Violence and birth outcomes: Evidence from homicides in Brazil

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This paper uses microdata from Brazilian vital statistics on births and deaths between 2000 and 2010 to estimate the impact of in-utero exposure to local violence - measured by homicide rates - on birth outcomes. The estimates show that exposure to violence during the first trimester of pregnancy leads to a small but precisely estimated increase in the risk of low birthweight and prematurity. Effects are found both in small municipalities, where homicides are rare, and in large municipalities, where violence is endemic, and are particularly pronounced among children of poorly educated mothers, implying that violence compounds the disadvantage that these children already suffer as a result of their households' lower socioeconomic status.

JEL: I12, I15, I39, J13, K42

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1. Introduction

In this paper we analyze birth outcomes of children whose mothers were exposed to violence in their local environment during pregnancy. Exposure to violence is likely to induce fear and psychological stress, and the medical literature suggests that an increase in mother's psychological stress, especially in the first trimester of pregnancy, can lead to prematurity and low birthweight. Evidence though remains elusive and calculations of the cost of crime typically ignore this margin.

For the purpose of this exercise we link microdata from Brazilian birth statistics over eleven years to microdata from mortality vital statistics. Importantly, birth records provide information on the mother's place of residence while death records provide the place of occurrence as well as the precise cause of death, including death as a result of a homicide. This allows us to measure how birth outcomes vary when a homicide - our measure of violence - occurs in the mother's area of residence, and to estimate how the effect varies at different stages of pregnancy.

In particular, in the empirical analysis we exploit information available in the vital statistics on the precise municipality of occurrence of a homicide and the municipality of residence of the mother. We focus on small municipalities for which municipality-level homicide rates provide a localized measure of violence. We complement the analysis with a study of the city of Fortaleza - one of the most violent cities in Brazil, or for that matter in the world - for which the data provide detailed information on the mother's neighborhood of residence and the neighborhood of occurrence of homicides. This also allows us to contrast the effects of homicides in a setting where these are rare and presumably largely unexpected, and perhaps more traumatic events to a setting where homicides are frequent and violence is endemic.

The information available in the vital statistics data allows us to measure the effect of homicides on a variety of outcomes, including birthweight and gestational length, as well as potential margins of selection due to fertility, abortion, and miscarriage. The richness of the data also allows us to investigate how these effects vary across a number of mothers' characteristics, among which, educational level, and hence to study whether high socio-economic status provides a buffer to the effects of local violence.

Other papers before ours, which we discuss at length below, investigate the effects of violence on birth outcomes. Some of these papers (Brown 2014, Mansour and Rees 2012, Torche and Villareal 2014), though, exploit large secular rises in violence in connection to the onset of conflict or to large escalation in violence, raising the possibility that other behavioral responses, which can result from conflict or a secular upsurge in violence (e.g. falls in living standards), might be at work. By converse, other papers (Camacho 2008, Eccleston 2012, Quintana-Domeque and Rodenas 2014) focus on extreme events such as landmine explosions, bomb casualties, or even the 9/11 attacks in New York City. Again it is possible that, given their rare nature, in addition to instilling fear, these events also have additional indirect immediate effects on birth outcomes (e.g. disrupting access to medical services or to the workplace, or affecting, as in the case of 9/11, the level of environmental pollution). The rare and extreme nature of these events also makes it hard to generalize these results to the effect of homicides, let aside day-to-day violence and crime, on birth outcomes. It seems plausible a priori to speculate that extreme violent events might have larger adverse effects compared to single homicides, especially when violence is endemic. In this respect, our paper has the potential to generalize to many other countries and settings, as a much higher number of women worldwide are exposed to everyday violence and homicides compared to those who are exposed to events such as terrorist attacks or landmine explosions.

Even if not as extreme as bombs and terrorist attacks, homicides are known to instill fear and induce anxiety. A large literature in criminology and psychology investigates the determinants of the fear of crime, i.e. the perceived risk of victimization. Not only exposure to crime and violence through direct victimization or witnessing of a crime but also exposure to the news of crimes and violence through friends, neighbors and coworkers are known to considerably raise the fear of crime (Skogan and Maxfield 1981) and to cause mental distress (Dustmann and Fasani 2015). In part due to the amplifying role of the media, violent crimes, and in particular homicides, are believed to instill the strongest response, despite the fact that the risk of being a victim of a homicide may be objectively small compared to other crimes (Warr 2000).

The analysis focuses on Brazil, a country with one of the highest levels of violence worldwide (UNODC 2011), with a homicide rate of 21 per 100,000 population as of 2011, approximately five times the rate in the United States and more than 20 times the rate in the United Kingdom. Sixteen among the top 50 cities in the world ranked based on murder rate are in Brazil and 43 out of 50 are in Latin America and the Caribbean (with the remaining seven cities being either in the USA or in South Africa; Citizens' Council for Public Security and Criminal Justice 2014). Homicide is the leading cause of death in men aged 15-44 (Reichenheim et al. 2011), and day-to-day violence is a top concern among citizens of Brazil. According to Latinobarometer (2010), about 16 percent of Brazilian respondents list violence and public security as the most important problem, and existing estimates put the direct costs of violence and crime at between 3 and 5 percent of annual GDP (Heinemann and Verner 2006, World Bank 2006). As uniform crime reports are not publicly available for Brazil, homicide rates from death records constitute a unique source of information on violence and crime that is uniform across space and time.

