

Effects of increased minimum wages by unemployment rate on suicide in the USA

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ABSTRACT

Background Social welfare policies such as the minimum wage can affect population health, though the impact may differ by the level of unemployment experienced by society at a given time. **Methods** We ran difference-in-differences models using monthly data from all 50 states and Washington, DC from 1990 to 2015. We used educational attainment to define treatment and control groups. The exposure was the difference between state and federal minimum wage in US\$2015, defined both by the date the state law became effective and lagged by 1 year. Models included state and year fixed effects, and additional state-level covariates to account for state-specific time-varying confounding. We assessed effect modification by the state-level unemployment rate, and estimated predicted suicide counts under different minimum wage scenarios. **Results** The effect of a US\$1 increase in the minimum wage ranged from a 3.4% decrease (95% CI 0.4 to 6.4) to a 5.9% decrease (95% CI 1.4 to 10.2) in the suicide rate among adults aged 18–64 years with a high school education or less. We detected significant effect modification by unemployment rate, with the largest effects of minimum wage on reducing suicides observed at higher unemployment levels. **Conclusion** Minimum wage increases appear to reduce the suicide rate among those with a high school education or less, and may reduce disparities between socioeconomic groups. Effects appear greatest during periods of high unemployment.

INTRODUCTION

Suicide is a major cause of death in the USA.¹ In 2017, there were >47 100 preventable suicide deaths in the USA; suicide accounted for 19% of deaths among adults ages 18–24% and 11% among adults ages 25–44 years,² and 8% of total years of life lost before age 65 years.³ Suicide rates have increased by >30% in half of US states from 1999 to 2017,¹ contributing to a decline in US life expectancy.^{4 5} Suicide loss has a tremendous impact on families, communities and employers, with lifetime medical and work loss costs in the US totaling US\$50–US\$90 billion in 2013.^{6 7}

Suicide is often associated with financial stressors such as job loss, debt or financial hardship,^{8 9} but less is known about how economic interventions such as minimum wage policies could ameliorate these risk factors. Suicide¹⁰ and depression^{11 12} disproportionately affect individuals with lower educational attainment and lower incomes. Individuals with less education are more likely to work at or near the minimum wage; among workers ages ≥16 years in

2017, 4% of those without a high school diploma were paid the federal minimum, compared with <1% of college graduates.¹³ There is evidence of spillover effects of minimum wage increases such that people working at low-wage jobs above the minimum also benefit,^{14 15} with some estimates that a federal increase would impact 25% of US workers. Groups with lower educational attainment in the USA also experience higher unemployment rates.¹⁶ Periods of unemployment have been linked to increases in adverse mental health outcomes including depression, substance use disorders and suicide.^{17 18}

Life expectancy of the richest 20% of Americans has increased over the last three decades, while life expectancy of the middle 60% has changed little, and has decreased for the poorest 20%.¹⁹ Minimum wage increases may be one intervention to reduce income-based disparities in life expectancy, including from suicide; two recent studies found that state minimum wage increases may reduce suicide rates.^{10 20} However, this effect may differ depending on the economic environment in which minimum wage policies operate. More generous social welfare policies, such as unemployment insurance, can offset the impact of unemployment on suicide rates, especially during economic recessions.^{8 21 22} Thus, the level of unemployment experienced by society at a given time may be an important effect modifier of the relationship between minimum wage policies and mental health. The buffering effect of higher minimum wages on suicide risk for low-wage workers and their dependents may be stronger during times of high unemployment, when acute and chronic financial stress are higher.

We conducted a natural experiment study using difference-in-differences (DD) models to estimate the effect of an increased minimum wage on suicide rates among US adults with a high school education or less, using data from all 50 states and Washington, DC from 1990 to 2015. We used educational attainment to define treatment (≤high school education) and control (≥college degree) groups. To build on prior studies,^{10 20} we assessed how the state-level unemployment rate modifies the relationship between minimum wage and suicide, and estimated the number of suicides that may have occurred under different minimum wage scenarios given this effect modification. Though the federal minimum hourly wage increased from US\$3.80 in 1990 to US\$7.25 in 2015, adjusting for inflation reveals essentially no change, and since the 1968 peak the inflation-adjusted minimum wage has decreased²³; currently, 29 individual states and



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Washington, DC have raised their minimum wages, while 21 maintain the lower federal minimum.

