Vitamin A and Resilience to Early Life Shocks:

Evidence From the Interaction of a Natural Experiment and a Randomized Control Trial*

Snaebjorn Gunnsteinsson Achyuta Adhvaryu Parul Christian Alain Labrique
Jonathan Sugimoto Abu Ahmed Shamim Keith P. West, Jr.

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Abstract

Recent studies have documented the immediate and lasting effects of trauma in early life, but little is understood about how to protect children from these negative impacts. Protective effects are difficult to identify empirically, because both preventative and corrective investments are endogenous choices. We leverage a unique combination of events, in which a tornado struck an area of northwest Bangladesh involved in a double-blind cluster randomized controlled trial (RCT) of maternal and newborn vitamin A supplementation, along with detailed birth and mortality records and anthropometric measurements at 0-6 months, to test whether vitamin A supplementation mitigates the deleterious effects of experiencing a natural disaster in early life. Exposure to the tornado at 0-3 months had a negative impact on infants' anthropometric outcomes, and increased the frequency of severe fevers. However, infants treated with vitamin A at birth through the RCT were largely protected from these effects. Maternal supplementation did not exhibit a similar protective capacity. Our results suggest that simple health interventions at birth can protect effectively against trauma in early life and that more research on the role of micronutrients in infant's resilience to shocks is likely to be valuable.

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*Preliminary draft. Gunnsteinsson: University of Maryland; sgunnste@umd.edu; snaebjorn.com; Adhvaryu: University of Michigan; adhvaryu@umich.edu; achadhvaryu.com; Christian, Labrique and West: Johns Hopkins Bloomberg School of Public Health. Sugimoto: Fred Hutchinson Cancer Research Center; Shamim: Jivita Bangladesh. Thanks to Prashant Bharadwaj, Pam Jakiela, Anant Nyshadham, Rafael Perez-Escamilla and Atheen Venkataramani for helpful discussions. Adhvaryu gratefully acknowledges funding from the NIH/NICHD (5K01HD071949).

1 Introduction

Recent studies from around the world have demonstrated that trauma *in utero* and in early life can have large impacts on the health and survival of infants and children. Much of this literature has focused on air and water pollution (Adhvaryu et al., 2014; Chay and Greenstone, 2003a,b; Currie and Neidell, 2005; Currie and Walker, 2011; Currie et al., 2009, 2011; Greenstone and Hanna, 2011); the effects of income shocks (Baird et al., 2011; Bhalotra, 2010), nutrient availability (Almond et al., 2011), clinical intervention at birth (Almond et al., 2010; Bharadwaj et al., 2013), sanitation (Watson, 2006), and access to health care (Almond et al., 2006) have also been documented.

This mounting evidence begs the question: how do we protect vulnerable children? In other words, is it possible to engender resilience to early life shocks? This question is not answered easily. While it is plausible that exposure to many types of early-life shocks is effectively random, measures taken to prevent negative impacts–and measures to mitigate impacts once a shock has occurred–are likely not random at all; they are rather deliberate choices. The extent to which parents invest in restoring their child's wellbeing after a shock is likely correlated with unobserved characteristics that also determine the child's outcomes. Assessing outcomes after these endogenous choices thus cannot produce a rigorous answer regarding how much a particular investment actually contributes to resilience.

In this study, we exploit data from a unique situation that by chance combined an exogenous negative shock with a randomized health intervention in early life. On March 20, 2005, a tornado struck several areas of northwest Bangladesh that were involved in a double-blind cluster randomized controlled trial (RCT) of maternal and newborn vitamin A supplementation. The tornado killed 56 people and injured almost 4000, and generated significant property damage in about 7 percent of the villages under study (Klemm et al., 2008). Both treatment and control villages were affected. We leverage this rare combination of events, along with detailed birth and mortality records and anthropometric measurements at 0, 3, and 6 months, to test whether vitamin A supplementation mitigates the deleterious effects of experiencing a natural disaster in early life.[1]

Our empirical strategy exploits the contemporaneous combination of an RCT and a natural experiment. To estimate the effects of the tornado, we compare the health of infant cohorts exposed to

[1]The protective role of vitamin A has a well charted physiological basis. Vitamin A promotes the functioning of neutrophils, macrophages, and natural killer cells – vital components of the body's immune system. It also helps restore innate immunity after infection by promoting the normal regeneration of mucosal barriers (Stephensen, 2001).

the tornado *in utero* and at 0-3 months to unexposed cohorts, across villages (also called sectors) falling within and outside the tornado's path. Then, to identify the potential protective effects of vitamin A supplementation, we add a third difference, across treatment and control sectors.

We show that exposure to the tornado at 0-3 months (the results are much weaker for *in utero* exposure) had a substantial negative impact on key anthropometric measures of infant health–namely mid-upper arm circumference (MUAC) and chest circumference (CC), and increased the frequency of severe fevers in infancy. However, those treated with vitamin A at birth through the RCT were effectively protected from these deleterious effects. For example, a standardized anthropometric index at 3 months, constructed for mean effects analysis (Kling et al., 2007), dropped by .32 SD if the child was exposed to the tornado at 0-3 months in a placebo (control) sector. That difference all but vanishes for the same exposed cohort in treatment sectors. This pattern is consistent for anthropometrics at 6 months. Results on the incidence of fevers between 0 and 3 months reinforce the results on anthropometric outcomes: exposure to the tornado in the first three months of life increases the incidence of severe fevers, but this impact is wholly blunted in treatment sectors.

Our study is the first to our knowledge to rigorously demonstrate that it is possible to protect against the deleterious effects of early life trauma. We show that health investments in early life can engender nearly complete resilience to negative shocks. This result relates to recent studies suggesting that intervention at birth can correct for health-related or economic disadvantage (Almond et al., 2011, 2010, 2006; Bharadwaj et al., 2013). These studies show that intervention in early life can improve survival and health outcomes for children with low baseline health or economic status. Our findings add to this literature in two ways. First, we measure a preventative (as opposed to a corrective) effect of investments at birth. Taken together, then, the evidence to date demonstrates that investments at birth work toward both improving outcomes after fetal disadvantage as well as protecting against trauma in early infancy.

Second, previous work has stopped short of showing what outcomes *would have been* if the child had been born without trauma. That is, how close does one get to coming to par with healthy babies' outcomes if one intervenes on low birth weight babies at birth? This question can only be answered well if the shock to the endowment is also plausibly random. We leverage the unique combination of an RCT and a natural experiment to show that not only are babies who receive vitamin A more robust after the tornado, as compared to exposed babies who did not receive vitamin A, but there is also full catch up. Babies exposed to the tornado who received vitamin A are no worse off than babies who were

not exposed to the tornado.

We also add to the understanding of the "fetal origins" hypothesis–that early life factors have long-lasting effects on health and economic well-being (Almond and Currie, 2011; Currie and Vogl, 2012; Heckman, 2006, 2007). Recent work in this literature has emphasized the need to look at the long-term effects of investments, asking the question: do early investments serve as complements or substitutes to initial endowments (Almond and Mazumder, 2012; Bhalotra and Venkataramani, 2011; Cunha et al., 2010). Our findings make some inroads toward answering this question. Our result–that outcomes for exposed infants who received supplementation are no worse than for unaffected infants–supports the hypothesis that, at least in the short term, endowments and investments are substitutes. Since the RCT did not track infants beyond 6 months, we cannot determine whether this substitutability persists for longer-term outcomes. Though much more work is needed in this area, our results suggest that it is perhaps possible to protect young children from the lifelong disadvantage that can result from early life trauma.

Finally, we provide evidence in support of policies encouraging vitamin A supplementation at birth in low-income contexts. Our results suggest that much of the impact of supplementation, at least on infant mortality, can be attributed to the large benefits accruing to the most distressed infants (in this case, to tornado-affected infants, and more suggestively, to low birth weight babies). To enhance their impact, supplementation policies should thus target distressed infants, particularly those living through traumatic experiences – natural disasters, disease outbreaks, war, and the like – in the first few months of life.

The remainder of the paper is organized as follows. Section 2 describes the child health in the Bangladeshi context, and provides details regarding the vitamin A supplementation RCT and the tornado event. Section 3 describes our data, and section 4 provides details on our empirical strategy. Section 6 describes the results, and section 7 concludes.

2 Context

2.1 The RCT

The two randomized field experiments we study were nested double-blind placebo-controlled cluster randomized trials of maternal and newborn vitamin A (and in the maternal trial, β-carotene) supple-

mentation in Bangladesh, conducted from 2001 to 2007.[2] These trials are part of the JiVitA Bangladesh international nutrition research project on maternal and child health. Both trials were conducted in a contiguous 435 square kilometer area in northwest Bangladesh, in Rangpur Division, with an estimated population of about 600,000. The study site is typical of rural Bangladesh, lying at approximately the 35th percentile of the distribution of economic and quality of life indicators among rural areas in Bangladesh (see Labrique et al. (2011) for more details on representativeness of the study area).

The study area was subdivided into 596 sectors, each of which was populated with 107 to 377 households at baseline. These sectors were randomized using a 3x2 cluster randomized factorial design with three different groups for pregnant women and 2 groups for their newborn children. The 3-group randomization (maternal trial) used a geographic block randomization, which is described in detail in West et al. (2011). The 2-group randomization (infant trial) was done by geographic block randomization, where each block was defined within one of the three earlier groups, as described in Klemm et al. (2008).

All married women in the study area in 2001 (totaling 102,769) and newlywed women (during the study, totaling 27,711), ages 13-45, were surveilled for pregnancy. In total, 60,294 pregnancies were identified and, if consent was given (>99% of cases), the pregnant woman was enrolled in the maternal supplementation study. The infant trial was nested within the maternal trial and was conducted during part of the maternal trial, or between January 2004 and December 2006. A total of 15,937 infants received supplementation (or placebo) directly at birth or shortly thereafter (79% within 24 hours; 90% within 1 week) and were followed until 6 months after birth.

The two treatment groups in the maternal trial received the recommended weekly allowance of vitamin A, either in the form of vitamin A or β-carotene (which the body converts into vitamin A), as weekly supplements from first trimester through 12 weeks post partum, while the control group received a placebo supplement. Life born infants in each sector were randomized to receive either 50,000 IU[3] of vitamin A once at birth or to receive placebo once at the same time.

Further information on field procedures and other details can be found in Labrique et al. (2011), West et al. (2011) and Klemm et al. (2008).

[2]These trials and the tornado survey referred to below were all approved by the Institutional Review Board of the Bloomberg School of Public Health, Johns Hopkins University, and the Ethics Committee of the Bangladesh Medical Research Council. Each of the trials was pre-registered at clinicaltrials.gov; Identifiers: NCT00198822 (maternal trial) and NCT00128557 (infant trial).

[3]International Units

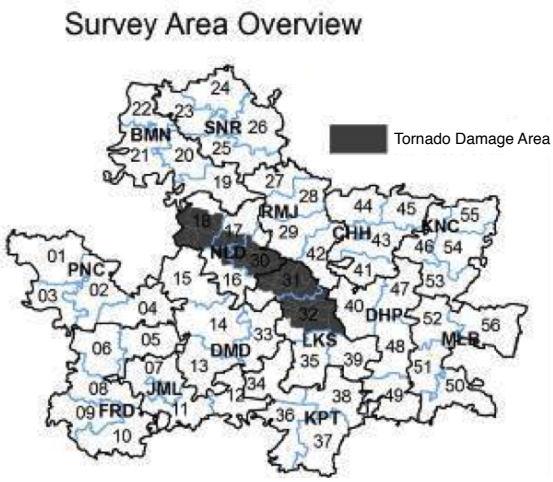


Figure 1: Area damaged by the tornado. The figure was produced by the JiVitA GIS Unit.