In order to proceed with our exercise, we adopt a difference-in-differences strategy across small geographical areas and time. In practice, we net out common time effects across areas and we compare mothers who were exposed to a homicide during pregnancy to otherwise similar mothers residing in the same area, who happened not to be exposed, as they were pregnant at times when a homicide did not occur. Rather than using large changes in homicide rates over time, we exploit within area variation in the precise timing of homicides. As these mothers are likely to live in similar environments, including in terms of the level of endemic violence, by exploiting the precise timing of homicides we attempt to disentangle the causal effect of homicides from other correlated effects, most notably changes in local economic conditions that might affect both birth outcome and the onset of violence.

Our main results show that gestational length and birthweight fall considerably among newborns exposed to a homicide during the first trimester of pregnancy. This is consistent with a large body of medical literature claiming that stress-inducing events affect birth outcomes through an increased rate of prematurity and that these effects act largely in the first trimester of pregnancy (see Section 2).

In particular, in small municipalities, one extra homicide during the first trimester of pregnancy leads to an increase in the probability of low birthweight (<=2.5 kg) of around 0.6 percentage points (an 8 percent increase). This effect is largely ascribable to increased prematurity rather that intrauterine growth retardation. The estimated effect is economically meaningful, being approximately ten times the effect estimated for the United States of being a recipient of Food Stamps (Almond et al. 2011).

Estimates of the effect of one extra homicide during pregnancy for Fortaleza are around 15 percent of what is found for small municipalities. This is consistent with our hypothesis that the effects of violence are relatively less pronounced when violence is endemic. Despite this, a much larger fraction of pregnant women is exposed to homicides in large versus small municipalities. In the conclusions to the paper, we calculate that homicides are a relatively more important contributor to adverse birth outcomes in Fortaleza compared to small municipalities.

In the analysis we also show that homicides have no effect on birth rates, implying that our estimates are unlikely to be affected by margins of endogenous fertility or selective fetus survival, through abortion or miscarriage, which might bias our estimates.

In order to bring ammunition to our claim that the estimated effects are causal, we show that homicides at different leads and lags from pregnancy have no effect on birth outcomes. The absence of significant effects of lagged homicide rates helps us rule out endogenous selection effects, which could mechanically explain our impact estimates if mothers with a lower propensity to give birth to low weight children tended to be more responsive to homicides in terms their fertility rates. Similarly, the absence of significant effects on leaded homicide rates tends to rule out potential selection effects acting through anticipation of future homicides.

As an additional check, and for the purpose of lending further credibility to our identification assumption that - absent a homicide, treatment and control mothers would have had similar pregnancy outcomes - we also show that our results are robust to the inclusion in the regressions of a large array of observable mother, newborn, pregnancy and time-varying local characteristics, as well as to area (i.e., municipality or neighborhood of Fortaleza) specific time trends, which subsume differential trends in outcomes across areas with different homicide rates. These checks tend to rule out that our results are driven by underlying changes in local economic or other conditions that simultaneously lead to a rise in violence and a deterioration in birth outcomes.

Importantly, we find that both socio-economic and biological factors, such as mothers' low levels of education and previous stillbirths appear to magnify the adverse consequences of violence on birth outcomes, implying that mother's high socio-economic status acts as a buffer to the effects of violence on birth outcomes and that violence compounds the disadvantage that low SES newborns already suffer.

The rest of the paper proceeds as follows. In Section 2 we discuss the literature on early life health and previous work in economics on maternal stress and birth outcomes. In Section 3 we provide information on the data used in the rest of the paper. Section 4 introduces the methodology. Section 5 presents the results of the empirical exercise while Section 6 concludes.

2. Maternal stress, violence and birth outcomes

The consequences of low birthweight and fetal health more generally on long-run outcomes, such as educational attainment, later life health, mortality, and labor market performance have been established in a large body of literature. Low-birthweight and premature infants display a greater risk of neonatal or infant death and are more likely to require additional outpatient care and hospitalization during childhood compared to newborns of normal weight, adding to the private and social costs of poor birth outcomes (Almond et al. 2005). Of those living into adulthood, some suffer from increased morbidity and cognitive and neurological impairment, conditions typically associated with lower productivity in a range of educational, economic, and other dimensions (Almond and Currie 2011, Black et al. 2007, Figlio et al. 2014, Royer 2009).

Mechanically, low birthweight can result from either reduced gestational length or intrauterine growth retardation (IUGR) (Kramer 1987). There is evidence that household income and maternal nutrition during pregnancy, especially in the last trimester, and the disease environment during pregnancy affect the incidence of low birthweight through IUGR (see for example Almond 2006, Almond and Mazumder, 2011, Almond et al. 2011, Amarante et al. 2015, Rocha and Soares 2015). Smoking is also a significant predictor of low birthweight (Almond et al. 2005).

