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State-level minimum wage and heart disease death rates in the United States, 1980–2015: A novel application of marginal structural modeling

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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.

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

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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 multivariable 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