METHODS

Data

The main independent variable was the difference between the effective state and federal minimum hourly wage for each of the 50 states and Washington, DC for each month from 1990 to 2015, based on the date a legislative bill became effective as law (rather than the passage date), and this metric lagged by 1 year. The US federal minimum wage is the lower bound hourly pay rate required by federal law, though state governments may set higher rates; thus, the difference between the effective state and federal minimum for states not raising it is zero. We used the unlagged metric to estimate immediate effects of policy change, for example, on acute stress, and used the lagged metric as a robustness check as we do not know what the relevant population-average lag time for an effect is, for example, if the effect is primarily on chronic stress. We adjusted for inflation by expressing all minimum wage variables in US\$2015. For quality control, two trained legal researchers performed blinded independent coding of minimum wage policy data, with 86% first-pass agreement. A supervising attorney reviewed protocols with coders for variables showing $\geq 5\%$ disagreement between coders, and resolved all divergences. We derived state specific monthly unemployment rates for 1990–2015 from the Bureau of Labor Statistics Local Area Unemployment Statistics file; estimates were not specific for educational levels because of data limitations.

The dependent variable was suicide rates by month for 50 states and Washington, DC from 1990 to 2015 for adults ages 18–64 years. We obtained data on suicide counts by month by state and related covariates (e.g., educational attainment) from the National Vital Statistics System, which provides complete, longitudinal mortality data with every death certificate. We estimated state-by-year populations by education level, percent male, percent white, and mean age using weighted data from the current population survey.²⁴ We obtained additional state-level economic covariates from the University of Kentucky Center for Poverty Research.

Design and analysis

We treat variation in the state-specific minimum wage as a continuous treatment variable. Changes in state-specific minimum wage over time reflect a change in the ‘dose’ of state-specific income support, representing a long-term, ongoing natural experiment. To isolate effects of minimum wage on suicide, we use the DD design,²⁵ using natural assignment to a state-month with a particular minimum wage rather than randomised exposure. In addition to our state-level minimum wage variable, all models included a full set of year fixed effects to control for time-dependent factors common across states, and state fixed effects to control for time-invariant state-specific factors. We further include the following state-by-year economic covariates to control for state-specific time-varying confounding: gross state product, unemployment rate, number of Aid to Families with Dependent Children (AFDC)/Temporary Assistance for Needy Families (TANF) recipients and personal income. To better approximate an intent-to-treat analysis, we restricted our models to those with \leq high school education, who are more likely to work at or near the minimum wage and are therefore more likely to be affected by minimum wage changes. In addition to estimating the overall effect of minimum wage on suicide,

we estimated whether this effect varied across the state-specific unemployment rate over time.

We used generalised estimating equations with robust SEs to account for clustering by state. To estimate changes in suicide rates, we used Poisson regression to model suicide counts among those with \leq high school education, using the log of state population with \leq high school education as the offset. All models included fixed effects for state and year. Models estimating whether the effect of minimum wage varied across level of unemployment included additional terms for monthly state-specific unemployment rate and the interaction between minimum wage and unemployment rate. All models were estimated using PROC GENMOD in SAS V.9.4. To increase interpretability of this continuous-by-continuous interaction, we used marginal standardisation²⁶ via PROC PLM to estimate model-predicted suicide rates in each state-month. These estimates were then graphed as a contour map to show the effect of minimum wage on suicide at differing unemployment levels. To further illustrate the impact of minimum wage on suicide, we estimated the yearly total predicted suicide count among adults aged 18–64 years with \leq high school education under three different scenarios: the prevailing state minimum wage, and all states fixed to US\$1 and US\$2 above the effective state level (in US\$2015).