There is less clear evidence on the determinants of prematurity. This paucity of evidence - rather than the fact that prematurity has less serious consequences than IUGR - seems to explain why most of the existing policy interventions focus on the latter (e.g. through nutritional programs) rather than on the former (Almond et al. 2005).

There is some evidence in economics that environmental pollution reduces birthweight, apparently via reduced gestational length (see for example Currie at al. 2011 and Currie and Walker 2011), but little evidence on other factors impacting birthweight through lower gestational length.

A large number of epidemiological studies have established a role for maternal stress as a significant and independent risk factor for low birthweight, via pre-term delivery (Wadhwa et al. 2001). Faced with an adverse gestational environment due to maternal stress, the fetus may engage in a range of responses, including the possibility for early maturation (McLean et al. 1995, Hobel et al. 1998) and early delivery. From an evolutionary perspective this is seen as the result of a woman’s need to balance investment in an individual pregnancy with the reproductive opportunities across childbearing age.

The underlying biological mechanism appears to be the release of maternal glucocorticoids in response to stress. This leads to excess production of the placentallyderived corticotrophin releasing hormone (CRH), in turn accelerating the maturation of the fetus' organs - such as the lungs (McLean et al. 1995, Mulder et al. 2002) - and leading to preterm delivery (Latendresse 2009). In order for these responses to be effective and to limit maternal investments in pregnancies at risk of failure, cues of an adverse environment are most useful and hence more likely to prompt a response in the early stages of pregnancy (Pike 2005, McLean et al. 1995). This explains why exposure to stress in the first trimester of pregnancy is likely to have the largest effects.[1]

Few papers in economics directly study the effect of maternal stress on birth outcomes. Black et al. (2015) focus on grief associated with the death of the child's maternal grandparents and find small but statistically significant effects on birthweight and APGAR scores (but no evidence of longer-term adverse consequences). The authors also present suggestive evidence ruling out that other mechanisms, such as lack of parental support during pregnancy, are responsible for this effect. Aizer et al. (2015) find that, despite long-term adverse consequences, there is no significant association between elevated levels of cortisol during pregnancy and birth outcomes, although the interpretation of these findings is complicated by the selective nature of the sample considered in their study.[2]

Bozzoli et al (2014) study the effect on birth outcomes of the large financial and economic crisis in Argentina at the beginning of the last decade. In principle the crisis might have affected birth outcomes through both reduced nutrition, due to a dramatic fall in living standards, an effect that should manifest as a result of exposure in the last trimester of pregnancy, and mothers' increased psychological stress, an effect likely to be at play as a result of exposure during the first trimester of pregnancy. The authors find evidence in favor of both effects. Exposure to the crisis during the first trimester of pregnancy negatively affected birthweight - apparently through reduced gestational length - among newborns of all

[1] Other research argues that the link between maternal stress and low birthweight works though intrauterine growth retardation. A stream of research in particular hypothesizes that the release of excess cortisol in response to maternal stress may pass the placental barrier (Harris and Seckl 2011, Reynolds et al. 2013,). This may subsequently increase the production of glucocorticoids that are known to enhance metabolism and via this slow the growth of the fetus. Evidence in favor of this hypothesis in human pregnancies is nevertheless rather weak and several studies have shown little correlation between maternal stress and maternal cortisol levels (Harville et al. 2009, Reynolds et al. 2013). A potential alternative explanation relates to the response of the sympathetic nervous system and the ensuing releasing the hormones epinephrine and norepinephrine, which form part of the fight or flight response of organs to stress (Mulder et al. 2002). The release of epinephrine increases the heart rate and causes blood vessels to dilate in muscles and to constrict in less vital organs. This may result in a limitation of blood flow to the unborn child and hence lead to growth retardation (Vinkelsteijn et al. 2004). In both cases the critical period for the adverse effects on intrauterine growth is not well established (Glover et al. 2010).

[2] There is very little direct evidence on the effect of mother's victimization. One exception is Aizer (2011), which shows that mother hospitalization considerably reduces birthweight.

pregnant women, irrespective of their socio-economic status, consistent with the maternal stress channel. On the other hand, only children of low socio-economic status, i.e. liquidity constrained, mothers were affected by exposure in the third trimester, consistent with a nutrition channel.

Similar to our study, a small but growing body of literature focuses on violent events. These papers though typically focus on violence escalation or extreme, largely unexpected, violent events, such as terrorist attacks, bombings and landmine explosions or the onset of conflict. Mansour and Rees (2012) for example focus on the conflict in the West Bank and Gaza during the second Intifada and show that a higher number of noncombatant fatalities are associated to a modest fall in birthweight. Brown (2014) finds that exposure to the escalation in violence related to the war on drugs in Mexico early in gestation led to a substantial decrease in birthweight.

While, similar to the channel we have in mind, conflict escalation is likely to affect birth outcomes directly through the mother's fear of victimization and increased psychological stress, this is also likely to affect outcomes through a variety of additional channels. Deterioration in living standards and changes in labor supply, household income and consumption, increased difficulties in, or higher cost of, accessing local health services, as well as resource diversion on the part of communities and households in order to prevent or counteract a rise in violence are all likely to have additional direct and indirect adverse effects on newborns' well-being, hence complicating the interpretation of the underlying channels.

