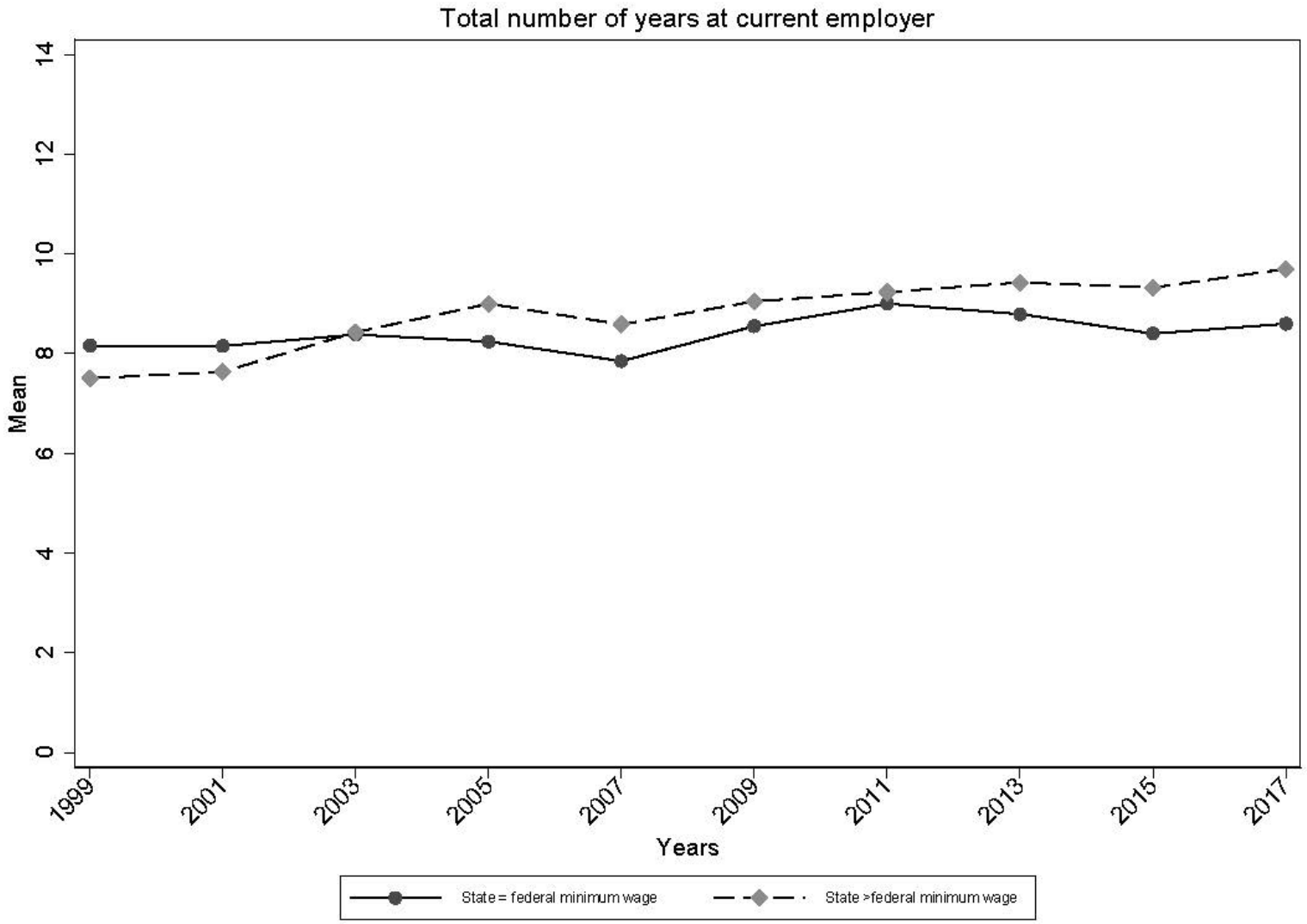
Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics
Note: Prevalence estimates are unweighted.

Supplementary Figure 2. Prior year unemployment and weeks unemployed by minimum wage for those with a high school education or less



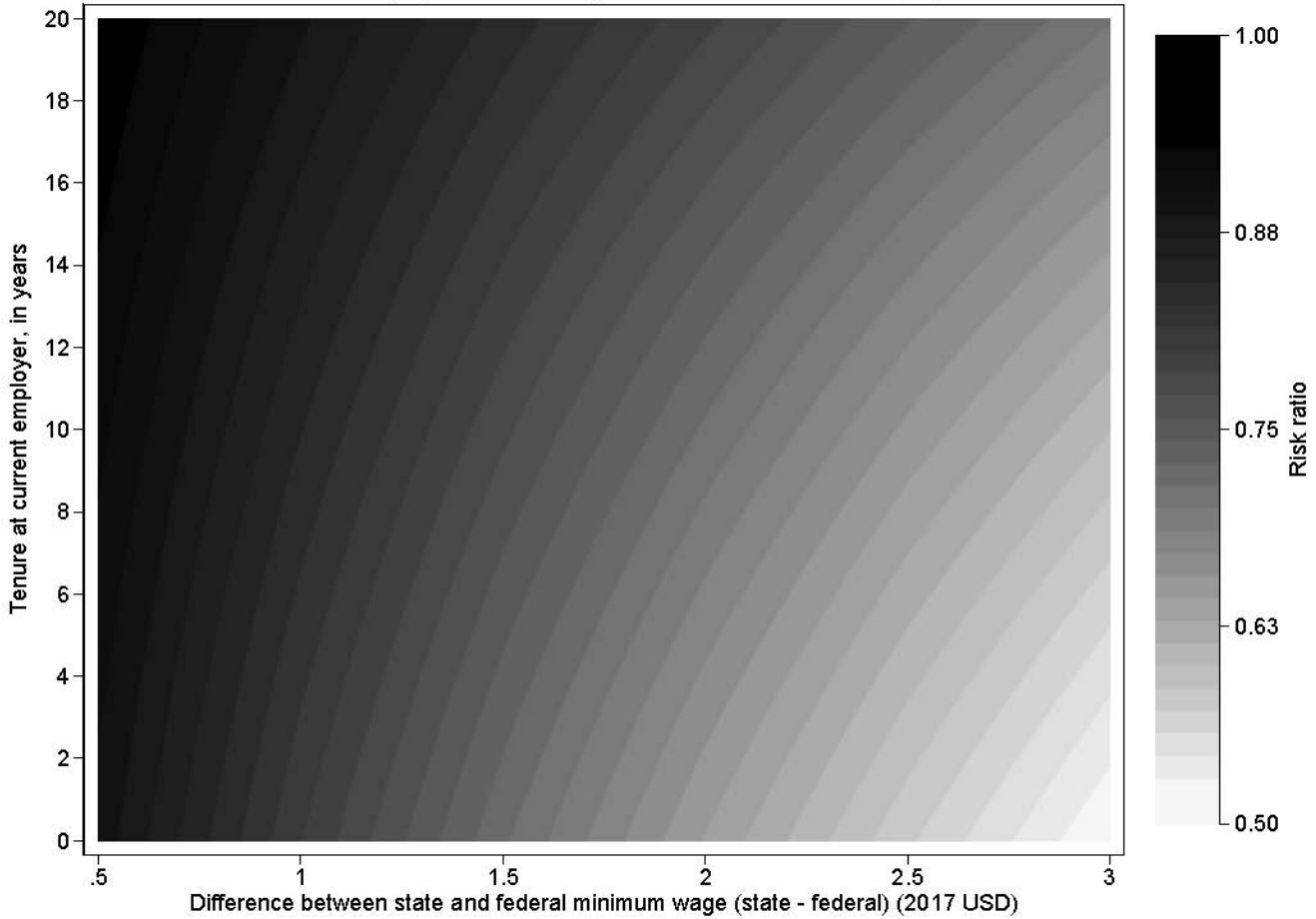
Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics
Note: The prevalence estimates for unemployment is unweighted. Mean number of weeks unemployed in prior year included those who experienced 0 weeks of unemployment.

