THE LONG-TERM ECONOMIC EFFECTS OF SCHOOL IMMUNIZATION MANDATES: DOES PRENATAL EXPOSURE TO STATE SCHOOL IMMUNIZATION POLICY IMPACT HEALTH AND WELL-BEING IN LATER LIFE?

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State school immunization mandates of the late 1960s and 1970s had a substantial and immediate impact on measles, mumps and rubella incidence. While these mandates were targeted at the school age population, evidence presented implies significant benefits for children in-utero. Specifically, this paper shows that individuals whose prenatal period occurred after mandate adoption had much to gain from such policies. Using variability in the timing of immunization mandates across states and comparing individuals with prenatal periods before and after immunization laws were enacted, I show that adoption of school mandates had an immediate effect on birth weight and a long-term effect on adult health. This is after controlling for individual characteristics, state specific characteristics and flexible functions of the date of conception. Moreover, results are strongest for individuals whose gestational period covers the seasonal epidemic period for measles, mumps and rubella. Evidence of the contemporaneous and long term-effect of prenatal exposure to entry laws suggests that external benefits from mandatory immunization policies are much broader than accounted for in previous literature.

Introduction

Recent literature has shown that adverse events in early childhood can dampen later adulthood economic success (Cunha and Heckman 2010; Cunha, Heckman and Schennach 2010; Almond and Currie 2010; Case and Paxson 2010). Of particular focus, is the timing of these adverse events, and from the perspective of fetal origins hypothesis, the fetal environment has been emphasized as a determinant of the initial health endowment and later adult well-being.

This paper provides evidence of a key improvement to the fetal environment: the near elimination of pervasive childhood disease through school entry mandates for measles, mumps and rubella (MMR) immunization. While school-entry immunization mandates in the 1960s and 1970s had a primary focus on prevention of measles, mumps and rubella in early childhood, they had a secondary benefit of preventing fetal infection via maternal exposure to disease (fetal infection can occur for diseases able to cross the placental wall, as is the case for MMR). This paper addresses the external benefits of school entry immunization mandates on fetal health and documents the health and economic gains in the short and long-term.

Given the current debate surrounding immunization mandates, research on the long-term effects of school immunization policy is timely. First, children who were in their early developmental period when school immunization laws were passed have come of age and entered the post-educational period of the life cycle. This allows us to evaluate the long-term effect of early school immunization laws circa the 1960s and 1970s. Second, recent controversy over vaccine safety and freedom of choice has led a growing number of parents to choose legal exemption, which often requires less effort than fulfilling immunization requirements (CDC 2010; Omar 2006; Rota, et. al. 2001). The option for legal exemption from mandated immunization relies on the argument that the benefits of immunization may not be worth the risks. Importantly, these arguments *do not* account for the long-term gains accrued to children born into a disease free environment.

There is reason to believe that the benefits of limiting maternal illness in pregnancy are large. Early literature on the fetal effects of maternal disease demonstrates that children with prenatal exposure are more likely to experience cognitive impairment, low birth weight and congenital malformation, and further study reveals that fetal infection is possible in mothers who are asymptomatic or who have already faced a previous infection themselves (Ornoy and Tenenbaum 2006; Atmar, et. al. 1992; Horstmann 1969; Horstmann, et. al. 1969; Wilkins, et. al. 1969; Siegel and Fuerst 1966).

A separate strand of literature has linked features of poor development at birth with adverse economic outcomes in adulthood, but concern exists over whether environmental influences at birth can be disentangled from other unobserved determinants of adult economic outcomes. Several recent studies have conducted careful analyses to disentangle the effects of prenatal exposures to disease from such alternative explanations. Almond (2006) studies the effect of the 1918 influenza pandemic on educational attainment and economic status of those with early life exposure, and finds that prenatal exposure is particularly harmful. Chay, Guryan and Mazumder (2009) find that reduced exposure to pneumonia and diarrhea among Blacks in the 1960s, closes the gap in Black-White AFQT scores by 50 to 80 percent. Case and Paxson (2009) show that reductions in child mortality from disease in the early 20th century are associated with improved cognitive performance at older ages. The proposed research will continue in this vein, but will address the role of school immunization policies in the 1960s-70s on the economic well being of today's adults. Such research is policy relevant as an increasing number of parents begin to choose legal exemption from school immunization, a trend that, if continued, could threaten the return of several childhood diseases.

The study design benefits from the variation in adoption of school-entry policies over state and time, which allows the impact of immunization policy to be disentangled from other cohort effects across state. The seasonality in disease contagion is a second source of variation we explore. Notably, in the pre-law period, disease contagion primarily occurs during the second quarter, a seasonal feature of MMR circulation, which is leveled in the post-law period. This implies that children conceived before or during the first quarter have the most to gain from school immunization policies, compared to children conceived once the threat of seasonal disease has passed.