Torche and Villareal (2014) focus specifically on the mediating effect of behavioral responses to violence on birth outcomes. Using an approach similar to ours, and differently from Brown (2014) the authors find that homicide escalation in Mexico between 2008 and 2010 led to *increased* infant birthweight, especially among low SES mothers, an effect that they ascribe to increased pre-natal care utilization in response to violence escalation, with beneficial cascade effects on birth outcomes.

Other papers focus on terrorist attacks. These papers are more similar to ours in exploiting unexpected violent events that occur during pregnancy. Eccleston (2012), among others, focuses on the 9/11 attack in New York and finds that exposure in the first and second trimester of pregnancy leads to a reduction in birthweight and an elevated level of prematurity. Although this paper and other papers (e.g. Eskenazi et al. 2007) emphasize the role of maternal stress and fear, the effect found may nevertheless be due to exposure to pollutants resulting from the attack (Currie and Schwandt 2015). Quintana-Domeque and

Rodenas (2014) study the effects of the ETA terrorism in Spanish provinces on birth outcomes and find that in-utero exposure to bomb casualties early in pregnancy leads to lower gestational length and an increase in the prevalence of low birthweight, while Camacho (2008) finds a significant negative effect of landmine explosions in Colombia during the first trimester of pregnancy on birthweight.

In sum, the literature seems to point into the direction of rare, extreme violent events negatively affecting birthweight, potentially through a stress channel. There is some dispute about the effect of a secular upsurge in violence on birth outcomes, as this might induce offsetting behavioral responses, potentially through anticipation effects. We complement this literature by focusing on less extreme but more widespread violence.

3. Data

3.1 Birth statistics

In order to characterize the distribution of birthweight and other birth outcomes, in the rest of the paper we use public use microdata from vital statistics from the Brazilian Ministry of Health between 2000 and 2010. This information comes from birth certificates issued by the health institution where the delivery occurred.[3] Microdata from vital statistics are publicly available through the System of Information on Life Births (SINASC) of DATASUS, literally the Brazilian *Departamento de Informática do Sistema Único de Saúde*.[4]

Data from the 2010 population census show that more than 99 percent of children born between 2000 and 2010 have birth certificates implying that coverage in the data is practically universal.

The data provide a large array of information on the pregnancy, the newborn(s) and the mother. Similar to other vital statistics systems in high income countries, such as those collected and administered by the National Center for Health Statistics (NCHS) and the Centers for Disease Control and Prevention (CDC) in the USA, the data include information on the precise date and place of birth, including an identifier for the health institution where

[3] In the case of a home birth, this information is provided by the midwife who attends the birth. If the home birth is not attended by a medical professional, a birth certificate is issued by the civil registry at the time of registering the birth. Only 1 percent of births in Brazil are home births.

[4] The data can be downloaded at http://goo.gl/KIqhYA (data last downloaded in August 2012).

delivery occurred (unless the birth occurred at home), mothers' characteristics (age, education, marital status, usual occupation and pregnancy history), characteristics of the pregnancy (gestation duration in classes, i.e., less than 22 weeks, 22 to 27, 28 to 31, 32 to 36, 37 to 41 and 42 or more, and number of prenatal visits, also in classes, i.e., 0, 1-3, 4-6 and 7 or more), as well as characteristics of the birth (e.g. if a C-section or a multiple birth) and of the newborn (race, gender, weight at birth, APGAR scores at 1 and 5 minutes after birth).[5]

Importantly, in addition to the precise place where the birth occurred, the data provide information on the mother's place of residence. This piece of information is particularly useful for the purposes of our analysis, as it allows us to identify the environment where the pregnancy developed, and hence to derive a measure of the fetus' exposure to local violence during this critical period.

Specifically, for all births, the data provide information on the mother's municipality of residence. Municipalities in Brazil are geographical units roughly equivalent to a U.S. county. At an average total population of just over 184 million over the period 2000-2010, each of the 5,566 municipalities of the country accounts on average for 33,000 individuals.[6] Obviously, population size varies tremendously across municipalities. While Sao Paulo and Rio de Janeiro have respectively more than 11 and 6 million inhabitants, according to the standard national statistical office (IBGE) definition nearly a quarter of Brazilian municipalities are small, i.e., with population of up to 5,000. In the rest we focus on these small municipalities, for which municipality-level homicide rates are more likely to provide a localized measure of violence. Small municipalities cover areas of approximately 22 X 22 km on average, and are geographically rather dispersed (see Figure 1).

Data for large municipalities also provide in some instances (for selected municipalities and only up to 2009) the neighborhood of residence of the mother. Unfortunately the classification of these neighborhoods in DATASUS does not typically correspond to the classification of the census districts adopted by IBGE. The latter is crucial for normalizing homicides described below using official population numbers and for computing local demographic characteristics that we use as controls in the regressions. One exception is Fortaleza, the state capital of Ceará, in the North-east of Brazil, and the fifth

[5] There is no unique mother identifier in the data meaning that, unfortunately, subsequent births for the same mother cannot be identified.

