COVER SHEET

Stress and Birth Weight: Evidence from Terrorist Attacks

Adriana Camacho

Mailing address: Calle 73 # 00-64 apt 502 Bogotá, Colombia

Phone: (571)339-4949 ext. 3193 or (571)540-1971

Fax: (571) 332-4021

Email: adcamach@uniandes.edu.co or adrianacamacho@gmail.com

Session Title: Marriage and Motherhood in Developing Countries

Session Chair: Nancy Qian

Discussant: Adriana Lleras-Muney

Stress and Birth Weight: Evidence from Terrorist Attacks

By **Adriana Camacho**[*]

While terrorist attacks are relatively infrequent, Gary Becker and Yona Rubinstein (2005) provide evidence that they generate a disproportionate amount of stress and fear, suggesting that the indirect effects may be far more reaching than the direct ones. The international organization, *Medecins Sans Frontiere* 2006, claims that the physiological effect of the conflict is Colombian's worst public health problem. This paper is the first attempt to measure the effect of prenatal psychological stress due to terrorism on child birth outcomes. The medical literature (Pathik D. Wadhwa et al. 1993, among others) indicates that prenatal stress increases levels of Corticotrophin-Releasing Hormone (CRH), which regulates the duration of pregnancy and fetal maturation, increasing the risk of adverse birth outcomes. There is also evidence that birth outcomes are most sensitive to maternal stress in early stages of pregnancy.

This study links the intensity of random terrorist activities during a woman's first trimester of pregnancy with significant negative impacts on child birth weight. This finding persists when mother fixed effects are included, suggesting that neither observable nor unobservable characteristics of the mothers are driving the results. This paper has three specific strengths and makes one main contribution to the literature. Among the strengths: First, I use a large data set, comprising approximately 4 million births in Colombia from 1998 to 2003, that enables me to observe multiple births by the same mother and gives strong statistical power to discern patterns.

*adcamach@uniandes.edu.co Assistant Professor, Department of Economics at Universidad de los Andes. I thank Anna Aizer, Jere Behrman, Emily Conover, Andrew Foster, Alaka Holla, Daniel Mejia, LACEA 2007, seminar participants at Brown University, Universidad del Rosario and Universidad de los Andes for helpful comments and suggestions. I am also grateful to Departamento Nacional de Planeación (DNP) and Departamento Administrativo Nacional de Estadisticas (DANE) for providing the data.

Second, the data allows me to link the date of terrorist attacks with the trimester of the pregnancy, and thereby to identify the stage of pregnancy at which stress influences the outcome. And third, it uses land mine explosions, which occur all over the country [1] with different levels of intensity, as exogenous stress shocks to the population. This yields a very powerful quasi-experimental design to test the effects of stress on birth outcomes, overcoming both the difficulty of doing an experiment that would be unethical. The main contribution to the literature is that this paper identifies another important channel through which violence may have long-lasting intergenerational effects on human capital accumulation; given the strong intergenerational correlations of Low Birth Weight (LBW) found by Janet Currie and Enrico Moretti (2007). Moreover, previous work has established that birth weight is an important predictor of aspects of health later in life, including higher probability of infant mortality (Douglas Almond, Kenneth Chay and David Lee, 2005), lung disease, heart disease, type II diabetes, lower cognitive abilities, and learning disorders (Jennifer Couzin, 2002). In addition, it is strongly associated with socioeconomic outcomes (Behrman and Rosenzweig, 2004; and Sandra Black, Paul J. Devereux and Kjell G. Salvanes, 2007).

I. Data

The Vital Statistics Records, collected by the Administrative Department of Statistics (DANE), correspond to 4.3 million births certificates filed in hospitals within the 1120 municipalities in Colombia from 1998 to 2003. The final analysis of this paper will use a panel of mothers appearing more than once between 1998 and 2003, reducing the sample to 781,000 birth records. As a general description of the sample, the average birth weight in Colombia is 3153 grams,

[1] Landmines have been laid all over the country, they have been found in 422 out of 1120 municipalities (counties) and 31 out of 32 *departmentos* (states).