Supplementary Figure 3. Mean years of tenure at current employer by minimum wage for those with a high school education or less



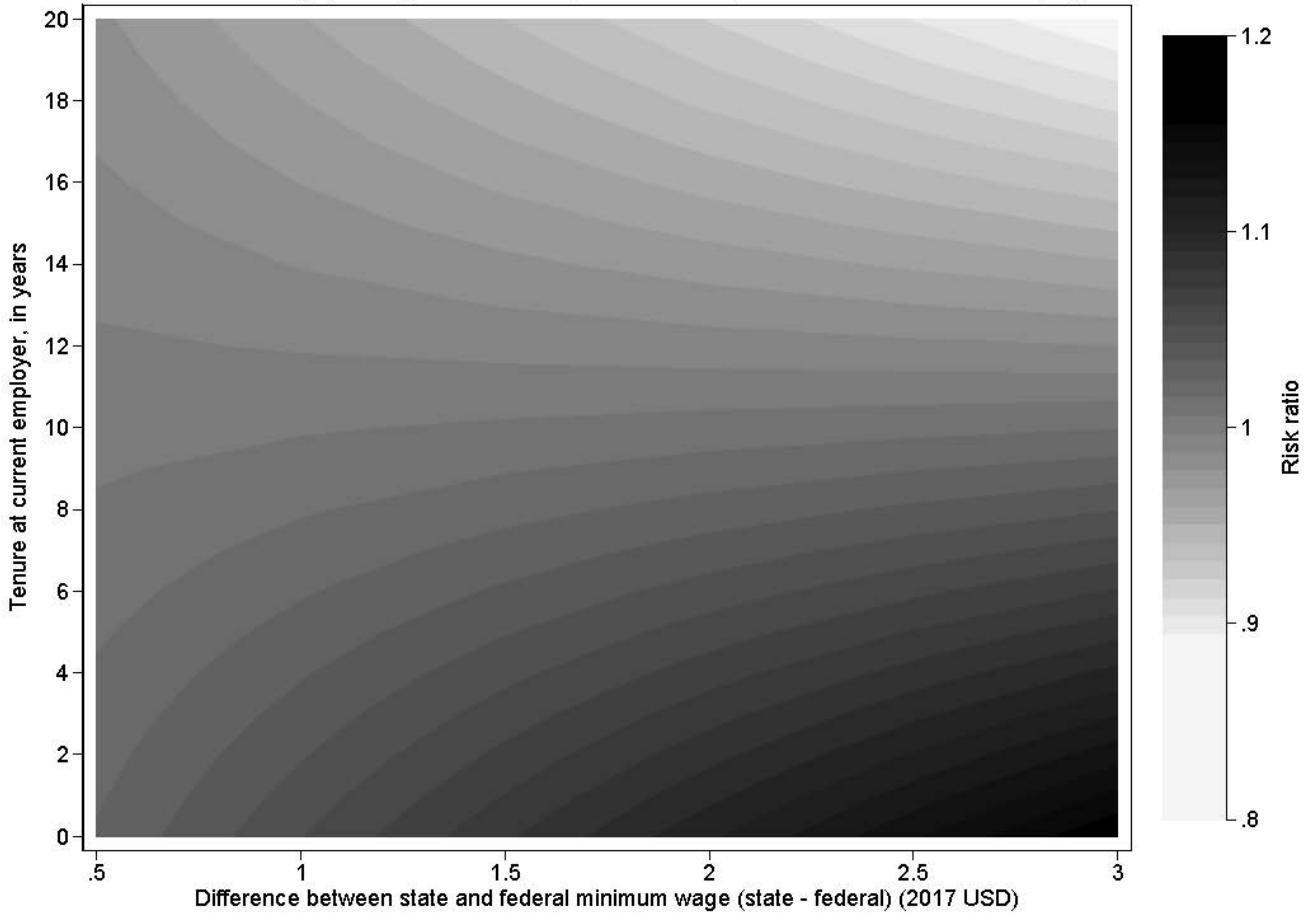
Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics
Note: The prevalence estimate for unemployment is unweighted. 0 indicates a tenure of <1 year.

Supplementary Figure 4. Risk of obesity by minimum wage and tenure at current employer in workers with a high school education or less



Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics
Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 29,804 person-years for the full sample and spans the 1999 to 2017 biannual PSID survey waves. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

Supplementary Figure 5. Risk of moderate psychological distress by minimum wage and years of tenure at current employer in workers with a high school education or less



Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics
Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 9,898 person-years for the full sample and spans the 2007-2017 biannual PSID survey waves. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

Supplemental Table 1. Sample characteristics at first observation for the full sample for those with a high school education or less, 2007 to 2017

Characteristics	Unweighted	Weighted
Sample size, individuals	5,833	3,692
Person-years, n	26,633	17,721
Number of observations per individual, mean (SD)	4.6 (1.5)	5.2 (1.2)
Demographics		
Age (years), mean (SD)	39.1 (11.1)	41.4 (8.0)
Women, %	51.6	51.8
Persons of color, %	55.1	36.7
Married, %	54.4	54.5
Education and employment		
Average years of education (years), mean (SD)	11.5 (1.4)	11.5 (1.1)
Current employment status, %[a]		
Employed	74.6	76.4
Unemployed[b]	11.4	8.9
Not in labor force	14.1	14.7
Experienced any weeks unemployed, past year, %	14.1	11.0
Number of weeks unemployed, past year, mean (SD)[a]	24.4 (17.8)	21.0 (13.8)
Tenure at current employer (years), mean (SD)[b]	7.5 (8.2)	8.1 (6.0)
Health outcomes		
Obesity	17.9	13.4
Moderate psychological distress[c]	32.7	29.7

n = sample size, SD = standard deviation
Source: Authors' calculation using the Panel Study of Income Dynamics
Note: All percentages calculated using the number of unique individuals.
[a]Only calculated for those who experienced any weeks of unemployment in the past year
[b]Only calculated for those currently employed
[c]Calculated using only the 2007 to 2017 PSID survey waves

Supplementary Table 2. Risk of obesity and moderate psychological distress by minimum wage and prior year unemployment in those with some college education or more

	Weeks of unemployment, past year					
	0 weeks		24 weeks		52 weeks	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Obesity						
$1.00	1.09	(0.96, 1.24)	1.03	(0.76, 1.39)	0.96	(0.55, 1.69)
$2.00	1.18	(0.91, 1.53)	1.05	(0.58, 1.92)	0.92	(0.30, 2.84)
$3.00	1.29	(0.87, 1.89)	1.08	(0.44, 2.66)	0.88	(0.16, 4.79)
Moderate psychological distress[a]						
$1.00	1.17*	(1.02, 1.36)	1.17	(0.96, 1.42)	1.16	(0.80, 1.68)
$2.00	1.37*	(1.03, 1.84)	1.36	(0.92, 2.01)	1.34	(0.63, 2.83)
$3.00	1.62*	(1.05, 2.49)	1.59	(0.88, 2.85)	1.55	(0.51, 4.76)

RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

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

Supplementary Table 3. Risk of obesity and moderate psychological distress by minimum wage and years of tenure at current employer in workers with some college education or more

	Years of tenure, current employer					
	1 year		5 years		10 years	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Obesity						
$1.00	1.08	(0.91, 1.28)	1.08	(0.92, 1.26)	1.08	(0.93, 1.25)
$2.00	1.16	(0.83, 1.63)	1.16	(0.85, 1.59)	1.16	(0.86, 1.57)
$3.00	1.25	(0.75, 2.07)	1.25	(0.78, 2.00)	1.25	(0.79, 1.96)
Moderate psychological distress[a]						
$1.00	1.29**	(1.07, 1.57)	1.24*	(1.03, 1.49)	1.17	(0.97, 1.42)
$2.00	1.68**	(1.15, 2.45)	1.54*	(1.07, 2.22)	1.38	(0.94, 2.02)
$3.00	2.17**	(1.23, 3.84)	1.91*	(1.10, 3.30)	1.62	(0.91, 2.88)

RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

* p <0.05, ** p <0.01, *** p <0.00

Supplemental Table 4. Sample characteristics at first observation for the full sample for those with some college education or more, 1999-2017

Characteristics	Unweighted	Weighted
Sample size, individuals	8,178	4,764
Person-years, n	98,228	59,896
Number of observations per individual, mean (SD)	6.0 (2.8)	7.5 (2.5)
Demographics		
Age (years), mean (SD)	34.9 (9.8)	36.4 (7.1)
Women, %	53.5	51.2
Persons of color, %	36.4	21.4
Married, %	61.4	57.0
Education and employment		
Average years of education (years), mean (SD)	15.1 (1.4)	15.3 (0.9)
Current employment status, %[a]		
Employed	87.2	88.4
Unemployed[b]	4.7	4.2
Not in labor force	8.1	7.3
Experienced any weeks unemployed, past year, %	9.0	8.5
Number of weeks unemployed, past year, mean (SD)[a]	16.3 (14.5)	14.7 (9.9)
Tenure at current employer (years), mean (SD)[b]	6.0 (6.7)	6.5 (4.9)
Health outcomes		
Obesity	20.7	18.3
Moderate psychological distress[c]	24.7	23.0

n = sample size, SD = standard deviation
Source: Authors' calculation using the Panel Study of Income Dynamics
Note: All percentages calculated using the number of unique individuals.
[a]Only calculated for those who experienced any weeks of unemployment in the past year
[b]Only calculated for those currently employed
[c]Calculated using only the 2007 to 2017 PSID survey waves