[6] In the analysis we restrict to the 5,556 municipalities that are consistently defined over the period of observation and we drop municipalities that were at one point during the period split into smaller administrative units.

largest city in Brazil (population just above 2.5 million) for which a one-to-one correspondence exists between the neighborhoods in the mortality and birth data and the census districts in the population census.[7] The average neighborhood in Fortaleza has a population of just above 21,000 and an extension of around 1.6 X 1.6 km. We were able to obtain official information from the municipal government of Fortaleza allowing us to link the neighborhood identifier from the vital statistics data to official census district data from IBGE. This also allows us to analyze the effect of homicides on birth outcomes across neighborhoods of the city of Fortaleza (see Figure 2).

The top panel of Table 1 presents descriptive statistics on births for all of Brazil, separately by municipality size, including for small municipalities that constitute the focus of our analysis. Although, as said, we have data for all births that occurred between January 2000 and December 2010, in the rest of the paper we restrict to births for which conception occurred between October 2000 and June 2009. We recover date of conception by subtracting gestational length from the precise date of birth.[8] This allows us to measure the effect of homicides at different leads and lags since the time of conception, which we use as additional regressors in the analysis below.

With an incidence of low birthweight (up to 2.5 kg) of around 9 percent, Brazil ranges above the average for OECD countries but considerably below some low-income countries (UNICEF 2006). Around respectively 1 and 0.5 percent of children are born very low (<=1.5 kg) and extremely low (<=1 kg) birthweight, while 6.6 percent of children are born premature (less than 37 weeks of gestation).

The risk of low birthweight is strongly associated with prematurity. This is evident in Figure 3, which plots the fraction of children classified as low, very low and extremely low birthweight as a function of gestational length, where a vertical line denotes 37 weeks, i.e. normal gestational length. It is apparent that premature children are disproportionately at risk

[7] DATASUS - responsible for collecting and disseminating birth and death data - uses its own system of coding neighborhoods. For the majority of municipalities, this classification of neighborhoods does not correspond to the one in other official data, including the population censuses administered by the Brazilian statistical office (IBGE). Furthermore, for many municipalities the codes in the birth and mortality records are not consistent across datasets and/or time. An exception is Fortaleza, for which the coding is consistent across time and datasets and for which a one-to-one correspondence exists between IBGE census districts DATASUS and neighborhoods.

[8] As the length of gestation is recorded in intervals for most of the period (2000-2009), we use information on precise gestation in weeks that is only available in the 2010 birth data to convert these intervals into average gestational length in weeks. In particular we assign a gestational length of 20, 26, 30 35, 39 and 42 weeks for gestational intervals of less than 22 weeks, 22 to 27 weeks, 28 to 31 weeks, 32 to 36 weeks, 37 to 41 weeks, and 42 weeks or more respectively. Clearly this implies that our measure of gestational length is affected by measurement error.

of being born low birthweight and that the risk of low birthweight decreases almost monotonically with the length of gestation.[9] [10]

Column (1) of Table 1 presents descriptive statistics for small municipalities.[11] With more than 500,000 births over the period considered, small municipalities account for around 2 percent of all births in the country (and 2.4 percent of the population). Roughly speaking, birth outcomes are better in small municipalities than in larger municipalities, with a lower incidence of low birthweight and prematurity. Out of 1,000 newborns in small municipalities, around 79, 10 and 4 are born low, very low and extremely low birthweight, respectively, while around 59, 10 and 3 are born before 37, 32 and 28 weeks of gestation respectively.

A greater incidence of low birthweight is observed in large relative to small municipalities despite the fact that mothers in small municipalities have on average lower levels of education and lower living standards, both of which are known to affect the incidence of low birthweight. Although one potential explanation for these differences are the higher levels of violence in large compared to small municipalities (see section 3.2), clearly these municipalities differ in many dimensions (e.g. levels of pollution or mothers' work involvement, both of which are known to negatively affect birth outcomes, see for example Currie et al. 2011, Rossin 2011). We attempt to isolate the effect of violence on birth outcomes separately from the potential array of other correlated effects in the regression analysis below.

Data for Fortaleza are reported in the last column of Table 1. With an incidence of low birthweight of around 83 per 1,000 children and a rate of prematurity on the order of 64 per 1,000 children, Fortaleza shows results that are slightly better than other large municipalities but worse than small municipalities.

Average data for the 109 neighborhoods of Fortaleza for which information is available in the vital statistics data are reported in Appendix Table A1.[12] Given that birth data only report the neighborhood of residence of the mother up to 2009 and that the death records only report the neighborhood of occurrence of a death since 2006 (see next section), and that we also include in the regressions leads and lags of the homicide rate, we only restrict to

[9] Also, approximately 46 per cent of low birthweight children and 89 percent of very low birthweight children are born premature.
[10] Interestingly, the fraction of low birthweight children born within week 22 is slightly off-trend, perhaps suggesting that survival probabilities are higher among very premature children who developed faster.
[11] Population classes are defined based on average population between 2000 and 2010.
[12] There are 109 neighborhoods available in both the birth and the mortality data out of the 115 official neighborhoods of Fortaleza. These account for 94.6 percent of the total population.

births that were initiated between January 2006 and December 2008. There are just over 110,000 births in Fortaleza over this period, with around 10 percent having a missing neighborhood of residence of the mother. Table A1 shows that results for these neighborhoods are roughly in line with data for the whole of Fortaleza in Table 1.