7.74% of births are Low Birth Weights (LBW) and 0.81% are Very Low Birth Weights (VLBW)[2].

Municipalities' showed substantial variation in violence levels over the period 1998-2004. Naively, any violence indicators could be tested for correlations with child birth outcomes, but it is important to be able to argue the exogeneity of the violence indicator used. In order for this study to be thought of as a quasi-experiment, the violence shock needs to be exogenous and almost randomly assigned. In that case, I want to have a measure that mainly captures a shock of violence and not persistent levels of violence. Terrorism, as the name suggests, intends to create fear or "terror" in the general population by affecting random victims unpredictably. Using terrorist attacks instead of general violence allows me to assume that people perceive the prevalent level of violence in their area of residence; however they are uncertain about the time, magnitude, and exact place of the terrorist attack. Therefore, landmine explosions are used as the most credible violence exogenous stress shock that can generate fear of stepping on a landmine based on the knowledge that others in their same area have suffered from it.

The working data set merges Vital Statistics Records with quarterly data on landmine explosions by municipality of residence.

II. Theoretical Framework and Empirical Specifications

Taking the following health production function:

$$b_{imj} = \Gamma(Y_{imj}, l_{imj}, \mu_{mj}, e_{imj})$$

Where the subscript i refers to the child, m to the mother, and j to the area of residence. b corresponds to the birth weight, Y are goods that can affect birth weight, l are health inputs that require time, μ is a family-specific exogenous health endowment, and e is an input that can be

[2] Very Low Birth Weight is defined as birth weight less than 1500 grams.

added to the standard health production function. Here, *e* corresponds to an environmental factor that causes stress. These environmental factors can be perceived differently among mothers.

Using cross-sectional samples of births, at the *departamento* or municipal level, could lead to biases because of unobserved heterogeneity with respect to genetic endowments, parental behavior, and differences in perception of stress. Since the data permits the construction of a panel of mothers, comparing siblings is a better way to deal with unobserved heterogeneity as mother fixed effects will account for all family-specific heterogeneity. Two assumptions are needed: first, the mother's unobservable characteristics that affect birth outcomes do not change through time, and second, siblings share the same health endowments.

The reduced form linear relation of the health production function estimated will be given by:

$$b_{imjt} = \beta_0 + \beta_1 v_{j(t)} + \beta_2 v_{j(t-1)} + \beta_3 v_{j(t-2)} + \beta_4 v_{j(t-3)} + \beta_5 X_{imjt} + \gamma_{year} + \gamma_{month} + \gamma_j + \mu_{mj} + \varepsilon_{imjt}$$

Where $v_{j(t-2)}$ corresponds to the violence shock specific to the place of residence *j* in quarter *t-2*, and similarly for the second, third and fifth terms. The purpose of using number of landmine explosions $v_{j(t)}$ and lags for the previous three trimesters is to identify the stage of pregnancy when stress has the most impact. As mentioned before, the medical literature indicates that the strongest effect will be found in coefficient β_3 which accompanies $v_{j(t-2)}$ (the violence shock in the first trimester of pregnancy). The matrix X_{ijt} contains the following control variables: age, education, and marital status of the mother, sex of the baby, multiple birth, parity, urban residence dummy, place of delivery, and type of insurance. I also include year γ_{year} and month γ_{month} dummies to control for unobservables changing over time, such as seasonal patterns of birth weight. γ_j are fixed effects that control for all unobservables varying at *j* level

(*departmento*, municipality or mother) but constant over time. The error term ε_{imjt} is assumed to be orthogonal to birth weight, and μ_{mj} is the family-specific health endowment that will only be absorbed when using a mother fixed effects specification. Unbiased estimates from a cross-sectional study using municipality or department fixed effects require a strong assumption about the shock being equally perceived or homogenous across all births within the geographical area of study *j*. Given the controls included and the variation by quarter, any confounders would have to vary at the municipality*quarter level to affect my results.