2.2 The Tornado

On the night of March 20th, 2005, a tornado swept through Gaibandha District, affecting about 7% of the study area (Sugimoto et al., 2011) (see Figure 1). Between August and October 2005 each household in affected areas was visited by a survey enumerator, who asked questions on mortality and morbidity of household members as well as damage to homes as a result of the tornado. Based on this survey, the tornado resulted in 56 deaths, injured 3,710 people and destroyed 3,540 houses(Sugimoto et al., 2011). Out of 596 study sectors, 41 sector had some houses destroyed and in 24 sectors more than 20% of houses were destroyed. Our evidence suggests that the tornado had no effect on the timing of supplementation or anthropometric and survey measurements. For instance, among infants in their second or third trimesters in-utero during the tornado those in the tornado area were supplemented within 24 hours at the rate of 80% while those outside of this area were dosed at the rate of 79.2%. Birth anthropometry for this same population was obtain within 7 days in the tornado area at the rate of 88.2% and outside this area at the rate of 89.5%.

3 Data

3.1 Sample

In defining the sample we follow Klemm et al. (2008) and include infants who were met and dosed with vitamin A or placebo within 30 days of birth, and for which vital status at 24 weeks is known. We limit the sample to those infants born in or after April 2004, at which time the trial procedures were fully in place (this excludes 2113 infants for which data quality is lower). The randomized study was discontinued after December 31st, 2006, and all infants born after that date were supplemented with vitamin A (regardless of randomization status). We therefore exclude the 3721 infants born after this date. We also exclude non-singleton births (298 infants) and those that we can not assign to a cohort (63 infants). This leaves us with a final core analysis sample of 16684 infants.

3.2 Summary Statistics

Table 1 reports means and standard deviations of important outcomes and control variables. We report means for the whole sample, as well as within and outside of tornado-affected sectors, and across treatment and control sectors within the tornado area. We also report differences in means across these sub-samples. Differences noted with asterisks denote statistically significant differences.

Babies in this area of Bangladesh are small relative to reference populations. The mean weight is 2.5 kg, exactly at the threshold for classification as low birth weight. Average length at birth in cm is approximately 47, a full 3 cm less than the reference US population. Head circumference is 32.7 cm at birth, which is 3 cm less than the same measurement for the reference US population. This difference (with respect to the reference population) shrinks slightly by 6 months: head circumference at 6 months is 40.84 cm as compared to 43.5 cm for reference infants.[4]

3.2.1 Comparisons across affected and unaffected areas

Means of health outcomes at birth and at 3 and 6 months are mostly balanced across the tornado and non-tornado areas. There is, however, some evidence that infants in tornado-affected sectors were slightly healthier, particularly by 6 months. 8 out of the 11 anthropometric measurements recorded are

[4]Data for reference populations are from the Centers for Disease Control and Prevention Growth Charts for the United States (Kuczmarski et al., 2000).

larger in the tornado area, though none of these differences are statistically significant. The anthropometric index at 6 months, the average of mid-upper arm circumference, head circumference and chest circumference, is also significantly larger in the tornado area. A comparison of key maternal characteristics across the two areas also provides bolsters the notion that tornado areas were slightly better off, though none of the differences is statistically significant. Mothers' living standards index (LSI) and education are both larger in tornado-affected sectors.

Taken together, this evidence tells us that child health outcomes and mothers' characteristics are generally comparable across affected and unaffected areas. However, tornado areas do appear to be slightly better off, a fact that lends purpose to the triple difference strategy we outline in the next section.

3.2.2 Comparisons across treatment arms within tornado sectors

Next, we compare means across treatment sectors (infants who received vitamin A supplementation at birth) and control (placebo) sectors within the tornado-affected area. Reassuringly, most birth outcomes (weight and anthropometry) and maternal characteristics are balanced across the treatment arms within the tornado area. Height at birth is significantly different, though the point estimate is quite small (.68 cm, from a mean of 46.2 cm in placebo sectors).

Most infant anthropometric measures at 3 and 6 months are not significantly different across the two groups, though surprisingly, two of three measures at 3 moths are larger in the control sectors, while all three outcomes are larger in the treatment sectors by 6 months. These differences can be read as the main effect of vitamin A supplementation at birth (only within the tornado areas). We see that supplementation had mildly positive effects by 6 months. In particular, MUAC at 6 months is larger by .31, or about 2.4 percent of the control group mean.

3.2.3 Dosing

Infants were dosed within hours of birth with either treatment (vitamin A) or placebo. The trial was double blind, so the implementation teams did not know whether they were dosing infants with treatment or placebo. In Table 2, we report dummies reflecting the distribution of time to dosing (in hours after birth) across key groups.

44 percent of infants were dosed within 6 hours of birth. 60 percent were dosed within 12 hours, and 73 percent by 24 hours. The dose timing distribution has a long right tail: 16 percent of infants were

dosed more than 7 days after birth. Overall, the distribution of dosing timing was statistically similar across tornado and non-tornado sectors, and within the tornado area across vitamin A and placebo groups. We verify this similarity using regression analysis in Table 21.

4 Empirical Strategy

4.1 Sources of variation

We leverage three sources of variation to identify the protective effect of vitamin A: 1) spatial variation in tornado exposure; 2) temporal overlap between the tornado event and key early life periods; and 3) the randomized allocation of vitamin A to newborns.

With regard to spatial variation, we compare infants born in sectors that were in the tornado's path with those born in sectors outside this path. Our baseline definition of spatial exposure classifies a particular sector as exposed if there was any tornado damage in the sector. Under this definition, 41 sectors, or 7 percent of all sectors involved in the RCT, were exposed. Since several sectors experienced a low degree of damage (less than 20 percent of homes were destroyed in 17 sectors), we may be misclassifying these sectors as "exposed" according to the baseline definition. We can thus define an alternative that includes only sectors affected to a greater degree – for example, sectors in which greater than 20 percent of homes were destroyed. Results are qualitatively unchanged when we use the alternative definition of spatial exposure. The caveat to using this alternative is that as we increase the cutoff, the number of exposed sectors shrinks, leading to imbalance in the sample across the exposed and unexposed groups, thus power goes down. A summary of tornado-affected sectors is provided in Table 3.

Second, we construct dummies for two main time periods of early exposure: the prenatal period (i.e., the infant was *in utero* during the tornado event) and early life (i.e., the infant was either 0-10 weeks or 0-22 during the tornado event, depending on the timing of the measurement of the outcome variable). Throughout the paper we define the *in utero* period as the time between our best guess of the date of conception (based on the last menstrual period) and birth. This definition has the advantage of being the normal definition of the *in utero* period but the disadvantage that it induces a mechanical correlation between exposure to shocks *in utero* and gestational length(Currie and Rossin-Slater, 2013). We discuss what effect this has on our results in Section 6.6.4 based on re-estimation of our models using a definition of the *in-utero* period as the 7 months before birth. For the postpartum period, we chose 10 rather than

12 (and 22 rather than 24) weeks because our measurements of anthropometric outcomes and the survey of mothers were done at 12 and 24 weeks postpartum. We thus leave at least 2 weeks' gap for the effects of the tornado to manifest themselves in infant outcomes.[5]

Third, we use randomized variation in the allocation of vitamin A to newborns by sector. Accordingly, we construct a dummy for whether the infant was born in a treatment sector, meaning he was dosed with vitamin A at birth. As explained earlier, supplementation at birth in the RCT was cross-randomized with prenatal supplementation. We focus on supplementation at birth in the body of the paper, and describe the prenatal supplementation results in the appendix.

5 Estimation

Perhaps the most intuitive candidate strategy for identification of a protective effect for vitamin A is to compare infants born in some window of time around the tornado event, inside and outside the tornado area, and across treatment (vitamin A supplementation) versus control (placebo) sectors–a difference in differences strategy. This would, however, require two fairly strong assumptions for identification. First, we would have to assume that the tornado hit a random subset of sectors. This is clearly violated, as the tornado affected a spatially contiguous area. Second, we would need that the randomization was balanced both inside and outside the tornado-affected area. Due to the small number of sectors inside the tornado area, this assumption may not hold.

Our strategy, which leverages the timing of births using a triple difference specification, allows for much weaker assumptions. In particular, in the difference in differences strategy above, we would rely on a single (spatial) difference across tornado and non-tornado areas to identify the effects of the tornado. In contrast, here we can rely on both spatial and temporal variation (around the tornado window) to identify the tornado effect. That is, we can compare babies born at different times (within and outside of a window around the tornado event), across sectors affected by and unaffected by the tornado. Then, we can essentially compare the size of this effect across vitamin A treatment sectors and placebo sectors. This strategy also lowers concern about imbalance between the vitamin A and placebo sectors as we estimate how birth outcomes change over time rather than comparing main effects across sectors.

Finally, we must also assume that the tornado hit vitamin A and placebo sectors equally hard. This

[5] For regressions using the history of fever episodes at 12 and 24 weeks as the dependent variables, we use the full 12 and 24 weeks of exposure, respectively, since fever should respond more immediately than anthropometry.

can be checked in the data. In fact, the average number of houses destroyed in the tornado hit vitamin A sectors was 33.7% compared to 47.6% in the tornado hit control sections. This is in part because the 6 sectors hit hardest (by this measure) were all control sectors. Excluding those sectors the average damage in tornado hit vitamin A sectors is 33.5% compared to 28.7% in the tornado hit control sectors. However, as discussed below and displayed in Table 16, our findings are unchanged (and in fact statistically stronger) if we exclude those sectors.

We thus estimate a triple difference across the three dimensions described above to identify the protective effect of vitamin A. We assess the impact of the tornado by comparing outcomes for infants across sectors affected by the tornado v. unaffected sectors and for those whose prenatal and early life periods coincided with the tornado timing v. those for whom these periods did not. We then take a third difference across treatment v. control sectors, to estimate the protective effect of vitamin A supplementation at birth.

In section 6, we begin by presenting the raw conditional means of key outcome variables (anthropometry, fever incidence, and mortality) within these groups. The differences across groups suggest a large negative impact of tornado exposure and an equally large protective effect of vitamin A supplementation.

We then estimate the full triple difference specification via ordinary least squares (OLS):

$$\begin{aligned} O_{ij} = \quad & \alpha + VitA_j\left(\beta_1 + \beta_2 T_j + \beta_3 U_i + \beta_4 E_i + \beta_5 T_j U_i + \beta_6 T_j E_i\right) \\ & + \gamma_1 T_j + \gamma_2 U_i + \gamma_3 E_i + \gamma_4 T_j U_i + \gamma_5 T_j E_i + X_{ij}'\delta + \varepsilon_{ij}. \end{aligned} \tag{1}$$

Here, i denotes infant and j denotes sector. O_{ij} is a health outcome measure. T_j is a dummy for tornado-exposed sector. U_i is a dummy that is 1 if the infant was *in utero* during the tornado event, and E_i is a dummy that is 1 if the infant was 0-10 weeks during the tornado. $VitA_j$ is a dummy for treatment sector in the RCT. X_{ij} is a vector of determinants of child health used as controls. Standard errors are clustered at the sector level.

6 Results

6.1 Birth outcomes

We begin with impacts on birth outcomes. The main purposes of this analysis are 1) to estimate the impacts of *in utero* exposure to the tornado on birth outcomes, and 2) to assess the protective effect of maternal (prenatal) supplementation with vitamin A or β-carotene. The main outcomes we assess as birth are birth weight, gestational age, small for gestational age (below 25th percentile birth weight adjusted for gestational age), height, MUAC, HC, CC, and a mean effects index comprised of all of the measurements at birth just mentioned.

Table 4 reports results of regressions of these outcomes on tornado exposure and its interaction with prenatal vitamin A supplementation. For nearly all variables, we estimate a substantial negative impact of *in utero* exposure. For example, the likelihood of low birth weight (birth weight < 2.5 kg) is higher by 15 percentage points; likelihood of prematurity increases by 7 percentage points; height decreases by .54 cm; and other anthropometric measurements (MUAC, HC, and CC) decline by .25 to .54 cm. In short, we find strong evidence of negative impacts of *in utero* tornado exposure on outcomes at birth.