3.2. Mortality data

Mortality data come from death certificates that are also collected by DATASUS and are available for the period 2000-2010.[13] The data provide detailed information on the date and cause of death, and a variety of information on the characteristics of the deceased (age, gender, race, education, place of residence). The data also report information on the place of occurrence of the death (but not on place of residence of the deceased), including, importantly, municipality of occurrence of the death and, for Fortaleza (as well as for other large municipalities), the neighborhood of occurrence of the death, although this piece of information is only available starting from 2006.

The data report a flag indicator for deaths due to non-natural causes. Similar to the classification used by the NCHS, this is an abstractor-assigned variable that builds upon information from a variety of sources (death certificate, coroner's statement and other sources).[14] Non-natural deaths are further classified into those resulting from accidents, homicides and suicides, plus a residual category. Homicides are defined as violent non-natural deaths occurring as a result of assault. For non-natural deaths, the data also report the place of occurrence of the death (but not of the injury that led to the death), separately for those that occurred in a health institution, in the public way, in one's residence or elsewhere.

In the rest of the paper we focus on homicides for which the death occurred in the public way, as these are more likely to be visible to the public and to be associated to generalized measures of violence (as opposed to, say, homicides for which the death occurred in one's residence that might be more likely to result from domestic violence), and hence more likely to induce stress among pregnant women. This also leads us to exclude homicides for which the death occurred in a health institution and for which the injury at the origin of the death is likely to have occurred elsewhere, including possibly in another municipality.

[13] The data can also be downloaded at http://goo.gl/LvKpfT (data last downloaded in August 2012).
[14] In line with CDC guidelines, we use the abstractor assigned indicator for homicides as opposed to using the cause of death from the WHO International Statistical Classification of Diseases and Related Health Problems (ICD-10), as the former typically identifies homicides more precisely.

Descriptive statistics on homicide rates per 100,000 individuals are reported in the bottom panel of Table 1. Averages across municipalities within each population class are weighted by municipal population. We standardize homicides to the municipality population to derive ratios. We derive population from census data, interpolating linearly across the 2000 and 2010 censuses.[15]

During the period of observation, around 500,000 homicides are recorded throughout Brazil, equivalent to a yearly homicide rate of around 26 per 100,000 individuals. Homicide rates tend to be higher the larger the municipality: while there are around 7 homicides a year per 100,000 people in small municipalities, this number is about six times larger in large municipalities (>500,000 population). At an average population of respectively 3,400 and 1.5 million, this implies that there are on average around 0.25 homicides per year in small municipalities (7.186 X 3,418/ 100,000), i.e., a homicide every four years. By converse, in large municipalities there are around 600 homicides a year (41.132 X 1,487,000/ 100,000), i.e., roughly two homicides a day. Although this clearly signals that homicides are much rarer events in small municipalities compared to large municipalities, the homicide rate in small municipalities is still about seven times larger than the average in Western European countries (UNODC 2013).

Of all homicides, around one third occur in the public way, with this number being larger (around 45 percent) in larger cities where gang violence and street confrontations are more frequent.[16] [17] Unsurprisingly, in small cities, a much lower fraction of deaths related to homicides occur in health institutions compared to large cities, where hospitals are typically

[15] We use official data from IBGE on population by municipality for each year between 2000 and 2010 (using the months of June of the years 2000 and 2010 as base months) and we compute the population in each intervening month by simple linear interpolation, i.e., a regression of log population on a linear month trend. Data are available at http://goo.gl/xOO22 (data last downloaded in January 2015).

[16] Although we have no way to identify the motives behind such high rates of homicide from these data, there is claim that a significant fraction of homicides in Brazil is associated with drug trafficking and the ensuing disputes among criminal gangs and between gangs and police forces (UNODC 2005). Recent evidence suggests a role for an institutionalized culture of violence, whereby people commit murder for trivial reasons as a way, for example, to settle disputes with neighbors or spouses, or during incidents of road rage (Waiselfisz 2013). There is also evidence that homicides are related to a wide variety of other violent activities, such as robberies, kidnapping, assaults, and muggings (Heinemann and Verner 2006). Indeed, homicide rates are often used as crime and violence indicators (UNODC 2011) and evidence for Brazil, in particular, shows a close correlation between different forms of violent crime and homicides (World Bank 2006).

