A Nationwide Investigation of the Impact of the Tipped Worker Subminimum Wage on Infant Size for Gestational Age

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INTRODUCTION

Driven by a myriad of factors, including poverty-related stress and malnutrition, maternal socioeconomic disadvantage prior to and during pregnancy is robustly associated with adverse birth outcomes.[1] One factor that may be contributing to maternal socioeconomic disadvantage in the United States (US) – where approximately 3 million women work in a tipped occupation[2] – is the two-tiered minimum wage structure that permits a reduced hourly wage for workers in tipped occupations.[3] At the federal level, this "subminimum wage" has been frozen at $2.13 since 1991. Consequently, tipped workers are reliant on unpredictable gratuities for the majority of their wages.[4] Correspondingly, tipped workers are twice as likely to live in poverty relative to untipped workers[4] and young women in tipped occupations experience an elevated burden of poor mental health relative to similar women in other occupation types.[5]

Leveraging the heterogeneity in subminimum wage policy across and within states over time, a previous study found that increasing the subminimum wage was associated with a reduction in poverty-related antenatal stress. This finding was particularly pronounced among vulnerable subgroups of women who theoretically have the highest probability of exposure to tipped work and experience differential vulnerability due to factors like their race, educational attainment, and marital status (under review). However, the potential implications of increasing the subminimum wage for health of the next generation are underexplored.

Among birth outcomes, low birthweight and preterm birth are the most frequently evaluated in reproductive outcomes research. However, when considering the implications of applying a state-level policy like subminimum wage to the whole population, infant size for gestational age is of particular interest, as both infants born small or large are at risk for poor health across the lifecourse.[6–9] Previous examinations of the effects of income support policies on infant birthweight have largely focused on increasing birth weight in infants who are born small,[10] or examined associations with mean birthweight using classical linear regression[11] – an approach that can mask differential effects that may be occurring at different places in the birthweight distribution. That infants at both tails of the birthweight for gestational age distribution are at risk of poor health raises important concerns when considering interventions that are applied at the population level. Namely, if an intervention has the same effect across the entirety of the birthweight for gestational age distribution, interventions aimed at increasing birth weight among infants born small for gestational age will do the same for large for gestational age infants, and vice versa for interventions aimed at reducing birth weight among large for gestational age infants; that is, move the whole distribution of birthweight for gestational age to the left or right. In contrast, an ideal population-level intervention for birthweight for gestational age would simultaneously increase birth weight in the smallest infants while decreasing birth weight in the largest infants, narrowing the distribution of birthweight for gestational age and accomplishing the intervention goal of improving population health.[12]

The objective of this study was to estimate the impact of changes in the subminimum wage policy on the location (e.g. shifts to the left or right) and dispersion infant size for gestational age distribution. We further estimated the extent to which historical, existing, and proposed wage policy scenarios could promote or inhibit healthier birthweight in infants.

METHODS

Data

We examined individual birth records from the U.S. Vital Statistics Natality Files, reported by all 50 states and the District of Columbia to the National Center for Health Statistics. We linked natality data to state-level wage policy data ascertained from the Department of Labor and Wage and Hour laws archived on each state's labor office established website.[13] To ascertain state characteristics beyond subminimum wage policy, we also linked natality data to publicly available state-level contextual data from the University of Kentucky Center for Poverty Research[14] and the American Community Survey.[15] This study was exempted by our institutional review board.

Measures

Our exposure was the time-varying state-level subminimum wage in the mother's state of residence two years prior to her infant's birth. The mandated minimum hourly rates for tipped workers, and the date ranges associated with them, were abstracted from Wage and Hour laws retrieved from each state's labor office website. In a given month, the state-level subminimum wage could stay the same, increase, or decrease, however the wage could not be below the federal subminimum wage ($2.13 per hour).[3] Thus, the applicable subminimum wage for these analyses was the higher of either the state's subminimum wage or the federal subminimum wage. In instances where there was more than one state-level subminimum wage policy in a given month, we selected the policy that corresponded to food service workers, as waiters and bartenders make up 58% of the tipped-wage work force,[4] or subminimum wage stipulated for larger employers; these stipulations were mutually exclusive as states only dictated one or the other.

Our primary outcome was continuous infant birthweight for gestational age Z-score (BWz). This variable was constructed using natality data for continuous birthweight in grams and gestational age in weeks and the reference population described by Talge et al.[16] as the external standard. Infant size for gestational age was determined to be plausible if z-scores were between -5 and

5 for term births (>37 weeks) or between -3 and 2 for preterm births (≤ 37 weeks).[17] We subsequently identified additional implausible gestational age values using a method described by Alexander et al.[18]

We accounted for potential confounders and effect modifiers by incorporating individual and state-level covariates. Individual-level covariates from the time of delivery, selected based on prior literature, were ascertained from the birth record and included maternal educational attainment (<high school, high school, some college, college graduate), maternal race/ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic American Indian or Alaskan Native, Non-Hispanic Asian or Native Hawaiian or Pacific Islander, Hispanic), maternal marital status (married, unmarried), parity (nulliparous, multiparous), maternal nativity (US native, foreign born), and maternal continuous age (linear and quadratic terms). State-level covariates included time-varying state sociodemographic composition (percent non-Hispanic White, percent college graduates, number working in the food service industry, percent unemployed, percent food insecure, percent living under the federal poverty level, and mean personal income) and state public policy (median welfare benefit package and average proportion of democratic representation in state legislature). We adjusted all calculations for inflation by converting all dollar values to 2014 dollars.[19]State-level covariates were lagged by three years from date of birth (2001-2013) to ensure they preceded changes to wage policy.

Analytic Sample

Our original data set contained 53,067,840 mother-infant dyads. Because state of residence was used to determine a mother's subminimum wage policy exposure, data were restricted to women residing in the US (N=52,960,994). We restricted our sample to women ≥20 years of age (N=48,382,049) so as to not confound our analysis by the legally permissible reduced youth minimum wage.[20] We further required singleton births (N=46,638,549) with gestational age 22-44 weeks (N=46,145,206) and birthweight. We retained infants with plausible BWz as described above (779,753 (1.7%) excluded). Next, while all states capture maternal education across all years in the studied period, due to discrepancies in how education is recorded across versions of the US standard certificate of live birth,[21] education is only included in the NVSS public use file for states and jurisdictions that have implemented the 2003 revision of the birth certificate (**Appendix C1**). Thus, we further restricted sample to state-years for which education data are not excluded from public use file (N=3,236,835 (7.1%) excluded). After accounting for missing values in individual-level characteristics (908,665 (2.1%) excluded), our final sample consisted of 41,219,953 women giving birth between 2004 and 2016 in all 50 states and the District of Columbia.

Statistical analysis

All analyses were conducted in Stata version 14.2 (StataCorp LP, College Station, Texas). A detailed description of our statistical approach is available in **Appendix A1**. Briefly, we used unconditional linear quantile mixed effects regression to estimate the impact of subminimum wage change over time on the location and scale of the infant BWz distribution.[22] We integrated a difference-in-differences approach [23] to account for unobservable differences between individuals in states that changed their wages and states that did not. That is, we estimated separate mixed effects regression models at every 5^{th} percentile across the continuum of the BWz distribution, essentially estimating the association for the 5^{th}, 10^{th},…, 95^{th} quantiles. The pertinent coefficients are those corresponding to the interaction between the time-varying state-level subminimum wage and time. To address a non-linear trend of size for gestational age over time, calendar year was incorporated in the model as a series of categorical indicator variables. To assess the robustness of our estimates to the state-level discrepancies in the availability of education data during some years, we subsequently restricted analyses to states with maternal education data available for the entire study period (29 states and DC; N=29,914,598 mother-infant dyads).