The specific design of this research compares the long-term economic and educational outcomes of children in-utero before and after school-entry immunization laws were introduced by exploiting differences in the timing of the introduction of these laws across U.S. states. While all children born directly before or after the introduction of school-entry mandates will be subject to eventual school immunization, children born directly after school entry mandates benefit from a prenatal environment that is free of targeted diseases. This research is relevant to the current policy debate surrounding immunization, and, since children in their prenatal period cannot be protected through their "own" immunization in-utero, this evidence will suggest further economic repercussions from the recent trend of parents choosing legal exemption from school immunization mandates.

This work offers a number of new contributions to the literature. (1) While several recent studies have considered the long-term impact of other changes to the child developmental environment (see Almond and Currie 2010 for a survey), none have looked at the long-term impact of immunization policies, policies which virtually eliminated previously pervasive childhood disease. (2) In another strand of literature, several studies have made use of "birth quarter" as an independent factor determining education, arguing that compulsory school attendance laws *alone* account for the association between birth quarter and education (the seminal paper in this area is Angrist and Krueger 1991). More recent literature has documented an attenuation of the seasonality in outcomes over the birth quarter. Given the seasonality of MMR incidence pre-mandate and the leveling of incidence post-mandate, this paper documents the role that disease plays in the relationship between birth quarter and later economic outcomes. (3) Because this research will focus on relatively young cohorts born in the 1960s and 1970s, it can take advantage of several large data sets with detailed information on the socioeconomic circumstance of these cohorts, both at birth and in adulthood. This allows us enough power to identify heterogeneous effects.

Methodology

The study will draw on several sources of observational data from the U.S., an approach that offers a number of advantages in assessing the effects of school immunization policies. First, school-entry laws in the U.S. were phased in over the 1960s and 1970s, with different states adopting the laws in different years. This variation in the timing of adoption allows us to separate the impact of school laws on fetal development from other cohort effects that may arise over time. Second, the American Community Survey (a 1-in-232 national random sample of the U.S. population) includes information on the quarter and state of birth in the 2005-2009 surveys. This information allows us to link the current educational and economic outcomes for adults back to school immunization policies present in the year, quarter, and state of birth.

We start by collecting detailed information on school-entry immunization laws (SEILs) and disease incidence for each state. Just after licensure of the MMR vaccines in the late 1960s, few states required immunization at school entry. By 1970, 22 states had introduced school immunization laws and by 1976 almost all states (47) had school entry laws in place (CDC 1978, CDC 1970). Summary evidence reveals that school immunization policies, motivated primarily by licensure of MMR vaccines (circa 1963-1967), have large effects on the incidence of MMR.[1] To document the effect of SEILs on MMR circulation, data on MMR incidence are collected from two sources. The first is weekly surveillance counts of disease submitted by state health departments to the Center for Disease Prevention and

[1] Most SEILs also required immunization for smallpox, polio, diphtheria, pertussis, and tetanus; but these diseases had become a relative rarity by the late 1960s.

Control and are published in the Morbidity and Mortality Weekly Report. The second source of data is obtained from National Bureau of Economic Research holding of CDC Vital Statistics Mortality records (http://www.nber.org/data/vital-statistics-mortality-data-multiple-cause-of-death.html). Monthly counts of MMR deaths are then calculated for each state.

Figure 1 shows average monthly MMR incidence for states that introduced laws in the 1963-1976 period. Each state timeline is centered on the first September a school mandate was adopted and the figure depicts the average decline in MMR incidence at the September introduction of a school-entry law. The figure also shows the seasonal aspects of MMR incidence. Pre SEIL, MMR epidemics occurred mainly in the early spring whereas after SEIL implementation, this seasonal component is substantially leveled. These patterns are confirmed in Figure 2, which shows average MMR by month and the relative reduction in MMR in SEIL versus non-SEIL states over the 1963-1975 period. After accounting for state specific characteristics and year-to-year differences in incidence level, the introduction of a SEIL reduces overall MMR surveillance by 71.8% relative to baseline levels. Given the seasonal variation on MMR incidence pre-law and the effectiveness of SEILs in reducing incidence, the impact of SEILS has the largest effect in the early spring. If SEILs yield benefits to fetal health through reduction in maternal exposure to disease, then we should expect the largest effects for infants with gestation period that include the MMR epidemic season and smallest for children conceived just after the epidemic period. In addition to estimating the baseline effects of SEILs, this seasonal aspect is explored in the empirical work below.