Supplemental Table 5. Sample characteristics at first observation for the full sample for those with some college education or more, 2007-2017

Characteristics	Unweighted	Weighted
Sample size, individuals	7,209	4,357
Person-years, n	32,388	19,991
Number of observations per individual, mean (SD)	4.5 (1.5)	5.1 (1.2)
Demographics		
Age (years), mean (SD)	37.6 (11.2)	40.0 (7.8)
Women, %	54.5	51.6
Persons of color, %	36.9	21.9
Married, %	62.5	60.3
Education and employment		
Average years of education (years), mean (SD)	15.1 (1.4)	15.3 (0.9)
Current employment status, %[a]		
Employed	86.0	85.9
Unemployed[b]	5.0	4.7
Not in labor force	9.1	9.4
Experienced any weeks unemployed, past year, %	8.1	7.4
Number of weeks unemployed, past year, mean (SD)[a]	18.1 (15.6)	16.4 (10.3)
Tenure at current employer (years), mean (SD)[b]	6.6 (7.3)	7.3 (5.2)
Health outcomes		
Obesity	14.9	10.0
Moderate psychological distress[c]	24.7	23.0

n = sample size, SD = standard deviation
Source: Authors' calculation using the Panel Study of Income Dynamics
Note: All percentages calculated using the number of unique individuals.
[a]Only calculated for those who experienced any weeks of unemployment in the past year
[b]Only calculated for those currently employed
[c]Calculated using only the 2007 to 2017 PSID survey waves

Supplementary Table 6. Risk of obesity and moderate psychological distress by minimum wage and prior year unemployment comparing those with a high school education or less to those with some college education or more

	Weeks of unemployment, past year					
	0 weeks		24 weeks		52 weeks	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Obesity						
$1.00	0.95	(0.87, 1.03)	1.17	(0.88, 1.55)	1.49	(0.82, 2.71)
$2.00	0.90	(0.75, 1.07)	1.36	(0.77, 2.41)	2.22	(0.67, 7.32)
$3.00	0.85	(0.65, 1.10)	1.59	(0.67, 3.75)	3.30	(0.55, 19.81)
Moderate psychological distress[a]						
$1.00	0.89	(0.77, 1.03)	1.09	(0.91, 1.30)	1.37*	(1.02, 1.83)
$2.00	0.80	(0.60, 1.06)	1.18	(0.83, 1.69)	1.87*	(1.05, 3.35)
$3.00	0.72	(0.46, 1.09)	1.29	(0.76, 2.20)	2.56*	(1.07, 6.12)

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-difference-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate in those with ≥some college education. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007-2017 when the Kessler-6 item module was asked continuously

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

Supplementary Table 7. Risk of obesity and moderate psychological distress by minimum wage and years of tenure at current employer comparing those with high school education or less to those with some college education or more

	Years of tenure, current employer					
	1 year		5 years		10 years	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Obesity						
$1.00	0.92	(0.8, 1.05)	0.93	(0.85, 1.03)	0.96	(0.88, 1.04)
$2.00	0.84	(0.64, 1.09)	0.87	(0.72, 1.06)	0.92	(0.78, 1.08)
$3.00	0.77	(0.51, 1.15)	0.82	(0.61, 1.1)	0.88	(0.69, 1.13)
Moderate psychological distress[a]						
$1.00	0.88	(0.71, 1.1)	0.90	(0.75, 1.07)	0.92	(0.76, 1.1)
$2.00	0.78	(0.5, 1.2)	0.81	(0.57, 1.15)	0.84	(0.58, 1.22)
$3.00	0.68	(0.36, 1.32)	0.72	(0.43, 1.23)	0.77	(0.44, 1.35)

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-difference-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate in those with ≥some college education. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

[a] The Kessler 6-item module (K-6) was not asked in 2005, analyses restricted to 2007 to 2017 when the Kessler-6 item module was asked continuously

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

Supplementary Table 8. Risk of obesity by minimum wage and prior year unemployment in those with high school education or less excluding proxy responses

	Weeks of unemployment, past year					
	0 weeks		24 weeks		52 weeks	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
$1.00	0.89	(0.73, 1.08)	0.99	(0.78, 1.27)	1.14	(0.76, 1.69)
$2.00	0.79	(0.53, 1.16)	0.99	(0.61, 1.60)	1.29	(0.58, 2.85)
$3.00	0.70	(0.39, 1.26)	0.98	(0.47, 2.02)	1.46	(0.44, 4.81)

RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

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

Supplementary Table 9. Risk of obesity by minimum wage and tenure at current employer in those with high school education or less excluding proxy responses

	Years of tenure, current employer					
	1 year		5 years		10 years	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
$1.00	0.76*	(0.58, 0.99)	0.78	(0.61, 1.01)	0.81	(0.64, 1.03)
$2.00	0.58*	(0.34, 0.99)	0.61	(0.37, 1.01)	0.66	(0.41, 1.06)
$3.00	0.44*	(0.20, 0.98)	0.48	(0.23, 1.02)	0.54	(0.26, 1.10)

RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

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

Supplementary Table 10. Risk of obesity by minimum and tenure at current employer in those with a high school education or less excluding those workers who started their job in the same year the survey was administered

	Years of tenure, current employer					
	1 year		5 years		10 years	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Obesity						
$1.00	0.80	(0.61, 1.05)	0.82	(0.65, 1.04)	0.86	(0.70, 1.05)
$2.00	0.63	(0.37, 1.09)	0.68	(0.42, 1.09)	0.73	(0.49, 1.11)
$3.00	0.50	(0.22, 1.14)	0.56	(0.27, 1.14)	0.63	(0.34, 1.17)
Moderate psychological distress						
$1.00	1.02	(0.67, 1.55)	1.02	(0.70, 1.49)	1.02	(0.72, 1.45)
$2.00	1.03	(0.45, 2.39)	1.03	(0.48, 2.21)	1.04	(0.51, 2.09)
$3.00	1.05	(0.30, 3.69)	1.05	(0.34, 3.30)	1.06	(0.37, 3.03)

RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the 1999 to 2017 Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

* p <0.05, ** p <0.01, *** p <0.00

Supplementary Table 11. Risk of moderate psychological distress by minimum wage and prior year unemployment in those with high school education or less restricted to 2011 to 2017

	Weeks of unemployment, past year					
	0 weeks		24 weeks		52 weeks	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Overall						
$1.00	1.15	(0.87, 1.51)	1.30	(1.00, 1.7)	1.48*	(1.06, 2.06)
$2.00	1.32	(0.75, 2.29)	1.70	(1.00, 2.89)	2.19*	(1.13, 4.24)
$3.00	1.51	(0.66, 3.47)	2.21	(0.99, 4.92)	3.24*	(1.21, 8.72)
By gender						
Women						
$1.00	1.12	(0.82, 1.52)	1.13	(0.72, 1.78)	1.14	(0.53, 2.46)
$2.00	1.26	(0.68, 2.33)	1.28	(0.52, 3.18)	1.31	(0.28, 6.07)
$3.00	1.41	(0.56, 3.55)	1.45	(0.37, 5.67)	1.49	(0.15, 14.95)
Men						
$1.00	1.15	(0.75, 1.76)	1.44	(1.00, 2.09)	1.81**	(1.24, 2.66)
$2.00	1.32	(0.57, 3.09)	2.08	(0.99, 4.39)	3.29**	(1.53, 7.06)
$3.00	1.52	(0.42, 5.42)	3.01	(0.99, 9.19)	5.97**	(1.90, 18.75)

RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 14,726 person-years for the full sample, 9,898 person-years for women and 8,902 person-years for men. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

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

Supplementary Table 12. Risk of moderate psychological distress by minimum wage and years of tenure at current employer in those with high school education or less restricted to 2011 to 2017

	Weeks of unemployment, past year					
	0 weeks		24 weeks		52 weeks	
Minimum wage (State - Federal)	RR	95% CI	RR	95% CI	RR	95% CI
Overall						
$1.00	1.12	(0.74, 1.7)	1.10	(0.75, 1.60)	1.07	(0.75, 1.52)
$2.00	1.25	(0.54, 2.89)	1.20	(0.56, 2.57)	1.14	(0.56, 2.30)
$3.00	1.40	(0.40, 4.92)	1.31	(0.42, 4.11)	1.21	(0.42, 3.49)
By gender						
Women						
$1.00	1.06	(0.72, 1.56)	1.04	(0.74, 1.45)	1.00	(0.74, 1.35)
$2.00	1.13	(0.52, 2.45)	1.07	(0.55, 2.09)	1.00	(0.55, 1.81)
$3.00	1.20	(0.38, 3.83)	1.11	(0.41, 3.02)	1.00	(0.41, 2.43)
Men						
$1.00	1.12	(0.59, 2.13)	1.14	(0.61, 2.13)	1.16	(0.62, 2.17)
$2.00	1.26	(0.35, 4.55)	1.29	(0.37, 4.53)	1.35	(0.38, 4.71)
$3.00	1.41	(0.20, 9.71)	1.47	(0.23, 9.63)	1.56	(0.24, 10.22)