Identifying an effective wage policy intervention: policy simulations. Using coefficients from the quantile models, we estimated effects of four hypothetical subminimum wage policy scenarios for infants in the smallest (5^{th} percentile) and largest (95^{th} percentile) quantiles: (1) a flat $2.13, the current federal subminimum wage since 1991; (2) 50% of the federal minimum wage as it was prior to a 1996 addendum of the Fair Labor Standards Act; (3) 70% of the federal minimum wage as was proposed in S. 1737 (113th): Minimum Wage Fairness Act; and (4) equivalent to the federal minimum wage ($5.15-$7.25).

RESULTS

Table 1 displays characteristics of mother-infant dyads and their state of residence by select percentiles of the unconditional distribution of BWz for infants born during the first year of the studied period (2004). Relative to infants in larger quantiles, the smallest infants (5^{th} percentile) were disproportionately born to women who were younger, Black, had lower educational attainment, were unmarried, and/or nulliparous. In terms of pregnancy conditions, hypertension was most prevalent among the mothers of the smallest infants while diabetes was most prevalent among the mothers of the largest infants (95^{th} percentile). The state of residence for mothers of the smallest infants had slightly lower mandated subminimum wage on average as well as smaller welfare packages.

From 2002 to 2014, the state tipped worker subminimum wage in 2014 dollars averaged $3.97 (SD: 1.99) and ranged from $2.13 to $9.40. There were 140 changes in state subminimum wage, with the change averaging +$0.34 (SD = 0.46) and ranging from

-$1.84 to +$1.94 (**Appendix C2**).

Multivariable Models. As described above, we applied quantile regression at different places along the BWz distribution. We first provide a brief explanation of the model results, apply these coefficients to four wage policy scenarios for infants in the smallest and largest quantiles, and then demonstrate the additional change in BWz across the continuum of the BWz distribution attributed to the most effective wage policy (difference-in-differences).

Appendix Table B1 displays the coefficients for the 5th, 25th, 50th, 75th, and 95th percentiles of BWz. The association between change in subminimum wage and infant BWz – indicated by the interactions between subminimum wage and year – differs across the BWz distribution, in effect narrowing the distribution of BWz and shifting it slightly to the left. Notably, for the smallest infants (5th percentile) increases in subminimum wage are associated with an increase in infant BWz (e.g. an increase by 0.005 [95% CI:0.004,0.007] for every dollar above the federal $2.13 in 2016 relative to 2004) while for the largest infants (95th percentile) increases are associated with a reduction in BWz (e.g. a decrease by 0.016 [95% CI:-0.018,-0.015] for every dollar above the federal $2.13 in 2016 relative to 2004). Moreover, the largest increases are observed among the smallest infants and the largest decreases are observed among the largest infants.

Identifying an effective wage policy intervention. We examined four subminimum wage policy scenarios for the smallest (5th percentile) and largest (95th percentile) infants across the studied period of 2004 to 2016 (**Figure 1a-b**). Under all scenarios, changes in predicted BWz are not linear over time, with the largest deviation from linearity spanning 2008 to 2011. For the smallest infants, subminimum wage policy set to the federal subminimum $2.13 (red line) was associated with a net 1.3% decrease in BWz from 2004 to 2014, while wages set to 100% of the federal minimum (green line) were associated with a 1% increase in BWz. For the largest infants, BWz was estimated to decrease by ~3% irrespective of policy scenario from 2004 to 2008, and similarly increase by ~0.5% from 2008 to 2011. However, from 2011 to 2016, subminimum wage policy set to the federal subminimum $2.13 was associated with a 1.3% *increase* in BWz, while wages set to 100% of the federal minimum were associated with a 1.8% *decrease* in BWz among the largest infants. Intermediary policies where subminimum wage was set to 50 to 70% of the minimum wage yielded intermediate effects for both the smallest and largest infants, suggestive of a dose response.

Additional change overtime attributed to the most effective wage policy (difference-in-differences). Using coefficients from the mixed effects models, we estimated the change in infant BWz over time (2004-2016) for the most effective subminimum wage policy – as identified above – relative to the current static subminimum wage all along the continuum of the BWz distribution. **Figure 2**. We compared estimates when subminimum wage remained at $2.13 for the duration of the studied period (Scenario 1) to those when the subminimum wage was set to be the same as the federal minimum wage ($5.15-$7.25; Scenario 4 above). Quantile regression results show that the more generous wage policy is associated with *increased* BW (an increase of 0.039 [95% CI: 0.033, 0.044] BWz) for the smallest infants; and *decreased* BW (a decrease by 0.051 [95% CI: -0.058,-0.045] BWz) for the largest infants. In addition, the BWz distribution shifts slightly to the left, as evidenced by decreases in BWz attributed to the most effective wage policy from the 30th to 95th percentiles. We observed a similar pattern upon restriction to states with consistent availability of maternal educational attainment data (**Appendix C3**).

DISCUSSION

In this study, we estimated the impact of increasing the state-level subminimum wage on infant BWz across the entirety of the BWz distribution for infants born in the United States 2004-2016. Our results suggest that increasing the state-level tipped worker subminimum wage can promote healthier birthweight in infants, simultaneously increasing BWz of the smallest infants and decreasing BWz of the largest infants. Moreover, the largest estimated potential benefit of subminimum wage increases occur in the tails of the BWz distribution – in which the highest health risks are observed. In our examination of the potential impact of 4 different hypothetical subminimum wage policies, the most conservative policy – maintaining the current federal subminimum wage of $2.13 – is simultaneously associated with further reductions in size for the smallest infants and further increases in size for the largest infants in recent years (2011-2016). The most progressive policy – setting the subminimum wage to the federal minimum wage – was the only strategy that was not associated with increased BWz among the largest infants in recent years (2011-2016).

Our study is the first to examine the implications of state-level tipped worker subminimum wage laws for the health of infants. Our finding that subminimum wage increases may promote healthier birthweight in infants are consistent with those observed in other studies examining the health implications of wage policies aimed at increasing the incomes of working class families.[24] While we present the first examination of the effects of a wage policy across the entirety of the birthweight for gestational age distribution, one study estimated that a $1 increase in the minimum wage would result in 1% decrease in the likelihood of giving birth to a low birthweight infant;[11] another study cited 2,790 fewer low birthweight births annually.[10] One study utilizing quantile regression to examine the effect of another income support – the earned income tax credit - on birthweight similarly observed larger effects in the left tail of the distribution.[25] Modification of health behaviors, leisure expenditures, and financial stress have been highlighted and evaluated as mechanisms underlying the observed improvements in health in response to wage increases[26] and one previous study found increases in the tipped worker subminimum wage were associated with a reduction in poverty-related stress (under review).