The DD design relies on an identifying assumption that pre-intervention trends in less intensely treated states sufficiently represent the counterfactual among more intensely treated states, that is, the parallel trends assumption. This assumption could be violated if state-specific changes in other factors related to suicide occur contemporaneously with changes in the state-specific minimum wage. Many potential confounds are static or change as a function of national trends, accounted for in the DD design via state and year fixed effects. We relax this assumption by controlling for additional state-specific economic support covariates. To further enhance our ability to draw a causal inference from the described models, we performed a series of placebo tests checking for potential violations in the parallel trends assumption. We estimated placebo effects by re-estimating the main effects and unemployment interaction models restricted to those with \geq college degree assuming that few in this group receive a direct benefit of an increased minimum wage.

RESULTS

From 1990 to 2015, there were 478 changes in state minimum wages, out of $n=15\,912$ state-month units of analysis. For state-months with a minimum wage above the federal, the mean difference in hourly minimum wage was US\$1.10 (range: US\$0.03–US\$3.26), equivalent to US\$2200/year for a full-time worker. In 1990, there were 36 states without a minimum wage above the federal; in 2015, there were 21 such states. From 1990 to 2015, there were 399 206 suicides among those with \leq high school diploma and 140 176 among those with \geq college degree. **Table 1** displays distributions of state-month suicide counts and rates.

We estimated a 6% reduction in suicide for every dollar increase in the minimum wage among adults aged 18–64 years with \leq high school education (rate ratio=0.941; 95% CI 0.898 to 0.986). As theorised, no effect of minimum wage was observed on suicide among those with \geq college degree, supporting the parallel trends assumption and thus the plausibility of our results (**table 2**). For the lagged metric, we estimated a 4.4% decrease (rate ratio=0.956; 95% CI 0.925 to 0.988) per dollar minimum wage increase among those with \leq high school education. When further controlling for state-specific time-varying economic

Table 1 Distributions of monthly suicide counts and rates, stratified by educational attainment, for 50 US states and Washington, DC, for all months from 1990 to 2015

| Percentile | Suicide count, ≤high school diploma | Suicide count, ≥college degree | Suicide rate per 100 000, ≤high school diploma | Suicide rate per 100 000, ≥college degree |
|------------|-------------------------------------|--------------------------------|--|---|
| 0 | 0 | 0 | 0.00 | 0.00 |
| 10 | 2 | 1 | 0.77 | 0.28 |
| 25 | 8 | 2 | 1.25 | 0.57 |
| 50 | 18 | 5 | 1.70 | 0.91 |
| 75 | 33 | 10 | 2.25 | 1.46 |
| 90 | 55 | 20 | 2.94 | 2.71 |
| 95 | 79 | 32 | 3.48 | 4.31 |
| 99 | 123 | 58 | 4.88 | 10.75 |
| 100 | 177 | 121 | 8.67 | 45.48 |

Based on a total of 15 912 states by month, that is, 12 months per year for 50 states and Washington, DC, for 26 years from 1990 to 2015.

variables, we estimated a 3.5% reduction in the suicide rate for every additional dollar in state minimum wage (rate ratio=0.964; 95%CI 0.934 to 0.995). Further adjustments for state-year demographic composition (mean age, percent white and percent male) did not substantially change effect estimates (table 2).

We found a statistically significant interaction between minimum wage and unemployment ($z=-2.48$, $p=0.013$), indicating that the impact of minimum wage varies across the unemployment rate. The marginal predicted rates are presented in figure 1. When unemployment is high (>6.5%), progressively higher minimum wages are associated with lower suicide rates, while at low unemployment (3.8%–6.5%) the effect of minimum wage is attenuated, with little effect observed at very low unemployment (<3.8%). We observed the highest suicide rates when state minimum wage was no higher than the federal and unemployment was high. Curiously, the lowest suicide rates were observed when both minimum wage and unemployment were high (eg, unemployment >7% and minimum wage ≥US\$1.75 above the federal). Following the 2009 peak in unemployment during the great recession, we estimated that 13 800 suicides could have been prevented between 2009 and 2015 among those ages 18–64 years with ≤high school education given an increase in the minimum wage equivalent to US\$1 above prevailing levels in US\$2015 (figure 2); a US\$2 increase could have prevented 25 900 suicides (figure 2). Over the entire study period from 1990 to 2015, we estimated that a US\$1 increase in state minimum wage above prevailing levels could have prevented

27 550 suicide deaths in this group, and a US\$2 increase could have prevented 57 350 suicides.