III. Results

Section A in Tables 1 presents the regressions of birth weight on the incidence of landmine explosions in a trimester. The variable *dmines* corresponds to a dummy variable for having mines in the trimester of birth, while *dmines1*, *dmines2* and *dmines3* capture if there were mine explosions for one, two and three lagged trimesters respectively. Section B of these same tables presents the regressions using the variable of interest defined as the number of landmines exploded in the trimester of birth and the three previous trimesters. To test for non-linearity given the wide variation in violence data, I also included a quadratic term to represent landmines only during early pregnancy (mines2sq) that will be reported in Section B.

Beginning with a naïve approach, I first assume that the "true" effect of exposure to violence at a certain time is homogeneous across infants born within a geographic area. The different models and empirical specifications using department (column 1 from Table 1) and municipality fixed effects (columns 2 to 4 from Table 1) consistently find a negative effect of landmine explosions during pregnancy on birth weight. The department fixed effects estimates overstate the impact

of stress on health outcomes compared to municipality fixed effects. Children born in a department with at least one landmine explosion in each trimester of pregnancy weigh on average 27.76g less than those born with no explosions. Landmines exploding during early pregnancy have the strongest effect compared to other trimesters, contributing a reduction of -11.6 grams. In fact, the municipality fixed effects regressions are much more appropriate, given that resources for public health investments and health care subsidies are administered at the municipal level.

Table 1-Effect of Stress over Birth Weight (in grams)
Place of Residence FE

SECTION A	1	2	3	4
dmines	-4,8240	-1,7958		
	(4,9247)	(2,1521)		
dmines1	-8,5881	-3,9416		
	(3.2353)***	(2,6355)		
dmines2	-11,5918	-7,5301	-7,7106	
	(3.1095)***	(2.4560)***	(2.2569)***	
dmines3	-7,5848	-6,1787		
	(3.5869)**	(4,0243)		
Observations	2.890.417	2.409.122	2.890.417	
R-squared	0,09	0,11	0,10	
SECTION B	1	2	3	4
Mines	-1,6061	-0,3533		
	(0.8440)*	(0,4086)		
Mines1	-2,3695	-0,8059		
	(0.8109)***	(0,6198)		
Mines2	-3,4750	-2,0204	-2,2124	-4,1643
	(0.8378)***	(0.5576)***	(0.5826)***	(0.8997)***
Mines2sq				0,2625
				(0.0934)***
Mines3	-2,7684	-1,668		
	(0.6504)***	(1,0295)		
Observations	2.890.417	2.409.122	2.890.417	2.890.417
R-squared	0,09	0,11	0,10	0,10

Robust standard errors (in parentheses) cluster at the municipal level
* significant at 10%; ** significant at 5%; *** significant at 1%
dmines is a dummy variable for having landmines
mines is the number of landmines
mines2sq is the number of landmines squared

Looking exclusively at municipal fixed effects models, the average difference in birth weight for children born in a municipality with and without landmine explosions during early pregnancy will be 7.5 grams, as shown in column 2. Interestingly, there is no significant effect of stress in periods other than early pregnancy when municipality fixed effects are included. Column 3 only includes landmine explosions lagged by two periods, finding a similar effect of -7.7 grams. This finding supports the stress hypothesis instead of a nutritional channel, given that if I was observing a reduction in the amount of food caused by violence, the strongest effect will be seen in the third trimester, as babies grow most in the third trimester.

Section B in the municipality fixed effects estimation shows that the effect of each landmine explosion during early pregnancy in the municipality of residence is -2.2 grams. The difference in these results from section A and B could be a sign of non-linear effects of additional landmine explosions. To test for these, column 4 shows that a quadratic term for landmines during early pregnancy that turns to be statistically significant, thus confirming the existence of non-linearities in the effect of stress. The value of the quadratic term is positive, indicating that additional explosions have an accelerating effect on reducing birth weight.