We set out to estimate the impact of a policy that is applied at the state-level on the population as a whole. While fewer than 10% of employed women in the US work in tipped occupations,[4] our examination of the association across the entirety of the BWz distribution enabled us to see that effects were most prominent in the tails, where infants are disproportionately born to women with a higher probability of tipped work exposure as well as differential vulnerability to differential exposure to poverty on account of their race, educational attainment, and marital status[5,27] We observed a narrowing of the distribution and the greatest *increase* in BWz among the smallest infants. In accordance with Geoffrey Rose's population strategy[12], we present evidence that wage policy applied to the whole population may have a larger impact on risk reduction than the application of a high risk approach – and at the very least does not exacerbate inequities.

This study has important limitations. First, we assume that maternal state of residence – and ostensibly employment – two years prior is the same as that reported at the time of infant birth. While migration is differential, fewer than 2% of the US population move from one state to another in a given year.[28] Second, in order to interpret the association for individual infants within a given quantile (versus simply speaking to the changes in the location and dispersion of the distribution), we assume rank similarity;[29] namely that infants stay within a given quantile given their characteristics irrespective of policy change, or at the very least do not systematically change ranks. However, even if this assumption does not hold, our results still suggest increasing the subminimum wage is associated with a slight leftward shift and narrowing of the BWz distribution. Finally, because income is inversely associated with risk of spontaneous abortion[30] and wage policy and national economic trends impact fertility;[31] there is potential for effects of survival bias, with anticipated bias of our results towards the null. However, the magnitude of bias for conditioning on live births is generally small,[32] and our analyses incorporate individual-level factors that are risk factors of both small or large for gestational age as well as spontaneous abortion.

PUBLIC HEALTH IMPLICATIONS

While economists have long been discussing the implications of minimum wage policy for the economy, public health leaders – and thus considerations for the health of our most vulnerable - are newer to these conversations. Newer still is the consideration of subpopulations – like tipped workers – who are subjected to a subminimum wage because of nuances in the Fair Labor Standards Act. While observed associations in the present study were small, they provide evidence that increasing the subminimum wage – or eradicating the current two-tiered minimum wage system – could simultaneously reduce the burden of being born small or large for gestational age, both of which have ramifications for poor health across the lifecourse. With 82% of the tipped workforce currently employed in states that permit a subminimum wage (33% at the federal $2.13),[4] increasing the subminimum wage is an actionable strategy that may promote healthier birthweight in infants.

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TABLES

Table 1. Characteristics[a] of mother-infant dyads and their state of residence by infant birthweight standardized for gestational age percentile, 2004 U.S. Vital Statistics Natality Files

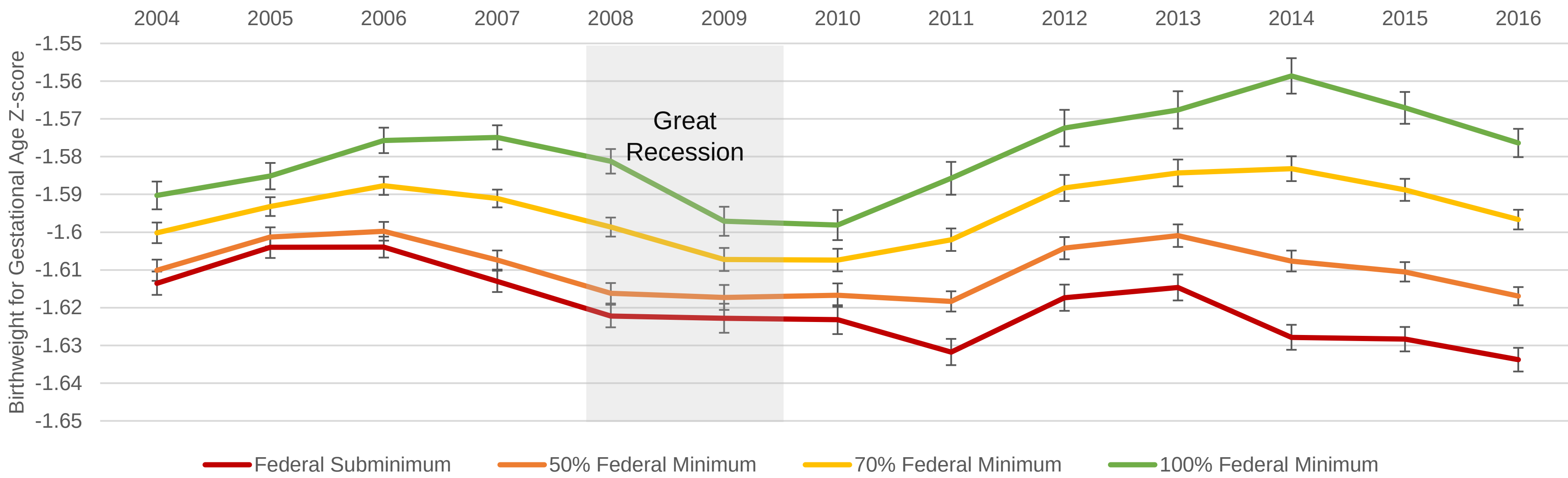
	Birthweight standardized for gestational age Percentile				
	5th	25th	50th	75th	95th
Individual-Level Characteristics					
Maternal Age (years)[b]	27.70 (0.18)	27.79 (0.18)	28.21 (0.17)	28.63 (0.16)	29.10 (0.15)
Maternal Race/Ethnicity					
Non-Hispanic White	47.8	51.3	56.4	60.8	64.6
Non-Hispanic Black	22.3	17.8	13.8	11.2	9.3
Non-Hispanic AI/AN	0.9	0.8	0.8	0.9	1.0
Non-Hispanic Asian/NHOPI	7.7	7.9	6.6	5.3	4.1
Hispanic	21.3	22.2	22.4	21.9	21.1
Educational Attainment					
< High School	22.9	19.8	17.6	16.1	15.1
High School	34.0	31.4	29.3	28.0	26.9
Some College	22.4	23.4	24.0	24.5	24.9
≥ College	20.7	25.4	29.1	31.5	33.2
Maternal Nativity					
US Native	74.9	73.4	74.1	75.5	77.1
Foreign Born	25.1	26.6	25.9	24.5	22.9
Maternal Marital Status					
Married	57.0	63.3	68.5	72.1	74.9
Unmarried	43.0	36.7	31.5	27.9	25.1
Parity					
Nulliparous	44.0	41.4	38.1	34.9	33.4
Multiparous	56.0	58.6	61.9	65.1	68.7
Infant Sex					
Female	48.2	49.2	49.0	48.9	48.4
Male	51.8	50.8	51.0	51.1	51.6
Gestational Age (weeks)[b]	38.99 (0.02)	38.98 (0.03)	38.86 (0.03)	38.76 (0.03)	38.67 (0.04)
Extremely Preterm (22-27 weeks)	0.6	0.4	0.4	0.4	0.4
Very Preterm (28-31 weeks)	1.1	0.7	0.6	0.6	0.6
Preterm (32-36 weeks)	7.6	6.5	7.1	8.0	9.7
Term (37-42 weeks)	86.3	88.9	89.2	88.8	87.8
Post-term (42-44 weeks)	4.3	3.5	2.8	2.2	1.5
Diabetes (Gestational and/or Pre-pregnancy)	3.6	3.3	3.3	3.5	4.2
Any Hypertension	9.7	5.8	4.5	4.1	4.1
Chronic Hypertension	1.9	1.2	1.0	0.9	0.9
Eclampsia	0.7	0.4	0.2	0.2	0.2
Pregnancy Associated Hypertension	7.3	4.4	3.4	3.1	3.1
State-Level Characteristics[c]					
Subminimum Wage ($)[b]	3.15 (0.45)	3.21 (0.47)	3.25 (0.48)	3.27 (0.48)	3.29 (0.48)
Percent White	74.2	74.4	74.6	74.8	75.1
Percent College Graduate	26.0	26.1	26.2	26.2	26.2
Number Employed in Food Service (10,000s)	41.40 (8.82)	41.96 (9.14)	41.15 (9.36)	42.06 (9.43)	41.73 (9.31)
Unemployment Rate	4.8	4.7	4.7	4.7	4.7
Percent Food Insecure	12.4	12.4	12.4	12.3	12.2
Poverty Rate	12.0	11.9	11.8	11.7	11.7
Median Household Income ($1,000s)[b]	31.28 (0.75)	31.40 (0.74)	31.45 (0.73)	31.47 (0.72)	31.50 (0.71)
Median Welfare Benefit Package ($100s)[b]	5.52 (0.28)	5.57 (0.29)	5.61 (0.29)	5.64 (0.29)	5.65 (0.28)
Minimum Wage ($)[b]	5.43 (0.16)	5.45 (0.17)	5.46 (0.18)	5.47 (0.18)	5.48 (0.18)
Average Democratic Composition of State Governance (i.e. Senate, House of Representatives, Governor)	46.9	46.7	46.6	46.6	46.7