RR = risk ratio, CI = confidence interval

Source: Authors' calculation using the Panel Study of Income Dynamics

Notes: Estimates generated using a differences-in-differences model using modified Poisson regression. Educational attainment measured at baseline. Reference group for RR calculations is $0.00 or a state minimum wage equal to the federal minimum wage rate. Sample size is 14,726 person-years for the full sample, 9,898 person-years for women and 8,902 person-years for men. Models are adjusted for age, gender, marital status, race/ethnicity, state gross product, whether the state has a refundable EITC program, state sales tax rate, a SNAP policy indicator based on 1) non-citizens in the state are fully eligible for SNAP benefits, 2) state allows for the application of SNAP online, 3) state has any SNAP ban for drug felons, 4) state uses broad-based categorical eligibility to, a Medicaid policy indicator based on 1) Medicaid eligibility limits for children above median, 2) Medicaid eligibility limits for parents above median, 3) state has Medicaid program for non-citizens, 4) state expanded Medicaid program as part of the Affordable Care Act, state TANF benefit for a family of four, the percentage of residents who are in a union, and state and year fixed effects.

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

PROJECT CONCLUSION

In this project, we aimed to examine the longitudinal relation between higher minimum wages and obesity, hypertension, fair or poor health, and moderate psychological distress. This project also aimed to investigate how higher minimum wages were related to changes in daily cigarette and alcohol consumption, among consumers of those products, as well as engagement in physical activity. We further endeavored to explore the potential role of employment instability, as measured by the number of weeks spent unemployed in the prior year, and current employer tenure, in modifying the relation between obesity and moderate psychological distress.

We found no association between minimum wage and the selected health outcomes in the overall sample of employed and unemployed working-age adults. Although health behaviors such as smoking, drinking, and physical activity represent a key pathway through which minimum wage can influence long-term body weight and other health outcomes, we found little evidence, overall, of a relation. In most cases these primary findings in the full sample were similar when restricted to those adults who were employed and paid hourly at baseline.

However, we did find evidence of heterogeneity by race/ethnicity and gender for: obesity and smoking in non-Hispanic White men, obesity and moderate psychological distress in non-Hispanic White women, and fair or poor self-reported health in men of color. Estimates were largely robust to restriction to workers employed hourly at baseline. We also found limited but suggestive evidence that prior unemployment, but not employer tenure, may modify the relation between minimum wage, obesity, and moderate psychological distress with those exposed to both high minimum wages and greater unemployment having the highest risk.

These results, taken as a whole, suggest that higher minimum wages have little influence on health or health behavior. These findings are strikingly given that income and wages are known and strong determinants of health and well-being. However, these findings do not discount the value of higher minimum wages as a societal good. It is estimated that raising the US minimum wage to $15 an hour on the national scale could provide a pay increase to nearly half of all Americans.[5] While this increase would represent a boon to many individuals earning low and minimum wage along with their families, it is possible that such an incremental increases on the local and national scale may not go far enough to

improve health. Although the goal of minimum wage increases is to improve the economic rather than the physical and mental well-being, good health should figure prominently into how we as a society measure the benefits of social and income policies. As a 2008 report by World Health Organization's Commission on the Social Determinants of Health astutely put: *"Health and health equity may not be the aim of all social policies, but they will be a fundamental result."*[127]

We also found limited but suggestive evidence that prior unemployment, but not employer tenure, may modify the relation between minimum wage, obesity, and moderate psychological distress. We found that the greatest risk of obesity and moderate psychological distress was highest when less-educated individuals experienced full-year unemployment in states when the minimum wage was $3 higher than the federal wage rate. These findings highlight the importance of examining the economic circumstances of individuals when evaluating the relation between social and income policies and health. In addition, these results have implications for labor, social, and income policies. Policies which increase wages or provide boluses of income will likely have little influence on health on their own. Instead, local and state governments as well as the federal government should consider moving multiple policy leverages jointly to simultaneously address multiple determinants of health and provide greater economic stability and security for individuals and households. One example of this would be to raise the income cut off points for local, state, federal benefit programs such as SNAP, WIC, TANF, and EITC when the minimum wage is increased.[70,128] Another would be to provide free or subsidized childcare so that parents can more easily participate in the labor force without a heavy cost burden.[129] The pathways through which minimum wage policies could act to influence health and are nuanced and multifaceted and may manifest differently across subpopulations. We will believe that examination of the influence of multiple policy levers combined with economic circumstances, such as unemployment, on health represents an important and fruitful avenue of research. This line of research is also particularly timely as the US debates a federal minimum wage increase and as governments worldwide seek to ameliorate the long-term health and economic impacts ushered in by the current public health crisis through innovative policies targeted at individuals and businesses.

Future studies should examine local minimum wage initiatives as well as the psychosocial and behavioral pathways through which minimum wage may operate to influence health through mediational

analyses. In addition, this study highlights the need for more diverse cohorts with sufficient representation to evaluate the combined influence of race/ethnicity and gender as well as other sociodemographic factors. Studies should also consider the extent to which macroeconomic conditions (e.g. state unemployment) or social and incomes (e.g. EITC) could jointly operate with minimum wage policies influence health and behavior. Furthermore, researchers should consider examine how other aspects of, and cumulative exposure to, employment instability influences the relation between minimum wage and incident as was as recurrent physical and mental health outcomes.

REFERENCES

1. Centers for Disease Control and Prevention. *CDC Health Disparities and Inequalities Report, United States, 2013*. Vol 62.; 2013. http://health-equity.lib.umd.edu/4187/1/CDC_Health_Disparities_and_Inequalities_Report.pdf. Accessed June 24, 2018.
2. American Public Health Association. Improving Health by Increasing the Minimum Wage. https://www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2017/01/18/improving-health-by-increasing-minimum-wage. Published 2016. Accessed June 24, 2018.
3. Leigh JP, Leigh W, Du J. Minimum Wages and Public Health: A Literature Review. *Prev Med (Baltim)*. 2019;118:122-134.
4. Bureau of Labor Statistics. *Characteristics of Minimum Wage Workers, 2019*.; 2020. https://www.bls.gov/opub/reports/minimum-wage/2019/home.htm. Accessed May 26, 2020.
5. Ross M, Bateman N. *Meet the Low-Wage Workforce*.; 2019. https://www.brookings.edu/wp-content/uploads/2019/11/201911_Brookings-Metro_low-wage-workforce_Ross-Bateman.pdf.
6. Henry J. Kaiser Family Foundation. Disparities in health and health care: five key questions and answers. https://www.kff.org/disparities-policy/issue-brief/disparities-in-health-and-health-care-five-key-questions-and-answers/. Accessed July 26, 2018.
7. Townsend J, Roderick P, Cooper J. Cigarette smoking by socioeconomic group, sex, and age: effects of price, income, and health publicity. *BMJ*. 1994;309(6959):923-927. http://www.ncbi.nlm.nih.gov/pubmed/7950662. Accessed August 11, 2018.
8. Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci*. 2012;1248(1):107-123. doi:10.1111/j.1749-6632.2011.06202.x
9. Laaksonen M, Rahkonen O, Karvonen S, Lahelma E. Socioeconomic status and smoking. *Eur J Public Health*. 2005;15(3):262-269. doi:10.1093/eurpub/cki115
10. Karriker-Jaffe KJ, C. M. Roberts S, Bond J. Income Inequality, Alcohol Use, and Alcohol-Related Problems. *Am J Public Health*. 2013;103(4):649-656. doi:10.2105/AJPH.2012.300882
11. Shimotsu ST, Jones-Webb RJ, Lytle LA, MacLehose RF, Nelson TF, Forster JL. The Relationships among Socioeconomic Status, Fruit and Vegetable Intake, and Alcohol Consumption. *Am J Heal Promot*. 2012;27(1):21-28. doi:10.4278/ajhp.110311-QUAN-108
12. Elliott M, Lowman J. Education, income and alcohol misuse: a stress process model. *Soc Psychiatry Psychiatr Epidemiol*. 2015;50(1):19-26. doi:10.1007/s00127-014-0867-3
13. Kari JT, Pehkonen J, Hirvensalo M, et al. Income and Physical Activity among Adults: Evidence from Self-Reported and Pedometer-Based Physical Activity Measurements. Harezlak J, ed. *PLoS One*. 2015;10(8):e0135651. doi:10.1371/journal.pone.0135651
14. Shuval K, Lik Q, Gabriel KP, Tchernis R. Income, physical activity, sedentary behavior, and the 'weekend warrior' among U.S. adults. *Prev Med (Baltim)*. 2017;103:91-97. https://www-clinicalkey-com.offcampus.lib.washington.edu/#!/content/playContent/1-s2.0-S0091743517302803?returnurl=null&referrer=null. Accessed August 11, 2018.
15. Buszkiewicz J, House C, Aggarwal A, Long M, Drewnowski A, Otten JJ. The Impact of a City-Level Minimum Wage Policy on Supermarket Food Prices by Food Quality Metrics: A Two-Year Follow Up Study. *Int J Environ Res Public Health*. 2019;16(1):102. doi:10.3390/ijerph16010102
16. Leigh JP. Arguments for and Against the $15 Minimum Wage for Health Care Workers. *Am J Public Health*. 2019;109(2):206-207. doi:10.2105/AJPH.2018.304880
17. Horn BP, Maclean JCJC, Strain MR. Do minimum wage increases influence worker health? *Econ Inq*. 2017;55(4):1-34.
18. Lenhart O. The impact of minimum wages on population health: evidence from 24 OECD countries. *Eur J Heal Econ*. 2017;18(8):1031-1039.
19. Lenhart O. Do Higher Minimum Wages Benefit Health? Evidence From the UK. *J Policy Anal Manag*. 2017;36(4):828-852.
20. Buszkiewicz JH, Hill HD, Otten JJ. State minimum wage rates and health in working-age adults using the National Health Interview Survey. *Am J Epidemiol*. February 2020. doi:10.1093/aje/kwaa018
21. Andreyeva E, Ukert B. The impact of the minimum wage on health. *Int J Heal Econ Manag*. March 2018:1-39.

