

**Does Grief Transfer Across Generations?
In-Utero Deaths and Child Outcomes***

by

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Abstract

While much is now known about the effects of physical health shocks to pregnant women on the outcomes of the in-utero child, we know little about the effects of psychological stresses. One clear form of stress to the mother comes from the death of a parent. We examine the effects of the death of the mother's parent during pregnancy on both the short-run and the long-run outcomes of the infant. Using a variety of empirical strategies to address the issue of non-random exposure to death during a pregnancy, we find small negative effects on birth outcomes, and these effects are bigger for boys than for girls. The effects on birth outcomes appear larger for deaths due to cardiovascular causes suggesting that more unexpected deaths are associated with more stress at the time of the death. However, we find no evidence of adverse effects on adult outcomes. The results are robust to alternative specifications.

What is the effect of stress while pregnant on the health of the baby? This is a question faced by all women—both in developed and developing countries. In an article in the New York Times on July 21, 2011 entitled, “The Pregnant Superwoman,” the author discusses the role of stress during pregnancy and how society should, or should not, respond.¹ However, a key underlying assumption of this and other popular discussion is that we have actually identified the effect of stress while pregnant on the children’s outcomes, and it is not at all clear that this is the case.

While much is now known about the effects of shocks to the physical health of pregnant women on the outcomes of the in-utero children, with evidence that adverse health or nutrition shocks to pregnant women have significant and often long-lasting effects on the outcomes of their children, much less is known about the effects of psychological stresses.² This is despite the fact that, in developed countries, this type of stress is likely more prevalent than nutritional deficits during pregnancy. In addition, much of the existing work on physical shocks to the environment in utero may be confounded by the fact that these physical shocks are also often associated with psychological stress.³

There are a number of mechanisms through which stress could affect a developing fetus. One plausible biological mechanism is that stress triggers the production of a placental corticotrophin-releasing hormone (CRH), which has been shown to lead to reduced gestational age and low birth weight (Hobel and Culhane, 2003). In addition, stress suppresses the immune system, thereby making pregnant mothers more susceptible to sickness, and can cause high blood pressure, which increases the chance of having pre-term labor or a low birth weight infant.

¹ Belkin, Lisa, “Myth of the Pregnant Superwoman” July 21, 2011.

<http://parenting.blogs.nytimes.com/2011/07/21/myth-of-the-pregnant-superwoman/>

² See Almond and Currie (2010) and Currie (2011) for surveys of some of this work.

³ See for instance, Scholte, van den Berg, and Lindeboom, 2012, examining the Dutch famine, and Almond (2006) examining the effect of exposure to disease.

Finally, there may be adverse behavioral responses to stress, such as smoking cigarettes or drinking alcohol, which can also have adverse effects on the health of the fetus.

In general, it is difficult to identify the causal effect of stress due to the difficulty of separating out the stress effect from the direct effect of the event causing the stress (natural disaster exposure, for example). In this paper, we use register data on the population of Norway to examine the effect of stress caused by the death of a pregnant woman's parent on both the short-run and long-run outcomes of her children.⁴

While using parental death as a shock to the mother's stress level eliminates a number of the problems faced by earlier identification strategies, some issues do remain. First, parental death can affect individuals in many ways other than through stress.⁵ In particular, parents may be important sources of financial support or parents and children may co-reside—as a result, parental death might represent a shock to one's lifestyle or income. To reduce the potential impact of these issues, we restrict the sample to women who have children between the ages of 25-45, when they are less likely to be dependent on parental resources. We also conduct a number of specification checks to confirm that it is not the loss of help during the pregnancy that is driving our results.

Second, individuals who have a parent die younger are not a random sample of the population. Lower income families are likely to both have parents who die earlier and poorer child outcomes, both in the short-run and in the longer-run. To deal with this, we integrate two approaches in our estimation strategy.

⁴ The death of a parent of the father may also increase the stress levels of the mother during pregnancy. We have investigated this issue and found no evidence for any adverse effect of such an event on child outcomes.

⁵ The death of a parent is generally regarded as a very stressful event. For example, the Holmes-Rahe Stress Inventory treats the death of a close family member as the fifth most stressful life event (the death of a spouse is considered to be the most stressful life event).

Our first approach involves comparing the outcomes of children who experience the death of a grandparent while in utero to the outcomes of similar children who experience the death of a grandparent in the period just before or just after the in utero period. By making this comparison, we are able to isolate the effect of a death during pregnancy from the effect of a death in the general time period around pregnancy.

The second approach is to use mother fixed effects. In this case, we are comparing two children born to the same mother, with the mother experiencing a parental death during only one of the pregnancies.⁶ While this approach may be more problematic for the long-run outcomes to the extent that parents change their investment behavior in response to a death of a grandparent while pregnant, it relies on entirely different variation and demonstrates the robustness of our results to the choice of specification.

Finally, there is also the mechanical relationship that a parental death is more likely to occur during pregnancy if the gestation period is longer. To account for this, we instrument the occurrence of a death during pregnancy with whether a death occurred during the 9 months following conception.

We find that, regardless of which approach we use, a parental death experienced while pregnant leads to small negative effects on birth outcomes, including birth weight and APGAR scores. When we look by cause of death, we find that the effects are largest when cardiovascular disease is the cause of death, suggesting that more unexpected deaths have bigger adverse effects. However, despite these small negative effects at birth, we find no evidence for adverse effects on the children's outcomes later in life, suggesting no persistent negative effects. These results are quite robust to the choice of specification and a variety of robustness checks.

⁶ Much of the research in the literature on child outcomes has used mother fixed effects, for example Currie and Rossin-Slater (2013).

The paper unfolds as follows. Section 2 discusses the related literature, while Section 3 describes our empirical strategy, and Section 4 describes our data. Section 5 presents the results for the effects on birth outcomes and describes heterogeneous effects by cause of death and by grandparent characteristics. Section 6 then shows the longer-run effects on education and earnings. Section 7 describes the various robustness checks we conduct, showing the insensitivity of the results to sample selection and specification choices. Section 8 then concludes.

2. Related Literature

There is a large literature examining the effects of physical insults to the mother while pregnant on the outcomes of the children. This includes studies on the effects of the 1918 flu epidemic (Almond, 2006), the 1957 Asian flu pandemic (Kelly, 2011), the 1959 to 1961 Chinese famine (Almond, Edlund, Li, and Zhang, 2010), the Dutch famine in 1945-46 (Scholte, van den Berg, and Lindeboom 2012), exposure to radiation (Almond, Edlund and Palme, 2009 and Black, Buetikofer, Devereux and Salvanes, 2013), temperature during gestation (Bruckner et al. 2014), and the effects of maternal smoking and drinking (Currie, Neidell and Schmieder, 2009; Fertig and Watson, 2009).⁷

There is a more limited amount of research examining the effects of stress while pregnant on children's outcomes. The majority of these studies focus on stress induced by large disasters, such as earthquakes (Glynn *et al.*, 2001; Torche 2011), extreme weather events, such as hurricanes (Simeonova, 2011 and Currie and Rossin-Slater, 2013), the terrorist attacks of 9/11 (Berkowitz *et al.*, 2003, and Lauderdale, 2006), and the prevalence of landmines in Columbia (Camacho, 2008). These studies tend to find a negative effect of stress on children's outcomes at

⁷ See Currie (2011) for a review.

birth. However, a key limitation of this work is that these disasters may have direct effects on the pregnant women, and hence the effects observed may be due to the combination of the direct (physical) and indirect (through stress) effects on the mother.

There are a number of exceptions. Aizer, Stroud and Buka (2012) use a sample of pregnancies from the early 1960s in Providence and Boston and estimate sibling fixed effects models of the effects of cortisol levels (a marker for maternal stress) during pregnancy on educational attainment. While this study has the advantage of having a direct measure of stress (cortisol levels), it is somewhat limited by small sample sizes. Additionally, there remains the concern that stress levels are correlated with unobserved events that have direct effects on the mother.

There are also a few papers that examine the effect of stress resulting from the death of someone close to the pregnant mother on the birth outcomes of the children. Most closely related to our own work is work done concurrently by Persson and Rossin-Slater (2014), who look at the death of a family member in utero on the short- and long-run health outcomes of children in Sweden.⁸ Using a similar identification strategy comparing children in utero for the death of a close family member to those who experience a similar death immediately after birth, the authors find that in utero exposure to stress through the death of a family member affects health at birth and later psychological conditions. While we use a slightly different identification strategy, examining only the death of grandparents of the child in utero to avoid any other confounding factors associated with the death, such as changes in resources, we view this paper

⁸ Other related work includes that by Catalano and Hartig (2001), who examine the effect of the assassination of Olaf Palme in Sweden on pregnancy outcomes just after, thereby relying on time-series variation, and work Li *et al.* (2010), who use micro data from Denmark and compare the Body Mass Index (BMI) of children of mothers who experienced a death during pregnancy to children of those who did not. However, a key limitation is that this study does not deal with the non-random timing of fertility or deaths. Our paper attempts to isolate the causal effect of stress by taking into account the non-random timing of fertility and deaths.

as a complement to our own—despite their finding of longer run effects on mental health, we find no significant effects on education or future labor market success.