AI/AN, American Indian or Alaskan Native; NHOPI, Native Hawaiian or Pacific Islander
[a]Includes women aged 20 and older
[b]Values are expressed as mean (standard error); clustered on state
[c]Based on 2002 subminimum wage values and 2001 for all others.

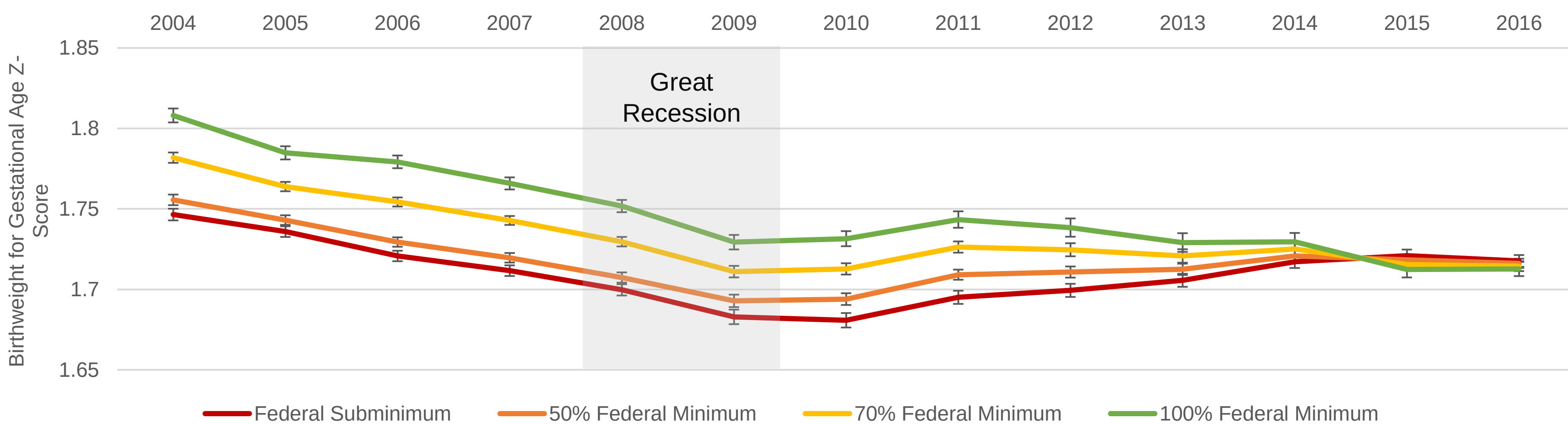
FIGURES

Figure 1. Predicted birthweight standardized for gestational age by subminimum wage policy[a] for infants in the (a) smallest quantile and (b) largest quantile, 2004-2016 Vital Statistics Natality Files