The coefficients on the interaction of exposure with maternal supplementation with vitamin A are in general imprecisely estimated, but show a pattern towards protection. For example, the likelihood of low birth weight increases by 15 points with *in utero* tornado exposure, but that increase is cut approximately in half for mothers receiving vitamin A supplementation during pregnancy. The magnitudes of the interaction coefficients are similar (about half the size of the main effect of the tornado) for MUAC, HC, and CC. Overall, the results, though not precise enough to claim conclusively, suggest a role for prenatal vitamin A or β-carotene supplementation in protecting against *in utero* assault.

6.2 Anthropometry at 3 and 6 months

6.2.1 Preliminary Evidence

Next we present preliminary evidence from means across groups of the anthropometric index (AI) at 3 months. The AI is constructed as the normalized sum of the three (normalized) independent measures of anthropometry we have in the data: mid-upper arm circumference (MUAC), head circumference (HC), and chest circumference (CC). The normalization centers the mean of the index over the whole

sample at 0 and standardizes the variance to 1. The AI is meant to be a summary measure of anthropometry at 3 and 6 months.

AI group means are reported in Table 5. There are three panels of two-by-two tables; each panel corresponds to a time period of birth relative to the time of the tornado event. A birth during the tornado window is defined as being born up to 10 weeks before the tornado (early life exposure) or up to 40 weeks after the tornado (*in utero* exposure). The first panel reports means for infants born outside the tornado window, the second reports means for those with *in utero* exposure, and the third reports means for those with early life exposure. Each panel reports means across tornado v. non-tornado sectors and across vitamin A treatment v. placebo sectors (where treatment is supplementation with a single vitamin A dose at birth). This generates 4 means per panel. We also calculate differences across these groups, and a difference in differences estimate within each panel. Finally, we take the triple difference across panels. We report two such triple differences – one comparing *in utero* exposure (second panel) to no exposure (first panel), and one comparing early life exposure (third panel) to no exposure.

We begin with the first panel of Table 5. We see that outside the tornado window, there are fairly large differences across sectors falling within and outside of the tornado's path. In particular, babies born in tornado sectors have significantly better anthropometry (by .10 SD in treatment sectors and .16 SD in control sectors), in both vitamin A treatment and placebo sectors. This fact underscores the non-random selection of tornado sectors, and therefore the need for a third difference over time. Reassuringly, there are no significant differences across treatment and placebo sectors, though, as we might expect given the smaller sample, the estimates are somewhat imprecise in tornado areas. The difference in differences estimate is also not significantly different from 0.

The second panel of Table 5 reports AI means at 3 months for infants exposed to the tornado *in utero*. In placebo sectors, mean AI in tornado areas was only .06 SD higher than in non-tornado areas (as compared to .16 SD for infants outside the tornado window), suggesting, that the tornado may have had a small adverse effect on infants who were exposed *in utero*. In vitamin A treatment sectors, this difference was .09 SD, and thus the difference in differences estimate is slightly positive, at .04 SD. None of these estimates is significantly different from 0. Overall, this panel provides very limited evidence in support of the hypotheses that the tornado had an adverse impact on babies exposed *in utero*, and that vitamin A had any protective effect.

In contrast, the third panel of Table 5, with 3 month AI means for infant exposed in early life to the

tornado, shows large differences across groups. Non-tornado area means are essentially 0, as we would expect. In tornado areas, however, the mean AI in placebo sectors is -.10 SD, compared to .16 SD for infants outside the tornado window. This difference suggests a large negative impact of the tornado for infants exposed in the first 10 weeks of life. Yet in vitamin A treatment sectors, the tornado sector mean for exposed infants is the same as the mean AI in tornado areas (across vitamin A and placebo sectors) outside of the tornado time window.

Below these three panels, we report triple difference estimates for *in utero* and early life exposure. These estimates capture the corrective and protective effects of vitamin A, respectively. The triple difference estimate for the corrective effect of vitamin A after *in utero* exposure is .1 (and insignificant), and the estimate for the preventative effect is .31 and significantly different from 0.

We report an analogous set of means for AI at 6 months in Table 6. The pattern of differences is exactly the same as those reported in the previous table. The first panel demonstrates that, outside the tornado time window, infants in tornado sectors are significantly larger at 6 months than those born in non-tornado sectors. From the means in the second panel for infants exposed *in utero*, we see the same pattern, suggesting that the tornado did not have a large impact by 6 months for those infants exposed during gestation.

The third panel, however, with AI means for infants exposed in the first 22 weeks of life, suggests two things. First, the tornado did indeed impact these infants–the difference in the placebo group across tornado and non-tornado sectors is -.4, compared to .15 for infants outside the tornado time window, indicating a large impact of tornado exposure on these infants. Yet in the vitamin A treatment group, the difference across tornado and non-tornado sectors is .16, i.e., equivalent to the difference outside of the tornado time window. That is, those infants born in the vitamin A sectors appear protected from the negative impacts of the tornado in early life. The triple difference estimates are consistent with the difference in differences estimates from the separate panels (though neither the corrective nor the protective effect of vitamin A are significant using the raw group means).

6.2.2 Regression Results

Next, we estimate impacts of the tornado for infants exposed *in utero* and in early life, as well as the corrective and protective effects of vitamin A supplementation, using linear regression models of the form shown in equation 1. We regress AI and, separately, its individual components–MUAC, CC, and

HC[6]–on the triple interaction of a vitamin A treatment sector dummy, a tornado area dummy, and a dummy for either *in utero* or early life (0-10 weeks) exposure (we include both triple interactions in the specification). All secondary interactions and main effects are also included. In addition, we control in all models for the best guess length of gestation in weeks; in some models we also control for maternal MUAC, maternal height, and a living standards index, which is a principal components analysis of household assets data.

The results for AI and its components at 3 months are reported in Table 7. The triple interactions for *in utero* and early life exposure are reported at the top of the table. These tell us the magnitudes of the corrective and protective effects of vitamin A, respectively. Next, we report the double interactions with tornado area and being born in the tornado time window. These coefficients tell us the size of the negative effects of the tornado. We then report other double interactions, main effects, and controls.

The results in Table 7 generally confirm what we learned from the preliminary evidence from AI group means. We discuss AI results first, reported in columns 1 and 2 of the table. The interaction of birth in tornado area with early life exposure has a large and negative coefficient (-.33, $p<.05$); the coefficient on the interaction with in utero exposure is also negative, but smaller (-.14) and insignificant. That is, by 3 months, infants exposed in early life to the tornado were more than .3 SD smaller than non-exposed infants.

The triple interaction coefficients suggest that vitamin A has a significant protective effect, dampening the impact of tornado exposure substantially. The coefficient on the triple interaction with early life exposure is .37 without controls (column 1) and .29 with controls (column 2), indicating that infants in vitamin A sectors were not significantly affected by the tornado, while those in placebo sectors experienced large negative impacts. The patterns for MUAC, CC and HC are similar, but triple difference estimates of the protective effect of vitamin A are significantly different from 0 in both specifications (with and without controls) only for MUAC. Length of gestation, maternal MUAC and height, as well as living standards, are all positively associated with anthropometry.

In Table 8, we show the negative impacts of the tornado and the protective effect of vitamin A both continue to be salient for anthropometry at 6 months. Indeed, the estimates of the tornado impact on AI, MUAC, CC and HC are all larger at 6 months compared to 3 months, as are the protective

[6]The mid-upper arm circumference (MUAC), chest-circumference (CC) and head circumference (HC) are all measured in centimeters.

effects (read off the triple interactions). Again, we only find significant effects for early life exposure; the impacts of *in utero* tornado exposure and mitigative impacts are both insignificant.

6.3 Growth

Next, we test whether growth, in addition to levels of anthropometric outcomes, was affected. To do this, we use growth in anthropometric measures (AI, MUAC, CC, and HC) from 0 to 3 and 0 to 6 months as the outcome variables in the same specification as worked with earlier.

The results of these estimations are reported in Tables 9 and 10. Growth in both periods suffers for infants exposed to the tornado in early life. Vitamin A seems to have a small protective effect on growth at 3 months, but these estimates are rather imprecise and thus not significant at standard levels. By 6 months, however, the protective effect is fully evident: the triple interaction coefficients are large and statistically significant. Overall, the evidence suggests that levels as well as growth are affected by tornado exposure in early life, but that the protective effect of vitamin A is manifest for both types of anthropometric measurement.

6.4 Results on Fever Episodes

Here we present evidence on fever episodes, one mechanism underlying the impacts on anthropometric outcomes. Since vitamin A's primary role in infancy is to strengthen the immune system, we would expect that infants dosed with vitamin A at birth are less prone to fevers occurring because of poor nutrition, sanitation, and the like following tornado exposure. We test this hypothesis using data on infant fever episodes reported by mothers at 3 and 6 months.

Table 11 shows group means for the number of high (as classified by the respondent) fever episodes experienced in the first 3 months of life. The first panel shows that there were no differences in fever episodes across tornado and non-tornado areas or across vitamin A and placebo areas for infants outside the tornado time window. The average infant had just under 1 "high" fever episode in the first 3 months of life.

In the second panel, we report the same group means for infants born in the *in utero* exposure time window relative to the tornado. Here, we see significant differences in number of fever episodes across the tornado and non-tornado areas, indicating that *in utero* exposure was indeed detrimental for infants. In both vitamin A and placebo sectors, infants born in tornado areas had approximately .25 more fever

episodes. The double difference estimate (.03) is small and insignificant, indicating that vitamin A had no corrective effect for this cohort of exposed infants. This evidence is consistent with the lack of observed impact on anthropometric outcomes.

In the third panel of Table 11, we report group means for cohorts coinciding with early life exposure to the tornado. We find that mean fever episodes in non-tornado areas was about .9, consistent with the means for other cohorts reported in the previous panels. But the mean number of episodes in tornado areas that were placebo sectors in the RCT was 1.37, nearly .5 episodes (more than 50%) greater than non-tornado areas, while in tornado-exposed vitamin A sectors, the mean was unchanged, at .9. This difference is echoed in the triple difference estimates of the protective effect of vitamin A, offering powerful descriptive evidence that fevers indeed increased for infants exposed in early life, but this impact was mitigated by vitamin A supplementation.

The regression results for fever and episodes for 0-3 and 4-6 months, reported in Table 12, confirm these preliminary findings. The double interactions between tornado area and tornado time windows show that exposure to the natural disaster increased the incidence of fever for most types of exposure–*in utero* (in some specifications), at 0-3 months, and at 4-6 months. However, vitamin A had a protective effect for early life exposure (0-3 months), though this coefficient becomes insignificant when the triple interaction for 4-6 month exposure is added to the specification.

6.5 Maternal Supplementation Results

Finally, we discuss results on the interaction of tornado exposure and the maternal supplementation trial. Results are reported in Table 13. Overall, we find little evidence of a protective effect of prenatal vitamin A or β-carotene supplementation.

6.6 Robustness Checks

6.6.1 Restricting Control Group to Pre-Tornado Cohorts

In our main analysis, infants conceived after the tornado are considered part of the (temporal) control group. It is possible that these infants were affected by the aftermath of the tornado; for example, sanitation and health infrastructure likely took time to rebuild in affected areas, so infants born in some window well after the tornado could still have been exposed to its negative impacts.

To account for this possibility, we include additional interaction terms that effectively remove the cohort conceived after the tornado from the control group. Thus all cohorts are now compared only to the cohort born more than 3 months before the tornado. The results are reported in Table 14. We find that the results on AI, MUAC, and fever all retain their magnitudes and statistical significance. As we would predict, the inclusion of the cohort conceived after the tornado makes the estimates of tornado impact in early life and the protective effect of vitamin A stronger.