The objective of the empirical work is to assess the external benefits of immunization mandates for school entry on contemporaneous birth outcomes and longer-term adult health outcomes. In service of this objective, we first document the effect of immunization mandates on measures of infant health collected from the Vital Statistics of the United States (VSUS) documents (http://www.cdc.gov/nchs/products/vsus.htm). These data provide information on birth weight and fetal mortality by state, race and year for the sample period 1963-1976. While these data are limiting in exploring within year variation in infant health, they can provide a baseline for the effect of the immunization mandates. This analysis is supplemented with data from Natality Detail Birth Records maintained by the CDC (http://www.cdc.gov/nchs/data_access/Vitalstatsonline.htm). The Natality data has the advantage of allowing us to explore both the timing of the impact of immunization mandates, and heterogeneous effects by demographic group. In particular, the Natality files include information on date of conception, which can be used to date each infant's gestational period. We use this method of dating gestation instead of relative to the birth date because gestational outcomes may themselves be functions of conception date. The drawback of the Natality data is that the first year of availability is 1968, which means that this analysis will lose some variability in SEIL adoption from the first mover states in 1964 to 1968. Summary statistics from both data sources are shown in Table 1. Table 2 shows the baseline effects of immunization mandates on birth outcomes using the VSUS data. After accounting for time invariant state characteristics and year specific factors common to all states, the introduction of immunization mandates leads to an improvement in birth outcomes as measured by birth weight, a common proxy for the initial health endowment.

The impact is stronger for black and other races than for white infants. This fits with the pattern of baseline immunization rates: white children were far more likely to immunized before mandate adoption.

Results indicate that introduction of an immunization mandate is associated with an increase in birth weight of approximately 13 grams: 10 grams in white infants and 16 grams in infants of other races. While meaningful, these estimates provide no information regarding where in the distribution the gains have occurred. To explore this, table 2 presents results on clinically defined low birth weight (birth weight less than 2500 grams). SEILs decreases the incidence of low birth weight by half of a percentage point (a 5 percent decrease from the mean). This distributional effect is further explored in Figure 3, which shows the effect of mandate adoption on the relative proportion of births in each of nine categories. For white infants, births are less likely to occur in the ranges of 2500 to 3500 grams and are more likely to occur in the 3500 to 4000 gram range. The effects for other racial groups (primarily black infants) occur much earlier in the distribution, with the largest decreases in the 2000 to 2500 gram range and the corresponding increase primarily occurring the 300 to 3500 gram weight range.

Panel B of Table 2 shows the impact of mandate introduction on fetal mortality (here fetal death is censored below 20 weeks of gestation). If SEILs have an impact on the selection of live births where, for instance, the marginal fetal death is now born alive, then the estimated impact of immunization mandates could be undervalued if the marginal infant is of poorer than average health. Results for the number of fetal deaths per live births indicate that this is not an important factor for fetal death after 20 weeks of gestation. Results are small and statistically insignificant. This is similar to the results for neonatal and infant mortality. It appears that mandated immunization policies have very little effect on mortality in early life. One caveat to these results is that they are conditional on births that reach at least 20 weeks of gestation. Alternatively, evidence suggests that the effect of fetal disease exposure is largest when experienced in the first 12 weeks (Siegel and Fuerst 1966; Horstmann 1969; Horstmann and Liebhaber 1969). The question of whether or not negative selection before 20 weeks is an important factor cannot be addressed with these data, but if selection is an issue in this case, results reported here can be interpreted as a lower bound on the true effect.

Main Specification:

The results shown above indicate that mandated immunization at school entry improves birth outcomes in the year following mandate adoption. The empirical methodology will explore this relationship further by tying the timing of mandate introduction to the fetal conception date. The research strategy will compare children born directly before state laws were enacted to children born directly after.[2] Using information from the Natality Detail Files for contemporaneous health outcomes and information from the American Community Survey (collected 2005 to 2009) for later adult health outcomes for the same birth cohorts, I can link these outcomes to the immunization policies that exist during each

[2] This methodology is similar to that of Almond (2006), who compares cohorts born before and after the 1918 influenza pandemic across U.S.. However, unlike the time-series design in Almond (2006), the design described here will make use of state specific changes in disease arising from SEIL adoption.

individual's prenatal period, in each individual's birth state. This suggests the following model:

$$H_{ics} = \alpha_s + \delta_y + f(c) + X_{ics}\beta + SEIL_{cs}\gamma + \varepsilon_{ics}$$

where i indexes individuals; c indexes the year and month of conception; s indexes state of birth; the dependent variable H_{ics} is a measure of health; X_{ics} contains demographic controls; *SEIL,* is the proportion of the gestational period where *i's* state of birth has mandated school-entry immunization; the α_s are state of birth dummies; the δ_y are year of conception dummies; and $f(c)$ is a function of the conception year-month. In base specifications, $f(c)$ is defined as a cubic in conception month to capture seasonality in outcomes. In more restricted models, state specific trends are added to control for trend differences in outcomes across states. The variable of interest, *SEIL,* varies by year-month of conception, c, and state of birth, s, for children born between 1963 to 1976, but I also include cohorts born from 1960 to 1963 in order to control for preexisting trends in the ACS data. [3] This model can be modified to include SEIL status in the postnatal period to test the impact of immunization policy on children in their first or second year of life.

