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Abstract

Despite substantial declines since the 1960’s, heart disease remains the leading cause of death in the United States (US) and geographic disparities in heart disease mortality have grown. State-level socioeconomic factors might be important contributors to geographic differences in heart disease mortality. This study examined the association between state-level minimum wage increases above the federal minimum wage and heart disease death rates from 1980 to 2015 among ‘working age’ individuals aged 35–64 years in the US. Annual, inflation-adjusted state and federal minimum wage data were extracted from legal databases and annual state-level heart disease death rates were obtained from CDC Wonder. Although most minimum wage and health studies to date use conventional regression models, we employed marginal structural models to account for possible time-varying confounding. Quasi-experimental, marginal structural models accounting for state, year, and state × year fixed effects estimated the association between increases in the state-level minimum wage above the federal minimum wage and heart disease death rates. In models of ‘working age’ adults (35–64 years old), a $1 increase in the state-level minimum wage above the federal minimum wage was on average associated with ~6 fewer heart disease deaths per 100,000 (95% CI: −10.4, −1.99), or a state-level heart disease death rate that was 3.5% lower per year. In contrast, for older adults (65+ years old) a $1 increase was on average associated with a 1.1% lower state-level heart disease death rate per year (b = −28.9 per 100,000, 95% CI: −71.1, 13.3). State-level economic policies are important targets for population health research.

Conflict of interest

The authors have no conflicts of interest to disclose.
1. Introduction

Despite substantial declines in heart disease death rates in the United States (US) over the past 60 years (Cooper et al., 2000; Ford et al., 2007; Van Dyke et al., 2018), heart disease remains the leading cause of death (Xu et al.). Moreover, geographic disparities in heart disease mortality have grown in the US (Casper et al., 2016; Vaughan et al., 2014). State-level socioeconomic factors may be important contributors to geographic differences in heart disease death rates (Greer et al., 2016; Wing et al., 1988). Specifically, state-level minimum wage policies could influence the individual-level income of lower-wage workers, thereby impacting access to heart disease prevention and treatment (Mensah, 2005). Socioeconomic status as measured by income and/or education has been associated with the risk of heart disease among adults (Franks et al., 2011; Kaplan and Keil, 1993; Kelli et al., 2017).

Over time, Congress mandates increases in the federal minimum wage to adjust for inflation. However, some states choose to implement increases in the minimum wage above the federal minimum wage (Labor, U.S.D.o, 2017). Between-state variation in decisions to increase the minimum wage above the federal minimum provides an opportunity to examine the impact of the minimum wage on state-level health outcomes.

There is a small but growing literature examining the relationship between minimum wage policy changes in the US and health. A study examining the association between state minimum wage laws in the US and low birth weight and infant mortality from 1980 to 2011 found that every dollar increase in the state-level minimum wage above the federal minimum wage was linked with a 1–2% decrease in low birth weight and a 4% decrease in infant mortality (Komro et al., 2016). Another study spanning 25 years found that increases in the state minimum wage were associated with increases in birth weight, increases in prenatal care use, and declines in smoking during pregnancy (Wehby et al., 2016). A simulation study of the impact of a hypothetical increase in the minimum wage in New York City on premature mortality found that a $15 minimum wage may avert 4 to 8% of premature deaths, with most of the avoidable deaths being among lower-income communities consisting of primarily racial minorities (Tsao et al., 2016).

A study of 24 countries from 1980 to 2010 observed decreases in deaths from diseases of the circulatory system, stroke, and heart attack as the generosity of the minimum wage at the country-level increased, although much of the association appeared to be driven by lower-resource, as opposed to higher-resource, countries (Lenhart, 2016). To our knowledge, there are no studies estimating the association between changes in the state-level minimum wage and heart disease death rates over time in the US. This ecologic study aims to describe the association between state-level minimum wage increases above the federal minimum wage and heart disease death rates from 1980 to 2015 in the US. Although most minimum wage and health studies to date rely on conventional regression methods, this study employs...
marginal structural models given the possibility of time-varying confounding in the minimum wage-heart disease relationship over time.