3. Empirical Approach

As previously noted, because family deaths are not randomly assigned, a simple regression of birth weight on an indicator of whether the mother experienced the death of a parent while pregnant may lead to inconsistent estimates of the effect of stress on birth outcomes. Poorer families have lower life expectancy, suggesting parents are more likely to die relatively young. Therefore, the existence of a parental death while pregnant is likely to be correlated with the unobserved characteristics of the mother and child.⁹ In order to obtain consistent estimates, we use two different estimation strategies, both separately and, ultimately, combined; the first is a comparison of the effects of a death during a pregnancy to the effects of a death immediately before or after birth, and the second is a mother fixed effects approach.

To implement the first approach, we use the analysis sample of all births and include two indicator variables—an indicator if the mother experienced a parental death at any point in the period right before, during, or right after the pregnancy, and an indicator equal to one if this death occurred during the pregnancy itself. For mothers who experience a parental death either during pregnancy or just before or after pregnancy, it may be a matter of chance whether the death occurs specifically before, during, or after pregnancy. Therefore, conditional on a death around the time of pregnancy, whether or not the death occurs during pregnancy can be considered to be random. The indicator for death during pregnancy now reflects the additional

⁹ Appendix Table 1 presents summary statistics of the characteristics of those mothers who experienced a parental loss while pregnant compared to those who did not for our analysis sample. Clearly there are some systematic differences – pregnancies that have a death involve parents who are older and less educated than other pregnancies. Also, pregnancies with a death are less likely to occur later in the sample period. We control for all of these variables in estimation, but this highlights the importance of controlling for selection.

effect of having a death during pregnancy relative to the effect of experiencing a death in the window around the pregnancy. We later present results when, rather than control for a death during the window, we limit our sample to just the observations within the window to show that this does not affect our results.¹⁰

In applying this approach, we must make a two main assumptions: The first assumption is that the unobserved characteristics of the pregnancy are uncorrelated with whether a death is going to occur during it rather than just before or after it. This would be problematic if the health of the grandparent was affected by a difficult pregnancy. However, using the individuals who experienced a death before pregnancy as a comparison group would mitigate this issue, as the quality of the pregnancy is unobserved at the time of the death. It could also be the case, however, that fertility decisions of parents could be affected by grandparent death. We have examined this directly and find no evidence that this is the case. However, using individuals who experienced a death after the birth of the children as the comparison group should mitigate this issue, as the death followed the fertility choice. In our primary specifications, we use both individuals who experienced a death before pregnancy and those who experienced it after pregnancy as our comparison group. However, we later show the results when we use each group separately as the comparison group. While each of these comparison groups (those who experience death before and after the pregnancy) has their own limitations, it is comforting that our results are very similar regardless of which we use.

The second assumption required is that there is no direct effect of a death just outside the in-utero window on child outcomes. This seems quite reasonable when making the comparison between birth outcomes for those who experienced a grandparent death in utero to those who experienced it just after birth, since birth outcomes were realized prior to the death in the

¹⁰ These two methods of implementation are exactly equivalent in the absence of any control variables.

comparison group. However, this could be problematic if the grandparent were dying during the in-utero period but didn't actual die until after the birth—to the extent that the mother still experienced stress in utero, this would lead to a downward bias.¹¹ This assumption is more of a potential problem for studying later outcomes, to the extent that the death of a grandparent affects all children, regardless of the time at which it is experienced, but, again it would likely bias our estimates downward.

We implement this approach by choosing a window based on the conception date (as gestation is potentially endogenous). Our benchmark window includes all births in which a grandparent death occurs in the year before the conception date, during the 9-month interval after the conception date, or in the year immediately following this 9-month interval. Appendix Table 2 presents summary statistics by the timing of parental death to provide a basic sense of the comparison we are making—we are essentially comparing the outcomes for those children whose mother experienced a death while pregnant (in utero) relative to those who experienced it just before or after—and, observably, these groups are quite similar.

The equation we estimate is as follows:

$$H_{ift} = \alpha_0 + \alpha_1 DW_{it} + \alpha_2 D_{it} + \beta X_{it} + \gamma_t + \epsilon_{ift}.$$

Here H_{ift} represents outcomes, such as birth weight, for child i from family f at time t . DW is an indicator variable for whether there was a death (of a parent of the mother) in the window around pregnancy (in the year before, during the pregnancy, or in the year afterwards) and D is our variable of interest--an indicator for whether there was a death while the child was in utero. X is a vector of controls that includes age of mother at birth (in years), birth order of the

¹¹ The fact that we observe the largest effects when the death was more likely to be unexpected (cardiovascular disease) suggests that this may be the case.

child, years of education of both father and mother, and the gender of the child. We also include controls for year of birth by month of birth indicators (γ_t).

The second approach incorporates mother fixed effects. By incorporating mother's fixed effects, we are exploiting the fact that many mothers have more than one birth during the sample period. If a mother has two births, by chance, one pregnancy might coincide with the death of one of the mother's parents. By comparing the outcomes of the two births, we can evaluate the effect of the death, differencing out any time-invariant characteristics of the mother or family background more generally that could bias the results. In order to implement this design, we restrict the sample to mothers who have at least two births and include mother fixed effects in the regression. In the fixed effects specifications, we exclude mother's education because it is time invariant and mother's age at birth as it is subsumed by the year of birth by month of birth dummies.¹² An advantage of this fixed effects approach over the first approach is that there is no potential confounding from direct effects of deaths just before or after pregnancy on child outcomes. However, for the longer run outcomes, to the extent that the investment behavior of mothers responds to the relative endowments of her children, estimates using mother fixed effects may be biased.¹³

While the mother fixed effect helps eliminate differences in the fixed family characteristics of those who are more likely to lose a parent at a younger age, there may still be time-varying factors correlated with the death of a parent (for example, caring for a sick parent). To address this, in our final approach, we will combine the two methodologies by including both mother fixed effects and a control for whether there is a death in the window around pregnancy.

¹² One complication that arises is that the father of the children could potentially be different across births. Therefore, we include controls for paternal education. We also tested the robustness of our results when we restrict the sample to siblings with the same father; results are insensitive to this constraint.

¹³ Compensating responses could reduce endowment effects while re-enforcing behavior would increase them.

A final issue that arises in estimating the effect of a pregnant woman's parental death on children's outcomes is the mechanical relationship between duration of pregnancy and probability of experiencing a death. While gestation generally lasts about 9 months, it varies across pregnancies. If a pregnancy lasts longer, it is more likely that a grandparent death occurs during the gestation period. This leads to a mechanical positive relationship between a death in utero and gestation length. Given that gestation is correlated with birth weight and other birth outcomes, this relationship biases against finding a negative effect of family deaths on birth outcomes.

We deal with this issue by adopting an instrumental variable strategy used by Currie and Rossin-Slater (2013). Since we observe gestation length in the data, we can figure out the conception date counting backwards from the birth date. We create a predicted gestation period as the period from the conception date until 9 months after the conception date and measure family deaths that take place during this period. We then use family deaths in this predicted gestation period as an instrument for family deaths during the actual gestation. In practice, the first stage relationship is extremely strong so the instrumental variables estimates are very similar to the reduced form.

Appendix Table 3 presents the results when we run balancing tests for our three main specifications to verify that there are no observable differences in the characteristics of parents who experience a death while pregnant, conditional on the controls. We do this first for the specification with the window dummy, next for the specification with mother fixed effects, and third for the specification with both the window dummy and mother fixed effects. As we can see from the results, there are statistically significant differences for the mother fixed effects specification as mothers are more likely to be bereaved while pregnant if they are older and for

later births. This shows the necessity of our controls for maternal age and birth order in the main regressions. With the exception of one significant coefficient at the 10% level, there is no evidence of differences, with or without fixed effects, once we control for the dummy of a death occurring during the window around pregnancy. This suggests that there are unlikely to be unobservable differences as well.

4. Data

Birth Records

Our primary data source is the Medical Birth Registry of Norway that includes the birth records for all Norwegian births from 1967 to 2009. All births, including those born outside of a hospital, are included as long as the gestation period was at least 12 weeks. The birth records contain information on year and month of birth, birth weight, gestational length, age of mother, and a range of variables describing infant health at birth.¹⁴ In these data, we are also able to distinguish between singleton and multiple births, and we exclude multiple births from the sample.

Death Records

The Norwegian Death Register has information on deaths that occur in Norway between 1961 and 2010. For each death, we know the exact date of death and the cause of death. Using the individual identifiers, we can merge date of death to other information about the individual.

Other Register Data

Using unique personal identifiers, we match the birth and death files to the Norwegian Registry Data, a linked administrative dataset that covers the population of Norwegians alive at

¹⁴ We do not know the exact date of birth – in the empirical work we treat births as taking place on the 15th day of each month.

any point between 1960 and 2010 and is a collection of different administrative registers such as the education register, family register, and the tax and earnings register. These data are maintained by Statistics Norway and provide information about educational attainment, labor market status, earnings, and a set of demographic variables (such as age and gender) as well as information on families.