Identification of the effect of SEIL comes from variation by year-month of conception and state of birth. With the inclusion of state and cohort fixed effects, identification of this effect is contingent on the assumption that unobservable factors do not vary within birth cohorts and across states with the proximate pattern of SEILs. To assess the validity of this

[3] The earliest available year in the Natality Detail Files is 1968.

assumption, state linear time trends can be included to capture gradually evolving, unobserved state characteristics. In a second approach, the analysis is stratified by birth month to exploit the fact that SEILs differentially impact the seasonal disease environment throughout the year.

Evidence of the contemporaneous effect of immunization mandates is presented in Table 3. The first panel of the table contains a comparison of infants conceived in any period throughout the year. Overall, SEILs raised birth weights of infants by about 6 grams and reduced the incidence of low birth weight and preterm births by 0.2 and 0.6 percentage points respectively. The remainder of the table explores these results by sibling composition. Because immunization mandates for school-entry target children of school-age, we would expect infants with older siblings of school-age to experience the largest gains from immunization mandates. The table corroborates this by comparing 3 types of family structure: first born infants, infants with an older sibling younger than 5 and infants with older siblings of school age. The results for first-born infants and infants with an older sibling under 5 indicate that the effect of immunization mandates is similar for both groups over all birth outcomes. On the other hand, infants with a school-age sibling experience larger contemporaneous gains from immunization mandates at school entry, almost double those for infants without a school age sibling.

In addition to heterogeneous effects by sibling composition, we would expect that there is a differential impact of SEIL adoption for different conception periods throughout the year due to seasonal leveling in disease incidence. Figure 2 indicates that the largest disease reduction occurred in the peak months of March, April and May. Infants conceived just after May have the least to gain from MMR reduction, since baseline seasonal levels are the smallest for this group. On the other hand, given that previous evidence on the effects of prenatal exposure to MMR indicates that these diseases are most harmful when contracted early on in the gestational period, this suggests that infants conceived in the early months of the year would have the most to gain from mandated immunization (Siegel and Fuerst 1966; Horstmann 1969; Horstmann and Liebhaber 1969). To explore this further, Figure 4 presents results by month of conception. As shown in the figure, all measures of health at birth show a remarkably similar pattern over conception month. Effects are substantially larger for infants with conception dates in the January to March period, that is, infants that would have experienced the seasonal MMR epidemic in their first trimester.

These results are mirrored by evidence for longer-term outcomes, shown in Table 4. The first column indicates that at the introduction of SEILs, the reduction in exposure to MMR in the fetal period differs throughout the year depending on a child's birth quarter. This seasonality arises from the fact that peak disease occurs in the second quarter and implies that children conceived in the first quarter (experiencing the disease peak in the first-second trimester) experience a much higher rate of MMR throughout the prenatal period and face larger reductions in MMR after mandated immunization. The smallest relative change in MMR exposure occurs for children conceived in the late spring and summer period and the largest gains occur for children conceived early in the year or late in the previous year. This pattern is mirrored in the changes for birth weight and in longer-term outcomes. Here, the table indicates that the gain at SEIL adoption is largest in the first and fourth quarter, which corresponds to the larger changes in exposure to diseases in the early prenatal period of first and fourth-quarter babies. Specifically, after adoption of immunization mandates, individuals conceived in the fourth and first quarter are almost 1 percentage point less likely to report a cognitive, sensory or physical difficulty (an 8 percent decline from the mean). In terms of disabilities that cause difficulty working, there is a half percentage point decline specific to the conception quarters of first and fourth (a 7 percent decline from the mean). These patterns are also reflected in family income measures. Specifically, adoption of immunization mandates during the prenatal period, leads to a 5 percentage point increase in total income as percent of the poverty threshold for those individuals conceived in the first quarter. The corresponding value for those conceived in the fourth quarter is 4 percentage points, while the effects for second and third quarter are still positive, but smaller. Although the effects for high school completion follow a similar seasonal pattern, there is very little impact on this measure of education. This may reflect the fact that this cohort has already high rates of high school completion of 92 percent. Those with an Associate Degree or above represent 40 percent of the population and here immunization mandates in early life are associated with a 3 and 2 percentage point increase in the likelihood of having a post secondary degree for the first and fourth quarter respectively. Again, results in the second and third quarter are much smaller.