2. Methods

2.1. State-level heart disease death data

For our primary analyses, we extracted age-adjusted, annual heart disease death rates for the total population, ages 35–64, by year and state from CDC WONDER (https://wonder.cdc.gov/) for 1980–2015. This age restriction includes working age adults and recognizes the etiology for heart disease among people younger than 35 is different than that of people of older ages (Rubin and Borden, 2012). Data for adults ages 65 and older were extracted for supplemental analyses. Heart disease deaths were defined based on underlying cause of death according to the following International Classification of Diseases (ICD) codes: ICD-9: 390 to 398, 402, 404 to 429; ICD-10: I00 to I09, I11, I13, I20 to I51. Comparability ratios for heart disease ICD-codes are very close to 1 for the entire study period, indicating that changes in codes do not affect the ability to compare rates across ICD time periods (Anderson et al., 2001). We calculated heart disease death rates (deaths per 100,000 persons) for the 50 US states and the District of Columbia.

2.2. State-level minimum wage

State-level and federal minimum wage law for all 50 US states and the District of Columbia from 1980 to 2015 were extracted by research attorneys from the following: US Department of Labor website, state-specific legislature websites, and state-specific department of labor websites. Minimum wage data were coded based on the effective date rather than the passage date. Detailed information on the coding of the minimum wage data and the quality control measures for data collection and coding are described elsewhere (Komro et al., 2016). The difference between the state-level minimum wage and the federal minimum wage in June was calculated for each state and year from 1980 through 2015 and inflation adjusted to 2015 dollars. This magnitude of state-specific differences from the federal minimum wage is the primary exposure in this study.

2.3. Addressing confounding

Our aim is to leverage the ‘natural experiment’ represented by state-specific decisions to intermittently mandate a higher minimum wage than federal standards. However, this contrast of states with higher versus lower minimum wage could only reflect the causal effect of minimum wage policy if there were no other factors, such as demographic structure, concurrent social welfare policies, or socioeconomic status, that might confound the association. In our design, we consider three classes of state-level confounders.

First, there are measurable differences in state-level demographic structure and socioeconomic status that can be adjusted for in multi-variable regression. Unemployment rate among non-institutionalized civilians over age 16 was extracted annually from 1980 to 2015 (Labor, U.S.D.o, n.d). We extracted state median household income for 1984–2015, poverty rate for 1980–2015, proportion of population ages 25 and older with a high school education or more for 1980 and 1988–2015, and proportion black in 1980, 1990, 2000, and
2010 from US Census Bureau datasets. Median household income was inflation-adjusted to 2015 dollars. Linear interpolation and extrapolation imputed annual values of each measure when missing.

Second, there could be unobserved differences between states or trends over time that confound the association. For example, states with a higher minimum wage might have different political, social, and economic context that affects public health systems or social safety nets. These unobserved confounders can be adjusted for with fixed effects for state, year, and the interaction of state × year.

Finally, the rapid growth in causal inference literature has highlighted time-varying confounding as a third class of confounders that has been previously ignored. For example, in a given year, the unemployment rate might confound the association between the minimum wage and heart disease mortality, requiring statistical adjustment. However, there is some debate as to how the minimum wage in one year might affect unemployment in subsequent years (Card and Krueger, 1994; Dube et al., 2010; Neumark and Wascher, 1997; Office, 2014). In this setting, unemployment in a given year might confound the association in that year, but also mediate the association from the minimum wage to heart disease mortality in previous years (see Supplementary Fig. 1). Conventional multivariable regression methods are unable to adjust for time-varying confounding, but new causal methods including marginal structural models (MSM) using inverse probability of treatment weights can achieve this aim (Hernan et al., 2002; Hernan et al., 2005).