6.6.2 Changing the Definition of Tornado Exposure

Our baseline variable for tornado exposure is an indicator that equals 1 for each infant if the sector in which the infant was born had a positive percentage of homes destroyed. Exposure might be better defined using higher cutoffs, because low levels of tornado damage may not generate large enough impacts on infant anthropometry to detect statistically. On the other hand, since defining the exposure cutoff at 0 yields about 10 percent of sectors defined as exposed, increasing the cutoff will yield a very small fraction of the sample classified as exposed. This creates small cells of infants who were born in exposed sectors around the time of the tornado, and thus estimates become more imprecise. We favor the "any exposure" definition to mitigate this latter concern, but we check whether exposure at higher cutoffs has similar effects.

To do implement this, we take our basic specification and divide tornado exposure into two dummies – one for 0-20 percent of homes destroyed, and one for 20-100 percent. We look at the double and triple interaction coefficients for each of these indicators. The results are presented in Table 15. We find in general that the size of the coefficients for both the impact of the tornado and the protective effect of vitamin A are not statistically different for both definitions of exposure, suggesting that our baseline definition seems to capture the appropriate variation in exposure.

Another possible concern for our estimates is that 6 of the most damaged sectors were all control sectors. As a result, among the tornado hit sectors, 47.6% of houses in control sectors were destroyed compared to 33.7% of houses in vitamin A sectors. If we exclude those 6 sectors most damaged then the balance shifts such that 28.7% of houses in control sectors are destroyed compared to 33.5% in the vitamin A sectors. We re-estimated our key regressions excluding these 6 sectors and report the findings in Table 16. Our findings are similar and in fact statistically stronger than before. It therefore appears unlikely that our findings are driven by control sectors being especially hard hit, at least not by

our measure of residential house destruction.

6.6.3 Multilevel Random Effects Models

In Table 17 we re-estimate our key regressions as multilevel hierarchical random effects models instead of using OLS with standard errors corrected using the cluster sandwich estimator. In each model we have a random effect for within and outside of the tornado area (level 1) and for each sector (level 2). Instead of fixed effects for each sector (as in previous tables) we include the three main effects: whether the infant is in the tornado area, wether she is in a vitamin A sector, and the interaction of the two. Our findings in this table are very similar to estimates obtained using our main specifications.

6.6.4 Changing the definition of the in-utero period

In Table 18 we change the definition of the *in-utero* period to correspond to the 7 months before birth to remove the mechanical correlation between gestational length and tornado exposure (Currie and Rossin-Slater (2013) note that this causes a downward bias in estimates of the impact of shocks). Our results of the impact of the shock are largely unchanged. With this new definition the tornado is estimated to cause 0.16cm reduction in 3 month MUAC versus a 0.15cm drop using the original definition. The number of fever episodes is estimated to increase by 0.31 versus an increase of .38 using the original definition. We do find some positive effects of vitamin A on infants that experienced the tornado shock *in-utero* using this new definition, but the effect is marginally significant, only found for MUAC, and in other preliminary analysis, does not seem to be very robust.

7 Conclusion

Infants are vulnerable to a variety of assaults *in utero* and in early life. Quantifying the deleterious effects of environmental factors, income and nutritional scarcity, and natural disasters on infant health and survival is the focus of a rapidly expanding set of studies in economics. We know from this work that impacts, particularly in low-income contexts, can be large and long-lasting. But we have little rigorous empirical evidence that intervening in early life can change outcomes for children exposed to trauma.

In this study, we leverage the unique combination of a natural disaster and an RCT to estimate the negative impacts of tornado exposure on birth outcomes, and the protective effect of vitamin A

supplementation at birth. We find significant impacts of the tornado on anthropometric outcomes at 3 and 6 months. But babies who received a one-time dose of vitamin A at birth did not experience the same drops in anthropometric measures. Results on the incidence of fever episodes in infancy reinforce these findings, lending some insight into the mechanism through which the protective capacity of vitamin A operates.

The results this study demonstrate, to our knowledge for the first time, that simple interventions at birth can protect effectively against trauma in early life. This is important because improving the health and survival of infants, particularly in low-income countries, is a primary goal for global health policy. Moreover, a growing literature in economics shows that in addition to these immediate impacts, early life assaults have far-reaching long run consequences. Disease (Almond, 2006; Bleakley, 2007, 2010; Cutler et al., 2010), natural disasters (Currie and Rossin-Slater, 2013), income shocks (Maccini and Yang, 2009), and war (Akresh et al., 2012) all leave lasting scars on health, human capital, and welfare that persist well into adulthood. The role of public policy in mitigating these impacts or protecting against them is widely recognized but poorly understood. In large part the dearth of rigorous evidence on policy levers is due to the difficulty in finding overlapping episodes of early life trauma and an orthogonal natural experiment that changed the incentives for investing in children.

Our study takes a step toward filling this gap. Our results demonstrate a strong protective effect of one-time vitamin A supplementation at birth. We interpret this protection as evidence that, at least in very early life, endowments (as proxied for by tornado exposure) and investments (vitamin A) are substitutes. Whether this remains true when outcomes are measured in later childhood and adulthood is an open question. Although our findings hold up to various robustness checks and are consistent across a diverse set of outcomes (anthropometry, fever incidence and mortality), their strength is somewhat limited by the relatively small share of infants in the study affected by the tornado. Our results hopefully offer a valuable start and suggest that more research on the role of micronutrient deficiencies in infants' resilience to shocks is likely to be very valuable.

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Table 1: **Summary Statistics**

	Full sample N = 5343		Tornado N = 346		Non-tornado N = 4997		Difference		Within Tornado Area: Vitamin A N = 183		Within Tornado Area: Placebo N = 163		Within Tornado Area: Difference	
	Mean	SD	Mean	SD	Mean	SD	Mean	SE	Mean	SD	Mean	SD	Mean	SE
Infant birth anthropometry														
Weight (kg)	2.50	0.43	2.52	0.42	2.50	0.43	0.02	0.03	2.54	0.38	2.48	0.46	0.06	0.07
Height (cm)	46.71	2.35	46.55	2.20	46.72	2.37	−0.18	0.19	46.87	2.15	46.19	2.20	0.68	0.34**
MUAC (cm)	9.47	0.84	9.54	0.83	9.47	0.84	0.07	0.07	9.57	0.70	9.51	0.95	0.05	0.13
Head Circumference (cm)	32.68	1.62	32.73	1.75	32.68	1.61	0.06	0.13	32.87	1.56	32.58	1.92	0.29	0.27
Chest Circumference (cm)	30.72	2.10	30.79	2.05	30.71	2.10	0.08	0.17	30.85	1.74	30.73	2.36	0.12	0.32
Infant anthropometry at 3 months														
MUAC (cm)	12.37	1.05	12.40	1.10	12.37	1.04	0.03	0.08	12.46	1.04	12.34	1.17	0.12	0.16
Head Circ. (cm)	38.59	1.47	38.44	1.35	38.60	1.48	−0.17	0.11	38.45	1.29	38.43	1.42	0.02	0.20
Chest Circumference (cm)	38.82	2.23	38.87	2.21	38.82	2.23	0.05	0.17	38.83	2.29	38.91	2.13	−0.08	0.33
Anthropometric Index	0.16	0.98	0.15	0.97	0.16	0.99	−0.02	0.07	0.16	0.95	0.13	1.00	0.04	0.14
Infant anthropometry at 6 months														
MUAC	13.08	1.04	13.14	1.12	13.08	1.03	0.06	0.08	13.24	1.12	13.03	1.12	0.21	0.16
Head Circumference (cm)	40.84	1.42	40.99	1.33	40.83	1.43	0.17	0.11	41.06	1.34	40.92	1.32	0.14	0.19
Chest Circumference (cm)	41.38	2.14	41.52	2.19	41.37	2.13	0.15	0.16	41.50	2.21	41.54	2.17	−0.04	0.32
Anthropometric Index	0.04	0.99	0.13	1.03	0.03	0.98	0.10	0.07	0.19	1.04	0.07	1.02	0.12	0.15
Other infant outcomes														
Gender is Male	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.04	0.49	0.50	0.52	0.50	−0.03	0.07
Fever Incidence, 0-3 months	0.55	0.50	0.53	0.50	0.55	0.50	−0.01	0.04	0.55	0.50	0.52	0.50	0.03	0.07
Fever Incidence 0-6 months	0.54	0.50	0.58	0.49	0.54	0.50	0.04	0.04	0.58	0.50	0.58	0.50	0.00	0.07
Mortality 0-24 weeks	0.06	0.24	0.06	0.23	0.06	0.24	0.00	0.02	0.06	0.23	0.06	0.24	0.00	0.03
Maternal characteristics														
Parity	1.24	1.49	1.32	1.56	1.23	1.48	0.08	0.11	1.44	1.78	1.18	1.30	0.26	0.21
LSI	0.04	1.02	−0.03	0.97	0.04	1.02	−0.08	0.07	0.02	0.99	−0.09	0.95	0.12	0.13
Height (cm)	149.36	5.09	148.96	5.16	149.39	5.09	−0.43	0.36	148.87	5.10	149.04	5.23	−0.17	0.71
MUAC (cm)	22.74	1.94	22.67	2.07	22.74	1.94	−0.07	0.14	22.86	2.24	22.48	1.87	0.38	0.28
Education (years)	3.90	4.07	3.68	4.05	3.92	4.07	−0.24	0.29	4.26	4.42	3.08	3.54	1.18	0.55**
Dosing														
Dosed <= 6 hours	0.48	0.50	0.54	0.50	0.48	0.50	0.06	0.04*	0.50	0.50	0.59	0.49	−0.09	0.07
Dosed <= 12 hours	0.62	0.48	0.66	0.48	0.62	0.49	0.03	0.04	0.63	0.49	0.68	0.47	−0.06	0.07
Dosed <= 18 hours	0.70	0.46	0.73	0.45	0.70	0.46	0.03	0.03	0.70	0.46	0.77	0.42	−0.07	0.06
Dosed <= 24 hours	0.74	0.44	0.76	0.43	0.74	0.44	0.02	0.03	0.73	0.44	0.78	0.42	−0.05	0.06
Dosed <= 7 days	0.84	0.37	0.87	0.34	0.84	0.37	0.03	0.03	0.89	0.32	0.85	0.36	0.03	0.05

Summary statistics for the study sample (infant sample), limited to infants born at least 9 months before the tornado. Tornado and Non-Tornado refer to inside vs. outside the tornado area. The last three columns restrict the sample to only within the tornado area.
Significance: * < 0.1; ** < 0.05; *** < 0.01.

Table 2: **Time to Dosing by Tornado and Treatment Status for Infants In-Utero**

									Within Tornado Area					
	Full sample N = 5343		**Tornado N = 346**		**Non-tornado N = 4997**		**Difference**		**Vitamin A N = 183**		**Placebo N = 163**		**Difference**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SE	Mean	SD	Mean	SD	Mean	SE
Dosing														
Dosed <= 6 hours	0.44	0.50	0.48	0.50	0.44	0.50	0.04	0.02*	0.47	0.50	0.48	0.50	−0.01	0.04
Dosed <= 12 hours	0.60	0.49	0.62	0.49	0.60	0.49	0.01	0.02	0.61	0.49	0.62	0.49	−0.01	0.04
Dosed <= 18 hours	0.69	0.46	0.71	0.45	0.69	0.46	0.02	0.02	0.70	0.46	0.72	0.45	−0.02	0.04
Dosed <= 24 hours	0.73	0.44	0.75	0.43	0.73	0.44	0.02	0.02	0.74	0.44	0.77	0.42	−0.03	0.03
Dosed <= 7 days	0.84	0.36	0.85	0.35	0.84	0.36	0.01	0.01	0.84	0.37	0.87	0.34	−0.03	0.03

Summary statistics of the trial implementation (through dosing times) by area. Tornado and Non-Tornado refer to inside vs. outside the tornado area. The last three columns restrict the sample to only within the tornado area. The sample includes only infants that were in the cohorts exposed to the tornado defined as infants in the study area who were in utero at the time of the tornado (almost all infants already born at the time of the tornado would have already been dosed since 75% of infants in the trial are dosed within 24 hours and 86% within 7 days).