a. Infants in the 5th percentile

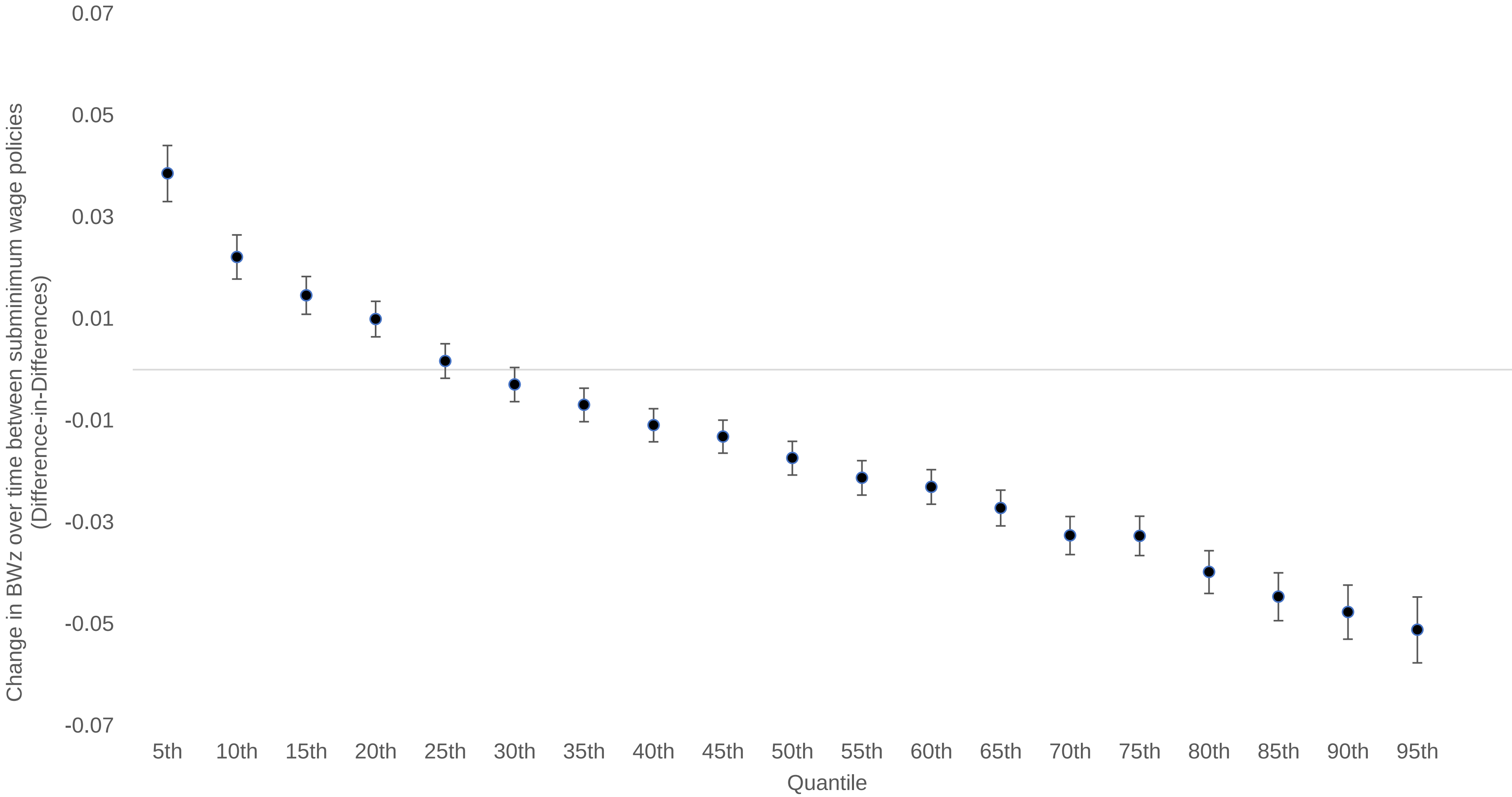


b. Infants in the 95th percentile



[a]Estimates under four policy scenarios presented with 95% confidence intervals. All models adjust for season, state-level variables lagged three years from infant year and month of birth (% Democrats in state government, maximum monthly benefits from state income supports, % White alone, % with college degree, number in food service occupation, % unemployed, % food insecure, and mean personal income) as well as maternal race/ethnicity, education, age, quadratic age, parity, nativity, marital status and infant sex. Shaded area denotes time period of the 2008 Recession

Figure 2. Change in birthweight standardized for gestational age over time (2004-2016) when wage policy is set to 100% federal minimum wage ($5.15 to $7.25) relative to the federal tipped worker subminimum wage (constant $2.13) as estimated in linear quantile mixed effects models[a], 2004-2016 Vital Statistics Natality Files



BWz, Birthweight for gestational age z-score
[a]Estimates are presented for each quantile with 95% confidence interval. All models adjust for season, state-level variables lagged three years from infant year and month of birth (% Democrats in state government, maximum monthly benefits from state income supports, % White alone, % with college degree, number in food service occupation, % unemployed, % food insecure, and mean personal income) as well as maternal race/ethnicity, education, age, quadratic age, parity, nativity, marital status and infant sex.

Appendix for "A Nationwide Investigation of the Impact of the Tipped Worker Subminimum Wage on Infant Size for Gestational Age"

Table of Contents

Supplementary Methods

Appendix A1. Description of statistical model

Quantiles were defined prior to multivariable regression by transforming the dependent variable with the recentered influence function (RIF) as follows:

$$RIF(Y; q_\tau, F_Y) = q_\tau + \frac{(\tau - 1\{Y \leq q_\tau\}}{f_Y(q_\tau)}$$

Where τ denotes a given quantile, q_τ is the value of birthweight for gestational age Z-score, Y, at the τth quantile. $f_Y(q_\tau)$ denotes the density of Y at q_τ and F_Y is the cumulative distribution function of Y. Finally, the indicator function $1\{Y \leq q_\tau\}$ creates a dummy variable set to 1 if a given infant's birthweight for gestational age is below τ. We estimated RIF for $\tau = 5 - 95$ in intervals of 5 (e.g. 5, 10,…,95) utilizing the Stata user developed rifreg command;[3] models included the outcome, size for gestational age z-score, only.

We subsequently utilized the transformed dependent variable in mixed effects linear regression models. Separate regression models were run for each quartile. Our simplified equation is as follows:

$$\begin{aligned} Y_{ist} = \beta_0 &+ \beta_1 Yr2005_t + \beta_2 Yr2006_t + \beta_3 Yr2007_t + \beta_4 Yr2008_t + \beta_5 Yr2009_t + \beta_6 Yr2010_t \\ &+ \beta_7 Yr2011_t + \beta_8 Yr2012_t + \beta_9 Yr2013_t + \beta_{10} Yr2014_t + \beta_{11} Yr2015_t \\ &+ \beta_{12} Yr2016_t + \beta_{13} SW_{st} + \beta_{14} Yr2005_t * SW_{st} + \beta_{15} Yr2006_t * SW_{st} + \beta_{16} Yr2007_t \\ &* SW_{st} + \beta_{17} Yr2008_t * SW_{st} + \beta_{18} Yr2009_t * SW_{st} + \beta_{19} Yr2010_t * SW_{st} \\ &+ \beta_{20} Yr2011_t * SW_{st} + \beta_{21} Yr2012_t * SW_{st} + \beta_{22} Yr2013_t * SW_{st} + \beta_{23} Yr2014_t \\ &* SW_{st} + \beta_{24} Yr2015_t * SW_{st} + \beta_{25} Yr2016_t * SW_{st} + \beta_{26} Seasonality_t + \beta_{27} P_{st} \\ &+ \beta_{28} X_{st} + b_{1s} + \epsilon_{st} \end{aligned}$$

Where Y_{ist} denotes the recentered birthweight for gestational age Z-score for infant i in state *s* and year *t*. Categorical indicators for each year were included to address a non-linear relationship between time and birthweight for gestational age. SW is the subminimum wage in state *s* and year-months *t*. We accounted for seasonality with a four level categorical variable of annual quarters (January – March, April – June, July – September, October – December). P_{st} is a vector of time-varying state-level characteristics and X_{ist} is a vector individual level characteristics. b_{1s} denotes random baseline state differences.