Conclusions

The research is concerned with the relationship between early life development and later adulthood economic outcomes. Previous literature has shown that adverse events in early childhood can dampen later adulthood economic success. This work adds to this literature by studying a key improvement to the developmental environment: that of immunization technology and the policy mandates associated with its adoption. The overarching objective of the empirical work is to assess whether school-entry immunization mandates for school aged children in the late 1960s and 1970s led to contemporaneous improvements in the prenatal environment of children in utero, and whether this directly affected child development and long-term economic well being into adulthood. There are several advantages to this research design: (1) since U.S. states adopted school immunization laws in different years, the pattern in adoption can be matched to the pattern in the economic well-being of cohorts born just before or just after the laws came into effect; (2) there are several large and detailed U.S. data sources allowing us to link immunization behavior, socioeconomic variables and economic outcomes for many age cohorts across time.

The evidence presented shows that immunization mandates for school entry had an immediate impact on MMR surveillance counts and death and that, notably, the largest declines in incidence are apparent during the seasonal epidemic period in March to May. Evidence from vital statistics data indicates that states that adopted immunization mandates had more favorable birth outcomes as measured by birth weight in the years following adoption. Merging information on state mandates to detailed Natality records confirms this conclusion and shows that improvements in low birth weight and preterm deliveries are largest for those infants that have a sibling of school age at the time of their conception. Specifically, these infants have differentially better birth outcomes after adoption of immunization mandates and after controlling for: state specific characteristics, individual specific demographic information, state invariant year-to-year differences and seasonal variability. Following these same cohorts of children forward in time, results show that individuals conceived after a SEIL has been adopted in their birth state have better health and economic outcomes, but that these effect are limited to the individuals whose gestational period falls primarily during the MMR epidemic season. In short, the leveling of seasonality in prenatal exposure to disease is mirrored in seasonal changes in later well being of children born in different periods throughout the year.

This research is relevant to the current policy debate surrounding immunization, and, since children in their prenatal period cannot be protected through their "own" immunization in utero, this evidence suggests further economic repercussions from the recent trend of parents choosing legal exemption from school immunization mandates. The current controversy over vaccine safety has led to increased use of legal exemption, which often requires less effort than fulfilling immunization requirements (CDC 2010; Omar 2006; Rota, et al. 2001). The use of legal exemption from mandated immunization relies on the argument that benefits of immunization may not be worth the risks. Importantly, these arguments *do not* account for the long term gains accrued to children born into a disease free environment.

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Table 1A - Summary Statistics: Vital Statistics (1963-1976)

	Birthweight		Mortality per 1000 live Births		
	BW	Low BW	Fetal	Neonatal	Infant
Overall	3215	0.096	17.5	18.8	24.5
	(115)	(.033)	(20.7)	(6.5)	(9.3)
White	3304	0.070	12.7	15.3	18.5
	(49)	(.009)	(3.3)	(3.1)	(3.7)
Other	3126	0.121	22.3	22.4	30.5
	(90)	(.028)	(28.3)	(7.0)	(9.4)

Table 1B - Summary Statistics: Natality and American Community Survey

Panel A - Natality Records (birth cohorts between 1968-1976)

	Mean	Standard Deviation
Birth weight	3297	586
Low birth weight	0.074	0.262
Gestation length	39.5	2.9
Preterm	0.141	0.348
Age of mother	24.6	5.4
Number live births	1.2	1.5
Male	0.513	0.500
White	0.819	0.385
Legitimacy	0.874	0.332
City 500,000+	0.155	0.362
N	12,545,147	

Panel B - American Community Survey (birth cohorts between 1960-1976)

	Mean	Standard Deviation
Disability (any)	0.104	0.305
Disability (work)	0.064	0.245
Poverty	340.7	155.7
High school	0.912	0.283
Secondary Degree	0.393	0.488
Age	40.2	5.4
Male	0.494	0.500
Married	0.592	0.491
White	0.808	0.394
N	4,500,861	

Table 2 -Effect of Immunization Laws for School Entry on Contemporaneous Infant Health: Vital Statistics (1963-1976)

Panel A - Birth weight (BW)

	BW	Ln BW	Low BW
Overall	13.162 **	0.004 **	-0.005 **
	(4.481)	(0.001)	(0.002)
White race	9.859 +	0.003	-0.002 +
	(5.504)	(0.002)	(0.001)
Other race	16.465 *	0.005 *	-0.007 *
	(7.216)	(0.002)	(0.003)

Panel B - Fetal and Infant Death per 1000 live Births

	Fetal	Neonatal	Infant
Overall	0.647	-0.425	-0.022
	(1.729)	(0.536)	(0.519)
White race	0.238	0.007	-0.166
	(0.652)	(0.236)	(0.305)
Other race	1.041	-0.858	0.123
	(3.073)	(1.088)	(1.028)

Notes: N=1,428. Standard errors, clustered by state, are in parenthesis. Significane levels: +0.10 *0.05 **0.01 ***0.001. Equations include year dummies, race dummies (where appropriate) and state dummies.