Table 2-Effect of Stress over Birth Weight (in grams)

	Mother FE	
SECTION A	1	2
dmines	-4,958	
	(3,105)	
dmines1	0,602	
	(6,876)	
dmines2	-8,323	-8,704
	(3.422)*	(3.282)***
dmines3	-3,577	
	-3,758	
Observations	390.837	390.837
R-squared	0,740	0,740
SECTION B	1	2
mines	-2,111	
	(1,264)	
mines1	0,599	
	(1,680)	
mines2	-2,845	-2,837
	(1.0488)**	(1.0686)***
mines3	-0,926	
	-0,857	
Observations	390.837	390.837
R-squared	0,74	0,74

Robust standard errors (parentheses) cluster municipal level
* significant at 10%; ** significant at 5%; *** significant at 1%
dmines is a dummy variable for having landmines
mines is the number of landmines
mines2sq is the number of landmines squared

The mother fixed effects regressions reported in Table 2 compare the birth weight of sibling number 1 to sibling number 2, who lived in the same municipality but were exposed to different levels of stress shocks during pregnancy. I reduce the sample to non-migrant mothers to mitigate concerns about unobserved lifetime exposure to violence and the endogeneity of migration. I also exclude multiple births, since these births are affected by the same maternal stress. These findings have little larger coefficients but qualitatively similar to the ones found with municipality fixed effects. The stability of the coefficients between the municipality and the

mother fixed effects models attests to the randomness of landmines. Pregnant mothers exposed to landmine explosions delivered babies who weighed 8.7 grams less at birth than their siblings who where not exposed to any landmine explosions while in utero.

Using estimates of the effect of birth weight on neonatal and infant mortality from a Norwegian study (Sandra Black, Paul J. Devereux and Kjell G. Salvanes, 2007) will give a lower bound of the effect of birth weight on infant mortality. Simple calculations imply that having no mines will reduce the neonatal mortality by 0.38% and infant mortality by 0.67%, which in Colombia represents 360 lives per year.

As a final exercise, I consider the possible sign of the bias for the estimated parameters of interest. It could be argued that the estimates reported will be a lower bound for two main reasons. First, births occurring outside medical institutions which do not report birth weight occur mainly in rural areas. People living in these areas are the most vulnerable to and affected by landmine explosions. Second, measurement error in the independent variable of interest when running fixed effects will generate attenuation bias of the coefficient of interest. It is therefore reasonable to consider that the present study represents a conservative estimate of the effect of landmines on birth weight.

IV. Final Remarks

One can argue that landmine explosions are essentially randomly assigned, and act as a convincing exogenous shock due to their terrorist nature. This quasi-experimental approach and the large sample size of the study overland considerable confidence to the conclusions derived relative to previous work on the effects of maternal stress on birth weight.

The study of birth outcomes is currently of particular interest to economists due to the strong link that exits between birth outcomes and cognitive development, socioeconomic and long-term health. A significant decrease of 8.7 grams in weight is found for a sibling experiencing maternal stress due to landmine explosions in the municipality of residence. This paper's findings about the negative relationship between stress during early pregnancy and birth outcomes is consistent with previous findings from the medical literature cited before.

References

Almond, Douglas, Kenneth Chay and David Lee. 2005. "The cost of Low birth weight". *Quarterly Journal of Economics*. August, 1031-1083.

Becker, Gary and Yona Rubinstein. 2005. "Fear and Response to terrorism. An economic analysis." Unpublished.

Behrman, Jere R. and Mark R Rosenzweig. "Returns to Birthweight." 2004. *The Review of Economics and Statistics.* May.

Black, Sandra.,Paul J. Devereux and Kjell G. Salvanes. 2007. "From the Cradle to the Market? The effect of birth weight on adult outcomes."

Couzin,J. 2002. "Quirks of Fetal Environment Felt Decades Later." *Science* .June 21, 2167-2169.

Currie, Janet and Enrico Moretti. "Biology as Destiny? Short- and Long-Run Determinants of Intergenerational Transmission of Birth Weight". Journal of Labor Economics, volume 25 (2007), pages 231–264

Medecins Sans Frontieres. 2006 ."Vivir con Miedo: El ciclo de la violencia en Colombia" MSF Holanda .April.

Wadhwa PD, Sandman CA, Porto M, Dunkel-Schetter C, Garite TJ. 1993. "The association between prenatal stress and infant birth weight and gestational age at birth: a prospective investigation." *Am J Obstet Gynecol* .October, 858-65.