DISCUSSION

Among those with a high school education or less, we found that a US\$1 increase in the state-level minimum wage appeared to decrease the suicide rate by about 6% when accounting for national secular trends and static state-specific confounding, and 3.5% when further accounting for state-specific time-varying confounding. We observed no effect among adults with a college degree or more, suggesting that minimum wage increases may reduce disparities in mental health and mortality between socioeconomic groups. These findings agree with two similar studies.^{10 20} Gertner *et al*²⁰ used DD models with data from 2006 to 2016 not accounting for education level, and estimated that a US\$1 increase in state-level minimum wage was associated with a 1.9% reduction in the suicide rate among the total US population. In a working paper, Dow *et al*¹⁰ used DD models stratified by education level with data from 1999 to 2015, and found that a 10% increase in the state-level minimum wage reduced ‘non-drug’ suicides by 3.6% among adults with a high school education or less, and found no effect among those with a college degree or more education. Two additional studies using DD methods examined the effect of minimum wage increases on general mental health in the US using data from 1993 to 2014²⁷ or 2015,²⁸ and found an association between increased minimum wage and reduced depressive symptoms²⁷ or reduced number of days with mental health problems²⁸ among those with a high school education or less.

We expanded on prior research by examining how the effect of minimum wage on suicide is modified by the unemployment rate. Our finding of a significant interaction between state-level minimum wage and unemployment rates generally agrees with prior research on the moderating effect of the generosity of economic security policies on the positive relationship between unemployment rates and suicide rates.^{8 21 22} We found that when the unemployment rate is high, there is an inverse relationship between state minimum wage and the suicide rate among those with a high school diploma or less education. During very low unemployment (<3.8%), however, we observed little effect of minimum wage on suicide rates. This could be partly explained by the increased demand for workers leading to higher wages during times of low unemployment, regardless of minimum wage. Our observation that the lowest suicide rates occurred when both minimum wage and unemployment were high could

Table 2 Effects of minimum wage on suicide by educational attainment

| | High school education or less | College degree or more |
|--------------------|-------------------------------|------------------------|
| | Rate ratio (95% CI) | Rate ratio (95% CI) |
| Crude | 0.941 (0.898 to 0.986) | 1.029 (0.945 to 1.122) |
| Adjusted* | 0.964 (0.934 to 0.995) | 1.044 (0.965 to 1.130) |
| Adjusted† | 0.966 (0.936 to 0.996) | 1.054 (0.981 to 1.132) |
| Crude, lagged‡ | 0.956 (0.925 to 0.988) | 1.048 (0.929 to 1.182) |
| Adjusted*, lagged‡ | 0.974 (0.944 to 1.001) | 1.075 (0.953 to 1.212) |
| Adjusted†, lagged‡ | 0.976 (0.947 to 1.005) | 1.084 (0.970 to 1.212) |

* Adjusted for gross state product, state unemployment rate, number of AFDC/TANF recipients and state personal income.

† Further adjusted for state mean age, percent white and percent male.

‡ Based on 1 year after the effective date of the minimum wage policy.