Military Data

We are also able to match the birth records to the Norwegian military records from 1984 to 2010 that contain information on height, weight, and IQ scores. In Norway, military service is compulsory for every able young man. Before entering the service, their medical and psychological suitability is assessed; this occurs for the great majority between their eighteenth and twentieth birthday.¹⁵ We match these data with our other data files and use the height, Body Mass Index (BMI – defined as kilograms divided by meters squared), and test score data as outcome variables for men.¹⁶

Outcomes

We study a variety of different outcomes, both at birth and later in life. One of the key variables we examine is birth weight, available beginning in 1967.¹⁷ In the literature, different variants of birth weight have been used as the primary variable of interest. These include birth weight, log(birth weight), and fetal growth (defined as birth weight divided by weeks gestation). Given that there is no obvious choice a priori, we report estimates for all of these variables in our

¹⁵ Of the men in the 1967-1987 birth cohorts, 1.2 percent died before 1 year and 0.9 percent died between 1 year of age and registering with the military at about age 18. About 1 percent of the sample of eligible men had emigrated before age 18, and 1.4 percent of the men were exempted because they were permanently disabled. An additional 6.2 percent are missing for a variety of reasons including foreign citizenship and missing observations. See Eide *et al.* (2005) for more details.

¹⁶ There is an extensive literature suggesting that height is a useful indicator of health, both in developed as well as developing nations. See Strauss and Thomas (1998) for references.

¹⁷ We set birth weight to missing in cases where it is reported to be less than 500 grams.

analysis.¹⁸ In our main specifications, we also report effects of parental bereavement on weeks of gestation and the height of the baby at birth, all available beginning in 1967.

To augment these results, we also incorporate a number of other characteristics of the birth or the first weeks of life that are reported in the Birth Register. A key indicator of health at birth is the 5-minute APGAR score. APGAR scores are a composite index of a child's health at birth and take into account Activity (and muscle tone), Pulse (heart rate), Grimace (reflex irritability), Appearance (skin coloration), and Respiration (breathing rate and effort). Each component is worth up to 2 points for a maximum of 10.¹⁹ We also study whether the birth was via Caesarian section, and whether the child was in the Neonatal intensive care (NICU) after birth.²⁰ We consider both of these as potentially reflecting the presence of problems at birth that may be associated with poor infant health.

Among the long-run outcomes, for the cohorts of men born from 1967 up to 1991 we have information from the military records on height and BMI, both of which were measured as part of the medical examination. The military records also contain an IQ score. The IQ measure is the mean score from three IQ tests -- arithmetic, word similarities, and figures (see Sundet *et al.* [2004, 2005] and Thrane (1977) for details). The arithmetic test is quite similar to the arithmetic test in the Wechsler Adult Intelligence Scale (WAIS) (Sundet *et al.* 2005; Cronbach 1964), the word test is similar to the vocabulary test in WAIS, and the figures test is similar to the Raven Progressive Matrix test (Cronbach 1964). The IQ score is reported in stanine (Standard Nine) units, a method of standardizing raw scores into a nine point standard scale that

¹⁸ The incidence of low birth weight (<2500 grams) is also frequently studied in the literature. Only 3% of our sample is low birth weight and we have found tiny insignificant effects when we have looked at the effect of parental deaths on this variable.

¹⁹ APGAR scores are available in the birth records beginning in 1977.

²⁰ We don't report results for infant mortality as it is very rare in our sample (less than 1% of births). When we have used it as an outcome we found tiny insignificant effects.

has a discrete approximation to a normal distribution, a mean of 5, and a standard deviation of 2.²¹

For both men and women, we study years of education for the cohorts born between 1967 and 1985 (and who are therefore at least 25 in 2010). Our measures of educational attainment are reported by the educational establishment directly to Statistics Norway, thereby minimizing any measurement error due to misreporting.²² We also create a binary indicator for whether the person has at least 12 years of education. For this variable, we include persons aged at least 21 in 2010, so we have cohorts up to 1989.

Finally, we are also able to look at labor market outcomes for both men and women. We first consider attachment to the labor force by studying whether individuals who are at least 25 years old are full-time, full-year workers in 2010 (the last year of our panel). To identify this group, we use the fact that our dataset identifies individuals who are employed and working full time (30+ hours per week) at one particular point in the year (in the second quarter in the years 1986-1995, and in the fourth quarter thereafter).²³ We label these individuals as full-time workers; about 60% of persons in our sample work full time in 2010.

We also study the earnings of individuals who are at least 25 years old and full-time full-year employees in 2010, measured as total pension-qualifying earnings reported in the tax registry. These are not topcoded and include labor earnings, taxable sick benefits, unemployment benefits, parental leave payments, and pensions.

Sample Restrictions

²¹ The correlation between this IQ measure and the WAIS IQ score has been found to be 0.73 (Sundet *et al.*, 2004).

²² See Møen, Salvanes and Sørensen (2003) for a description of these data.

²³ An individual is labeled as employed if currently working with a firm, on temporary layoff, on up to two weeks of sickness absence, or on maternity leave.

We restrict our sample to include only births where the mother is between 25 and 45 years old at the time of birth, drop multiple births, and drop cases with missing information on the control variables or with missing identifiers for the parents of the mother. We also include only live births where gestation length is at least 26 weeks, although we later test the sensitivity of our results to this restriction. Because we primarily use specifications with mother fixed effects, we limit our analysis sample to mothers who have at least two births in the sample; Table 1 presents summary statistics for the full sample of births and for the sample where mothers have at least two births (which we call the analysis sample). The means of most variables are similar in the two samples but parents in the analysis sample have higher education and their children tend to have better average outcomes. The analysis sample is used for all subsequent empirical work in this paper unless otherwise specified. We do, however, show the robustness of our results to the choice of estimating sample in Section 7.

5. Results

The first rows of Table 2 present the “naïve” cross-sectional OLS estimates without mother fixed effects or an indicator for a death in the window around the pregnancy to demonstrate the importance of instrumenting for death during pregnancy with death during the 9 months after conception. The first row presents the simple OLS results of the effect of a grandparent death while in utero for each outcome, the second row presents the reduced form when an indicator of death of grandparent in utero is replaced with an indicator for death of a grandparent up to 9 months after conception, and the third row presents the results when death of a grandparent in utero is instrumented with an indicator for death of a grandparent within 9 months after conception. In all specifications, we control for maternal and paternal education,

age of mother at birth, birth order of the child, gender of the child, and year by month of birth indicators.

The upward bias of “naïve” OLS due to the spurious relationship between gestation length and family deaths is obvious in the estimates. This is particularly apparent when weeks pregnant is the dependent variable, as the sign flips from positive to negative when we go from OLS to IV.²⁴ While the first stage is not reported, the first stage coefficient is close to one, leading the reduced form and IV estimates to be very similar.²⁵ While these estimates generally show adverse effects of a death on birth outcomes, we do not focus on these results because the specification does not allow for unobserved factors that may be correlated with timing of fertility and bereavement. All estimates going forward present instrumented results.

As mentioned earlier, to address issues of selection, we implement a number of different strategies, including a control variable for whether there is a death in the window around pregnancy as well as mother fixed effects. We first present the results from specifications where we include the indicator for a death in the window around the pregnancy but no mother fixed effects (IV Window, Rows 4 and 5 of Table 2), then the results from specifications where include just mother fixed effects and not the indicator for death in the window, (IV FE, Row 6 of Table 2) and, finally, the specification that includes both (IV Window FE, Rows 7 and 8 of Table 2). Note that all estimates instrument for death during pregnancy with death in the 9 months post-conception.

²⁴ To reassure that the magnitude of the change is reasonable, we have implemented a small monte carlo using a distribution of gestation lengths and a grandparent death rate that matches those in our sample. We found differences between “naïve” OLS and IV estimates that mimic those we find in Table 2 for weeks gestation, suggesting that the differences between OLS and IV results are driven by the mechanical relationship between gestation length and the probability of a death during pregnancy.

²⁵ The substantial difference between OLS and IV despite the strong first stage occurs because of the extreme reverse causality that arises from the fact that any event (including a death) is more likely to occur during pregnancy if gestation is longer.

It is important to observe that the results are extremely consistent across specifications—this is particularly notable given that the identifying variation is quite different across the different approaches. Although the conclusions do not vary across specifications, we focus on our preferred specification, which includes both mother fixed effects and an indicator for whether there was a death in the window surrounding the pregnancy.