Significance: * < 0.1; ** < 0.05; *** < 0.01.

Table 3: **Summary of Tornado Damage**

	Share of houses destroyed					
	0-20%	21-40%	41-60%	61-80%	81-100%	Total
Control (# of sectors):	6	4	1	3	6	20
Vitamin A (# of sectors):	11	1	2	7	0	21
All tornado damaged sectors						
Average Control:	47.6%					
Average Vitamin A:	33.7%					
Vitamin A - Control	= -14%					
Excluding sectors with > 80% damage						
Average Control:	28.7%					
Average Vitamin A:	33.5%					
Vitamin A - Control :	= 5%					

Tornado damage (share of houses destroyed) by treatment allocation (within sectors with any damage).

Table 4: **The effect of tornado exposure and maternal supplementation on birth outcomes**

	BW b/se	log(BW) b/se	LBW b/se	BGGA b/se	PM b/se	SMGA b/se	Height b/se	MUAC b/se	HC b/se	CC b/se	BirthAI b/se
In tornado area X In utero	-0.14**	-0.05**	0.15*	-0.54	0.06	0.05	-0.54**	-0.26**	-0.54*	-0.33*	-0.29**
	(0.06)	(0.03)	(0.08)	(0.38)	(0.04)	(0.06)	(0.24)	(0.12)	(0.28)	(0.18)	(0.13)
In tornado area X In utero X Maternal supplementation	0.06	0.02	-0.05	0.60	-0.09*	0.00	0.04	0.11	0.29	0.17	0.12
	(0.07)	(0.03)	(0.09)	(0.45)	(0.05)	(0.08)	(0.35)	(0.15)	(0.35)	(0.24)	(0.16)
In utero X Maternal supplementation	0.01	0.00	0.00	-0.14	0.04**	-0.02	-0.10	0.00	-0.04	-0.02	-0.01
	(0.02)	(0.01)	(0.02)	(0.11)	(0.02)	(0.02)	(0.12)	(0.04)	(0.10)	(0.07)	(0.05)
In utero	0.01	0.00	-0.00	0.40***	-0.06***	0.00	0.34***	-0.05	-0.01	0.01	0.02
	(0.02)	(0.01)	(0.02)	(0.09)	(0.01)	(0.02)	(0.10)	(0.03)	(0.08)	(0.06)	(0.04)
Age at newborn anthropometry	-0.01**	-0.00**	0.01*	0.00	0.00	-0.00***	0.05***	-0.08***	-0.05***	0.08***	-0.02*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Constant	2.44***	0.87***	0.55***	37.97***	0.25***	0.26***	46.31***	9.37***	30.42***	32.29***	0.03***
	(0.00)	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Observations	14023	14023	14023	16962	16962	16455	13656	13921	13790	13906	14037

Linear regression models of birth outcomes as a function of tornado exposure in utero, interacted with vitamin A supplementation of the mother. BW is birth weight in kilograms. log(BW) is the log of birth weight. LBW is an indicator for birth weight < 2.5kg. GA is our measure of gestational age. PM is an indicator for prematurity (gestational age < 37 weeks). Small for Gestational Age (SMGA) is an indicator that is equal to 1 if the infant is below the 25th percentile in weight given gestational age (for this sample). Height, mid-upper arm circumference (MUAC), head circumference (HC) and chest circumference are measured in centimeters. BirthAI is an index of the other birth anthropometric indicators (standardized average). Standard errors are clustered at the sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 5: **Difference-in-Difference Table: Anthropometric index at 3 months.**

	Placebo	Vitamin A	Difference (VA-PL)
	b (se)	b (se)	b (se)
Not in Tornado Window			
Not in Tornado Area	-0.02	-0.01	0.01 (0.03)
In Tornado Area	0.12	0.11	-0.02 (0.08)
Difference	0.14 (0.06)**	0.12 (0.06)*	-0.02 (0.09)
In utero at tornado			
Not in Tornado Area	0.01	0.01	0.00 (0.04)
In Tornado Area	0.02	0.10	0.07 (0.15)
Difference	0.01 (0.10)	0.08 (0.12)	0.07 (0.15)
In first 10 weeks at tornado			
Not in Tornado Area	0.02	0.01	-0.02 (0.05)
In Tornado Area	-0.06	0.13	0.19 (0.16)
Difference	-0.08 (0.14)	0.12 (0.10)	0.20 (0.17)
Triple-difference: In utero at tornado			0.10 (0.16)
Triple-difference: In first 10 weeks at tornado			0.23 (0.19)

The table shows means and differences (along with standard errors of differences) for the various subsamples that define the triple-difference strategy: within vs. outside the tornado area; within versus outside the tornado window (i.e. in utero or in first 10 weeks of life at the time of tornado) and in treatment versus control sectors. The outcome variable is the anthropometric index (standardized average of MUAC, head circumference and chest circumference) measured at 3 months of age (the index SD is 1). Standard errors are clustered at the sector (vitamin A randomization) level. Significance: * < 0.1; ** < 0.05; *** < 0.01.

Table 6: **Difference-in-Difference Table: Anthropometric index at 6 months.**

	Not in Tornado Window		
	Placebo	Vitamin A	Difference (VA-PL)
	b (se)	b (se)	b (se)
Not in Tornado Area	0.00	-0.01	-0.01 (0.03)
In Tornado Area	0.14	0.15	0.00 (0.10)
Difference	0.14 (0.07)*	0.15 (0.07)**	0.01 (0.10)
	In utero at tornado		
	Placebo	Vitamin A	Difference (VA-PL)
	b (se)	b (se)	b (se)
Not in Tornado Area	-0.01	-0.02	-0.00 (0.04)
In Tornado Area	0.11	0.16	0.05 (0.12)
Difference	0.12 (0.06)**	0.17 (0.11)	0.06 (0.12)
	In first 22 weeks at tornado		
	Placebo	Vitamin A	Difference (VA-PL)
	b (se)	b (se)	b (se)
Not in Tornado Area	-0.01	-0.02	-0.00 (0.04)
In Tornado Area	-0.05	0.18	0.23 (0.12)*
Difference	-0.04 (0.10)	0.20 (0.08)**	0.23 (0.13)*
Triple-difference: In utero at tornado			0.04 (0.13)
Triple-difference: In first 22 weeks at tornado			0.22 (0.14)

The table shows means and differences (along with standard errors of differences) for the various subsamples that define the triple-difference strategy: within vs. outside the tornado area; within versus outside the tornado window (i.e. in utero or in first 10 weeks of life at the time of tornado) and in treatment versus control sectors. The outcome variable is the anthropometric index (standardized average of MUAC, head circumference and chest circumference) measured at 6 months of age (the index SD is 1). Standard errors are clustered at the sector (vitamin A randomization) level. Significance: * < 0.1; ** < 0.05; *** < 0.01.

Table 7: **Anthropometry at 3 months: Main specification (triple-difference).**

	AI		MUAC		CC		HC	
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Triple interaction: In tornado area X Vit A X ..								
In utero	0.17	0.15	0.21	0.21	0.28	0.28	0.17	0.15
	(0.16)	(0.16)	(0.16)	(0.15)	(0.40)	(0.39)	(0.25)	(0.25)
0-10 weeks of age	0.26	0.19	0.32	0.25	0.52	0.45	0.19	0.13
	(0.20)	(0.20)	(0.21)	(0.21)	(0.42)	(0.43)	(0.28)	(0.28)
Double interaction: In tornado area X ..								
In utero	-0.16	-0.12	-0.18*	-0.14	-0.43	-0.33	-0.10	-0.05
	(0.12)	(0.12)	(0.11)	(0.10)	(0.28)	(0.28)	(0.19)	(0.19)
0-10 weeks of age	-0.29*	-0.28*	-0.31*	-0.29*	-0.77**	-0.77**	-0.15	-0.15
	(0.15)	(0.15)	(0.16)	(0.16)	(0.35)	(0.36)	(0.19)	(0.18)
Double interaction: Vit A X ..								
In utero	-0.01	0.00	-0.03	-0.02	0.04	0.06	0.01	0.01
	(0.04)	(0.04)	(0.04)	(0.04)	(0.09)	(0.09)	(0.06)	(0.06)
0-10 weeks of age	-0.03	-0.03	-0.06	-0.05	-0.06	-0.06	0.01	0.02
	(0.06)	(0.05)	(0.06)	(0.06)	(0.13)	(0.12)	(0.09)	(0.09)
Cohorts:								
In utero	0.01	-0.01	-0.00	-0.02	0.05	0.00	0.00	-0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.07)	(0.07)	(0.04)	(0.04)
0-10 weeks of age	0.04	0.04	0.05	0.05	-0.00	0.01	0.05	0.05
	(0.04)	(0.03)	(0.04)	(0.04)	(0.09)	(0.08)	(0.06)	(0.06)
- Other controls -								
Best guess length of gestation (weeks)	0.08***	0.07***	0.06***	0.05***	0.15***	0.13***	0.11***	0.10***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Maternal MUAC		0.06***		0.07***		0.13***		0.06***
		(0.00)		(0.00)		(0.01)		(0.01)
Maternal height		0.03***		0.03***		0.08***		0.04***
		(0.00)		(0.00)		(0.00)		(0.00)
Living Standards Index		0.12***		0.11***		0.24***		0.14***
		(0.01)		(0.01)		(0.02)		(0.01)
Observations	14502	14482	14485	14465	14028	14011	14465	14445

Linear regression models of infant development measured by anthropometry at 3 months. The outcome variables are mid-upper arm circumference (MUAC), head circumference (HC) and chest circumference (CC), all measured in centimeters and an anthropometric index (AI) that is a standardized (zero mean, unit SD) average of the three variables after each has been standardized to zero mean and unit standard deviation. "Vit A" is an indicator that is 1 if infants in the sector were given vitamin A and zero if they were in the placebo group. "In Tornado Area" is an indicator defined as 1 if any households in the sector were destroyed in the tornado. "In utero" is an indicator that is 1 if the infant was in utero at the date of the tornado and "0-10 weeks of age" is 1 if the infant was in his or her first 10 weeks of life at the date of the tornado. Combined these three types of indicators define our triple difference strategy. Each regression contains randomization sector fixed effects (this absorbs main effects of the tornado area and treatment indicators). Living Standards is an index based on a principal components analysis of household assets. Best guess gestational length is based on date of last menstrual period reported at enrollment in the study (in the first trimester). Standard errors are clustered at the sector (treatment randomization) level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 8: **Anthropometry at 6 months: Main specification (triple-difference).**