2.4. Statistical analysis

Descriptive statistics of all state-level variables were summarized by Census region (see Appendix A) for 1980 and 2015. Descriptive maps of the difference between the federal and the state-level minimum wage for each state for 1980 and 2015 were created using ArcMap 10.4.1 (Redlands, California).

To account for both conventional and time-varying confounding, our primary analyses estimate the association between the state level minimum wage and heart disease mortality using inverse probability of treatment weights to fit marginal structural models (Nandi et al., 2012; Robins et al., 2000) fit in R 3.3 (Vienna, Austria). Specifically, we adjusted for state-level socioeconomic and demographic variables described above, included fixed effects for state, year, state × year, and – recognizing that there may be not only state-level but also regional differences in political and social context – we included fixed effects for Census region. Further details about the MSM methodology can be found in Appendix B [insert link]. Time-lagged MSM examined the relationship between minimum wage policy and heart disease mortality in marginal structural models with zero, one, and two-year lags.

2.5. Exploratory analysis

We conducted three exploratory analyses to supplement our primary approach. First, as a form of negative control, we estimated the association between the minimum wage and heart disease mortality among adults over 65 who could be considered the placebo sample as they are presumably less directly affected by minimum wage policy than working age adults. Second, individuals in lower-paying, or minimum-wage, jobs are most susceptible to the
economic and health impacts of changes in minimum wage policy. Thus, conditional on the
valid estimation of the minimum wage-heart disease mortality relationship, we tested
whether minimum wage changes were associated more or less strongly with heart disease
mortality in states with larger versus smaller minimum wage worker populations. State-level
estimates of minimum wage workers from the US Bureau of Labor Statistics were only
available for years 2002–2015. Finally, we estimated conventional multivariable regression
models. Marginal structural models and conventional multivariable regression should give
similar results in the absence of time-varying confounding (Hernan et al., 2005); therefore,
this supplementary analysis aims to quantify the degree of time-varying confounding.

3. Results

3.1. Descriptive analyses

Region-specific descriptive summaries of state-level minimum wage, socioeconomic
measures, and heart disease death rates for 1980 and 2015 are provided in Table 1 and Fig.
1. In 1980, average minimum wage values (in 2015 dollars) were similar across US regions
at $8.94–$8.95. However, in 2015, there was greater variation– Northeastern states had the
highest average minimum wage value at $8.40, and Southern states had the lowest average
minimum wage value at $7.61. In 1980, Southern states on average had the largest deviation
from the federal minimum wage with 8.5 cents more, while in 2015, Northeastern states on
average had the largest difference—$1.13 over the federal minimum wage. Heart disease
death rates for individuals aged 35–64 year were on average highest in Southern states in
1980 (219.5 per 100,000) and 2015 (110.8 per 100,000) and lowest in Western states in 1980
(158.7 per 100,000) and in Northeastern states in 2015 (62.6 per 100,000) (Table 1).

3.2. Primary analysis

In fully-adjusted marginal structural models (Table 2), increases in the state-level minimum
wage above the federal value were associated with a reduction in heart disease death rates.
In lag-zero models, a $1 increase was associated with ~6 fewer heart disease deaths per
100,000 individuals aged 35–64 years per year (b = −6.22 per 100,000, 95% Confidence
Interval (CI): −10.4, −1.99). In one- and two-year lagged models—examining the effect of
the minimum wage in a given year on heart disease one and two years later—a $1 increase
in the state-level minimum wage above the federal minimum wage was associated with ~5
fewer deaths per 100,000 (lag-1: b = −5.44 per 100,000, 95% CI: −9.28, −1.60; lag-2: b =
−5.07 per 100,000, 95% CI: −8.04, −2.09).