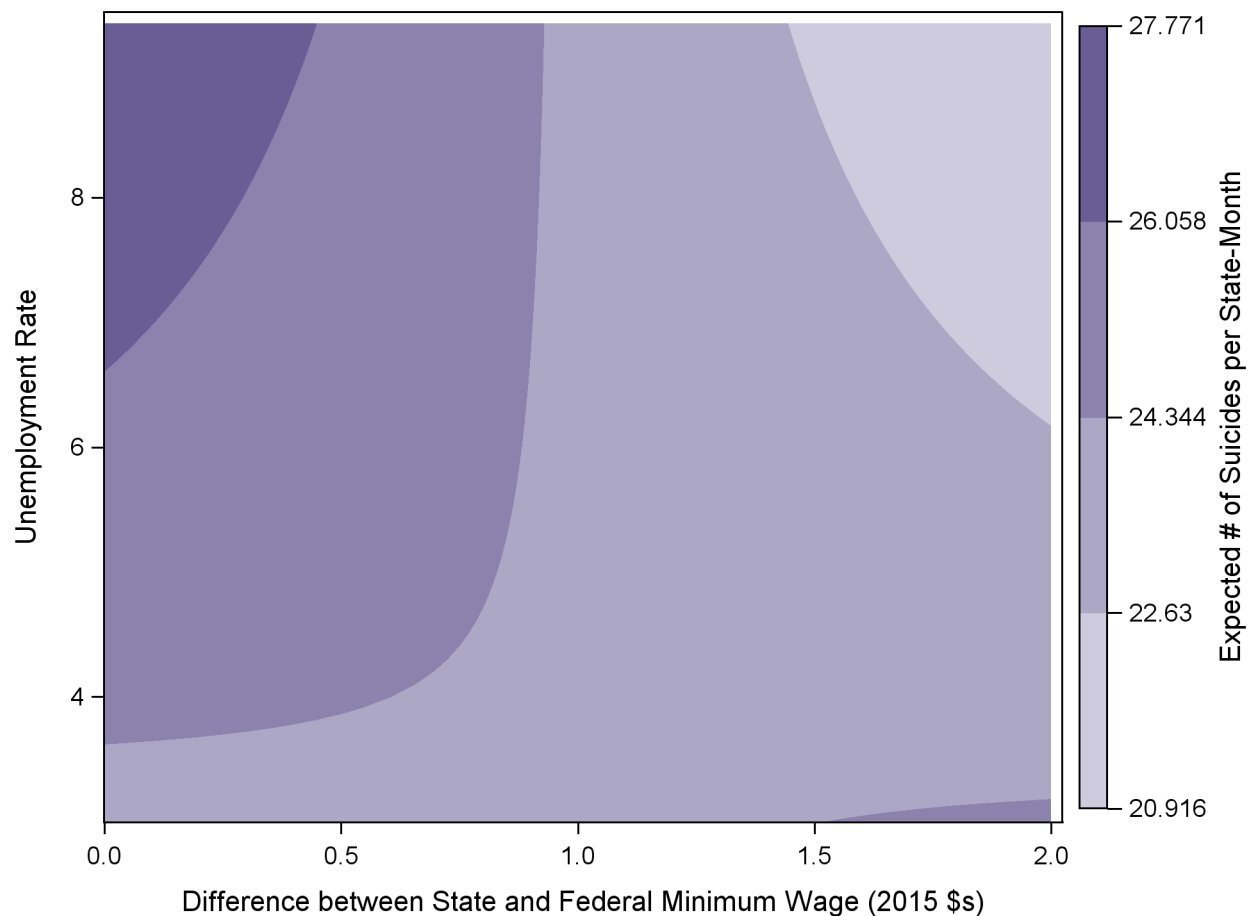


Figure 1 Effect on suicide rates of the interaction between minimum wage and unemployment. Minimum wage levels are expressed in US\$2015. estimates are for all 50 US states and Washington, DC models include the difference between state and federal minimum wage in US\$2015, state and year fixed effects, state unemployment rate and the interaction between the minimum wage and unemployment. Modelled unemployment rates run from the 5th to 95th percentile for state-months (3.0%–9.4%).

be partly explained by the generosity of other unmeasured state programme, such as unemployment insurance, though state fixed effects might partially control for this. Prior research on unemployment and suicide in the USA has reported a buffering effect of more generous state-level unemployment benefits²¹ and increased social welfare spending.⁸ Another explanation could be related to sociological aspects of unemployment, such as that when unemployment is high an unemployed individual is less likely to feel a failure or isolated, compared with during times of low unemployment.²⁹