	AI		MUAC		CC		HC	
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Triple interaction: In tornado area X Vit A X ..								
In utero	0.07	0.07	0.24	0.25	0.02	0.03	-0.06	-0.08
	(0.14)	(0.14)	(0.15)	(0.15)	(0.29)	(0.27)	(0.21)	(0.21)
0-10 weeks of age	0.45**	0.38**	0.62***	0.54***	0.59	0.48	0.46*	0.40
	(0.20)	(0.19)	(0.20)	(0.20)	(0.45)	(0.43)	(0.26)	(0.25)
11-22 weeks of age	0.05	0.07	0.25	0.28	0.09	0.15	-0.21	-0.19
	(0.20)	(0.21)	(0.22)	(0.23)	(0.40)	(0.42)	(0.27)	(0.28)
Double interaction: In tornado area X ..								
In utero	-0.04	-0.00	-0.04	-0.02	-0.03	0.03	-0.08	-0.03
	(0.09)	(0.09)	(0.11)	(0.11)	(0.18)	(0.17)	(0.14)	(0.14)
0-10 weeks of age	-0.33**	-0.31**	-0.36***	-0.34***	-0.59*	-0.57*	-0.31	-0.30
	(0.14)	(0.13)	(0.12)	(0.12)	(0.34)	(0.32)	(0.21)	(0.19)
11-22 weeks of age	-0.10	-0.12	-0.20	-0.23	-0.27	-0.32	0.12	0.10
	(0.13)	(0.13)	(0.16)	(0.16)	(0.24)	(0.25)	(0.19)	(0.19)
Double interaction: Vit A X ..								
In utero	0.01	0.02	-0.03	-0.02	0.02	0.05	0.05	0.05
	(0.04)	(0.04)	(0.05)	(0.04)	(0.09)	(0.09)	(0.06)	(0.06)
0-10 weeks of age	-0.03	-0.03	-0.10	-0.10*	-0.11	-0.11	0.07	0.08
	(0.06)	(0.06)	(0.06)	(0.06)	(0.13)	(0.13)	(0.09)	(0.09)
11-22 weeks of age	0.01	0.01	-0.01	-0.00	-0.03	-0.03	0.07	0.07
	(0.06)	(0.05)	(0.06)	(0.06)	(0.12)	(0.12)	(0.08)	(0.08)
Cohorts:								
In utero	-0.03	-0.05*	-0.05*	-0.08***	0.01	-0.04	-0.01	-0.03
	(0.03)	(0.03)	(0.03)	(0.03)	(0.07)	(0.07)	(0.04)	(0.04)
0-10 weeks of age	0.06	0.06*	0.05	0.05	0.12	0.13	0.07	0.07
	(0.04)	(0.04)	(0.04)	(0.04)	(0.09)	(0.09)	(0.06)	(0.06)
11-22 weeks of age	-0.07*	-0.06	-0.10***	-0.10**	-0.18**	-0.17**	0.01	0.02
	(0.04)	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)	(0.06)	(0.05)
- Other controls -								
Best guess length of gestation (weeks)	0.05***	0.04***	0.04***	0.03***	0.10***	0.08***	0.06***	0.05***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
Maternal MUAC		0.07***		0.08***		0.14***		0.06***
		(0.00)		(0.00)		(0.01)		(0.01)
Maternal height		0.03***		0.02***		0.07***		0.04***
		(0.00)		(0.00)		(0.00)		(0.00)
Living Standards Index		0.13***		0.12***		0.26***		0.13***
		(0.01)		(0.01)		(0.02)		(0.01)
Observations	14273	14252	14261	14240	13687	13667	14177	14156

Linear regression models of infant development measured by anthropometry at 6 months. The outcome variables are mid-upper arm circumference (MUAC), head circumference (HC) and chest circumference (CC), all measured in centimeters and an anthropometric index (AI) that is a standardized (zero mean, unit SD) average of the three variables after each has been standardized to zero mean and unit standard deviation. "Vit A" is an indicator that is 1 if infants in the sector were given vitamin A and zero if they were in the placebo group. "In Tornado Area" is an indicator defined as 1 if any households in the sector were destroyed in the tornado. "In utero" is an indicator that is 1 if the infant was in utero at the date of the tornado and "0-10 weeks of age" is 1 if the infant was in his or her first 10 weeks of life at the date of the tornado. Combined these three types of indicators define our triple difference strategy. Each regression contains randomization sector fixed effects (this absorbs main effects of the tornado area and treatment indicators). Living Standards is an index based on a principal components analysis of household assets. Best guess gestational length is based on date of last menstrual period reported at enrollment in the study (in the first trimester). Standard errors are clustered at the sector (treatment randomization) level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 9: **Anthropometry Growth at 3 Months.**

	Δ AI		Δ MUAC		Δ CC		Δ HC	
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Triple interaction: In tornado area X Vit A X ..								
In utero	0.21	0.22	0.22	0.23	0.32	0.34	0.19	0.19
	(0.14)	(0.14)	(0.15)	(0.15)	(0.30)	(0.30)	(0.17)	(0.18)
0-10 weeks of age	0.26	0.23	0.31*	0.28	0.61	0.59	0.07	0.06
	(0.19)	(0.19)	(0.18)	(0.18)	(0.42)	(0.42)	(0.22)	(0.21)
Double interaction: In tornado area X ..								
In utero	-0.03	-0.02	-0.02	-0.01	-0.13	-0.12	0.03	0.04
	(0.10)	(0.10)	(0.12)	(0.11)	(0.22)	(0.22)	(0.14)	(0.14)
0-10 weeks of age	-0.25**	-0.25**	-0.27**	-0.26**	-0.71**	-0.72**	-0.01	-0.01
	(0.12)	(0.12)	(0.12)	(0.12)	(0.31)	(0.31)	(0.14)	(0.14)
Double interaction: Vit A X ..								
In utero	-0.12***	-0.11***	-0.11***	-0.10**	-0.18**	-0.17**	-0.13***	-0.13***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)	(0.05)	(0.05)
0-10 weeks of age	-0.12*	-0.11*	-0.11*	-0.11*	-0.24*	-0.24**	-0.08	-0.08
	(0.06)	(0.06)	(0.06)	(0.06)	(0.12)	(0.12)	(0.08)	(0.08)
Cohorts:								
In utero	0.06**	0.04	0.03	0.02	0.13**	0.11*	0.05	0.04
	(0.03)	(0.03)	(0.03)	(0.03)	(0.06)	(0.06)	(0.03)	(0.03)
0-10 weeks of age	0.06	0.06	0.06	0.06	0.05	0.06	0.07	0.07
	(0.04)	(0.04)	(0.04)	(0.04)	(0.09)	(0.08)	(0.06)	(0.06)
Weight at birth (kg)	0.54***	0.50***	0.43***	0.39***	0.95***	0.86***	0.59***	0.56***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.11)	(0.11)	(0.06)	(0.06)
Height at birth (cm)	0.06***	0.06***	0.04***	0.04***	0.13***	0.12***	0.07***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
MUAC at birth (cm)	-0.38***	-0.39***	-0.76***	-0.77***	-0.14***	-0.15***	-0.15***	-0.15***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)
Head circumference at birth (cm)	-0.13***	-0.13***	0.06***	0.05***	0.10***	0.10***	-0.56***	-0.56***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Chest circumference at birth (cm)	-0.13***	-0.13***	0.02*	0.02*	-0.68***	-0.68***	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Maternal MUAC		0.04***		0.04***		0.07***		0.02***
		(0.00)		(0.00)		(0.01)		(0.01)
Maternal height		0.01***		0.01***		0.03***		0.01***
		(0.00)		(0.00)		(0.00)		(0.00)
Living Standards Index		0.09***		0.08***		0.17***		0.06***
		(0.01)		(0.01)		(0.02)		(0.01)
Observations	11692	11674	11681	11663	11346	11331	11666	11648

Linear regression models of anthropometric growth at 3 months using our main specifications. The outcome variables are changes in anthropometry between birth and 3 months (Δ MUAC = MUAC at 3 months - MUAC at birth) measured in centimeters. Δ*AI* is a standardized (zero mean, unit SD) average of the three variables (Δ MUAC, Δ CC and Δ HC) after each has been standardized to zero mean and unit standard deviation. Living Standards is an index based on a principal components analysis of household assets. Standard errors are clustered at the sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 10: **Anthropometry Growth at 6 Months.**

	Δ AI		Δ MUAC		Δ CC		Δ HC	
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Triple interaction: In tornado area X Vit A X ..								
In utero	0.17	0.18	0.30*	0.32**	0.23	0.24	0.06	0.05
	(0.12)	(0.12)	(0.16)	(0.15)	(0.29)	(0.28)	(0.19)	(0.20)
0-10 weeks of age	0.42**	0.39**	0.65***	0.62***	0.38	0.34	0.42*	0.41*
	(0.18)	(0.17)	(0.20)	(0.20)	(0.47)	(0.45)	(0.24)	(0.23)
11-22 weeks of age	0.18	0.18	0.29	0.29	0.34	0.35	0.09	0.09
	(0.22)	(0.24)	(0.24)	(0.25)	(0.50)	(0.52)	(0.25)	(0.26)
Double interaction: In tornado area X ..								
In utero	0.03	0.03	0.05	0.05	0.12	0.13	-0.06	-0.05
	(0.09)	(0.08)	(0.12)	(0.11)	(0.21)	(0.19)	(0.14)	(0.14)
0-10 weeks of age	-0.30**	-0.30***	-0.36***	-0.35***	-0.48	-0.48	-0.29	-0.29
	(0.12)	(0.10)	(0.10)	(0.10)	(0.34)	(0.31)	(0.19)	(0.18)
11-22 weeks of age	-0.26*	-0.26*	-0.32*	-0.32*	-0.57*	-0.57*	-0.14	-0.13
	(0.14)	(0.14)	(0.17)	(0.18)	(0.31)	(0.32)	(0.16)	(0.16)
Double interaction: Vit A X ..								
In utero	-0.07*	-0.06	-0.09*	-0.07	-0.11	-0.08	-0.06	-0.05
	(0.04)	(0.04)	(0.05)	(0.05)	(0.09)	(0.09)	(0.06)	(0.06)
0-10 weeks of age	-0.08	-0.08	-0.12*	-0.12*	-0.19	-0.19	-0.02	-0.02
	(0.06)	(0.06)	(0.06)	(0.06)	(0.13)	(0.13)	(0.09)	(0.09)
11-22 weeks of age	0.05	0.05	0.03	0.03	0.05	0.05	0.11	0.11
	(0.05)	(0.05)	(0.06)	(0.06)	(0.12)	(0.12)	(0.08)	(0.08)
Cohorts:								
In utero	0.02	-0.00	-0.01	-0.03	0.07	0.04	0.03	0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.07)	(0.07)	(0.04)	(0.04)
0-10 weeks of age	0.10**	0.10**	0.08*	0.08*	0.18**	0.18**	0.13**	0.13**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.09)	(0.09)	(0.06)	(0.06)
11-22 weeks of age	0.02	0.02	-0.03	-0.03	-0.02	-0.02	0.11**	0.11**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)	(0.05)	(0.05)
Weight at birth (kg)	0.50***	0.45***	0.44***	0.39***	0.96***	0.86***	0.60***	0.56***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.12)	(0.12)	(0.07)	(0.07)
Height at birth (cm)	0.05***	0.04***	0.03***	0.03***	0.11***	0.09***	0.07***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
MUAC at birth (cm)	-0.39***	-0.40***	-0.79***	-0.79***	-0.24***	-0.25***	-0.17***	-0.17***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.03)	(0.03)
Head circumference at birth (cm)	-0.14***	-0.15***	0.03***	0.02**	0.09***	0.09***	-0.59***	-0.59***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Chest circumference at birth (cm)	-0.15***	-0.15***	-0.01	-0.02	-0.75***	-0.75***	-0.05***	-0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Maternal MUAC		0.04***		0.06***		0.09***		0.02***
		(0.00)		(0.00)		(0.01)		(0.01)
Maternal height		0.01***		0.01***		0.03***		0.02***
		(0.00)		(0.00)		(0.00)		(0.00)
Living Standards Index		0.10***		0.11***		0.21***		0.07***
		(0.01)		(0.01)		(0.02)		(0.01)
Observations	11500	11481	11494	11475	11052	11034	11426	11407

Linear regression models of anthropometric growth at 6 months using our main specifications. The outcome variables are changes in anthropometry between birth and 3 months (Δ MUAC = MUAC at 6 months - MUAC at birth) measured in centimeters. Δ*AI* is a standardized (zero mean, unit SD) average of the three variables (Δ MUAC, Δ CC and Δ HC) after each has been standardized to zero mean and unit standard deviation. Living Standards is an index based on a principal components analysis of household assets. Standard errors are clustered at the sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 11: **Difference-in-Difference Table: Fever episodes at 0-3 months.**

	Not in Tornado Window		
	Placebo	Vitamin A	Difference (VA-PL)
	b (se)	b (se)	b (se)
Not in Tornado Area	0.88	0.87	-0.00 (0.03)
In Tornado Area	0.88	0.93	0.04 (0.10)
Difference	0.01 (0.07)	0.05 (0.06)	0.04 (0.10)
	In utero at tornado		
	Placebo	Vitamin A	Difference (VA-PL)
	b (se)	b (se)	b (se)
Not in Tornado Area	0.87	0.87	-0.01 (0.04)
In Tornado Area	1.09	1.18	0.09 (0.17)
Difference	0.22 (0.11)**	0.31 (0.14)**	0.09 (0.18)
	In first 10 weeks at tornado		
	Placebo	Vitamin A	Difference (VA-PL)
	b (se)	b (se)	b (se)
Not in Tornado Area	0.85	0.88	0.03 (0.06)
In Tornado Area	1.34	0.86	-0.48 (0.25)*
Difference	0.49 (0.19)**	-0.02 (0.16)	-0.51 (0.25)**
Triple-difference: In utero at tornado			0.05 (0.17)
Triple-difference: In first 10 weeks at tornado			-0.55 (0.22)**

The table shows means and differences (along with standard errors of differences) for the various subsamples that define the triple-difference strategy: within vs. outside the tornado area; within versus outside the tornado window (i.e. in utero or in first 10 weeks of life at the time of tornado) and in treatment versus control sectors. The outcome variable is number of fever episodes in the first 3 months top coded at 4 (> 4 episodes are set to 4). Standard errors are clustered at the sector (vitamin A randomization) level. Significance: * < 0.1; ** < 0.05; *** < 0.01.