3.3. Exploratory analysis

In models in which heart disease death rates were restricted to adults aged 65 and older,
there was a non-significant decline in heart disease deaths with each $1 increase in the
minimum wage (b = −28.9 per 100,000, 95% CI: −71.1, 13.3; Supplementary Table 1). To
contrast this association with the primary association, we must recognize that the baseline
heart disease death rate in adults aged 65 and older is approximately ten times greater than
the rate for adults aged 35–64. Normalizing the beta coefficient for the minimum wage to
the intercept in each model, we see that each $1 increase in the minimum wage is associated
with a significant 3.5% decline in heart disease deaths for working age adults, and with a non-significant 1.1% decline for those 65 and older.

Considering the modifying role of the percent of minimum wage workers in a state, the primary exposure-outcome association was strongest in states with the largest percent (between 6 and 9%) of minimum wage workers ($b = -786.2$ per 100,000, 95% CI: −1850.7, 278.4) and was attenuated among states with a lower percent of minimum wage workers (between 0 and 6%, $b = -10.2$ per 100,000, 95% CI: −10.3, −9.97). However, these results should be interpreted with caution given the imprecise CIs and small sample size for states with the largest percent of minimum wage workers, the relatively low percent of minimum wage workers in states, and the wide gap in the effect estimates between categories.

To diagnose the presence and magnitude of time-varying confounding, we compared our primary results from marginal structural models to those from conventional multivariable regression models, including the same covariates as marginal structural models. Both crude and multivariable-adjusted conventional regression models had associations in the same direction as marginal structural models, although the associations were substantially attenuated and not statistically significant (Supplementary Table 2).

4. Discussion

In the current study, increases in the state-level minimum wage above the federal value were associated with a reduction in heart disease death rates among individuals aged 35–64 years. The inverse associations between state-level minimum wage increases above the federal minimum wage and state-level heart disease death rates are consistent with research documenting the importance of economic policy for health (Leigh, 2016; Wehby et al., 2016), and more specifically of minimum wage policy for health (Bullinger, 2017; Komro et al., 2016; Tsao et al., 2016; Wehby et al., 2016). In particular, our findings are in line with a study which observed an inverse association between the generosity of the minimum wage at the country-level and deaths from diseases of the circulatory system, stroke, and heart attack from 1980 to 2010 (Lenhart, 2016).

Although our primary study findings are in line with recent work, these findings should be interpreted with caution for several reasons. For instance, the ecologic design of this study evaluates the relationship between state-level minimum wage policy and state-level heart disease mortality rates but does not necessarily reflect the association for individuals. A strength of this ecologic design, however, is that, aside from the federal government, states are the political unit where minimum wage policy is most often implemented, and therefore a meaningful level of aggregation. Thus, comparing the experience of states with higher versus lower minimum wage standards permits examination of population health under competing ‘intervention’ levels.

However, one challenge with understanding the effects of individual state-level policies on health is concern for confounding: minimum wage policies likely do not act independently of other welfare and social policies. It is possible that states who choose to adopt minimum wages above the federal minimum wage may be more likely to invest in safety net and
health promotion and access policies that are important for heart health. Prior research has documented the intertwined relationship of state contextual factors and the distribution of health in the US (Montez et al., 2017). In a study examining state-level differences in adult disability, US states with less income inequality, longer histories of low-income tax credits, and greater economic output had a lower prevalence of adult disability (Montez et al., 2017). By including fixed effects for state, year, and state × year (state-specific time trends) in our analysis, we aim to control for multiple sources of unobserved confounding by social and political context. Although this approach adjusts for within and between state differences, it does not account for the implementation of other social policies in the same year and state as a change in the minimum wage. Related to confounding by other social policies, is the interest in the synergistic effects of multiple social policies. Future research should consider the combined role of minimum wage policy and other economic policies, such as the Earned Income Tax Credit (EITC) (Hoynes et al., 2012), although secondary analyses found a weak association between changes in the state minimum wage and changes in the state specific EITC. Other policies of interest may include healthcare access and public health policies (Mays and Smith, 2011).