The first finding is that there is a negative effect of a bereavement in utero on birth weight. To get a sense of the magnitudes, the estimate of the birth weight effect is about 23 grams. This is relative to a mean of about 3500 grams and standard deviation of about 500 grams, so it is approximately 5% of a standard deviation. The coefficient in the log birth weight regression is about $-.007$ (note that, for presentation purposes, this estimate is multiplied by 10 in the tables), which implies that a death reduces birth weight by less than 1%.²⁶ These small birth weight effects occur both because of a small reduction in gestation length (by .09 weeks or less than one day) and due to a fall in the rate of fetal growth. The reduction in birth weight is mirrored by a negative effect on birth length (infant height). Once again this effect is very small as the coefficient implies a magnitude of less than one 10th of a centimeter. Overall, our results for birth weight and length imply adverse but very small effects of a grandparent death in utero.

Table 2 also presents results for other birth outcomes. Again focusing on the specification with both mother fixed effects and an indicator for a death within the window surrounding the pregnancy, we find that stress leads to a lower 5 minute APGAR score and increased likelihood of having a caesarian section.²⁷ The effect on the APGAR score is small at about 4% of a standard deviation, but the effect on caesarian section is larger – a death in utero increases the

²⁶ Based on the Black, Devereux, and Salvanes (2007) estimates of the effects of birth weight on adult outcomes, this would imply that a family death reduced the probability of finishing high school and log earnings by only about .0006 and .0008, respectively.

²⁷ Because data on APGAR scores begin in 1977, sample sizes are smaller for this outcome.

probability of a C-section by about 1% (from a baseline of about 11%). Finally, we find no evidence of any effect on the likelihood of the child being transferred to the Neonatal Ward.

In Table 2, we also report the coefficients on the variable that measures whether there is a death in the window that envelops the pregnancy. It is difficult to interpret these coefficients, as they may reflect true causal effects of deaths just before or just after pregnancy, or they could be picking up systematic differences between the unobserved characteristics of pregnancies that occur during periods with a death and periods without a death.

Magnitudes

In terms of how these estimates compare to the existing literature, most credible studies find small negative effects of stress in utero on birth outcomes. Using a family fixed effects strategy, Currie and Rossin-Slater (2013) find no evidence of effects of hurricanes on birth weight or gestation length but some evidence of effects on C-sections and abnormalities. Simeonova (2011) finds a natural disaster reduces birth weight by 1 gram and weeks of gestation by .01, and Camacho (2008) finds that living near a landmine explosion in Colombia reduces birth weight by 9 grams. Persson and Rossin-Slater (2014) find that exposure to maternal bereavement in utero leads to increases in the likelihood of low birth weight and very low birth weight and an increase in the likelihood of a small-for-gestation-age birth. Our findings of small negative effects are in line with these other estimates.

By Cause of Death

While it is clearly stressful to lose a parent to any cause, there may be some types of deaths that are more stressful than others. For example, more sudden, unexpected deaths, such as those resulting from a heart attack, may lead to more concentrated stress at the time of the passing. Appendix Table 4 presents the causes of grandparent deaths during pregnancy for the

analysis sample. As is well known, the two major distinct causes of death are cancers and cardiovascular disease.

To examine whether there are differential effects by cause of death, we include separate dummy variables for each of three causes of death —cardiovascular disease, cancer, and other or unknown. Table 3 presents these results. In this table, and in the remaining tables for birth outcomes, we report estimates from the instrumental variables estimator including both mother fixed effects and the indicator for a death within the window surrounding the pregnancy.

Importantly, we see that the estimates are generally larger for deaths from cardiovascular disease, with larger and statistically significant negative birth outcomes resulting from this cause of death of the mother's parent. There is less evidence of negative birth outcomes related to death by cancer or other causes.

Timing

Given that stress does seem to matter, we then investigate when during the pregnancy the fetus is most vulnerable. To do so, we divide the pregnancy into trimesters. Table 4 presents the results when we estimate the effect of the death of a grandparent on birth outcomes by trimester of exposure. Once again, we only report IV estimates with mother fixed effects and an indicator for death within the window surrounding the pregnancy. The results suggest no clear pattern of timing—while some specifications are statistically significant, the coefficient sizes are relatively constant across the trimesters, leaving us reluctant to draw any strong conclusions about timing.

By Type of Grandparent

One concern about our interpretation of a grandparent death as being a source of grief or stress is that grandparents may provide support to the mother during pregnancy (helping with housework, looking after other children etc). While we cannot examine this directly, we can

investigate whether the effects vary by grandparent characteristics in a manner that would be consistent with this interpretation. We look at two different splits of the data. The first is whether it is the grandmother or grandfather who dies, with our prior being that the grandmother is likely to provide more direct help to the pregnant daughter and, as a result, her loss might affect the daughter both because of stress and perhaps also a loss of help. We also examine whether the grandparent dies in the same county as the birth occurs, again hypothesizing that grandparents are more likely to provide help for the pregnant daughter if they live nearby.

The estimates by grandparent gender are in Table 5. For most birth outcomes, the grandfather estimate is bigger in absolute terms than the grandmother estimate. The only exception is that the grandmother death coefficient is larger for C-sections. The coefficient estimates are generally not statistically significant for grandmother deaths, so there is stronger evidence for adverse effects of grandfather deaths. If grandmothers are more likely to provide these services than grandfathers, our finding above of a significant effect for grandfathers suggests stress is likely to be driving our results.

We also look at how the effects of a death differ depending on the proximity of the grandparent to the mother. To do so, we look at differential effects by whether the death occurred in the same county as the birth.²⁸ These estimates are presented in Table 6. While the estimates are sometimes bigger for deaths that occur in the same county, there is no clear pattern, and there is still evidence of adverse effects on birth outcomes when the death occurs in a different county. This re-enforces our view that stress/grief is the important component of the effects of grandparent deaths. Note that these estimates also suggest that it is very unlikely that our results

²⁸ There are 19 counties in Norway. We treat Oslo and Akershus as one county as Akershus contains many suburbs of Oslo.

are driven by some common shock like a local flu epidemic that both leads to the death of the grandparent and to adverse consequences for the fetus.

By Child and Mother Characteristics

There is some evidence in the literature that boys are more vulnerable to insults in utero than are girls (See for example Eriksson *et al.*, 2010). To examine this directly, we interact the death-in-utero variable with the gender of the child.²⁹ Note that we also interact the death-in-window variable with gender and include a control for whether the child is male.

Table 7 presents the estimates with the gender interaction. The results suggest bigger effects for boys than girls. For the birth weight outcomes, fetal growth, and height, the interaction with male is statistically significant and the effect is bigger for boys than girls. Indeed while there is evidence that gestation length is reduced and the probability of C-section is increased for both boys and girls, there is no other evidence that girls are adversely affected by a death.³⁰

6. Long-Run Outcomes

Given the negative (albeit small) effects of stress on birth outcomes, we next examine whether there are any longer-run effects on children's outcomes. Earlier work on the effect of physical insults in utero, such as those generated as a result of exposure to nuclear fallout from Chernobyl while pregnant, found little if any effect on short-run health outcomes but did find longer-run cognitive effects (Almond *et al.*, 2009), so it is not clear what our expectation is in terms of exposure to stress.

²⁹ The alternative approach of splitting the sample by gender gives consistent results but is less efficient as it requires restricting the sample to mothers who have at least two children of the same sex.

³⁰ We have also examined whether the size of the effects differ over time and whether they differ by parental education. We find no systematic evidence of differences in these dimensions.

Table 8 presents the results when we estimate the relationship between grandparent death in utero and the long-run outcomes of children. Because of sample size issues, we pool men and women to increase the precision of the estimates and include a dummy variable for child gender.³¹ As before, we report estimates using several different strategies.

We find little evidence of any persistent effect of stress experienced in utero on the long-run outcomes of children. This is true both using the window approach and the mother fixed effects approach; the similarity of the estimates from two methods that exploit very different sources of variation is reassuring. In addition, we are able to reject large effects with our estimates. For example, when we use our preferred specification with mother fixed effects and a control for death in the window, the confidence intervals imply that we can rule out negative effects on completing 12 years or more of schooling of more than 1.6%, negative effects on full-time earnings of more than 4%, negative effects on IQ score (for men) of more than 7% of a standard deviation, and negative effects on adult height (of men) of more than half a centimeter. Moreover, the fact that all coefficients are small and are of varying sign provides strong evidence that there are not large effects on later outcomes.³²

This is an important finding in the context of the existing research in the area. The literature on the effects of physical insults in utero has been mixed, with most work finding adverse effects on both birth outcomes and on later measures of cognitive development, educational attainment, and labor market success. However, the literature on the effects of stress during pregnancy on child outcomes has generally focused only on short-run outcomes of children and found small adverse effects. We have been left to wonder whether these imply that

³¹ We have tried interactions with a male dummy variable but they are never statistically significant. We do not report any of the battery of heterogeneous effects that we did for the birth outcomes because interaction terms are almost always statistically insignificant.

³² We have also looked at whether there is an effect of cardiovascular deaths on later outcomes but found no significant effects on educational outcomes, cognitive scores, or labor market variables.

affected children will also have poorer later outcomes. The death of a parent clearly causes acute stress to pregnant women, but we have found no evidence of significant effects on later outcomes of children. This suggests that, even if there are measurable effects on birth outcomes, we may be able to be more sanguine about the effects of acute psychological stressors on later child outcomes.