22. National Center for Health Statistics. *Health, United States, 2016: With Chartbook on Long-Term Trends in Health*. Hyattsville, MD; 2017.
23. Ahonen EQ, Fujishiro K, Cunningham T, Flynn M. Work as an Inclusive Part of Population Health Inequities Research and Prevention. *Am J Public Health*. 2018;108(3):306-311. doi:10.2105/AJPH.2017.304214
24. Fujishiro K, MacDonald LA, Howard VJ. Job Complexity and Hazardous Working Conditions: How Do They Explain Educational Gradient in Mortality? *J Occup Health Psychol*. 2019. doi:10.1037/ocp0000171
25. UC Berkeley Labor Center. Inventory of US City and County Minimum Wage Ordinances. http://laborcenter.berkeley.edu/minimum-wage-living-wage-resources/inventory-of-us-city-and-county-minimum-wage-ordinances/. Accessed January 28, 2018.
26. Neumark D, Wascher W. *Minimum Wages*. Cambridge, MA: The MIT Press; 2008.
27. Belman D, Wolfson P. *What Does the Minimum Wage Do?* Kalamazoo, MI: Upjohn Institute for Employment Research; 2014.
28. Van Dyke ME, Komro KA, Shah MP, et al. State-level minimum wage and heart disease death rates in the United States, 1980–2015: A novel application of marginal structural modeling. *Prev Med (Baltim)*. 2018;112:97-103.
29. Kaufman JA, Salas-Hernández LK, Komro KA, Livingston MD. Effects of increased minimum wages by unemployment rate on suicide in the USA. *J Epidemiol Community Health*. January 2020. doi:10.1136/jech-2019-212981
30. Gertner AK, Rotter JS, Shafer PR. Association Between State Minimum Wages and Suicide Rates in the U.S. *Am J Prev Med*. 2019;56(5):648-654. doi:10.1016/j.amepre.2018.12.008
31. Dow W, Godøy A, Lowenstein C, Reich M. *Can Economic Policies Reduce Deaths of Despair?* Cambridge, MA; 2019. doi:10.3386/w25787
32. Conklin AI, Ponce NA, Frank J, Nandi A, Heymann J, Prättälä R. Minimum Wage and Overweight and Obesity in Adult Women: A Multilevel Analysis of Low and Middle Income Countries. Schooling CM, ed. *PLoS One*. 2016;11(3):e0150736. doi:10.1371/journal.pone.0150736
33. Reeves A, McKee M, Mackenbach J, Whitehead M, Stuckler D. Introduction of a National Minimum Wage Reduced Depressive Symptoms in Low-Wage Workers: A Quasi-Natural Experiment in the UK. *Health Econ*. 2017;26(5):639-655.
34. Kronenberg C, Jacobs R, Zucchelli E. The impact of the UK National Minimum Wage on mental health. *SSM - Popul Heal*. 2017;3:749-755.
35. Averett SL, Smith JK, Wang Y. The effects of minimum wages on the health of working teenagers. *Appl Econ Lett*. 2017;24(16):1127-1130.
36. Ogden CL, Fakhouri TH, Carroll MD, et al. Prevalence of obesity among adults, by household income and education — United States, 2011-2014. *Morb Mortal Wkly Rep*. 2017;66(50):1369-1373. doi:10.15585/mmwr.mm6650a1
37. Leigh JP, Du J. Are low wages risk factors for hypertension? *Eur J Public Health*. 2012;22(6):854-859. doi:10.1093/eurpub/ckr204
38. Frasquilho D, Matos MG, Salonna F, et al. Mental health outcomes in times of economic recession: A systematic literature review Health behavior, health promotion and society. *BMC Public Health*. 2016;16(1):1-40. doi:10.1186/s12889-016-2720-y
39. Leigh JP, De Vogli R. Low Wages as Occupational Health Hazards. *J Occup Environ Med*. 2016;58(5):444-447.
40. Braveman PA, Cubbin C, Egerter S, Williams DR, Pamuk E. Socioeconomic Disparities in Health in the United States: What the Patterns Tell Us. *Am J Public Health*. 2010;100(S1):S186-S196. doi:10.2105/AJPH.2009.166082
41. Pollack CE, Cubbin C, Sania A, et al. Do wealth disparities contribute to health disparities within racial/ethnic groups? *J Epidemiol Community Health*. 2013;67(5):439-445. doi:10.1136/jech-2012-200999
42. Pickett KE, Wilkinson RG. Income inequality and health: A causal review. *Soc Sci Med*. 2015;128:316-326.
43. Shern DL, Blanch AK, Steverman SM. Toxic stress, behavioral health, and the next major era in public health. *Am J Orthopsychiatry*. 2016;86(2):109-123. doi:10.1037/ort0000120
44. Silva D, Ferriani L, Viana MC. Depression, anthropometric parameters, and body image in adults: A systematic review. *Rev Assoc Med Bras*. 2019;65(5):731-738. doi:10.1590/1806-9282.65.5.731