An additional consequence of the ecologic design and our reliance on death certificates is that we are limited in our ability to disaggregate the population into the sub-groups most likely to be affected by minimum wage policy. One level of stratification that is possible with these data is by age, and we focus our primary analysis on adults presumed to be approximately of ‘working age’ (35–64 years old); we contrast this primary analysis to a negative control group, those who are 65 or older and presumed to be less likely to be affected by minimum wage policies. While there is an inverse association between minimum wage increases and heart disease in each group, the relative magnitude of the association is three times larger for working age adults as compared to older adults, with the association attenuated to null in older adults.

However, beyond age stratification, it is not possible to restrict our data to subpopulations defined by employment status, occupation type, education and/or income and thus more likely affected by the minimum wage. Our exploratory analyses suggest that the effects of the minimum wage on heart disease mortality are in fact stronger in states with a larger fraction of the population working in minimum wage jobs, but these estimates were imprecise and should be interpreted with caution. Other studies (Bullinger, 2017; Horn et al., 2017; Marks, 2011; Simon and Kaestner, 2004) have been able to identify populations that are more or less likely to be impacted by minimum wage changes. Sabia and Nielson (2015) found minimal support that state and federal minimum wage increases reduced poverty and material hardship between 1996 and 2007 among specific groups of the population, such as workers and younger individuals with less than a high-school diploma, although some evidence was found suggesting modest beneficial effects of minimum wage increases among lower skilled workers. Additionally, Kuroki (2017) observed an increase in life satisfaction among workers with less than a high-school diploma as state minimum wages increased from 2005 to 2010, and Lenhart (2017b) found a reduction in smoking, drinking, and body weight following an increase in the minimum wage specifically among lower-educated individuals from 1989 to 2015.
The emerging literature on causal inference in longitudinal data analysis has drawn attention to the unique challenges of addressing time-varying confounding, which occurs when past exposures or interventions (e.g., changes in minimum wage policy) affect not only concurrent, but future covariates. Thus, some variables (e.g., unemployment or poverty rates) that may confound the association at one point in time might also mediate a portion of the past effect of the minimum wage on subsequent heart disease rates. Conventional multivariable regression, which has been used by most minimum wage and health studies to date, fails to account for this class of confounder, but newer methods including marginal structural models relying on inverse probability of treatment weights can adjust for both time-varying and more conventional forms of confounding bias.

The difference in the magnitude of association between the minimum wage and heart disease mortality in conventional multi-variable regression as compared to marginal structural models in the current analysis suggests the presence of important time-varying confounding that would otherwise be missed (Nandi et al., 2012). While marginal structural models do aid in the valid estimation of casual effects in the face of time-varying confounding by measured covariates, just like conventional regression, valid inference is conditioned on correct specification of the causal structure (see Supplementary Fig. 1) and the absence of additional unmeasured confounding. For example, although the proportion of unemployed individuals in a given state is relatively small, evidence suggests that the relationship between employment status and health during economic progress (or recession) is complex (Ruhm, 2000). Thus, this complex relationship may not be fully accounted for in this study. Moreover, evidence suggests there is a complex relationship between poverty, employment, and minimum wage policy (Neumark and Wascher, 1997), such that changes in minimum wage policy have been found to be associated with increases in the likelihood that poor families leave poverty and non-poor families enter into poverty. Thus, the careful consideration of the interplay between these three factors is needed in future research.

Finally, our outcome—heart disease deaths—conflates the effects of increasing the minimum wage on heart disease incidence (i.e., primary prevention) versus progression of prevalent heart disease (i.e., secondary or tertiary prevention). This is important because economic policies such as the minimum wage could influence both short- and long-term health and health behaviors. For example, prior research has documented associations between reductions over time in the minimum wage and increases in obesity (Meltzer and Chen, 2009). Moreover, research has documented the association between low wages and future diagnosis of hypertension (Leigh and Du, 2012), and smoking (Du and Leigh, 2015). A 2017 study (Lenhart, 2017a) found that the introduction of a national minimum wage in the UK was associated with decreases in smoking and alcohol consumption and increases in gym membership and leisure activity expenditures among low-wage workers. Increases in income through raises in the minimum wage may lead to the increased ability to pay for necessities, as well as related decreases in financial stress and adverse psychosocial factors (Lenhart, 2017a; Reeves et al., 2016). Moreover, there may be a possible link between increases in the minimum wage and decreases in income inequality (Lenhart, 2017a), thereby positively impacting heart health. While these life course processes may well be important, our design and results are limited in disentangling the mechanisms, and this should be an area of future research.
5. Conclusion