Table 3 - Effect of Immunization Laws for School Entry on Contemporaneous Infant Health: Natality Records (1968-1976)

	BW	Ln BW	Low BW	Preterm
Overall	5.683 **	0.0022 **	-0.0019 **	-0.0059 *
(n=11118080)	(1.756)	(0.0007)	(0.0007)	(0.0029)
Sibling composition				
No older sibling	5.857 **	0.0023 **	-0.0019 +	-0.0053
(n=4424415)	(2.024)	(0.0009)	(0.0011)	(0.0032)
Older sibling, under school age	4.706 +	0.0017 +	-0.0013	-0.0058
(n=2408494)	(2.366)	(0.0009)	(0.0010)	(0.0038)
Older sibling, school age	8.407 **	0.0033 **	-0.0025 *	-0.0062 +
(n=2658734)	(2.700)	(0.0011)	(0.0011)	(0.0032)

Notes: Standard errors, clustered by state, are in parenthesis. Significance levels: +0.10 *0.05 **0.01 ***0.001. Equations include year dummies, state dummies, a cubic in month of conception, and controls for mothers age, race, birth history, infant sex, legitimacy and city size.

Table 4 - Effect of Immunization Laws for School Entry on Adult Outcomes: ACS birth cohorts 1960-1976

	MMR incidence	Disability (any)	Disability (work)	Poverty	High school	Secondary Degree
Overall		-0.0035 *	-0.0019 +	2.84 *	0.0055	0.0156 *
		(0.0017)	(0.0011)	(1.24)	(0.0066)	(0.0075)
Conception Quarter						
Quarter 1	-1646.20 ***	-0.0060 **	-0.0040 *	4.83 ***	0.0178	0.0337 +
(Jan-Feb-Mar)	(452.34)	(0.0022)	(0.0020)	(1.25)	(0.0151)	(0.0171)
Quarter 2	-1079.20 ***	0.0012	0.0026	2.93	0.0017	0.0095
(Apr-May-Jun)	(300.10)	(0.0030)	(0.0022)	(1.86)	(0.0081)	(0.0123)
Quarter3	-608.01 **	-0.0014	-0.0022	1.97	0.0079	0.0020
(Jul-Aug-Sep)	(174.98)	(0.0025)	(0.0017)	(1.78)	(0.0122)	(0.0129)
Quarter 4	-890.72 **	-0.0085 ***	-0.0043 +	3.52 *	-0.0019	0.0220 +
(Oct-Nov-Dec)	(299.76)	(0.0023)	(0.0022)	(1.52)	(0.0144)	(0.0112)

Notes: N=4,500,861. Standard errors, clustered by state, are in parenthesis. Significance levels: +0.10 *0.05 **0.01 ***0.001. Equations include year dummies, state dummies, a cubic in quarter of conception, and controls for age, race, sex, and marital status. Results in the MMR incidence column give the estimated reduction in MMR from SEIL adoption, where MMR incidence is measured as the moving average of measles mumps and rubella surveillance over the current and next 2 quarters. Disability indicates that the individual has a cognitive, physical or sensory disability. A work disability indicates that the individual has a disability that limits work. Poverty indicates the percentage of income relative to the poverty line. High school indicates that the individual has completed high school. Post secondary degree indicates that the individual has an associates degree or higher.