7. Robustness Checks

While our estimates are quite robust to choice of specification, we next examine how robust our results are to other choices we have made.

Selection into Sample- Including All Pregnancies with at least 12 Weeks of Gestation

One concern is that we are using only live births with at least 26 weeks gestation when creating our sample. To the extent that a bereavement early in a pregnancy may lead to a miscarriage or a stillbirth, we will understate the effect of bereavement on birth outcomes. To address this, we have tried a variety of tests. First, we examined whether or not bereavement increases the probability of a stillbirth, conditional on gestation lasting at least 12 weeks, and found no evidence of an effect. Second, we tried including all pregnancies with at least 12 weeks gestation, whether they are born live or not.³³ We have estimated specifications where we use this less restrictive sample inclusion criterion and found very similar, if not slightly larger, effects of stress during pregnancy on birth outcomes. This suggests that our results are unlikely to be tainted by differential selection into our sample along that dimension.

Before versus After

³³ Many miscarriages occur before the 12th week of pregnancy. However, the birth register does not have information on pregnancies that last less than 12 weeks.

A particular concern with the window approach is that there may be selection in terms of who chooses to become pregnant subsequent to parental death. This type of selection would imply that the group of births where the mother experienced a bereavement in the year before pregnancy might not be a suitable control for births where a death is experienced during pregnancy. While other information we have suggests this is unlikely to be a big issue (the mean parental characteristics in Appendix Table 2 are similar for all three groups within the window), we further examine this issue by separating the comparison group into births where there was a death before and births where there was a death after. In Appendix Tables 5A and 5B we separate the comparison group--first, it is a death in utero compared to a death in the 12 months before (implemented by including a control variable for a death occurring just before or during pregnancy), and then, it is a death in utero compared to a death in the 12 months after (implemented by instead including a control variable for a death occurring just after or during pregnancy). Once again, we do this both with and without mother fixed effects. The estimates are very similar in both cases, suggesting that our findings are generally robust to the choice of control group.

Analysis Sample v. Full Sample

For consistency, we have used the analysis sample for all of our specifications. However, because we are limiting our analysis to families with at least two children in our sample, one might worry that these results are not generalizable to the broader population. In Appendix Tables 6A and 6B, we present the results when we use the full sample—not limited to families with at least two children—in our estimation using the IV Window specification, and then provide the estimates from the same specification using the analysis sample for comparison. The

results are quite consistent across samples, suggesting the results are likely not driven by our choice of sample.

Using Only Observations in the Window

As we noted earlier, the simplest way to implement the IV Window approach is to restrict the sample to births where a death occurred in the period just before, during, or after the pregnancy and estimate the differential effect of experiencing the death while pregnant. For robustness, Appendix Tables 6A and 6B also show the results when we restrict our sample to just those observations, both on the Full and the Analysis samples separately. Not surprisingly, the results are quite insensitive to the exact method of implementation of the IV Window approach.

8. Conclusions

While we have substantial evidence that physical health shocks while pregnant have deleterious effects on the outcomes of children, much less is known about the effects of mental health shocks while pregnant on the well-being of the baby. Using unique data from Norway, we are able to estimate the effect of stress induced by the death of a parent while pregnant on the outcomes--both short- and long-run--of the children.

We find that maternal bereavement has small but statistically significant adverse effects on birth outcomes, and these effects are larger for boys than for girls. The effects on birth outcomes appear bigger for deaths due to cardiovascular causes, suggesting that sudden deaths due to heart attacks may be more difficult to deal with than deaths due to more persistent causes (such as cancer). However, there is no evidence of any adverse effects on any of our later outcomes including cognitive test scores, educational attainment, and earnings. This suggests that, even though there may be measurable effects on birth outcomes, acute psychological

stressors during pregnancy have limited adverse consequences on the child's success in education and the labor market.

One remaining issue is the mechanism through which bereavement affects birth outcomes. While the process may be purely physiological and be related to the body's natural responses to stress and grief, there may also be behavioral responses of the mother that affect the fetus. One such possibility is that stress increases the likelihood or level of maternal smoking. We have information on smoking behavior of mothers from 1998 onwards and we have used it to see whether bereavement affects smoking. We found no evidence of any effect. This suggests that behavioral responses may not be an important part of the story but more research with more detailed data (for example, on other behaviors such as drinking and pre-natal care) will be required to verify this conclusion.

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Table 1: Descriptive Statistics for Full Sample and Analysis Sample

	Full Sample			Analysis Sample		
	count	mean	sd	count	mean	sd
Birth weight	1096597	3585.49	567.50	784385	3606.49	557.45
Log birth weight (*10)	1096597	81.70	1.81	784385	81.77	1.75
Fetal growth rate	1096597	90.23	12.99	784385	90.75	12.80
Weeks gestation	1097918	39.65	1.93	785316	39.67	1.88
Height (birth length)	1061691	50.36	2.46	759988	50.43	2.40
5 minute APGAR	1014128	9.33	0.85	732943	9.34	0.82
C-Section	1097918	0.12	0.33	785316	0.11	0.32
Neo-natal Ward	1064850	0.04	0.20	759635	0.04	0.19
Education (2010)	219624	13.25	2.52	142260	13.48	2.51
Education \geq 12 (2010)	331113	0.83	0.38	223253	0.85	0.36
Full time (2010)	240066	0.60	0.49	156135	0.59	0.49
Log(earnings)	221683	12.61	0.82	144038	12.61	0.84
Log(earnings) full time workers	142853	12.92	0.44	92609	12.93	0.45
IQ score at 18	188189	5.30	1.74	130013	5.42	1.73
Height at 18	204453	180.45	6.56	140923	180.64	6.56
BMI at 18	204251	22.90	3.77	140780	22.80	3.65
Education of Mother	1097918	12.91	2.71	785316	13.19	2.69
Education of Father	1097918	12.71	2.78	785316	12.99	2.80
Age of mother at birth	1097918	29.96	3.81	785316	30.30	3.80
Month of Birth	1097918	6.38	3.37	785316	6.36	3.36
Year of Birth	1097918	1993.98	10.01	785316	1994.18	9.54
Birth Order	1097918	2.05	1.00	785316	2.10	1.04
Female	1097918	0.49	0.50	785316	0.48	0.50
Death during pregnancy	1097918	0.01	0.11	785316	0.01	0.11
Death in window	1097918	0.04	0.20	785316	0.04	0.20

The analysis sample includes all women who have at least two births during the sample period.

Table 2
Effect of a Death During Pregnancy on Various Child Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
OLS								
Death in utero	-6.523 (5.773)	-0.012 (0.018)	-0.202 (0.132)	0.020 (0.019)	0.012 (0.025)	-0.006 (0.009)	0.002 (0.003)	0.000 (0.002)
Reduced Form								
Death in utero	-21.835** (5.997)	-0.070** (0.019)	-0.392** (0.136)	-0.087** (0.021)	-0.054** (0.026)	-0.010 (0.009)	0.007** (0.003)	0.003 (0.002)
IV								
Death in utero	-22.172** (6.095)	-0.071** (0.020)	-0.398** (0.139)	-0.089** (0.021)	-0.055** (0.027)	-0.010 (0.009)	0.007** (0.004)	0.003 (0.002)
IV Window								
Death in utero	-17.463** (7.136)	-0.055** (0.023)	-0.295* (0.162)	-0.081** (0.025)	-0.049 (0.031)	-0.014 (0.011)	0.006 (0.004)	0.001 (0.002)
Death in window	-4.816 (3.763)	-0.017 (0.012)	-0.105 (0.086)	-0.008 (0.013)	-0.006 (0.016)	0.004 (0.006)	0.001 (0.002)	0.002 (0.001)
IV FE								
Death in utero	-16.109** (5.643)	-0.049** (0.019)	-0.282** (0.128)	-0.071** (0.022)	-0.025 (0.027)	-0.025** (0.012)	0.010** (0.003)	-0.001 (0.003)
IV Window FE								
Death in utero	-23.285** (6.669)	-0.072** (0.022)	-0.429** (0.151)	-0.089** (0.026)	-0.084** (0.032)	-0.029** (0.014)	0.013** (0.004)	-0.002 (0.003)
Death in window	7.484** (3.618)	0.024** (0.012)	0.153* (0.082)	0.019 (0.014)	0.062** (0.018)	0.004 (0.008)	-0.003 (0.002)	0.001 (0.002)
N	784385	784385	784385	785316	759988	732943	785316	759635

Standard errors in parentheses. Specifications without mother fixed effects have standard errors clustered by mother.

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

IV specifications include controls for age of mother, maternal and paternal education, gender of child, birth order of child, and year of birth by month of birth dummies. IV FE and IV Window FE specifications include mother fixed effects and exclude maternal age and education. IV Window and IV Window FE specifications include a control for whether there is a grandparent death in the window around pregnancy. The window around birth includes the year prior to conception, the 9 months post-conception, and the year subsequent to that. All the IV specifications instrument the indicator variable for a death during pregnancy with an indicator variable for a death within 9 months of the conception date. Coefficients on $\log(\text{birth weight})$ are multiplied by 10.