Other than those with lower education, other demographic groups including women, non-Hispanic blacks and Hispanics are more likely to work at the minimum wage.¹³ While increases in the minimum wage could have greater mental health effects for these groups, suicide rates also differ between these groups compared with men and non-Hispanic whites. We did not examine effect modification by gender or race within education levels because of limitations in our data sources. In two prior studies on minimum wage and suicide, Dow *et al*¹⁰ found greater effects among women than men (suicide rate decreases of 4.6% and 2.3%, respectively), while Gertner *et al*²⁰ observed no differences by gender. Neither study^{10 20} found effect modification by race, though Dow *et al*¹⁰ found effect modification by gender and race together. While there may be effect modification by demographic factors besides education, we expect our overall

estimates to be valid. We would not expect these factors to confound the relationship between minimum wage policy and suicide rates, as changes in state-level demographic composition would need to correlate with changes in state minimum wage policy. Our results adjusted for state population percent male, percent white and mean age did not meaningfully change effect estimates.

If minimum wage does indeed have a causal effect on suicide rates, it is unclear whether it is more relevant to base the exposure metric on the date a minimum wage law became effective or to incorporate a lag period. While a lagged metric may more accurately reflect the time for financial benefits to accumulate enough to reduce suicide risks, it could also be that the initial impact from minimum wage increases may benefit mental health, and that this benefit decreases over time. Our results indicate a very slightly larger effect for the unlagged metric compared with a 1 year lagged metric. An increased minimum wage may impact mental health via multiple pathways beyond reduced financial burden,^{14 30} including via increased job satisfaction, perceived social status and feeling control of circumstances affecting one's life.

While suicide represents the most extreme and salient indicator of despair, it is preceded by depression and a suicide attempt, outcomes which we did not study and for which data are less reliable or complete. Depression and suicide attempts