Figure 1 - Average MMR incidence

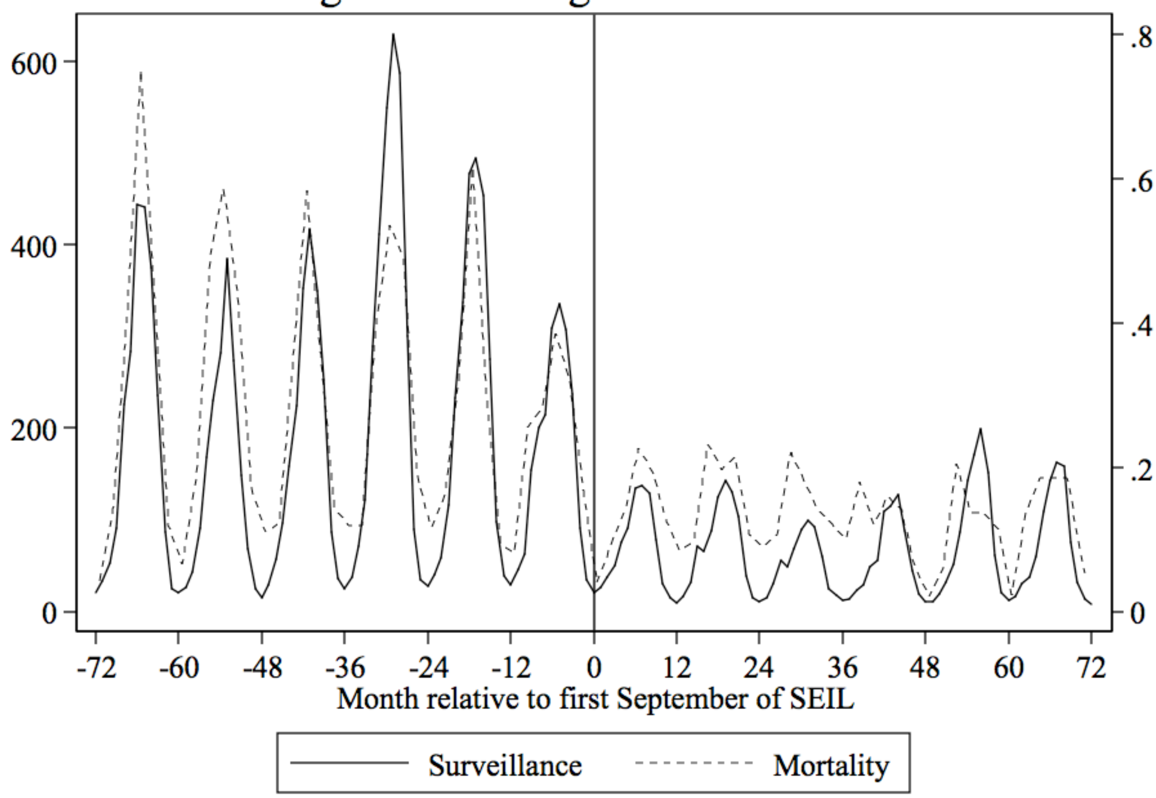

Figure 2
Estimated Impact of Immunization Mandates at School Entry

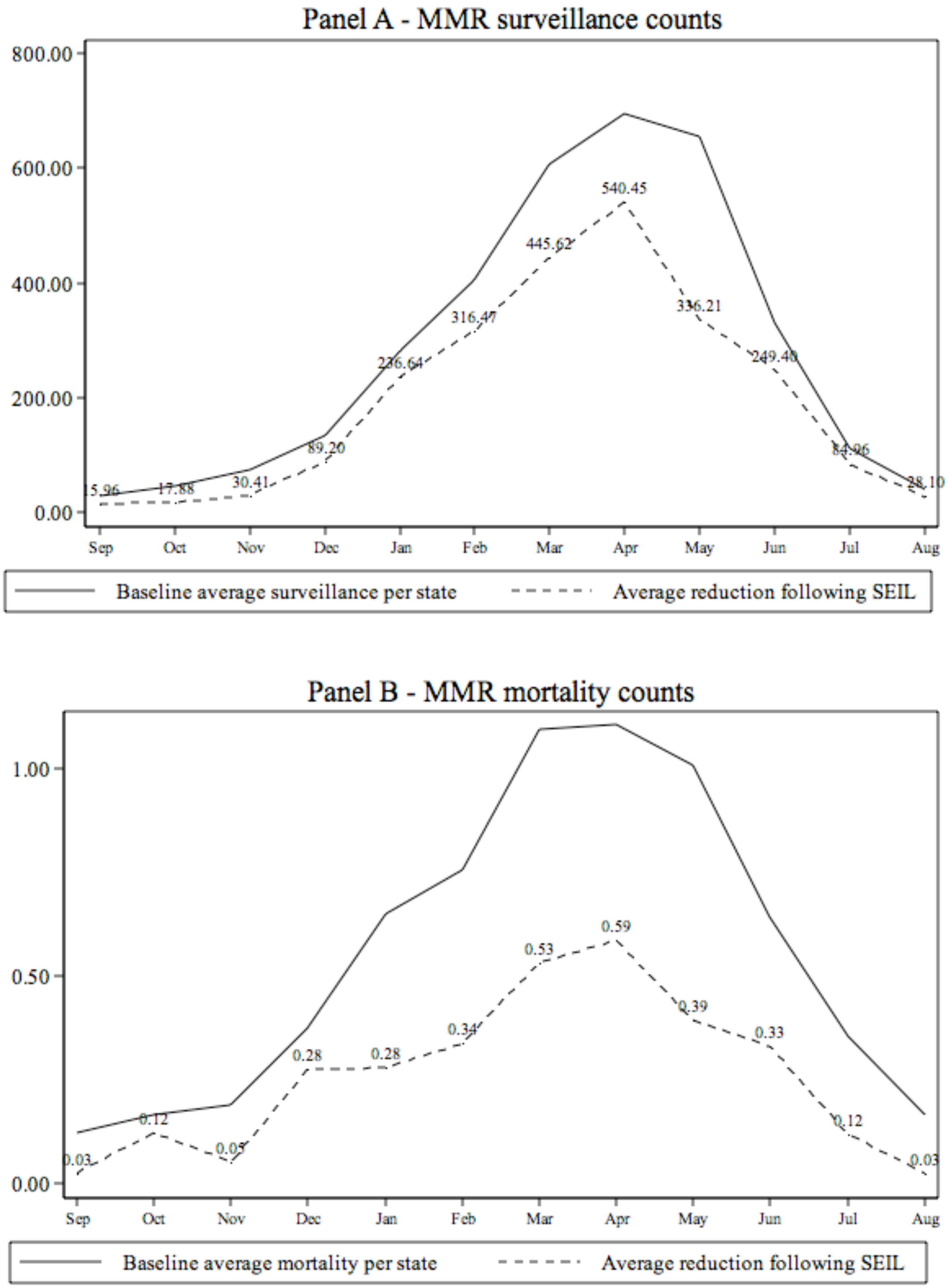