Inter-state variation in social and economic policies represent opportunities for leveraging natural experiments to understand population health consequences. In this study examining the association between the state-level minimum wage and heart disease death rates in the US among individuals aged 35–64 years from 1980 to 2015, increases in the state-level minimum wage above the federal value were associated with a reduction in heart disease death rates. This association persisted in time-lag models and was largely absent in a negative control population, adults over 65 years of age. The study of intended and unintended consequences of social and economic policy is complex, but the findings from this study are consistent with positive health consequences of increases in the minimum wage among working age individuals in the US. Moreover, this study provides an example of the utility of marginal structural modeling vs. conventional regression methods when time-varying confounding is a potential concern. This contributes to a small but growing body of literature characterizing population health consequences of a higher minimum wage.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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References


Card D, Krueger AB. Minimum wages and employment: a case study of the fast-food industry in New Jersey and Pennsylvania. Am Econ Rev. 1994; 84


Horn BP, Maclean JC, Strain MR. Do Minimum Wage Increases Influence Worker Health. 2017IZA Institute of Labor Economics IZA DP No. 10479


Lenhart O. Pathways Between Minimum Wages and Health: The Role of Health Care Access and Health Behaviors Social Science Research Network. 2017b


Office CB. The Effects of a Minimum-wage Increase on Employment and Family Income. 2014


Fig. 1.
Table 1

Distribution of state-level minimum wage, heart disease death rates, demographic and socioeconomic characteristics in the United States by region: 1980 and 2015 (n = 50 States and District of Columbia).