Table 12: **Incidence of fever: main specification (triple-difference)**

	In months 0-3		In months 4-6	
	Any fever b/se	Num. episodes b/se	Any fever b/se	Num. episodes b/se
Triple interaction: In tornado area X Vit A X ..				
In utero	-0.02	0.02	-0.01	0.07
	(0.08)	(0.18)	(0.08)	(0.17)
0-3 months of age	-0.17	-0.45**	-0.04	-0.17
	(0.11)	(0.19)	(0.10)	(0.28)
4-6 months of age			0.02	-0.08
			(0.10)	(0.26)
Double interaction: In tornado area X ..				
In utero	0.07	0.29**	0.03	0.13
	(0.05)	(0.11)	(0.05)	(0.11)
0-3 months of age	0.22***	0.50***	0.09	0.44**
	(0.07)	(0.12)	(0.08)	(0.21)
4-6 months of age			0.03	0.41**
			(0.08)	(0.19)
Double interaction: Vit A X ..				
In utero	-0.03	0.01	-0.01	-0.05
	(0.02)	(0.04)	(0.02)	(0.04)
0-3 months of age	-0.03	0.01	0.01	-0.02
	(0.03)	(0.05)	(0.03)	(0.06)
4-6 months of age			-0.01	-0.05
			(0.03)	(0.05)
Cohorts:				
In utero	0.01	-0.02	0.02	0.05
	(0.01)	(0.03)	(0.01)	(0.03)
0-3 months of age	0.00	-0.04	0.03	0.09**
	(0.02)	(0.03)	(0.02)	(0.04)
4-6 months of age			0.02	0.05
			(0.02)	(0.04)
- Other controls -				
Best guess length of gestation (weeks)	0.00	0.00	-0.00*	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Observations	14857	14764	14734	14591

Linear regression models of fever using our main specifications. The outcome variables of fever episodes in 0-3 months and 4-6 months are top coded at 4 (>4 episodes are coded as 4).
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 13: **Effect of maternal supplementation on postnatal resilience**

	AI		Fever episodes		Mortality
	3 months	6 months	3 months	6 months	at 24 weeks
	b/se	b/se	b/se	b/se	b/se
Triple interaction: In tornado area X VA X ..					
In utero	-0.07	-0.05	-0.36	-0.17	-0.00
	(0.23)	(0.20)	(0.22)	(0.16)	(0.03)
0-10 weeks of age	-0.20	-0.04	0.06	0.02	-0.04
	(0.23)	(0.23)	(0.34)	(0.29)	(0.04)
Triple interaction: In tornado area X BC X ..					
In utero	-0.08	0.01	-0.21	0.11	0.00
	(0.15)	(0.12)	(0.22)	(0.19)	(0.04)
0-10 weeks of age	-0.34	-0.29	-0.13	0.06	-0.05
	(0.23)	(0.25)	(0.28)	(0.29)	(0.04)
Double interaction: In tornado area X ..					
In utero	0.08	0.13	0.49***	0.14	-0.01
	(0.11)	(0.10)	(0.16)	(0.12)	(0.02)
0-10 weeks of age	0.13	0.14	0.27*	0.25	0.00
	(0.17)	(0.17)	(0.16)	(0.18)	(0.03)
Double interaction: VA X ..					
In utero	0.02	0.02	-0.04	0.05	-0.00
	(0.05)	(0.05)	(0.05)	(0.05)	(0.01)
0-10 weeks of age	-0.01	-0.02	-0.08	-0.01	0.01
	(0.06)	(0.06)	(0.07)	(0.08)	(0.01)
Double interaction: BC X ..					
In utero	0.04	0.03	-0.07	-0.00	-0.01
	(0.04)	(0.04)	(0.05)	(0.04)	(0.01)
0-10 weeks of age	0.11*	0.02	-0.06	-0.01	0.01
	(0.06)	(0.07)	(0.06)	(0.07)	(0.01)
Cohorts:					
In utero	-0.12***	-0.09***	0.04	-0.00	-0.01**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.01)
0-10 weeks of age	-0.12***	0.01	0.04	0.09*	-0.02**
	(0.04)	(0.05)	(0.05)	(0.05)	(0.01)
- Other controls -					
Best guess length of gestation (weeks)	0.07***	0.05***	-0.00	-0.01***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	26697	28270	27117	28905	40320

Linear regression models of infant outcomes using a triple difference strategy of maternal supplementation. The outcome variables are the Anthropometric Index (AI) at 3 and 6 months (standardized average of MUAC, CC and HC), the number of fever episodes at 3 and 6 months (top coded at 4) and 24 week infant mortality. All regressions include sector (randomization unit) fixed effects. Living Standards is an index based on a principal components analysis of household assets. Standard errors are clustered at the sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 14: **Robustness of key regressions to defining a post-tornado cohort.**

	AI		MUAC		Fever	
	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se
Triple int.: In tornado area X Vit A X ..						
Conceived after tornado	0.00	-0.16	-0.04	-0.20	0.02	-0.04
	(0.14)	(0.18)	(0.16)	(0.20)	(0.19)	(0.22)
In utero	0.16	-0.01	0.19	0.14	0.02	0.02
	(0.17)	(0.18)	(0.18)	(0.20)	(0.18)	(0.18)
0-10 weeks of age	0.26	0.37*	0.30	0.52**	-0.51**	-0.26
	(0.21)	(0.22)	(0.23)	(0.22)	(0.24)	(0.28)
11-22 weeks of age		-0.04		0.14		-0.21
		(0.24)		(0.26)		(0.28)
Double interaction: In tornado area X ..						
Conceived after tornado	0.23**	0.21	0.21**	0.15	-0.10	-0.08
	(0.10)	(0.15)	(0.11)	(0.15)	(0.14)	(0.17)
In utero	-0.07	0.07	-0.09	0.04	0.22**	0.10
	(0.12)	(0.13)	(0.12)	(0.15)	(0.11)	(0.15)
0-10 weeks of age	-0.19	-0.22	-0.22	-0.28*	0.38**	0.38*
	(0.16)	(0.16)	(0.18)	(0.15)	(0.19)	(0.23)
11-22 weeks of age		0.01		-0.12		0.51**
		(0.17)		(0.20)		(0.21)
Double interaction: Vit A X ..						
Conceived after tornado	-0.06	-0.08	-0.04	-0.07	0.00	0.02
	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)
In utero	-0.03	-0.03	-0.05	-0.07	0.01	-0.04
	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)
Age 0-10 weeks	-0.06	-0.07	-0.07	-0.14**	0.01	0.00
	(0.06)	(0.07)	(0.06)	(0.07)	(0.06)	(0.07)
Age 11-22 weeks		-0.03		-0.04		-0.03
		(0.06)		(0.06)		(0.06)
Cohorts:						
Conceived after tornado	-0.07**	-0.01	-0.05	0.00	0.29***	0.19***
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Age 0-10 weeks	0.01	0.05	0.03	0.05	0.10**	0.19***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
Age 11-22 weeks		-0.07*		-0.10**		0.16***
		(0.04)		(0.04)		(0.04)
In utero	-0.02	-0.03	-0.02	-0.05	0.10***	0.15***
	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)
- Other controls -						
Best guess length of gestation (weeks)	0.08***	0.05***	0.06***	0.04***	0.00	-0.01**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	14502	14273	14485	14261	14764	14591

Linear regression models of anthropometric growth and fever incidence using specifications similar to our main specifications except that we add a new cohort of those that were conceived after the tornado time (by our best guess). Using this specification the comparison (reference) group includes only infants born more than 2.5 months before the tornado. Standard errors are clustered at the sector level. Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 15: **Robustness of key regressions to different levels of tornado exposure.**

	AI		MUAC		Fever	
	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se
Triple: Tornado damage 0-20% X Vit A X ..						
In utero	0.19	0.04	0.13	0.18	-0.05	0.02
	(0.26)	(0.17)	(0.21)	(0.19)	(0.22)	(0.27)
Age 0-10 weeks	0.16	0.57***	0.19	0.51***	-0.32	-0.66
	(0.19)	(0.16)	(0.22)	(0.19)	(0.43)	(0.53)
Age 11-22 weeks		0.11		0.44		-0.65
		(0.35)		(0.36)		(0.43)
Triple: Tornado damage 20-100% X Vit A X ..						
In utero	0.26	0.14	0.35	0.31	0.10	0.02
	(0.22)	(0.20)	(0.24)	(0.24)	(0.29)	(0.22)
Age 0-10 weeks	0.36	0.47	0.46*	0.78***	-0.49	0.12
	(0.25)	(0.29)	(0.26)	(0.29)	(0.33)	(0.34)
Age 11-22 weeks		-0.01		0.20		0.06
		(0.24)		(0.28)		(0.41)
Double interaction: Tornado damage 0-20% X ..						
In utero	-0.35	-0.09	-0.24	-0.04	0.27	0.21
	(0.24)	(0.13)	(0.18)	(0.15)	(0.17)	(0.21)
Age 0-10 weeks	-0.29***	-0.55***	-0.31***	-0.44***	0.12	0.57
	(0.09)	(0.11)	(0.10)	(0.10)	(0.40)	(0.51)
Age 11-22 weeks		-0.10		-0.43		0.96***
		(0.27)		(0.30)		(0.37)
Double interaction: Tornado damage 20-100% X ..						
In utero	-0.06	-0.01	-0.14	-0.04	0.25*	0.10
	(0.11)	(0.12)	(0.12)	(0.14)	(0.14)	(0.12)
Age 0-10 weeks	-0.27	-0.24	-0.31	-0.32**	0.51***	0.35*
	(0.19)	(0.18)	(0.20)	(0.16)	(0.18)	(0.20)
Age 11-22 weeks		-0.09		-0.11		0.37
		(0.14)		(0.18)		(0.25)
Double interaction: Vit A X ..						
In utero	-0.01	0.01	-0.03	-0.03	0.01	-0.05
	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
Age 0-10 weeks	-0.03	-0.03	-0.06	-0.10	0.01	-0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Age 11-22 weeks		0.01		-0.01		-0.04
		(0.06)		(0.06)		(0.05)
Cohorts:						
In utero	0.01	-0.03	-0.00	-0.05*	-0.01	0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Age 0-10 weeks	0.04	0.06	0.05	0.05	-0.01	0.09**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Age 11-22 weeks		-0.07*		-0.10***		0.06
		(0.04)		(0.04)		(0.04)
- Other controls -						
Best guess length of gestation (weeks)	0.08***	0.05***	0.06***	0.04***	0.00	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	14502	14273	14485	14261	14764	14591