Supplementary Tables

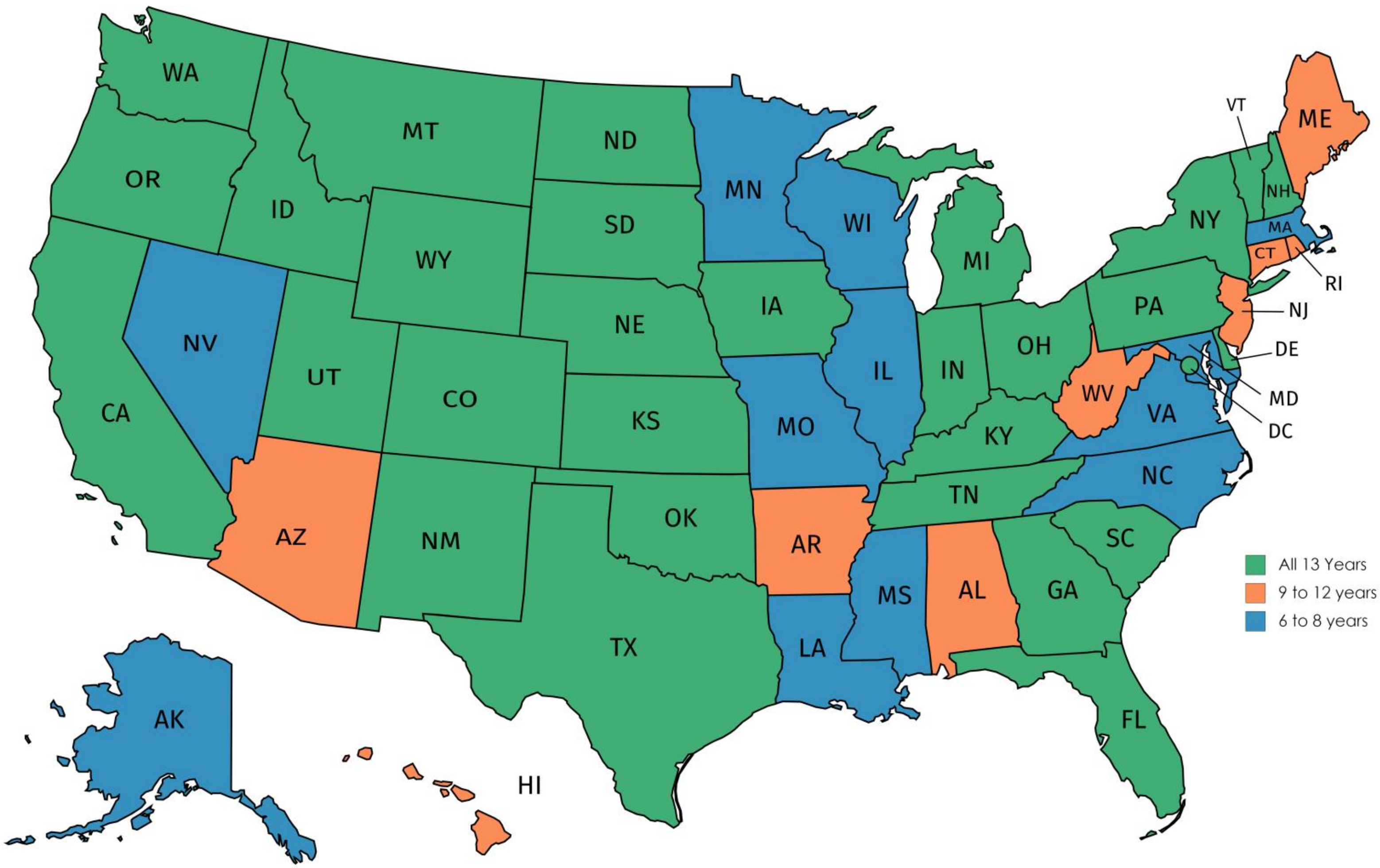
Appendix Table B1. Estimated mean and quantile annual effects of state-level subminimum wage on infant birthweight standardized for gestational age, NVSS 2004-2016

Parameters	Percentile				
	5th	25th	50th	75th	95th
Subminimum Wage[1]	0.006 (0.005,0.007)	0.008 (0.008,0.009)	0.011 (0.010,0.011)	0.013 (0.012,0.013)	0.015 (0.014,0.017)
Year of Birth					
2004	Ref	Ref	Ref	Ref	Ref
2005	0.010 (0.006,0.013)	0.004 (0.002,0.007)	-0.002 (-0.004,0.000)	-0.004 (-0.007,-0.002)	-0.011 (-0.015,-0.006)
2006	0.010 (0.006,0.013)	0.002 (-0.001,0.004)	-0.005 (-0.007,-0.003)	-0.011 (-0.013,-0.008)	-0.026 (-0.030,-0.021)
2007	0.000 (-0.003,0.004)	-0.006 (-0.008,-0.004)	-0.015 (-0.017,-0.012)	-0.022 (-0.025,-0.020)	-0.035 (-0.039,-0.030)
2008	-0.009 (-0.012,-0.005)	-0.020 (-0.022,-0.017)	-0.030 (-0.032,-0.028)	-0.039 (-0.041,-0.036)	-0.047 (-0.051,-0.042)
2009	-0.009 (-0.014,-0.005)	-0.026 (-0.029,-0.024)	-0.042 (-0.044,-0.039)	-0.054 (-0.057,-0.051)	-0.064 (-0.069,-0.058)
2010	-0.010 (-0.014,-0.005)	-0.029 (-0.031,-0.026)	-0.044 (-0.047,-0.042)	-0.057 (-0.060,-0.054)	-0.066 (-0.071,-0.061)
2011	-0.018 (-0.023,-0.014)	-0.029 (-0.032,-0.026)	-0.041 (-0.044,-0.038)	-0.048 (-0.052,-0.045)	-0.051 (-0.057,-0.046)
2012	-0.004 (-0.009,0.001)	-0.018 (-0.021,-0.015)	-0.031 (-0.034,-0.028)	-0.040 (-0.043,-0.036)	-0.047 (-0.053,-0.041)
2013	-0.001 (-0.006,0.004)	-0.013 (-0.016,-0.010)	-0.023 (-0.026,-0.020)	-0.033 (-0.036,-0.029)	-0.041 (-0.047,-0.035)
2014	-0.014 (-0.019,-0.009)	-0.015 (-0.018,-0.012)	-0.021 (-0.024,-0.018)	-0.027 (-0.030,-0.023)	-0.029 (-0.035,-0.024)
2015	-0.015 (-0.020,-0.010)	-0.015 (-0.018,-0.012)	-0.022 (-0.025,-0.019)	-0.028 (-0.031,-0.025)	-0.026 (-0.031,-0.020)
2016	-0.020 (-0.025,-0.016)	-0.022 (-0.025,-0.019)	-0.028 (-0.031,-0.026)	-0.034 (-0.037,-0.031)	-0.029 (-0.034,-0.023)
Subminimum Wage*Year of Birth					
2004	Ref	Ref	Ref	Ref	Ref
2005	-0.001 (-0.002,0.000)	-0.001 (-0.002,0.000)	-0.001 (-0.002,0.000)	-0.002 (-0.003,-0.001)	-0.003 (-0.005,-0.001)
2006	0.002 (0.000,0.003)	0.002 (0.001,0.003)	0.002 (0.001,0.003)	0.002 (0.001,0.003)	0.000 (-0.002,0.002)
2007	0.005 (0.003,0.006)	0.002 (0.002,0.003)	0.001 (0.001,0.002)	0.001 (0.000,0.002)	-0.001 (-0.002,0.001)
2008	0.006 (0.004,0.007)	0.004 (0.003,0.005)	0.003 (0.002,0.003)	0.002 (0.001,0.003)	-0.001 (-0.002,0.001)
2009	0.000 (-0.001,0.002)	-0.001 (-0.002,0.000)	-0.002 (-0.003,-0.001)	-0.003 (-0.004,-0.002)	-0.004 (-0.006,-0.003)
2010	-0.001 (-0.002,0.001)	-0.002 (-0.002,-0.001)	-0.003 (-0.004,-0.002)	-0.003 (-0.004,-0.002)	-0.005 (-0.007,-0.003)
2011	0.002 (0.001,0.004)	-0.001 (-0.002,0.000)	-0.003 (-0.004,-0.002)	-0.004 (-0.005,-0.004)	-0.007 (-0.008,-0.005)
2012	0.002 (0.001,0.004)	-0.001 (-0.002,0.000)	-0.004 (-0.005,-0.003)	-0.005 (-0.006,-0.004)	-0.008 (-0.010,-0.007)
2013	0.003 (0.002,0.004)	-0.002 (-0.003,-0.001)	-0.006 (-0.007,-0.005)	-0.008 (-0.009,-0.007)	-0.011 (-0.013,-0.009)
2014	0.007 (0.006,0.008)	-0.001 (-0.002,0.000)	-0.005 (-0.006,-0.004)	-0.009 (-0.010,-0.008)	-0.013 (-0.015,-0.011)
2015	0.006 (0.005,0.007)	-0.003 (-0.004,-0.002)	-0.008 (-0.009,-0.007)	-0.012 (-0.013,-0.011)	-0.017 (-0.019,-0.015)
2016	0.005 (0.004,0.007)	-0.003 (-0.004,-0.002)	-0.008 (-0.009,-0.007)	-0.012 (-0.013,-0.011)	-0.016 (-0.018,-0.015)
Spring	0.009 (0.007,0.010)	0.009 (0.008,0.010)	0.009 (0.008,0.010)	0.009 (0.008,0.011)	0.007 (0.005,0.009)
Summer	0.004 (0.002,0.006)	-0.000 (-0.001,0.001)	-0.003 (-0.004,-0.002)	-0.007 (-0.009,-0.006)	-0.011 (-0.013,-0.009)
Fall	-0.004 (-0.006,-0.003)	-0.009 (-0.01,-0.008)	-0.011 (-0.012,-0.010)	-0.013 (-0.015,-0.012)	-0.015 (-0.017,-0.013)
Time-Variant State Characteristics					
% Non-Hispanic White	-0.000 (-0.000,-0.000)	-0.001 (-0.001,0.000)	-0.000 (-0.001,0.000)	-0.000 (-0.000,-0.000)	-0.000 (-0.000,-0.000)
% College Grad	-0.003 (-0.003,-0.003)	-0.005 (-0.005,-0.005)	-0.006 (-0.006,-0.006)	-0.007 (-0.007,-0.007)	-0.008 (-0.008,-0.007)