<table>
<thead>
<tr>
<th>Region</th>
<th>Midwest (N = 12)</th>
<th>Northeast (N = 9)</th>
<th>South (N = 17)</th>
<th>West (N = 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>1980 Difference between state and federal minimum wage, (2015 dollars $^*$)</td>
<td>0 (0)</td>
<td>0.006 (0.019)</td>
<td>0.085 (0.350)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Minimum wage (2015 dollars $^*$)</td>
<td>8.94 (0)</td>
<td>8.94 (0)</td>
<td>8.94 (0)</td>
<td>8.95 (0.02)</td>
</tr>
<tr>
<td>Heart disease death rate (per 100,000) - 35–64 years old</td>
<td>180.7 (21.1)</td>
<td>189.7 (15.0)</td>
<td>219.5 (23.4)</td>
<td>158.7 (21.7)</td>
</tr>
<tr>
<td>Heart disease death rate (per 100,000) - 65+ years old</td>
<td>2581.9 (239.8)</td>
<td>2753.8 (266.4)</td>
<td>2597.6 (206.4)</td>
<td>2281.2 (248.8)</td>
</tr>
<tr>
<td>% black</td>
<td>6.0 (5.1)</td>
<td>5.7 (5.4)</td>
<td>22.1 (15.4)</td>
<td>2.7 (2.4)</td>
</tr>
<tr>
<td>% poverty</td>
<td>12.0 (3.0)</td>
<td>10.5 (2.5)</td>
<td>16.9 (4.0)</td>
<td>11.7 (3.3)</td>
</tr>
<tr>
<td>% population with high school degree or more</td>
<td>69.8 (3.0)</td>
<td>69.0 (3.6)</td>
<td>64.1 (8.2)</td>
<td>78.6 (4.4)</td>
</tr>
<tr>
<td>Median household income (2015 dollars $^*$)</td>
<td>47,767 (3398)</td>
<td>52,335 (7612)</td>
<td>43,993 (8609)</td>
<td>52,277 (7947)</td>
</tr>
<tr>
<td>% unemployment</td>
<td>6.9 (2.5)</td>
<td>6.6 (1.2)</td>
<td>6.9 (1.3)</td>
<td>6.8 (1.5)</td>
</tr>
<tr>
<td>2015 Difference between state and federal minimum wage, (2015 dollars $^*$)</td>
<td>0.409 (0.414)</td>
<td>1.134 (0.825)</td>
<td>0.342 (0.609)</td>
<td>0.909 (0.771)</td>
</tr>
<tr>
<td>Minimum wage (2015 dollars $^*$)</td>
<td>7.68 (0.41)</td>
<td>8.40 (0.83)</td>
<td>7.61 (0.61)</td>
<td>8.18 (0.77)</td>
</tr>
<tr>
<td>Heart disease death rate (per 100,000) - 35–64 years old</td>
<td>78.3 (16.8)</td>
<td>62.6 (9.5)</td>
<td>110.8 (26.1)</td>
<td>69.1 (17.2)</td>
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<tr>
<td>Heart disease death rate (per 100,000) - 65+ years old</td>
<td>1055.9 (143.2)</td>
<td>1058.3 (89.2)</td>
<td>1159.8 (150.9)</td>
<td>961.6 (105.8)</td>
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<td>% black</td>
<td>7.6 (4.7)</td>
<td>7.7 (5.6)</td>
<td>21.9 (11.4)</td>
<td>2.99 (2.39)</td>
</tr>
<tr>
<td>% poverty</td>
<td>11.4 (1.7)</td>
<td>10.2 (1.8)</td>
<td>14.9 (3.3)</td>
<td>11.8 (2.77)</td>
</tr>
<tr>
<td>% population with high school degree or more</td>
<td>91.9 (1.7)</td>
<td>92.3 (1.5)</td>
<td>89.2 (2.1)</td>
<td>90.5 (3.1)</td>
</tr>
<tr>
<td>Median household income (2015 dollars $^*$)</td>
<td>57,660 (4606)</td>
<td>63,236 (8348)</td>
<td>51,118 (9718)</td>
<td>59,809 (8601)</td>
</tr>
<tr>
<td>% unemployment</td>
<td>4.3 (1.0)</td>
<td>4.9 (0.9)</td>
<td>5.6 (0.8)</td>
<td>5.1 (1.2)</td>
</tr>
</tbody>
</table>

Note. Difference = Federal minimum wage minus state-level minimum wage.  
$^*$ Inflation-adjusted to 2015 dollars.
Table 2

Marginal structural model regression associations between state-level minimum wage increases above federal minimum wage and heart disease death rates among individuals aged 35–64 years in the United States, 1980–2015 (n = 50 States and District of Columbia).

<table>
<thead>
<tr>
<th></th>
<th>Marginal structural</th>
<th>Marginal structural one-year Lag&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Marginal structural two-year Lag&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta</td>
<td>95% CI lower</td>
<td>95% CI upper</td>
</tr>
<tr>
<td>Intercept</td>
<td>175.53</td>
<td>163.6</td>
<td>187.48</td>
</tr>
<tr>
<td>$1 increase in state-level minimum wage above federal minimum wage</td>
<td>−6.22</td>
<td>−10.4</td>
<td>−1.99</td>
</tr>
</tbody>
</table>

Note. HD = Heart Disease. CI = Confidence Interval. Marginal structural model adjusts for time-varying confounding via inverse probability treatment weighting. Beta = Change in heart disease death rates per 100,000 for $1 increase in state-level minimum wage above federal minimum wage.

<sup>a</sup>Model adjusted for state-level % population with high school degree or more, median household income, % unemployment, % poverty, and % black (all centered at mean) and includes fixed effects for state, year, state × year, and region.