Table 3
Effect of a Death During Pregnancy by Cause of Death (IV Window FE estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
Cardiovascular	-32.544** (10.589)	-0.112** (0.035)	-0.533** (0.240)	-0.160** (0.042)	-0.132** (0.051)	-0.057** (0.023)	0.012** (0.006)	0.004 (0.005)
Cancer	-21.198 (14.775)	-0.053 (0.049)	-0.450 (0.335)	-0.053 (0.059)	-0.159** (0.072)	-0.035 (0.032)	0.001 (0.008)	-0.000 (0.007)
Other cause	-16.314 (10.501)	-0.044 (0.035)	-0.321 (0.238)	-0.048 (0.042)	-0.002 (0.051)	-0.002 (0.022)	0.019** (0.006)	-0.009* (0.005)
Death in window- Cardio	4.682 (5.712)	0.014 (0.019)	0.020 (0.130)	0.046** (0.023)	0.045 (0.028)	0.027** (0.012)	-0.002 (0.003)	-0.000 (0.003)
Death in window- Cancer	11.273 (7.798)	0.038 (0.026)	0.320* (0.177)	-0.007 (0.031)	0.096** (0.038)	-0.005 (0.017)	-0.001 (0.004)	0.001 (0.004)
Death in window- Other	9.623* (5.660)	0.029 (0.019)	0.214* (0.128)	0.014 (0.022)	0.065** (0.028)	-0.012 (0.012)	-0.006* (0.003)	0.003 (0.003)
<i>N</i>	784385	784385	784385	785316	759988	732943	785316	759635

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

All specifications include controls for paternal education, gender of child, birth order of child, and year of birth by month of birth dummies.

All regressions include mother fixed effects and instrument the indicator variable for a death during pregnancy with an indicator variable for a death within 9 months of the conception date.

Coefficients on log(birth weight) are multiplied by 10.

The window around birth includes the year prior to conception, the 9 months post-conception, and the year subsequent to that.

Table 4
Effect of a Death During Pregnancy by Trimester (IV Window FE estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
1 st Trimester	-20.752** (10.373)	-0.063* (0.034)	-0.249 (0.235)	-0.119** (0.041)	-0.112** (0.051)	-0.037* (0.022)	0.014** (0.006)	-0.004 (0.005)
2 nd Trimester	-23.248** (10.249)	-0.070** (0.034)	-0.567** (0.232)	-0.043 (0.041)	-0.058 (0.050)	-0.028 (0.022)	0.013** (0.006)	0.003 (0.005)
3 rd Trimester	-25.888** (10.450)	-0.082** (0.035)	-0.469** (0.237)	-0.107** (0.041)	-0.083 (0.051)	-0.023 (0.022)	0.010* (0.006)	-0.004 (0.005)
Death in window	7.536** (3.618)	0.024** (0.012)	0.154* (0.082)	0.019 (0.014)	0.062** (0.018)	0.004 (0.008)	-0.003 (0.002)	0.001 (0.002)
<i>N</i>	784385	784385	784385	785316	759988	732943	785316	759635

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

All specifications include controls for paternal education, gender of child, birth order of child, and year of birth by month of birth dummies.

All regressions include mother fixed effects and instrument the indicator variables for a death during each trimester with indicator variables for a death within 3 months of the conception date, between 4 months and 6 months after the conception date, and between 7 months and 9 months after the conception date.

Coefficients on log(birth weight) are multiplied by 10.

The window around birth includes the year prior to conception, the 9 months post-conception, and the year subsequent to that.

Table 5
Effect of a Death During Pregnancy by Grandparent Gender (IV Window FE estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
Death of grandmother in utero	-9.175 (12.360)	-0.020 (0.041)	-0.185 (0.280)	-0.019 (0.049)	-0.037 (0.060)	-0.007 (0.026)	0.019** (0.007)	-0.002 (0.006)
Death of grandfather in utero	-30.169** (7.870)	-0.095** (0.026)	-0.545** (0.178)	-0.122** (0.031)	-0.109** (0.038)	-0.038** (0.017)	0.010** (0.004)	-0.002 (0.004)
Death of grandmother in window	-0.490 (6.528)	-0.007 (0.022)	0.052 (0.148)	-0.036 (0.026)	0.060* (0.032)	-0.016 (0.014)	-0.006 (0.004)	0.001 (0.003)
Death of grandfather in window	11.507** (4.214)	0.037** (0.014)	0.203** (0.096)	0.045** (0.017)	0.067** (0.021)	0.012 (0.009)	-0.002 (0.002)	0.001 (0.002)
<i>N</i>	784385	784385	784385	785316	759988	732943	785316	759635

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

All specifications include controls for paternal education, gender of child, birth order of child, and year of birth by month of birth dummies.

All regressions include mother fixed effects and instrument the indicator variables for a death of each grandparent during pregnancy with an indicator variable for a death of that grandparent within 9 months of the conception date.

Coefficients on log(birth weight) are multiplied by 10.

The window around birth includes the year prior to conception, the 9 months post-conception, and the year subsequent to that.

Table 6
Effect of a Death During Pregnancy by Whether Birth and Death Are in the Same County (IV Window FE estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
Death in utero - same county	-25.542** (8.255)	-0.086** (0.027)	-0.534** (0.187)	-0.075** (0.033)	-0.106** (0.040)	-0.040** (0.018)	0.012** (0.005)	-0.004 (0.004)
Death in utero - different county	-20.379* (11.424)	-0.050 (0.038)	-0.246 (0.259)	-0.127** (0.045)	-0.031 (0.056)	-0.012 (0.024)	0.015** (0.006)	0.002 (0.005)
Death in window - same county	6.779 (4.450)	0.021 (0.015)	0.165 (0.101)	0.002 (0.018)	0.056** (0.022)	0.008 (0.009)	-0.002 (0.003)	0.002 (0.002)
Death in window - different county	7.573 (6.182)	0.024 (0.020)	0.108 (0.140)	0.044* (0.025)	0.064** (0.030)	-0.005 (0.013)	-0.005 (0.003)	0.001 (0.003)
<i>N</i>	784385	784385	784385	785316	759988	732943	785316	759635

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

All specifications include controls for age of mother, paternal education, gender of child, birth order of child, and year of birth by month of birth dummies.

All regressions include mother fixed effects and instrument the indicator variables for each type of death during pregnancy with an indicator variable for a death of that type within 9 months of the conception date.

Coefficients on log(birth weight) are multiplied by 10.

The window around birth includes the year prior to conception, the 9 months post-conception, and the year subsequent to that.

Table 7
Effect of a Death During Pregnancy on Various Child Outcomes (IV Window FE estimates)
Interaction with Male Child

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
Death in utero	-8.829 (9.591)	-0.023 (0.032)	-0.086 (0.217)	-0.076** (0.038)	0.014 (0.047)	-0.028 (0.020)	0.010* (0.005)	-0.004 (0.004)
Death in utero*male	-27.862** (13.304)	-0.094** (0.044)	-0.662** (0.302)	-0.026 (0.053)	-0.190** (0.065)	-0.002 (0.028)	0.006 (0.007)	0.004 (0.006)
Male	132.936** (1.223)	0.362** (0.004)	3.345** (0.028)	-0.016** (0.005)	0.840** (0.006)	-0.064** (0.003)	0.007** (0.001)	0.009** (0.001)
Death in window	2.267 (5.092)	0.009 (0.017)	0.018 (0.115)	0.026 (0.020)	0.042* (0.025)	-0.005 (0.011)	-0.003 (0.003)	0.002 (0.002)
Death in window*male	10.061 (6.925)	0.028 (0.023)	0.261* (0.157)	-0.013 (0.027)	0.038 (0.034)	0.018 (0.015)	-0.001 (0.004)	-0.002 (0.003)
<i>N</i>	784385	784385	784385	785316	759988	732943	785316	759635

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

All specifications include controls paternal education, gender of child, birth order of child, and year of birth by month of birth dummies.

All regressions include mother fixed effects and instrument the indicator variable for death during pregnancy with an indicator variable for a death within 9 months of the conception date. The interaction of death in utero with male is also instrumented by the interaction of male with the instrument.

Coefficients on log(birth weight) are multiplied by 10.

The window around birth includes the year prior to conception, the 9 months post-conception, and the year subsequent to that.