45. Khubchandani J, Price JH. Association of Job Insecurity with Health Risk Factors and Poorer Health in American Workers. *J Community Health*. 2017;42(2):242-251. doi:10.1007/s10900-016-0249-8
46. Milner A, Witt K, LaMontagne AD, Niedhammer I. Psychosocial job stressors and suicidality: A meta-analysis and systematic review. *Occup Environ Med*. 2018;75(4):245-253. doi:10.1136/oemed-2017-104531
47. Drewnowski A, Buszkiewicz J, Aggarwal A, Rose C, Gupta S, Bradshaw A. Obesity and the Built Environment: A Reappraisal. *Obesity*. 2020;28(1):22-30. doi:10.1002/oby.22672
48. Drewnowski A, Kawachi I. Diets and Health: How Food Decisions Are Shaped by Biology, Economics, Geography, and Social Interactions. *Big Data*. 2015;3(3):193-197. doi:10.1089/big.2015.0014
49. Healy GN, Matthews CE, Dunstan DW, Winkler EAH, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 200306. *Eur Heart J*. 2011;32(5):590-597. doi:10.1093/eurheartj/ehq451
50. Malik VS, Popkin BM, Bray GA, Després J-P, Hu FB. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Circulation*. 2010;121(11):1356-1364. doi:10.1161/CIRCULATIONAHA.109.876185
51. University of Michigan Survey Research Center. Panel Study of Income Dynamics (PSID): Main Interview, 1968-2015. 2018.
52. United States Department of Labor Wage and Hour Division. Changes in basic minimum wage in non-farm employment under state law: Selected years 1968 to 2017. https://www.dol.gov/whd/state/stateMinWageHis.htm. Published 2017. Accessed August 28, 2018.
53. Tax Foundation. Sales Taxes. https://taxfoundation.org/state-tax/sales-taxes/. Published 2018. Accessed August 28, 2018.
54. Tax Policy Center. State EITC as Percentage of the Federal EITC. https://www.taxpolicycenter.org/statistics/state-eitc-percentage-federal-eitc. Accessed August 28, 2018.
55. University of Kentucky Center for Poverty Research. UKCPR National Welfare Data, 1980-2016. 2017. http://www.ukcpr.org/data. Accessed May 5, 2017.
56. United States Census Bureau. American Community Survey. https://www.census.gov/programs-surveys/acs/. Accessed August 28, 2018.
57. Henry J. Kaiser Family Foundation. Annual Updates on Eligibility Rules, Enrollment and Renewal Procedures, and Cost-Sharing Practices in Medicaid and CHIP. https://www.kff.org/medicaid/report/annual-updates-on-eligibility-rules-enrollment-and/. Published 2018. Accessed August 28, 2018.
58. Center for Economic and Policy Research. CPS ORG Uniform Extracts, Version 2.4. 2019.
59. Kessler RC, Green JG, Gruber MJ, et al. Screening for serious mental illness in the general population with the K6 screening scale: results from the WHO World Mental Health (WMH) survey initiative. *Int J Methods Psychiatr Res*. 2010;19 Suppl 1(0 1):4-22.
60. Prochaska JJ, Sung HY, Max W, Shi Y, Ong M. Validity study of the K6 scale as a measure of moderate mental distress based on mental health treatment need and utilization. *Int J Methods Psychiatr Res*. 2012;21(2):88-97. doi:10.1002/mpr.1349
61. Clark KL, Pohl RV, Thomas RC. Minimum Wages and Healthy Diet. *SSRN*. September 2019. http://dx.doi.org/10.2139/ssrn.2892894.
62. Du J, Leigh JP. Effects of Minimum Wages on Absence from Work Due to Illness. *B E J Econom Anal Policy*. 2018;18(1):1-23.
63. Angrist J, Pischke J. *Mastering Metrics: The Path from Cause to Effect*. Princeton: Princeton University Press; 2014. https://books.google.com/books?hl=en&lr=&id=dEh-BAAAQBAJ&oi=fnd&pg=PP1&dq=angrist+measuring+metrics&ots=mqGLGMzf3r&sig=64o2ERfdMJ71ISRL61yNx8SjSmQ.
64. Strumpf E, Harper S, Kaufman J. Fixed Effects and Difference-in-Differences. In: Oakes JM, Kaufman JS, eds. *Methods in Social Epidemiology*. Second. San Francisco, California: Jossey-Bass; 2017:341-368.
65. Zou G. A Modified Poisson Regression Approach to Prospective Studies with Binary Data. *Am J Epidemiol*. 2004;159(7):702-706. doi:10.1093/aje/kwh090
66. StataCorp. Stata Statistical Software: Release 15. 2017.

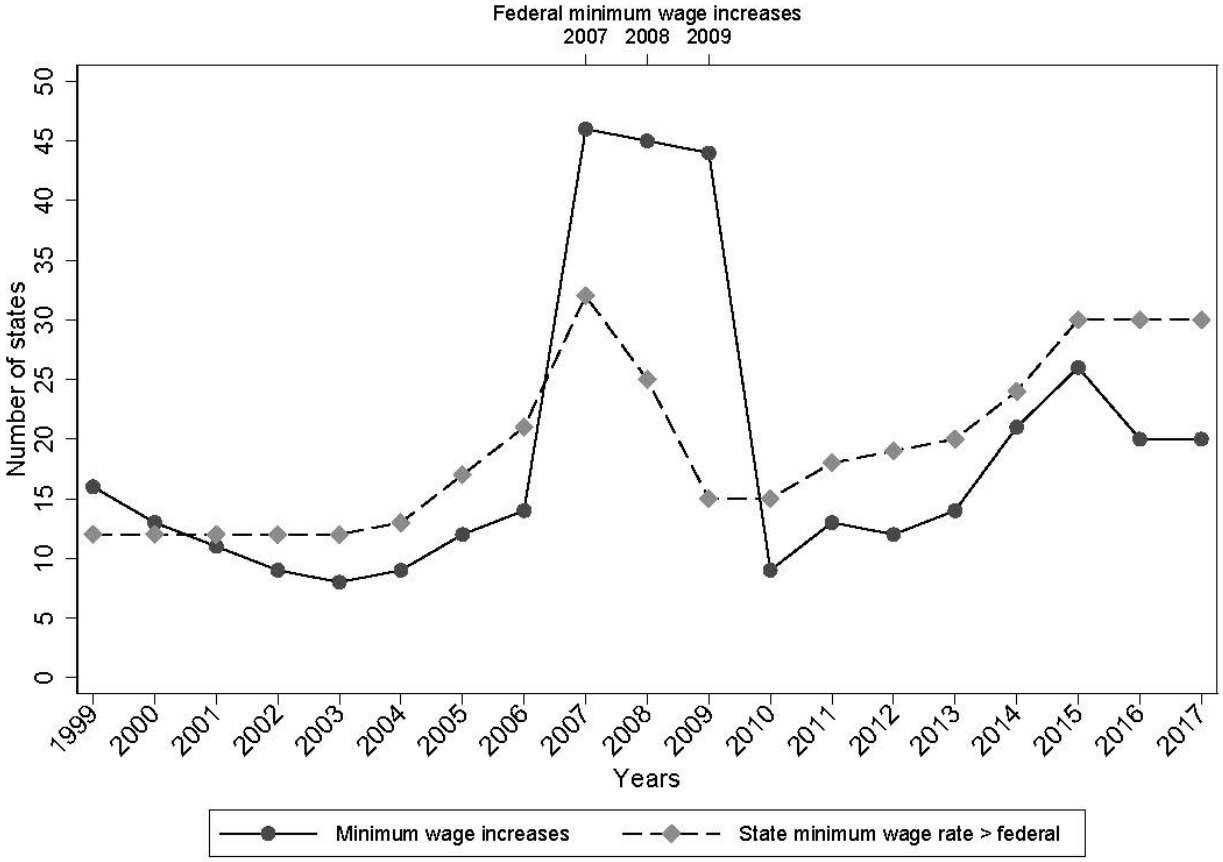
67. Wing C, Simon K, Bello-Gomez RA. Designing Difference in Difference Studies: Best Practices for Public Health Policy Research. *Annu Rev Public Health*. 2018;39(1):453-469. doi:10.1146/annurev-publhealth-040617-013507
68. Wehby G, Dave DM;, Kaestner R. Effects of the Minimum Wage on Infant Health. *IZA Discuss Pap*. 2018;(10039). doi:10.3386/w22373
69. Leigh JP. Could Raising the Minimum Wage Improve the Public's Health? *Am J Public Health*. 2016;106(8):1355-1356. doi:10.2105/AJPH.2016.303288
70. Hill HD, Romich J. How Will Higher Minimum Wages Affect Family Life and Children's Well-Being? *Child Dev Perspect*. 2017;12(2):109-114. doi:10.1111/cdep.12270
71. Lenhart O. Higher Wages, Less Gym Time? The Effects of Minimum Wages on Time Use. *South Econ J*. 2019;86(1). doi:10.1002/soej.12352
72. Reeves A, McKee M, Mackenbach J, Whitehead M, Stuckler D. Introduction of a National Minimum Wage reduced depressive symptoms in low-wage workers: a natural experiment in the UK. *Eur J Public Health*. 2014;24(suppl_2).
73. Fujishiro K, Hajat A, Landsbergis P, Meyer J, Schreiner P, JD K. Explaining racial/ethnic differences in all-cause mortality in the Multi-Ethnic Study of Atherosclerosis (MESA): Substantive complexity and hazardous working conditions as mediating factors. *SSM - Popul Heal*. 2017;3:497-505.
74. Assari S. Unequal gain of equal resources across racial groups. *Int J Heal Policy Manag*. 2018;7(1):1-9. doi:10.15171/ijhpm.2017.90
75. Dube A, Lester TW, Reich M. Minimum Wage Effects Across State Borders: Estimates Using Contiguous Counties. *Rev Econ Stat*. 2010;92(4):945-964. doi:10.1162/REST_a_00039
76. Kuehn D. Spillover Bias in Cross-Border Minimum Wage Studies: Evidence from a Gravity Model. *J Labor Res*. 2016;37(4):441-459. doi:10.1007/s12122-016-9234-3
77. McKinnish T. Cross-state differences in the minimum wage and out-of-state commuting by low-wage workers. *Reg Sci Urban Econ*. 2017;64:137-147. doi:10.1016/J.REGSCIURBECO.2017.02.006
78. Shirley P. The response of commuting patterns to cross-border policy differentials: Evidence from the American Community Survey. *Reg Sci Urban Econ*. 2018;73:1-16. doi:10.1016/J.REGSCIURBECO.2018.04.011
79. Grossman M. On the concept of health capital and the demand for health. *J Polit Econ*. 1972;80(2):223-255. http://www.jstor.org/stable/1830580. Accessed April 23, 2017.
80. Apouey B, Clark AE. Winning big but feeling no better? The effect of lottery prizes on physical and mental health. *Health Econ*. 2015;24:516-538.
81. Kenkel DS, Schmeiser MD, Urban C. Is smoking inferior? Evidence from variation in the earned income tax credit. *J Hum Resour*. 2014;49(4):1094-1120.
82. Chaloupka F, Warner K. *The Economics of Smoking*. Cambridge, MA; 1999.
83. Bravin JI, Bunge EL, Evare B, Wickham RE, Pérez-Stable EJ, Muñoz RF. Socioeconomic predictors of smoking cessation in a worldwide online smoking cessation trial. *Internet Interv*. 2015;2(4):410-418. doi:10.1016/j.invent.2015.10.001
84. Pryce R, Hollingsworth B, Walker I. Alcohol quantity and quality price elasticities: quantile regression estimates. *Eur J Heal Econ*. 2019;20(3):439-454. doi:10.1007/s10198-018-1009-8
85. van Kippersluis H, Galama TJ. Wealth and health behavior: Testing the concept of a health cost. *Eur Econ Rev*. 2014;72:197-220. doi:10.1016/j.euroecorev.2014.10.003
86. Dziadkiewicz J, Pisani A, Wong R. Does a Recession have an Impact on Alcohol Consumption? *Deakin Pap Int Bus Econ*. 2015;8(1). doi:10.21153/dpibe2015vol8no1art508
87. Strully KW, Rehkopf DH, Xuan Z. Effects of Prenatal Poverty on Infant Health. *Am Sociol Rev*. 2010;75(4):534-562. doi:10.1177/0003122410374086
88. Hoke O, Cotti C. Minimum wages and youth binge drinking. *Empir Econ*. 2016;51(1):363-381.
89. Cantrell J, Bennett M, Mowery P, et al. Patterns in first and daily cigarette initiation among youth and young adults from 2002 to 2015. *PLoS One*. 2018;13(8). doi:10.1371/journal.pone.0200827
90. Caetano R, Mills BA, Vaeth PAC, Reingle J. Age at first drink, drinking, binge drinking, and dsm-5 alcohol use disorder among hispanic national groups in the United States. *Alcohol Clin Exp Res*. 2014;38(5):1381-1389. doi:10.1111/acer.12354
91. National Institute on Alcohol Abuse and Alcoholism. Alcohol facts and statistics. https://www.niaaa.nih.gov/sites/default/files/AlcoholFactsAndStats.pdf. Published 2020.