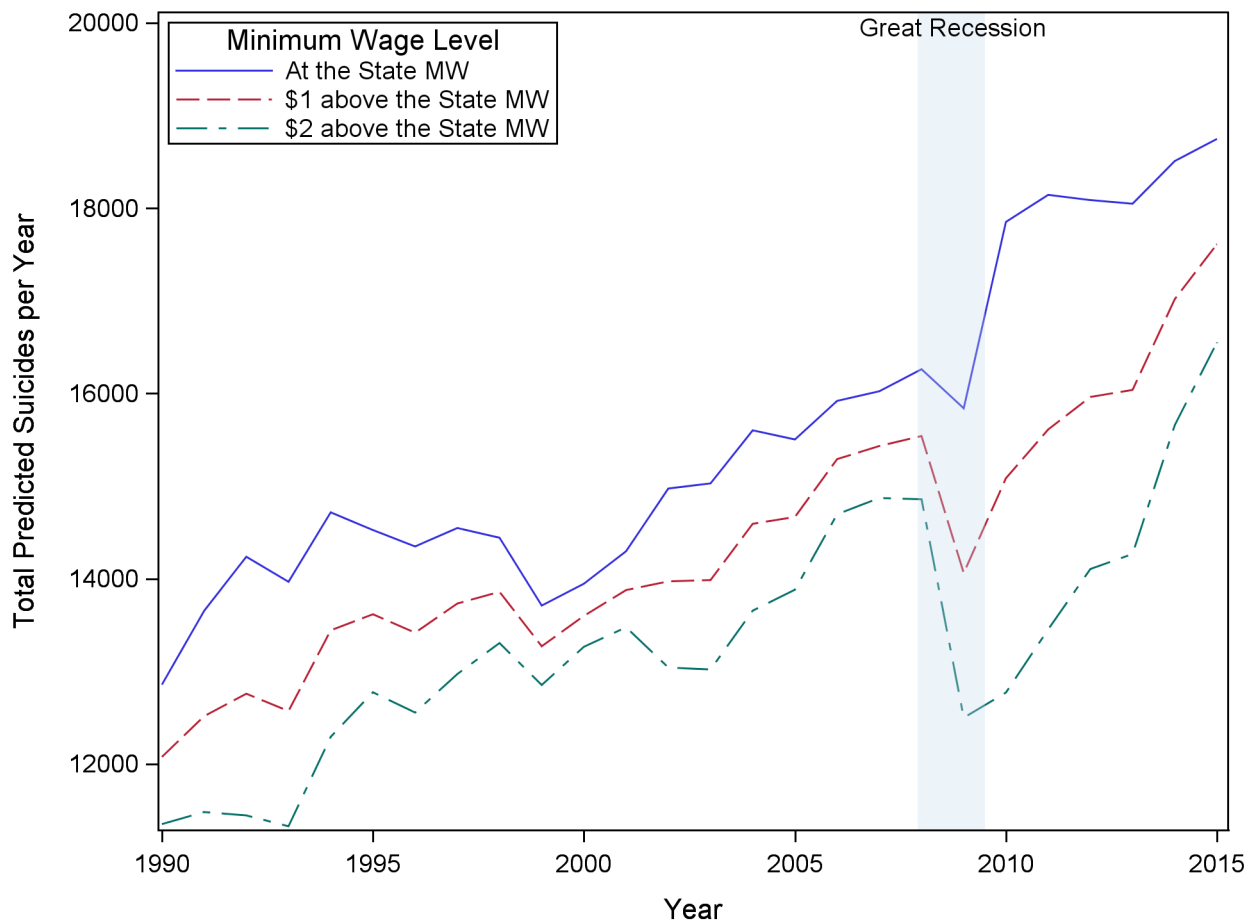


Figure 2 Total predicted suicides among US adults aged 18–64 years with a high school education or less at different minimum wage levels over time and varying unemployment rates. Minimum wage levels are expressed in US\$2015. estimates are for all 50 US states and Washington, DC models include the difference between state and federal minimum wage in US\$2015, state and year fixed effects, state unemployment rate and the interaction between the minimum wage and unemployment.

are much more common than completed suicides. If a causal relationship exists between minimum wage increases and suicide reductions, we would anticipate that depression rates and suicide attempts overall will decrease with an increased minimum wage. Depression rates in the USA are higher among demographic groups¹² that are also more likely to work at lower-wage jobs,¹³ including women, non-Hispanic blacks and Hispanics. In 2017, there were an estimated 1.4 million attempted suicides among American adults compared with 47 173 completed suicides.³¹ An estimated 1.7% of unemployed US adults attempted suicide in 2017, compared with 0.4% of those working full-time and 0.7% for those working part-time. Rates of serious thoughts of suicide also differ by socioeconomic status, with such thoughts reported by an estimated 6.1% of those living below the poverty level, 5.0% for those between 100% and 199% of the poverty level, and 3.3% for those over 200% of the poverty level. By level of educational attainment, serious thoughts of suicide affected 4.4% of those with a high school diploma compared with 3.2% of those with a college degree.³¹

Our findings are consistent with the notion that policies designed to improve the livelihoods of individuals with less education, who are more likely to work at lower wages and at higher risk for adverse mental health outcomes, can reduce the suicide risk in this group. Our findings also suggest that the potential protective effects of a higher minimum wage are

more important during times of high unemployment. While the minimum wage can serve as a population health intervention, it is important for society to provide other buffers between financial status and health, so that low education and economic insecurity do not increase the risk of mental illness and death.³²

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Contributors JAK wrote the majority of the manuscript, performed part of the analysis and performed part of the literature search. LKS-H performed part of the literature search and contributed to writing the introduction and discussion. KAK provided significant guidance on the study design and manuscript, and provided subject area expertise. MDL provided significant guidance on the study design and analysis, performed part of the analysis, contributed to writing the methods

What is already known on this subject

- ▶ Research has suggested that increases in minimum wage can improve population-level mental health outcomes including suicide.
- ▶ Separate research has demonstrated that while unemployment can negatively affect mental health, economic security policies may alleviate some of this impact.

What this study adds

- ▶ We use difference-in-differences methods to estimate the effect of an increased minimum wage on the suicide rate among adults with a high school education or less, who are more likely to be affected by minimum wage changes, and examine effect modification by unemployment rate.
- ▶ To our knowledge, this is the first study to estimate how the unemployment rate modifies the relationship between minimum wage policies and suicide rate.

and results and prepared the data. All authors agreed on the content of the final submitted manuscript.

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