Regression models of key outcome variables where exposure to the tornado is defined in two ways: 1) being in a sector where 0-20% of houses were destroyed by the tornado or 2) being in a sector where 20-100% of houses were destroyed by the tornado. Standard errors are clustered at the (randomization) sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 16: **Robustness of key regressions to excluding the most damaged sectors.**

	AI		MUAC		Fever	
	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se
Triple interaction: In tornado area X Vit A X ..						
In utero	0.21	0.08	0.20	0.19	-0.04	-0.02
	(0.19)	(0.15)	(0.17)	(0.16)	(0.19)	(0.19)
0-10 weeks of age	0.44*	0.69***	0.44*	0.76***	-0.52**	-0.30
	(0.23)	(0.20)	(0.24)	(0.21)	(0.25)	(0.33)
11-22 weeks of age		0.07		0.27		-0.39
		(0.21)		(0.24)		(0.32)
Double interaction: In tornado area X ..						
In utero	-0.21	-0.05	-0.17	0.01	0.32**	0.20
	(0.15)	(0.11)	(0.12)	(0.11)	(0.14)	(0.14)
0-10 weeks of age	-0.46**	-0.57***	-0.42**	-0.50***	0.43**	0.49*
	(0.19)	(0.15)	(0.21)	(0.14)	(0.19)	(0.27)
11-22 weeks of age		-0.12		-0.22		0.76***
		(0.15)		(0.19)		(0.24)
Double interaction: Vit A X ..						
In utero	-0.01	0.01	-0.03	-0.03	0.01	-0.05
	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
0-10 weeks of age	-0.03	-0.03	-0.06	-0.10	0.01	-0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
11-22 weeks of age		0.01		-0.01		-0.04
		(0.06)		(0.06)		(0.05)
Cohorts:						
In utero	0.01	-0.03	-0.00	-0.05*	-0.01	0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
0-10 weeks of age	0.04	0.06	0.05	0.05	-0.01	0.09**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
- Other controls -						
Best guess length of gestation (weeks)	0.08***	0.05***	0.06***	0.04***	0.00	-0.01**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
11-22 weeks of age		-0.07*		-0.10***		0.06
		(0.04)		(0.04)		(0.04)
Observations	14366	14140	14349	14128	14627	14456

Regression models of key outcome variables where we exclude the sectors that had more than 80 % of houses destroyed (which all happened to be control sectors). Standard errors are clustered at the (randomization) sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

8 Appendix

Table 17: **Robustness of key regressions to including random effects at the sector level.**

	AI		MUAC		Fever	
	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se
main						
Triple interaction: In tornado area X Vit A X ..						
In utero	0.15	0.07	0.19	0.22	0.04	0.06
	(0.14)	(0.15)	(0.15)	(0.16)	(0.15)	(0.15)
0-10 weeks of age	0.25	0.45**	0.31	0.61***	-0.53**	-0.20
	(0.21)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)
11-22 weeks of age		0.03		0.20		-0.18
		(0.20)		(0.20)		(0.20)
Double interaction: In tornado area X ..						
In utero	-0.16	-0.03	-0.17	-0.04	0.23**	0.12
	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
0-10 weeks of age	-0.27*	-0.31**	-0.31*	-0.35**	0.45***	0.42***
	(0.16)	(0.16)	(0.17)	(0.17)	(0.16)	(0.16)
11-22 weeks of age		-0.09		-0.17		0.55***
		(0.14)		(0.15)		(0.14)
Double interaction: Vit A X ..						
In utero	-0.00	0.01	-0.03	-0.03	0.00	-0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
0-10 weeks of age	-0.03	-0.02	-0.05	-0.08	0.02	0.00
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
11-22 weeks of age		0.02		0.01		-0.05
		(0.05)		(0.05)		(0.05)
Cohorts:						
In utero	0.01	-0.03	-0.01	-0.06**	-0.01	0.05*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
0-10 weeks of age	0.03	0.05	0.04	0.04	-0.02	0.09**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
11-22 weeks of age		-0.07*		-0.11***		0.07*
		(0.04)		(0.04)		(0.04)
Main effects:						
In tornado area	0.18**	0.16**	0.14*	0.05	0.01	-0.02
	(0.07)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)
Vitamin A Sector	0.01	-0.01	0.01	-0.00	0.00	0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
In tornado area X Vitamin A Sector	-0.06	-0.00	-0.02	0.03	0.05	0.04
	(0.10)	(0.11)	(0.10)	(0.12)	(0.10)	(0.11)
- Other controls -						
Best guess length of gestation (weeks)	0.08***	0.05***	0.06***	0.04***	0.00	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	14502	14273	14485	14261	14764	14591

Multilevel random effects models of key outcome variables. The models include random effects for each sector (randomization unit). Standard errors are clustered at the sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 18: **Robustness of in-utero results to definition of exposure time**

	AI		MUAC		Fever	
	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se	3 Mo. b/se	6 Mo. b/se
Triple interaction: In tornado area X Vit A X ..						
In utero	0.28	0.21	0.33**	0.30**	-0.04	0.18
	(0.17)	(0.14)	(0.16)	(0.15)	(0.19)	(0.16)
0-10 weeks of age	0.28	0.49**	0.34*	0.62***	-0.53**	-0.20
	(0.19)	(0.19)	(0.20)	(0.19)	(0.23)	(0.28)
11-22 weeks of age		0.08		0.25		-0.14
		(0.19)		(0.21)		(0.29)
Double interaction: In tornado area X ..						
In utero	-0.20	-0.11	-0.21*	-0.11	0.26*	0.08
	(0.13)	(0.10)	(0.12)	(0.10)	(0.13)	(0.12)
0-10 weeks of age	-0.28*	-0.35**	-0.31**	-0.38***	0.40**	0.39*
	(0.15)	(0.14)	(0.15)	(0.11)	(0.17)	(0.22)
11-22 weeks of age		-0.12		-0.22		0.52**
		(0.12)		(0.15)		(0.21)
Double interaction: Vit A X ..						
In utero	-0.01	0.00	-0.05	-0.03	0.06	-0.02
	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
0-10 weeks of age	-0.04	-0.03	-0.06	-0.10	0.02	0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
11-22 weeks of age		0.01		-0.00		-0.03
		(0.05)		(0.06)		(0.05)
Cohorts:						
In utero	0.08***	0.03	0.10***	0.01	0.01	-0.04
	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)
0-10 weeks of age	0.05	0.08**	0.07*	0.07*	-0.00	0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
- Other controls -						
Best guess length of gestation (weeks)	0.08***	0.05***	0.06***	0.04***	0.00	-0.01**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
11-22 weeks of age		-0.04		-0.08**		0.03
		(0.04)		(0.04)		(0.04)
Observations	14502	14273	14485	14261	14764	14591

Linear regression models of anthropometric growth and fever incidence using specifications similar to our main specifications except that we define the in-utero period to be the 7 months prior to birth to remove the mechanical correlation between gestational length and tornado exposure. Standard errors are clustered at the sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 19: **Vitamin Supplementation for Low Birthweight Infants**

	AI		Fever episodes		Mortality (p/1000)
	3 months	6 months	3 months	6 months	at 24 weeks
	b/se	b/se	b/se	b/se	b/se
Vitamin A X Birth weight < 2kg	0.04	0.05	-0.06	-0.13**	-18.28
	(0.05)	(0.05)	(0.06)	(0.05)	(15.38)
Vitamin A	0.01	0.01	0.01	0.00	-3.27
	(0.02)	(0.02)	(0.02)	(0.02)	(2.40)
Birth weight < 2kg	-1.21***	-0.97***	0.11***	0.12***	135.49***
	(0.04)	(0.04)	(0.04)	(0.04)	(10.89)
Constant	0.11***	0.10***	0.89***	0.94***	20.76***
	(0.01)	(0.02)	(0.02)	(0.02)	(1.71)
Observations	15162	14912	15499	15207	16357

Linear regression models of infant outcomes by birth weight. The outcome variables are the Anthropometric Index (AI) at 3 and 6 months (standardized average of MUAC, CC and HC), the number of fever episodes at 3 and 6 months (top coded at 4) and 24 week infant mortality. All regressions include sector (randomization unit) fixed effects. Living Standards is an index based on a principal components analysis of household assets. Standard errors are clustered at the sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.

Table 20: **Attrition by cohort inside and outside the tornado area**

	In tornado area										Not in tornado area									
	Pre-tornado		0-24 weeks		In-utero		Post-tornado		Unknown		Pre-tornado		0-24 weeks		In-utero		Post-tornado		Unknown	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total births in infant trial	209		315		343		270		4		3040		4367		4617		3679		61	
Singleton births	209	100	315	100	342	100	266	99	4	100	3016	99	4329	99	4565	99	3642	99	59	97
Non-missing birth anthropometry	195	93	305	97	323	94	252	93	2	50	2762	91	4053	93	4329	94	3424	93	25	41
On time birth anthropometry	166	79	260	83	277	81	219	81	0	0	2327	77	3404	78	3653	79	2974	81	17	28
Non-missing 3-month anthropometry	191	91	290	92	308	90	239	89	1	25	2643	87	3825	88	4126	89	3253	88	12	20
On time 3-month anthropometry	186	89	280	89	294	86	234	87	1	25	2567	84	3745	86	3990	86	3208	87	12	20
Non-missing 6-month anthropometry	195	93	291	92	307	90	233	86	1	25	2564	84	3749	86	4050	88	3169	86	15	25
On-time 6-month anthropometry	192	92	288	91	303	88	230	85	1	25	2465	81	3662	84	3988	86	3153	86	15	25
Non-missing 6-month vital status	208	100	314	100	337	98	259	96	2	50	3000	99	4310	99	4539	98	3526	96	46	75

The table lists the number of infants by cohort and area that were born during the trial in the first row. In subsequent rows it lists number of infants and percentage of the total that fulfill the given data requirements (e.g., having non-missing anthropometric data at birth (Row 3)). In analyses we use only singleton births (this sample is given in Row 2). Pre-tornado (Column 1) is the cohort of infants that were at least 6 months of age when the tornado hit. The next two columns are the cohorts affected by the tornado, in the first 24 weeks of life (Column 2) or in-utero (Column 3). Infants in the post-tornado cohort (Column 4) are those conceived after the tornado (based on reported last menstrual period). In Column 5 (Unknown) are infants for which we do not have enough data to determine the cohort (these are excluded from the analysis). Anthropometry at birth is considered on time if taken no later than 7 days after birth. Anthropometry at 3 and 6 months is considered on time if taken no later than 6 weeks after the target date (target date is 12 and 24 weeks, respectively).

Table 21: **Time at dosing.**

	Dosed at				
	<= 6 hours	<= 12 hours	<= 18 hours	<= 24 hours	<= 7 days
	b/se	b/se	b/se	b/se	b/se
Double interaction: In tornado area X ..					
In utero	-0.05	-0.02	-0.01	0.00	-0.01
	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)
0-10 weeks of age	-0.00	0.01	0.05	0.05	0.02
	(0.06)	(0.06)	(0.05)	(0.05)	(0.03)
Cohorts:					
In utero	0.01	0.01	0.00	-0.00	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
0-10 weeks of age	-0.05***	-0.05***	-0.03**	-0.03**	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	0.47***	0.63***	0.71***	0.75***	0.85***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	16140	16140	16140	16140	16140

Linear regression models of time at dosing using our main specifications. Standard errors are clustered at the sector level.
Significance: * < 0.10; ** < 0.05; *** < 0.01.