# employed in food service	0.000 (0.000,0.000)	0.000 (0.000,0.000)	-0.000 (-0.000,-0.000)	-0.000 (-0.000,-0.000)	-0.000 (-0.000,-0.000)
Mean Income	0.001 (0.001,0.002)	0.002 (0.001,0.002)	0.002 (0.002,0.002)	0.003 (0.002,0.003)	0.003 (0.003,0.003)
% Unemployed	-0.002 (-0.002,-0.001)	-0.000 (-0.001,0.000)	0.001 (0.001,0.002)	0.002 (0.002,0.003)	0.005 (0.004,0.006)
% Food Insecure	0.002 (0.001,0.002)	0.000 (0.000,0.001)	-0.000 (-0.001,-0.000)	-0.001 (-0.002,-0.001)	-0.002 (-0.003,-0.002)
Mean Welfare Benefit	0.008 (0.007,0.008)	0.007 (0.006,0.007)	0.005 (0.004,0.005)	0.003 (0.002,0.003)	0.005 (0.004,0.006)
% poverty	-0.006 (-0.007,-0.006)	-0.006 (-0.006,-0.006)	-0.006 (-0.006,-0.006)	-0.006 (-0.006,-0.005)	-0.005 (-0.006,-0.005)
% Democratic Representation	-0.035 (-0.038,-0.031)	-0.010 (-0.012,-0.008)	0.001 (-0.001,0.004)	0.013 (0.010,0.015)	0.033 (0.028,0.037)
Individual Characteristics					
Maternal age	0.025 (0.023,0.026)	0.031 (0.031,0.032)	0.034 (0.033,0.035)	0.036 (0.035,0.036)	0.039 (0.037,0.040)
Quadratic maternal age	-0.000 (-0.000,-0.000)	-0.000 (-0.000,-0.000)	-0.000 (-0.000,-0.000)	-0.000 (-0.000,-0.000)	-0.000 (-0.000,-0.000)
Infant Sex: Female	0.015 (0.014,0.016)	-0.003 (-0.004,-0.002)	-0.007 (-0.008,-0.007)	-0.007 (-0.008,-0.006)	-0.002 (-0.003,0.000)
Non-HispanicBlack	-0.296 (-0.298,-0.293)	-0.310 (-0.311,-0.309)	-0.309 (-0.310,-0.307)	-0.289 (-0.290,-0.287)	-0.238 (-0.241,-0.236)
Non-HispanicAI/AN	0.018 (0.011,0.024)	0.047 (0.043,0.052)	0.076 (0.072,0.080)	0.113 (0.108,0.118)	0.191 (0.183,0.200)
Non-HispanicAsian/NHOPI	-0.294 (-0.297,-0.291)	-0.379 (-0.38,-0.377)	-0.408 (-0.409,-0.406)	-0.401 (-0.403,-0.399)	-0.351 (-0.355,-0.348)
Hispanic	-0.007 (-0.009,-0.005)	-0.040 (-0.041,-0.039)	-0.061 (-0.062,-0.059)	-0.071 (-0.072,-0.069)	-0.065 (-0.068,-0.063)
Married	0.118 (0.116,0.119)	0.101 (0.100,0.102)	0.092 (0.091,0.093)	0.082 (0.081,0.083)	0.065 (0.063,0.067)
Foreign-Born	0.075 (0.073,0.077)	0.038 (0.037,0.039)	0.019 (0.018,0.020)	0.003 (0.002,0.004)	-0.011 (-0.014,-0.009)
Multiparous	0.201 (0.199,0.202)	0.197 (0.196,0.198)	0.203 (0.202,0.204)	0.204 (0.203,0.205)	0.193 (0.192,0.195)
High School	0.096 (0.094,0.098)	0.068 (0.067,0.070)	0.056 (0.054,0.057)	0.041 (0.040,0.043)	0.024 (0.022,0.027)
Some College	0.196 (0.194,0.198)	0.148 (0.147,0.150)	0.126 (0.124,0.127)	0.098 (0.097,0.100)	0.063 (0.061,0.066)
≥ College	0.278 (0.276,0.280)	0.201 (0.199,0.202)	0.161 (0.160,0.163)	0.114 (0.112,0.115)	0.039 (0.036,0.042)
Intercept	-2.193 (-2.215,-2.170)	-1.279 (-1.293,-1.265)	-0.64 (-0.654,-0.626)	0.032 (0.016,0.048)	0.954 (0.927,0.981)