92. Ruhm CJ. Healthy living in hard times. *J Health Econ*. 2005;24(2):341-363. https://www-sciencedirect-com.offcampus.lib.washington.edu/science/article/pii/S0167629604001250. Accessed August 11, 2018.
93. Ruhm C. *Health Effects of Economic Crises*. Cambridge, MA; 2015. doi:10.3386/w21604
94. Adams S, Blackburn ML, Cotti CD. Minimum Wages and Alcohol-Related Traffic Fatalities among Teens. *Rev Econ Stat*. 2012;94(3):828-840.
95. U.S. Department of Health and Human Services. *Physical Activity Guidelines for Americans, 2nd Edition.* Washington, DC; 2018.
96. Smith V, Halpin B. Low-wage Work Uncertainty often Traps Low-wage Workers - UC Davis Center for Poverty Research. https://poverty.ucdavis.edu/policy-brief/low-wage-work-uncertainty-often-traps-low-wage-workers. Accessed May 26, 2020.
97. Hill HD, Romich J, Mattingly MJ, Shamsuddin S, Wething H. An Introduction to Household Economic Instability and Social Policy. *Soc Serv Rev*. 2017;91(3):371-389. doi:10.1086/694110
98. Cooper M, Pugh AJ. Families Across the Income Spectrum: A Decade in Review. *J Marriage Fam*. 2020;82(1):272-299. doi:10.1111/jomf.12623
99. Kim TJ, Von Dem Knesebeck O. Is an insecure job better for health than having no job at all? A systematic review of studies investigating the health-related risks of both job insecurity and unemployment. *BMC Public Health*. 2015;15(1):985. doi:10.1186/s12889-015-2313-1
100. Waynforth D. Unstable employment and health in middle age in the longitudinal 1970 British Birth Cohort Study. *Evol Med Public Heal*. 2018;2018(1):92-99.
101. Julià M, Vanroelen C, Bosmans K, Van Aerden K, Benach J. Precarious Employment and Quality of Employment in Relation to Health and Well-being in Europe. *Int J Heal Serv*. 2017;47(3):389-409. doi:10.1177/0020731417707491
102. Phillips JA, Nugent CN. Suicide and the Great Recession of 2007-2009: The role of economic factors in the 50 U.S. states. *Soc Sci Med*. 2014;116:22-31. doi:10.1016/j.socscimed.2014.06.015
103. Flint E, Bartley M, Shelton N, Sacker A. Do labour market status transitions predict changes in psychological well-being? *J Epidemiol Community Health*. 2013;67(9):796-802. doi:10.1136/jech-2013-202425
104. Herber GC, Ruijsbroek A, Koopmanschap M, et al. Single transitions and persistence of unemployment are associated with poor health outcomes. *BMC Public Health*. 2019;19(1):740. doi:10.1186/s12889-019-7059-8
105. Zenger M, Hinz A, Petermann F, Brähler E, Stöbel-Richter Y. Gesundheit und Lebensqualität im Kontext von Arbeitslosigkeit und Sorgen um den Arbeitsplatz. *PPmP - Psychother · Psychosom · Medizinische Psychol*. 2013;63(03/04):129-137. doi:10.1055/s-0032-1332989
106. Griep Y, Kinnunen U, Nätti J, et al. The effects of unemployment and perceived job insecurity: a comparison of their association with psychological and somatic complaints, self-rated health and life satisfaction. *Int Arch Occup Environ Health*. 2016;89(1):147-162. doi:10.1007/s00420-015-1059-5
107. Beck L, Quinn EL, Hill HD, Wolf J, Buszkiewicz J, Otten JJ. Low-income worker's perceptions of wages, food acquistion, and well-being. *Transl Behav Med*. 2019;9(5):942-951.
108. Jardim E, Long M, Plotnick R, van Inwegen E, Vigdor J, Wething H. *Minimum Wage Increases and Individual Employment Trajectories*.; 2018.
109. Jardim E, Long M, Plotnick R, van Inwegen E, Vigdor J, Wething H. *Minimum Wage Increases, Wages, and Low-Wage Employment: Evidence from Seattle*. Cambridge, MA; 2018. doi:10.3386/w23532
110. Sandstrom H, Huerta S. *THe Negative Effects of Instability on Child Development*.; 2013.
111. Glonti K, Gordeev VS, Goryakin Y, et al. A Systematic Review on Health Resilience to Economic Crises. Nishi D, ed. *PLoS One*. 2015;10(4):e0123117. doi:10.1371/journal.pone.0123117
112. Windarti N, Hlaing SW, Kakinaka M. Obesity Kuznets curve: international evidence. *Public Health*. 2019;169:26-35. doi:10.1016/j.puhe.2019.01.004
113. Kim D, Leigh JP. Estimating the effects of wages on obesity. *J Occup Environ Med*. 2010;52(5):495-500. doi:10.1097/JOM.0b013e3181dbc867
114. Carlson A, Frazão E. Food costs, diet quality and energy balance in the United States. *Physiol Behav*. 2014;134:20-31. doi:10.1016/j.physbeh.2014.03.001
115. Larson NI, Story MT. Food insecurity and weight status among U.S. children and families: A review of the literature. *Am J Prev Med*. 2011;40(2):166-173. doi:10.1016/j.amepre.2010.10.028