Figure 3 - Effect of SEILS on distribution of birth weight

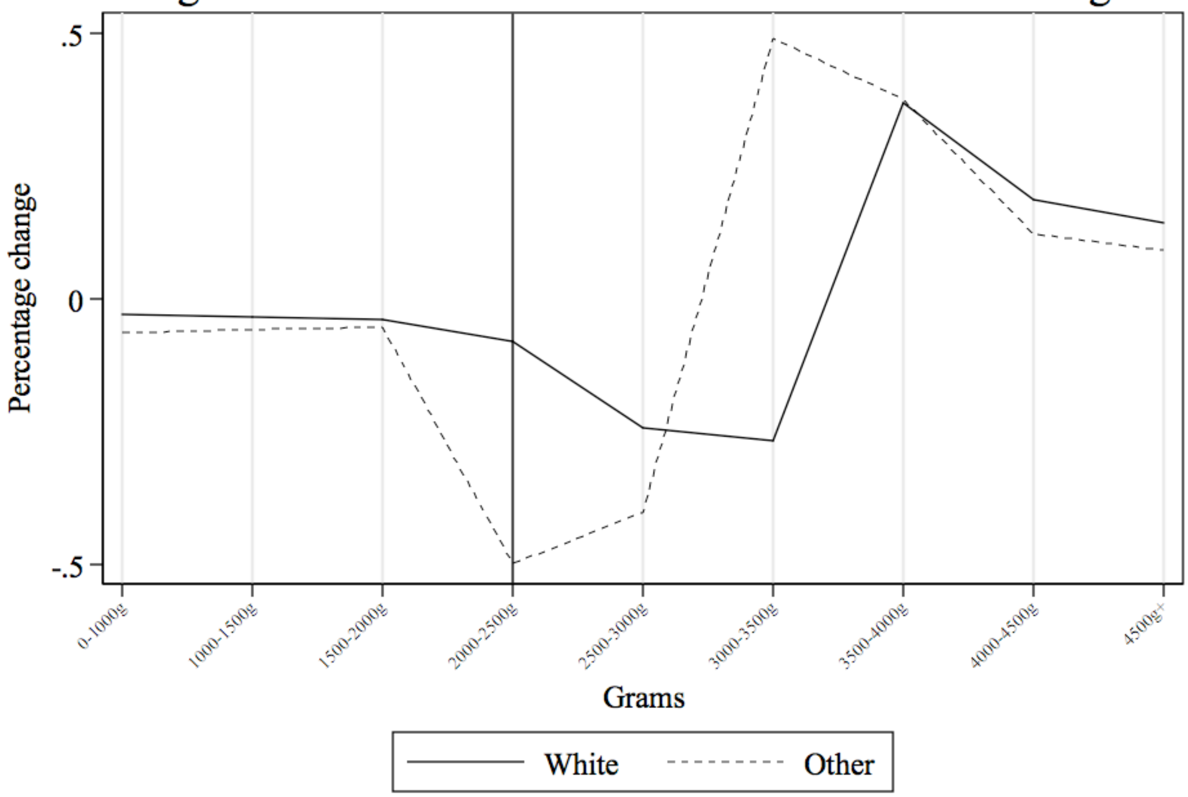

Figure 4
Estimated Impact of Immunization Mandates at School Entry