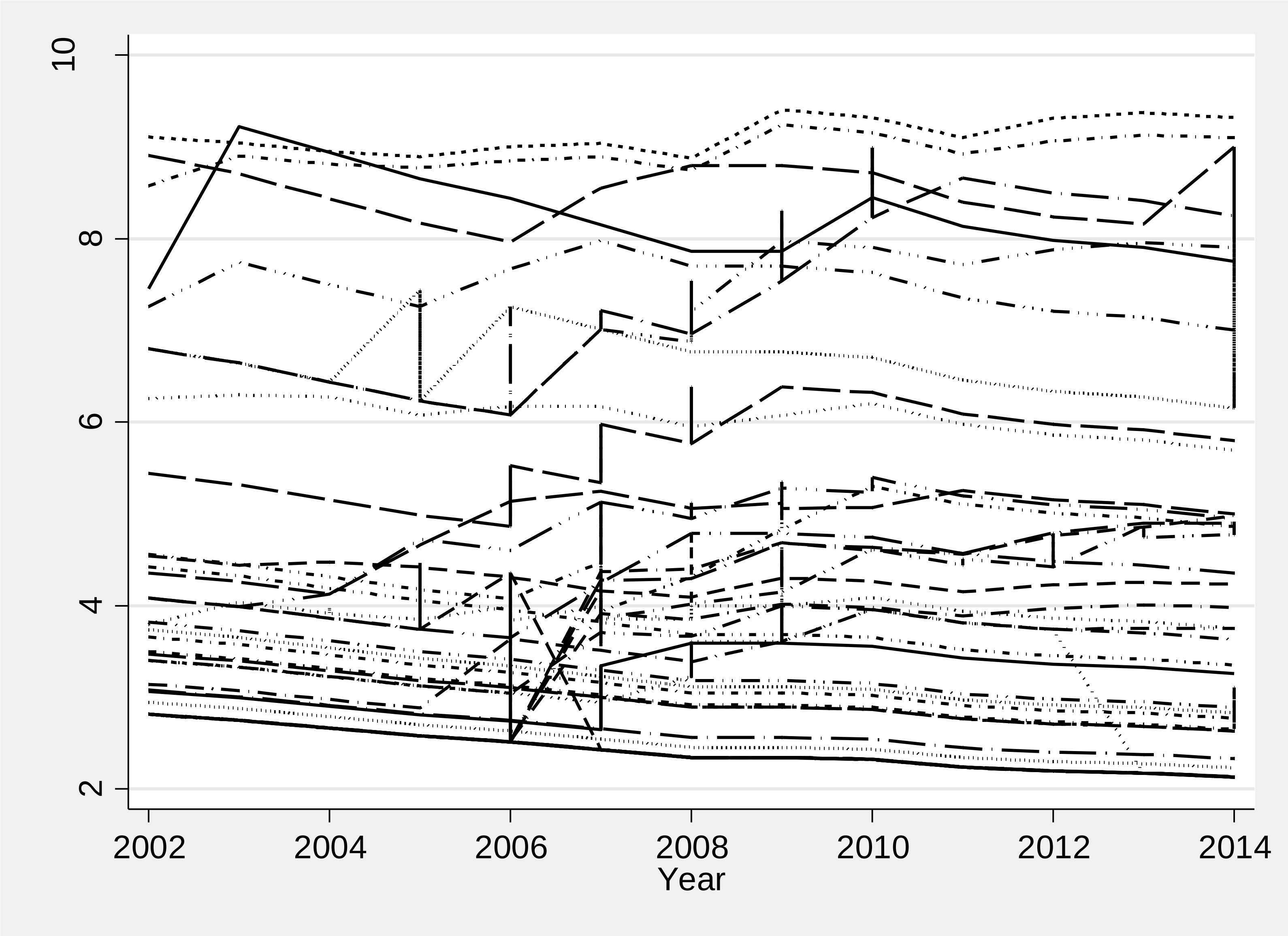
Supplementary Figures

Appendix Figure C1. Availability of maternal education data by state, 2004-2016 Vital Statistics Natality Files



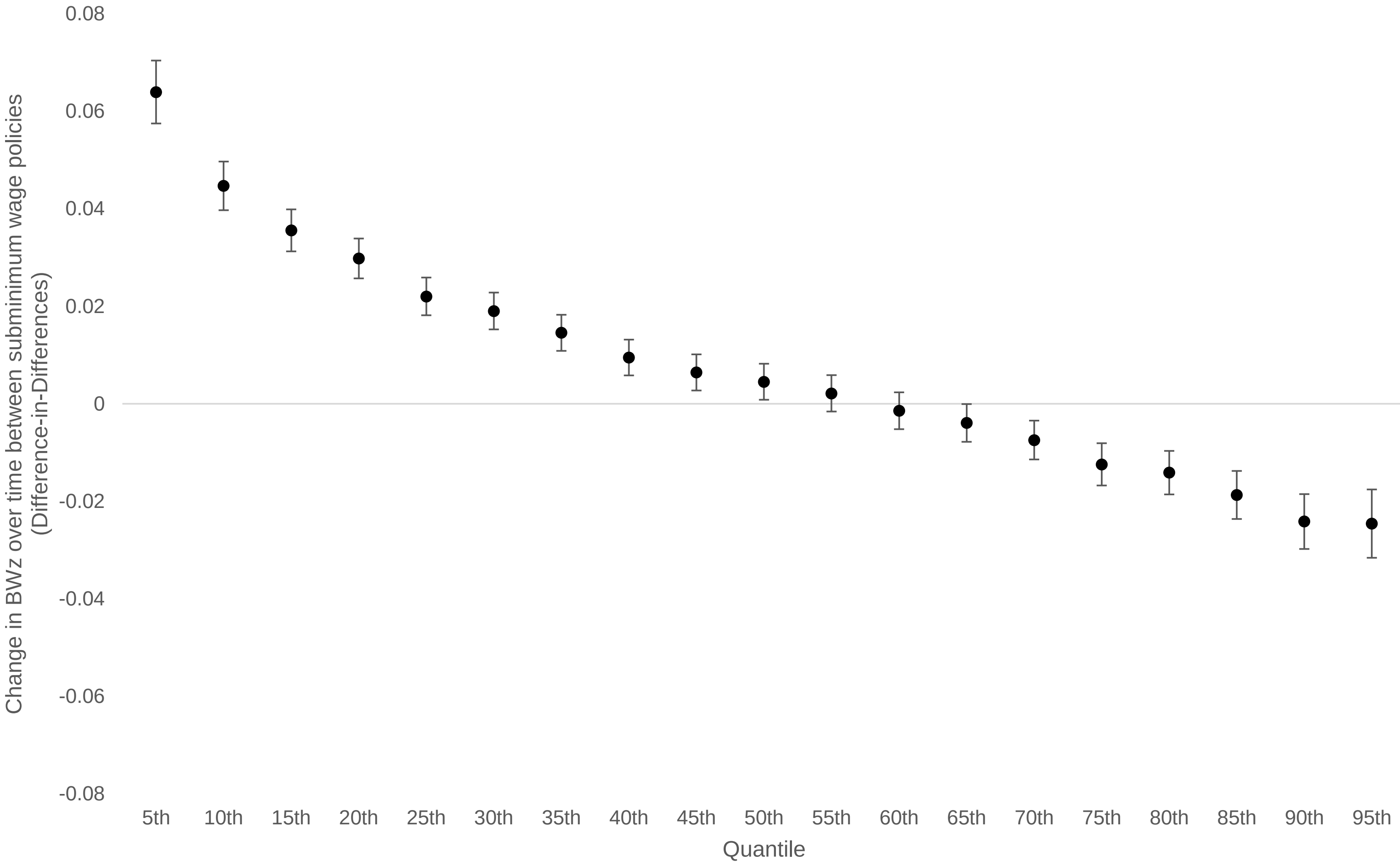
Created with mapchart.net ©

Appendix Figure C2. Tipped worker subminimum wage (2014 US dollars) over time by state



Each line represents the change in subminimum wage over time for a state.

Appendix Figure C3. Change in birthweight standardized for gestational age over time (2004-2016) when wage policy is set to 100% federal minimum wage ($5.15 to $7.25) relative to the federal tipped worker subminimum wage (constant $2.13) as estimated in linear quantile mixed effects models[a], 2004-2016 Vital Statistics Natality Files (restricted to states with consistent maternal education data availability)



BWz, Birthweight for gestational age z-score
[a]Estimates are presented for each quartile with 95% confidence interval. All models adjust for season, state-level variables lagged three years from infant year and month of birth (% Democrats in state government, maximum monthly benefits from state income supports, % White alone, % with college degree, number in food service occupation, % unemployed, % food insecure, and mean personal income) as well as maternal race/ethnicity, education, age, quadratic age, parity, nativity, marital status and infant sex