Table 8
Effect of a Death During Pregnancy on Various Child Outcomes – Later Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Completed Education	Education 12 years or more	Full time	Log (earnings)	Log (earnings) if full time	Cognitive Score	Height at 18	BMI at 18
OLS								
Death in utero	-0.038 (0.051)	0.001 (0.006)	-0.010 (0.010)	0.000 (0.017)	-0.010 (0.012)	-0.012 (0.037)	-0.052 (0.145)	0.082 (0.084)
Reduced Form								
Death in utero	-0.052 (0.051)	0.001 (0.006)	-0.010 (0.011)	0.000 (0.018)	-0.009 (0.012)	-0.023 (0.037)	-0.079 (0.147)	0.101 (0.085)
IV								
Death in utero	-0.052 (0.052)	0.001 (0.006)	-0.010 (0.011)	0.000 (0.018)	-0.009 (0.012)	-0.023 (0.038)	-0.080 (0.149)	0.103 (0.086)
IV Window								
Death in utero	-0.052 (0.060)	0.000 (0.008)	-0.002 (0.012)	0.004 (0.021)	-0.003 (0.014)	-0.021 (0.045)	0.051 (0.177)	0.036 (0.101)
Death in window	-0.001 (3.763)	0.001 (0.012)	-0.008 (0.086)	-0.004 (0.013)	-0.006 (0.016)	-0.002 (0.006)	-0.135 (0.002)	0.068 (0.001)
IV FE								
Death in utero	-0.061 (0.070)	0.010 (0.008)	-0.006 (0.015)	0.002 (0.025)	0.001 (0.020)	0.022 (0.063)	0.162 (0.205)	0.109 (0.127)
IV Window FE								
Death in utero	-0.126 (0.082)	0.004 (0.010)	0.007 (0.018)	-0.006 (0.029)	-0.008 (0.023)	0.014 (0.075)	0.035 (0.243)	0.023 (0.151)
Death in window	0.068 (0.044)	0.007 (0.005)	-0.014 (0.010)	0.008 (0.016)	0.010 (0.012)	0.008 (0.041)	0.131 (0.132)	0.089 (0.082)
N	142260	223253	156135	144038	92609	130013	140923	140780

Standard errors in parentheses. Specifications without mother fixed effects have standard errors clustered by mother.

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

“Naïve” OLS, Reduced Form, and IV specifications include controls for age of mother, maternal and paternal education, gender of child, birth order of child, and year of birth by month of birth dummies.

IV FE and IV Window FE specifications include mother fixed effects and exclude maternal age and education.

IV Window and IV Window FE specifications include a control for whether there is a grandparent death in the window around pregnancy.

The window around birth includes the year prior to conception, the 9 months post-conception, and the year subsequent to that.

All the IV specifications instrument the indicator variable for a death during pregnancy with an indicator variable for a death within 9 months of the conception date.

Appendix Table 1
Parental and Birth Characteristics by Whether Death During Pregnancy

	All		No Death in Utero		Death in Utero	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Education of Mother	13.19	2.69	13.19	2.69	12.86	2.76
Education of Father	12.99	2.80	12.99	2.80	12.80	2.87
Age of mother at birth	30.30	3.80	30.29	3.79	31.37	4.17
Month of Birth	6.36	3.36	6.36	3.36	6.32	3.35
Year of Birth	1994.18	9.54	1994.20	9.54	1992.64	9.53
Birth Order of Child	2.10	1.04	2.09	1.04	2.26	1.13
Female	0.48	0.50	0.48	0.50	0.48	0.50
<i>N</i>	785316		776110		9206	

The sample includes all women who have at least two births during the sample period.

Appendix Table 2
Means by Timing of Death

	Death in Utero	Death Before	Death After	Death Before or After
Parental and Birth Characteristics				
Education of Mother	12.86	12.79	12.79	12.79
Education of Father	12.78	12.74	12.75	12.74
Age of mother at birth	31.38	31.42	31.41	31.40
Month of Birth	6.32	6.35	6.35	6.35
Year of Birth	1992.68	1992.45	1992.49	1992.48
Birth Order	2.27	2.26	2.25	2.26
Female	0.48	0.49	0.48	0.48
Death during pregnancy	0.99	0.01	0.03	0.02
Age at death (grandmother)	69.25	69.20	69.74	69.51
Age at death (grandfather)	67.82	67.20	68.30	67.75
Child Outcomes				
Birth weight	3585.63	3597.83	3604.19	3600.84
Log birth weight (*10)	81.70	81.73	81.76	81.74
Fetal growth rate	90.38	90.56	90.67	90.62
Weeks gestation	39.58	39.65	39.68	39.66
Height (birth length)	50.39	50.40	50.46	50.43
5 minute APGAR score	9.32	9.34	9.32	9.33
C-Section	0.13	0.12	0.12	0.12
Neo-natal Ward	0.04	0.04	0.04	0.04
Education (2010)	13.36	13.38	13.41	13.39
Education \geq 12 (2010)	0.85	0.84	0.85	0.84
Full time (2010)	0.58	0.58	0.59	0.59
Log(earnings) in 2010	12.60	12.58	12.62	12.60
Log(earnings) full time workers 2010	12.91	12.92	12.92	12.92
IQ score at 18	5.35	5.37	5.35	5.36
Height at 18	180.55	180.54	180.38	180.45
BMI at 18	22.93	22.93	22.86	22.89
N	9116	11956	12966	24715

Death in utero is 1 if a grandparent death occurs in the 9 months following conception. Death before is 1 if a grandparent death occurs in the 12 months before conception. Death after is 1 if a grandparent death occurs in the 12 months after the predicted due date.

Appendix Table 3
Balancing Tests (IV Estimates)

Mother Fixed Effects				
	(1)	(2)	(3)	(4)
	Father's Education	Age of mother at birth	Birth Order of Child	Female Child
Death in utero	0.003	0.881**	0.189**	-0.004
	(0.008)	(0.050)	(0.013)	(0.007)
<i>N</i>	785316	785316	785316	785316

Window Approach					
	(1)	(2)	(3)	(4)	(5)
	Mother's Education	Father's Education	Age of mother at birth	Birth Order of Child	Female Child
Death in utero	0.068*	0.039	-0.016	0.013	-0.006
	(0.035)	(0.036)	(0.053)	(0.014)	(0.006)
Death in window	-0.419**	-0.254**	1.146**	0.166**	-0.000
	(0.019)	(0.020)	(0.029)	(0.008)	(0.003)
<i>N</i>	785316	785316	785316	785316	785316

Window Approach with Mother Fixed Effects				
	(1)	(2)	(3)	(4)
	Father's Education	Age of mother at birth	Birth Order of Child	Female Child
Death in utero	-0.004	-0.030	-0.014	-0.003
	(0.010)	(0.059)	(0.016)	(0.008)
Death in window	0.008	0.948**	0.212**	-0.001
	(0.005)	(0.032)	(0.009)	(0.005)
<i>N</i>	785316	785316	785316	785316

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

The IV estimates instrument the indicator variable for a death during pregnancy with an indicator variable for a death within 9 months of the conception date.

The window around birth includes the year prior to conception, the 9 months post-conception, and the year subsequent to that.

Appendix Table 4
Cause of Death during Pregnancy in Analysis Sample (Mother's Mother)

	Number	Percent
Cardiovascular Disease	1755	35.06
Cancer	1097	20.66
External Cause	121	2.28
Other Illness	1068	20.12
Unknown Cause	1268	23.88
Total	5309	

Cause of Death during Pregnancy in Analysis Sample (Mother's Father)

	Number	Percent
Cardiovascular Disease	3712	45.16
Cancer	1314	15.99
External Cause	158	1.92
Other Illness	1461	17.78
Unknown Cause	1574	19.15
Total	8219	

Appendix Table 5A
Different Comparison Groups-Short-Run Outcomes

IV Window	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
Comparison: Death Before								
Death in utero	-14.271* (8.000)	-0.043* (0.026)	-0.239 (0.182)	-0.069** (0.028)	-0.022 (0.035)	-0.023* (0.012)	0.005 (0.005)	0.001 (0.003)
Death just before	-7.923 (5.226)	-0.029* (0.017)	-0.159 (0.119)	-0.020 (0.018)	-0.033 (0.023)	0.014* (0.008)	0.002 (0.003)	0.002 (0.002)
Comparison: Death After								
Death in utero	-21.160** (7.945)	-0.068** (0.025)	-0.356** (0.181)	-0.097** (0.027)	-0.077** (0.034)	-0.004 (0.012)	0.007 (0.005)	0.001 (0.003)
Death just after	-1.017 (5.029)	-0.003 (0.016)	-0.042 (0.115)	0.009 (0.017)	0.023 (0.021)	-0.006 (0.008)	-0.000 (0.003)	0.001 (0.002)
<i>N</i>	784385	784385	784385	785316	759988	732943	785316	759635
IV Estimates using Mother Fixed Effects								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
Comparison: Death Before								
Death in utero	-23.129** (7.431)	-0.070** (0.025)	-0.449** (0.168)	-0.079** (0.029)	-0.062* (0.036)	-0.045** (0.016)	0.013** (0.004)	-0.002 (0.003)
Death just before	7.120 (4.893)	0.021 (0.016)	0.169 (0.111)	0.008 (0.019)	0.037 (0.024)	0.020* (0.010)	-0.003 (0.003)	0.001 (0.002)
Comparison: Death After								
Death in utero	-23.171** (7.439)	-0.072** (0.025)	-0.403** (0.169)	-0.100** (0.029)	-0.101** (0.036)	-0.012 (0.016)	0.012** (0.004)	-0.002 (0.003)
Death just after	7.147 (4.790)	0.023 (0.016)	0.122 (0.109)	0.029 (0.019)	0.077** (0.023)	-0.013 (0.010)	-0.003 (0.003)	0.001 (0.002)
<i>N</i>	784385	784385	784385	785316	759988	732943	785316	759635

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period.