[17] Appendix Figure A1 reports the incidence of low birthweight and homicide rates (in the public way) across all Brazilian municipalities. Although this is not immediately evident in the figure, a clear positive correlation exists between homicide rates and low birthweight. A GLS regression line of the incidence of low birthweight (multiplied by 1,000) on the homicide rate per 100,000 population with weights equal to the municipal population, gives an estimated coefficient of 0.175 (s.e. 0.017), implying that an extra homicide per 100,000 people is associated with 1.7 extra low birthweight children out of 1,000.

located. This is consistent with the hypothesis that a significant fraction of homicides for which the death occurs in a health institution is likely to be committed in other municipalities.

The last column of Table 1 reports homicide rates for Fortaleza.[18] In contrast to the moderate levels of violence in small municipalities and in line with data for other large municipalities, Fortaleza displays remarkably high homicide rates, with 32 homicides per 100,000 population, i.e., around 800 homicides per year, equivalent to three homicides per day. This very high homicide rate is matched by other crime indicators, with Fortaleza ranking among the top of state capitals for crime victimization, with 31 percent of the population reporting having been a victim of crime over the last 12 months (SSPDS 2014).

Data on homicides for the 109 neighborhoods of Fortaleza available in the vital statistics data are reported in Appendix Table A1.[19] For homicides where the victim dies in the public way, information on the neighborhood of occurrence is available for 72 percent of cases. This implies that we are unable to assign a precise neighborhood of occurrence to around 28 percent of homicides for which the death occurred in the public way in Fortaleza. For this reason, one will need to exert some caution in interpreting estimates for Fortaleza, as our homicide indicator is likely to be affected by measurement error. Even considering a non-negligible fraction of underreporting due to missing neighborhood of occurrence, data in Table A1 reveal that there are on average around 12.9 homicides in the public way per 100,000 thousand people in a neighborhood of Fortaleza. At an average population of around 21,500, this implies a number of homicides in the public way by neighborhood of around 2.8 per year.[20]

Figure 4, panels A and B, report trends in monthly homicide rates and the incidence of low birthweight across small municipalities. There is a very modest upward trend in homicide rates across these municipalities, with a monthly homicide rate per 100,000 people of around 0.5 in the yearly period (equivalent to a yearly rate of around 6) and a rate of 0.7 in

[18] We use official population data for the neighborhoods of Fortaleza provided to us by the municipal government of Fortaleza. As in the case of municipalities, we linearly interpolate across the two censuses dates to obtain estimates of the population in each month of observation.

[19] The data provide information on the neighborhood of occurrence for 48 percent of all homicides, irrespective of where the death occurred. In part this is due to the circumstance that the neighborhood of occurrence is not reported in the data when the death occurred in a health institution. This explains why the average homicide rate across neighborhoods of Fortaleza (in Table A1) is lower than the average homicide rate in the overall municipality of Fortaleza (Table 1).

[20] If one is willing to re-impute back homicides for which a neighborhood of occurrence is missing (28 percent) this implies almost one homicide in the public way per neighborhood every quarter.

the later period (equivalent to a yearly rate of around 9.5). Trends in homicides rates in the public way are flatter, with no appreciable change over the period.[21]

In contrast, the incidence of low birthweight falls only slightly over the period. Figure 4 shows that, while in the early period slightly more than 8 out 100 children were born low birthweight, this number is slightly below 8 in the second part of the period of observation.[22]

Similar data for Fortaleza are reported in Appendix figure B2. Homicide rates increase over time in Fortaleza, from an average monthly incidence of 2.5 homicides per 100,000 people, to around 3 at the end of the period. In contrast, the incidence of low birthweight increases sensibly in Fortaleza, from below 8 low birthweight children out of 100 in the early period to around 9 in the later period.

In sum, there seems to be some evidence that homicide rates and the incidence of low birthweight co-move in opposite directions over time. Clearly there should be no presumption that such negative correlation yields any causal interpretation: changes in living standards or other major determinants of birth outcomes and violence are likely to largely drive these results. As said, we attempt to identify the causal effect of violence on birth outcomes in the econometric analysis below, where we abstract from the pure time series variation and exploit differential changes in homicide rates and birth outcomes across municipalities (or neighborhoods of Fortaleza) over time.

3.3 Auxiliary data

We finally integrate our data with a large set of auxiliary data at the level of municipality (or neighborhood of Fortaleza). These variables are used in the regression below in order to probe the robustness of our results to the inclusion of a large array of socio-economic variables that might simultaneously affect local violence and birth outcomes.

We use published data from a variety of sources on municipality-level time-varying characteristics. These include municipality GDP, share of public expenditure as a fraction of local GDP, and fraction of local expenditure devoted to health, welfare, education, justice and security and defense, number of *Bolsa Família* recipients, total amount of *Bolsa Família* payments, number of health institutions and number of nurses. We also include climatic

[21] In contrast, there is a pronounced fall in homicide rates across large and very large municipalities (not shown). This fall is behind a major fall in average homicide rates across the whole of Brazil over this period of observation.

[22] Trends in the incidence of low birthweight in municipalities of other sizes (again not reported) are also substantially flat, with only a very modest decline over time.

monthly measures of precipitation and temperature, expressed in log deviation from the historic (1940-2010) municipality average, similar to Rocha and Soares (2015). Note that none of these variables are available for the neighborhoods of Fortaleza.[23]

The sources of data as well as their exact definition and the procedure used to derive them (when applicable) are described in the Data Appendix.