116. Nguyen BT, Shuval K, Bertmann F, Yaroch AL. The supplemental nutrition assistance program, food insecurity, dietary quality, and obesity among US adults. *Am J Public Health*. 2015;105(7):1453-1459. doi:10.2105/AJPH.2015.302580
117. Boyd-Swan CH, Herbst C, Ifcher J, Zarghamee H. The Earned Income Tax Credit, Health, and Happines. *SSRN Electron J*. December 2012.
118. Gundersen C. SNAP and Obesity. In: Bartfield J, Gundersen C, Smeeding T, Ziliak JP, eds. *SNAP Matters: How Food Stamps Affect Health and Well-Being*. Standford University Press; 2016:161-185.
119. Vandello JA, Hettinger VE, Bosson JK, Siddiqi J. When Equal Isn't Really Equal: The Masculine Dilemma of Seeking Work Flexibility. *J Soc Issues*. 2013;69(2):303-321. doi:10.1111/josi.12016
120. Lakerveld J, Mackenbach J. The Upstream Determinants of Adult Obesity. *Obes Facts*. 2017;10(3):216-222. doi:10.1159/000471489
121. Drewnowski A, Aggarwal A, Tang W, Moudon A. Residential property values predict prevalent obesity but do not predict 1-year weight change. *Obesity*. 2015;23(3):671-676. http://onlinelibrary.wiley.com/doi/10.1002/oby.20989/full. Accessed June 4, 2017.
122. Tekin E, McClellan C, Minyard KJ. *Health and Health Behaviors during the Worst of Times*. Cambridge, MA; 2017. doi:10.3386/w19234
123. Tekin E, McClellan C, Minyard KJ. Health and health behaviors during the great recession: a note on drinking, smoking, obesity, and physical activity. *Rev Econ Househ*. 2018;16(4):1017-1026. doi:10.1007/s11150-017-9364-2
124. Ruhm CJ. Health Effects of Economic Crises. *Health Econ*. 2016;25:6-24. doi:10.1002/hec.3373
125. Koltai J, Stuckler D. Recession hardships, personal control, and the amplification of psychological distress: Differential responses to cumulative stress exposure during the U.S. Great Recession. *SSM - Popul Heal*. 2020;10:100521. doi:10.1016/j.ssmph.2019.100521
126. Conklin AI, Daoud A, Shimkhada R, Ponce NA. The impact of rising food prices on obesity in women: a longitudinal analysis of 31 low-income and middle-income countries from 2000 to 2014. *Int J Obes*. August 2018. doi:10.1038/s41366-018-0178-y
127. Commission on Social Determinants of Health. *Closing the Gap in a Generation Health Equity through Action on the Social Determinants of Health*. Geneva; 2008. http://apps.who.int/iris/bitstream/handle/10665/43943/9789241563703_eng.pdf;jsessionid=68E667130750E16E33A98569E783B415?sequence=1. Accessed June 24, 2018.
128. Jennifer Romich, Heather D. Hill. Coupling a Federal Minimum Wage Hike with Public Investments to Make Work Pay and Reduce Poverty. *RSF Russell Sage Found J Soc Sci*. 2018;4(3):22. doi:10.7758/rsf.2018.4.3.02
129. Otten JJ, Bradford VA, Stover B, et al. The culture of health in early care and education: Workers' wages, health, and job characteristics. *Health Aff*. 2019;38(5):709-720. doi:10.1377/hlthaff.2018.05493

APPENDIX

Appendix Figure 1. Changes in minimum wage rates and their relation to the federal minimum wage rate across all 50 states and the District of Columbia, 1999-2017



Source: University of Kentucky Center for Poverty Research[55]
Note: Minimum wage rate assignment is based on the year in which the minimum wage law was first implemented. This differs from the Bureau of Labor Statistics estimates which assign the minimum wage rates to the first full year in which the minimum wage would cover workers. Therefore, above, minimum wage increases at the federal level occur from 2007-2009, but according to the Bureau of Labor Statistics these changes would occur from 2008-2010.

Appendix Table 1. State policies and characteristics, 1999-2017

State policy or characteristic	Year									
	1999	2001	2003	2005	2007	2009	2011	2013	2015	2017
Policies										
Minimum wage (USD), mean (SD)[a]	7.78 (0.43)	7.47 (0.68)	7.30 (0.84)	7.08 (0.95)	7.69 (0.78)	8.47 (0.39)	8.13 (0.43)	7.93 (0.50)	8.23 (0.82)	8.37 (1.22)
Relative minimum wage (SMW/MSW), %[b]	39.2	36.7	35.2	34.5	38.3	41.7	40.9	39.9	40.3	39.5
Refundable EITC, count	6	8	8	14	16	21	22	22	22	22
Sales tax, mean (SD)	4.7 (1.8)	4.7 (1.8)	4.7 (1.8)	4.8 (1.9)	4.9 (1.9)	5.1 (2.0)	5.1 (2.0)	5.1 (2.0)	5.1 (2.0)	5.1 (2.0)
TANF benefit (family of 4, USD), mean (SD)	837 (136)	863 (142)	913 (157)	955 (168)	981 (172)	1061 (178)	1142 (186)	1144 (187)	1140 (196)	1139 (195)
Medicaid policies										
Elig. limit for children >median, count[c]	12	12	13	13	16	23	25	25	24	25
Elig. limit for parents >median, count[d]	25	25	24	24	25	25	25	25	3	4
Expansion for ACA, count	0	0	0	0	0	0	0	0	30	32
Non-citizen program	0	0	0	0	0	0	22	26	30	32
Medicaid policy indictor										
0 policies, count	23	23	22	22	20	18	14	13	11	8
1 policy, count	19	19	21	21	21	18	16	15	14	16
2 policies, count	9	9	8	8	10	15	7	8	7	6
3-4 policies, count	0	0	0	0	0	0	14	15	19	21
SNAP policies										
Non-citizens fully eligible, count	8	9	6	6	6	6	3	3	3	3
Online application, count	0	0	4	9	19	25	35	43	45	45
No ban for drug felons, count	12	12	12	15	16	19	18	19	20	21
Broad-based categorical eligibility	0	9	9	11	13	27	41	41	40	40
SNAP policy indicator										
0 policies, count	34	28	27	21	17	10	2	1	1	1
1 policy, count	14	18	18	22	19	15	13	9	11	12
2 policies, count	3	3	5	6	11	17	25	27	21	19
3-4 policies, count	0	2	1	2	4	9	11	14	18	19
Characteristics										
GSP (in thousands USD), mean (SD)	188 (225)	206 (250)	223 (270)	254 (309)	282 (346)	281 (343)	303 (370)	327 (409)	355 (452)	380 (489)
% of population in a union, mean (SD)	14.6 (6.1)	14.0 (6.1)	13.3 (6.1)	12.9 (6.4)	12.6 (6.1)	12.7 (6.3)	12.1 (6.0)	11.6 (5.9)	11.4 (5.4)	11.0 (5.5)

USD = United States dollars; EITC = Earned Income Tax Credit; SD = standard deviation; TANF = Temporary Assistance for Needy Families; Elig. = eligibility; ACA = Affordable Care Act; SNAP = Supplemental Nutrition Assistance Program; GSP = Gross State Product

Sources: United States Department of Labor Wage and Hour Division,[52] Tax Foundation,[53] Tax Policy Center,[54] University of Kentucky Center for Poverty Research,[55] United States Census Bureau,[56] Henry J. Kaiser Family Foundation,[57] Center for Economic and Policy Research.[58]

[a]Adjusted to 2017 US dollars

[b]Adjusted state median wage based on all sectors, hourly and salaried, for workers 25-64 years of age

[c]Due to a preponderance of states with Medicaid eligibility limits for children ≤ the median value of 200% of the federal poverty level in 1999, 2001, 2003, 2005, and 2007, the distribution is skewed and the split uneven

[d]Due to a preponderance of states with Medicaid eligibility limits for parents ≤ the median value of 138% of the federal poverty level in 2015 and 2017, the distribution is highly skewed and the split uneven

Appendix Table 2. Sample characteristics at first observation comparing movers and non-movers, PSID 1999-2017

Characteristics	Movers	Non-movers	P-value
Sample size, individuals, n	3,173	10,557	--
Demographics			
Age (years), mean (SD)	31.9 (8.2)	35.6 (9.5)	<0.001
Women, %	48.1	50.4	0.022
Persons of color, %	39.5	45.5	<0.001
Race and gender, %			
Non-Hispanic White men	32.5	28.3	<0.001
Non-Hispanic White women	28.0	26.2	
Men of color	19.4	21.3	
Women of color	20.1	24.2	
Socioeconomic status			
Average years of education (years), mean (SD)	14.1 (2.2)	13.3 (2.3)	<0.001
Employment status, %[a]			
Employed	85.1	86.6	0.001
Unemployed	7.3	7.6	
Not in labor force	7.6	5.8	
Paid hourly, %[b]	51.4	62.4	<0.001
Hourly wage rate (USD), mean (SD)[b,c]	14.65 (13.87)	13.98 (21.71)	0.3103
Hourly wage rate ≤150% of state minimum wage, %)[b,c]	27.3	25.3	0.1600

SD = standard deviation; USD = United States dollars

Source: Author calculations using the 1999-2017 and 2007-2017 Panel Study of Income Dynamics

[a]11 individuals missing employment status at their first observation

[b]Unemployed category includes only those who were actively seeking employment, i.e. “attached to the labor force.”

[c]Only calculated for those individuals who were employed, and those individuals paid hourly with tips or commission were excluded

[d]Only calculated for those individuals who were paid hourly

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$