All specifications include controls for age of mother, paternal education, gender of child, birth order of child, and year of birth by month of birth dummies.

These IV estimates instrument the indicator variable for a death during pregnancy with an indicator variable for a death within 9 months of the conception date.

Coefficients on $\log(\text{birth weight})$ are multiplied by 10.

Death in utero is 1 if a grandparent death occurs in the 9 months following conception. Death just before is 1 if a grandparent death occurs in the 12 months before conception. Death just after is 1 if a grandparent death occurs in the 12 months after the predicted due date.

Appendix Table 5B
Different Comparison Groups-Later Outcomes

IV Window	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Completed Education	Education 12 years or more	Full time	Log (earnings)	Log (earnings) if full time	Cognitive Score	Height at 18	BMI at 18
Comparison: Death Before								
Death in utero	-0.050 (0.068)	0.001 (0.008)	-0.001 (0.014)	0.018 (0.024)	-0.008 (0.016)	-0.039 (0.052)	-0.039 (0.202)	0.018 (0.114)
Death just before	-0.002 (0.044)	0.000 (0.005)	-0.009 (0.009)	-0.018 (0.016)	-0.001 (0.010)	0.016 (0.035)	-0.041 (0.138)	0.085 (0.075)
Comparison: Death After								
Death in utero	-0.058 (0.068)	-0.000 (0.008)	-0.003 (0.014)	-0.008 (0.023)	0.002 (0.016)	0.001 (0.050)	0.135 (0.199)	0.053 (0.113)
Death just after	0.006 (0.043)	0.002 (0.005)	-0.007 (0.009)	0.009 (0.014)	-0.011 (0.011)	-0.024 (0.032)	-0.217* (0.130)	0.050 (0.072)
<i>N</i>	142260	223253	156135	144038	92609	130013	140923	140780
IV Estimates using Mother Fixed Effects								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Completed Education	Education 12 years or more	Full time	Log (earnings)	Log (earnings) if full time	Cognitive Score	Height at 18	BMI at 18
Comparison: Death Before								
Death in utero	-0.089 (0.091)	0.009 (0.011)	0.007 (0.020)	0.019 (0.033)	-0.011 (0.025)	0.035 (0.083)	0.067 (0.272)	0.146 (0.169)
Death just before	0.028 (0.060)	0.002 (0.007)	-0.014 (0.013)	-0.018 (0.021)	0.012 (0.017)	-0.014 (0.055)	0.096 (0.180)	-0.038 (0.112)
Comparison: Death After								
Death in utero	-0.159* (0.091)	-0.001 (0.011)	0.005 (0.020)	-0.026 (0.032)	-0.005 (0.025)	-0.002 (0.083)	0.004 (0.270)	-0.051 (0.168)
Death just after	0.100* (0.058)	0.011 (0.007)	-0.012 (0.013)	0.029 (0.021)	0.006 (0.016)	0.024 (0.054)	0.160 (0.174)	0.161 (0.108)
<i>N</i>	142260	223253	156135	144038	92609	130013	140923	140780

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

The sample includes all women who have at least two births during the sample period. All specifications include controls for age of mother, paternal education, gender of child, birth order of child, and year of birth by month of birth dummies. These IV estimates instrument the indicator variable for a death during pregnancy with an indicator variable for a death within 9 months of the conception date. Death in utero is 1 if a grandparent death occurs in the 9 months following conception. Death just before is 1 if a grandparent death occurs in the 12 months before conception. Death just after is 1 if a grandparent death occurs in the 12 months after the predicted due date.

Appendix Table 6A
IV Window Estimates Without Mother Fixed on Multiple Samples-Birth Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Birth weight	Log (Birth weight)	Fetal Growth	Weeks gestation	Height	5 minute APGAR	C-Section	Neonatal Ward
IV Window-Full Sample								
Death in utero	-14.798** (6.165)	-0.052** (0.020)	-0.282** (0.140)	-0.061** (0.022)	-0.040 (0.027)	0.002 (0.010)	0.004 (0.004)	0.001 (0.002)
Death in window	-8.529** (3.218)	-0.026** (0.010)	-0.184** (0.073)	-0.012 (0.011)	-0.020 (0.014)	-0.001 (0.005)	0.003 (0.002)	0.001 (0.001)
N	1096597	1096597	1096597	1097918	1061691	1014128	1097918	1064850
IV Window-Full Sample – Using ONLY Observations within the Window								
Death in utero	-14.853** (6.194)	-0.052** (0.020)	-0.290** (0.141)	-0.058** (0.022)	-0.042 (0.027)	0.002 (0.010)	0.004 (0.004)	0.001 (0.002)
N	46474	46474	46474	46550	44965	42158	46550	45335
IV Window-Analysis Sample								
Death in utero	-17.463** (7.136)	-0.055** (0.023)	-0.295* (0.162)	-0.081** (0.025)	-0.049 (0.031)	-0.014 (0.011)	0.006 (0.004)	0.001 (0.002)
Death in window	-4.816 (3.763)	-0.017 (0.012)	-0.105 (0.086)	-0.008 (0.013)	-0.006 (0.016)	0.004 (0.006)	0.001 (0.002)	0.002 (0.001)
N	784385	784385	784385	785316	759988	732943	785316	759635
IV Window-Analysis Sample – Using ONLY Observations within the Window								
Death in utero	-18.744** (7.191)	-0.060** (0.023)	-0.326** (0.164)	-0.083** (0.025)	-0.056* (0.031)	-0.013 (0.011)	0.006 (0.004)	0.001 (0.002)
N	33558	33558	33558	33612	32504	30867	33612	32707

Standard errors in parentheses. Standard errors are clustered by mother. * $p < 0.10$, ** $p < 0.05$

The analysis sample includes all women who have at least two births during the sample period.

All specifications include controls for age of mother, maternal and paternal education, age of mother at birth, gender of child, birth order of child, and year of birth by month of birth dummies.

These IV estimates instrument the indicator variable for a death during pregnancy with an indicator variable for a death within 9 months of the conception date.

Coefficients on log(birth weight) are multiplied by 10.

Appendix Table 6B
IV Window Estimates Without Mother Fixed Effects on Multiple Samples-Long-Run Outcomes

	(1) Completed Education	(2) Education 12 years or more	(3) Full time	(4) Log (earnings)	(5) Log (earnings) if full time	(6) Cognitive Score	(7) Height at 18	(8) BMI at 18
Full Sample								
Death in utero	-0.060 (0.049)	-0.005 (0.007)	-0.002 (0.010)	0.002 (0.017)	-0.003 (0.011)	-0.004 (0.038)	0.050 (0.147)	0.079 (0.088)
Death in window	-0.023 (0.026)	-0.002 (0.003)	-0.007 (0.005)	-0.000 (0.009)	-0.003 (0.006)	-0.013 (0.020)	-0.161** (0.080)	0.058 (0.045)
N	1096597	1096597	1096597	1097918	1061691	1014128	1097918	1064850
Full Sample – Using ONLY Observations within the Window								
Death in utero	-0.053 (0.049)	-0.005 (0.007)	-0.002 (0.010)	0.003 (0.017)	-0.003 (0.011)	-0.004 (0.038)	0.046 (0.149)	0.089 (0.088)
N	11363	17013	12452	11456	7296	9610	10420	10410
Analysis Sample								
Death in utero	-0.052 (0.060)	0.000 (0.008)	-0.002 (0.012)	0.004 (0.021)	-0.003 (0.014)	-0.021 (0.045)	0.051 (0.177)	0.036 (0.101)
Death in window	-0.001 (3.763)	0.001 (0.012)	-0.008 (0.086)	-0.004 (0.013)	-0.006 (0.016)	-0.002 (0.006)	-0.135 (0.002)	0.068 (0.001)
N	142260	223253	156135	144038	92609	130013	140923	140780
Analysis Sample – Using ONLY Observations within the Window								
Death in utero	-0.046 (0.062)	-0.000 (0.008)	0.001 (0.013)	0.002 (0.021)	-0.003 (0.014)	-0.027 (0.046)	0.087 (0.181)	0.036 (0.104)
N	7435	11558	8186	7547	4780	6721	7286	7278

Standard errors in parentheses. Standard errors are clustered by mother.

* $p < 0.10$, ** $p < 0.05$

The analysis sample includes all women who have at least two births during the sample period.

All specifications include controls for age of mother, maternal and paternal education, age of mother at birth, gender of child, birth order of child, and year of birth by month of birth dummies.

These IV estimates instrument the indicator variable for a death during pregnancy with an indicator variable for a death within 9 months of the conception date.