4. Econometric model

The difficulty in estimating the causal effect of violence on birth outcomes is that characteristics of different residential areas are unobservable to the econometrician. Some of these unobservable characteristics might be correlated with both newborns' health outcomes and homicide rates, even in the absence of a causal effect of violence on birth outcomes. If, for example, children born in poorer areas are more likely to display negative birth outcomes due to the lower socioeconomic characteristics of their parents or worse provision of health services in their neighborhood, and, possibly, to be exposed to a higher degree of violence, one would erroneously conclude that higher homicide rates lead to worse birth outcomes, a classic case of failed inference based on observational data.

In order to circumvent this problem, we use a difference-in-differences identification strategy that relies on differential changes in homicide rates across small geographical areas: this provides a way to control for unobserved time-invariant municipality characteristics and to subsume aggregate time effects.

In formulas, we estimate the following model:

$$Y_{iat}=\beta_0+\beta_1\, HOM_{at}+X_{it}'\beta_2 + Z_{at}'\beta_3 + d_a + d_t + u_{iat} \qquad (1)$$

where Y_{iat} is the individual outcome variable (birthweight, gestational length, etc.) in area (municipality or neighborhood) a at time t, HOM_{at} is the local homicide rate and d_a and d_t are

[23] IBGE provides statistics by neighborhood from the population census but only for variables that are contained in the short census form. These are at available at http://goo.gl/XqHhsV and http://goo.gl/6Odwl3 (data last downloaded in January 2015), respectively for 2000 and 2010. These allow us to recover information on the fraction of households with access to waste collection and fraction of individuals by gender X 10-years age groups. We linearly interpolate these variables over time in order to derive monthly values that we use as controls in the regressions for Fortaleza. Although these and many other socio-economic variables from the long form are also available for all Brazilian municipalities, we do not use census controls for municipality regressions. The reason for this is that in these regressions we control for municipality X linear month trends, which subsume any time series variation in the interpolated census controls.

respectively fixed effects for the mother's area of residence and for the month of conception. The latter is a variable running from 1 from the first month of conception observed in our data (October 2000) to 105 (for the last month of conception, June 2009). X_{it} denote mother, pregnancy and newborn characteristics, Z_{at} denote time varying area characteristics while u is an error term.

Equation (1) identifies the causal effect of homicides on birth outcomes if - conditional on observable controls - mothers in the same area have similar birth outcomes other than because of their differential exposure to homicide rates during pregnancy.

A major challenge to the identification is that time-varying individual and local characteristics might affect both birth outcomes and homicide rates. A deterioration in local economic conditions, for example might lead to an eruption of violence as well to poor birth outcomes, through increased mother's stress or other channels (i.e. a deterioration in living standards and poorer nutrition which, as discussed above, have negative effects on birth outcomes).[24] Similarly, climatic changes that are known to affect violence (Hsiang, Burke and Miguel 2013) might themselves affect the incidence of homicide as well as have direct effects on birthweight or gestational length (Andalón et al. 2014, Rocha and Soares 2015).

In an attempt to overcome these concerns, we include in the model a very large array of observable controls for the newborn, the mother, the pregnancy and the area of residence. We also experiment with specifications that include area-specific month trends (again a variable running from 1 to 105) plus, in the most saturated specifications, area specific seasonality effects (i.e. the interaction of calendar months dummies with area fixed effects) that subsume differential unobserved trends and cyclical patterns in violence and birth outcomes across areas that might contaminate our estimates.

We finally include in the model leads and lags of the homicide rates in order to subsume generalized levels of violence in periods surrounding pregnancy and to test whether or not it is precisely homicides during pregnancy that have an effect on birth outcomes. This serves as a falsification exercise, as one would not expect homicide rates pre- and post-

[24] There is an established literature relating local economic conditions and crime (Becker 1968). At the core of this literature is the idea that a deterioration in economic conditions can lead to an increase in crime by reducing the returns to non-criminal activities. Another body of research focuses on the effect of economic conditions on the onset of violent conflict (Dube and Vargas 2013, Miguel, et al. 2004). There is relatively little evidence on the effect of local economic conditions on violent crime. Raphael and Winter-Ebmer (2001) find that while in the USA unemployment is positively related to property crime, it exhibits a negative correlation with murder rates. Lin (2008) finds a small negative but insignificant effect of unemployment on violent crime.

pregnancy to affect birth outcomes and finding a significant effect of these variables would point to a violation of the identification assumption.

In the empirical analysis, we use as a regressor the quarterly homicide rate calculated over three month-intervals starting from the month of conception and we estimate the effect of the homicide rate at different stages of pregnancy (i.e., first, second, and third trimester). As explained in the previous section, we recover the month of conception based on the child's date of birth minus the length of gestation. This approach allows us to measure exposure in different trimesters of pregnancy, which would not be possible if we counted retrospectively three trimesters from the time of birth and ignored the variation in the length of gestation across pregnancies. In the spirit of an ITT estimator, we assign the homicide rates in each trimester following conception to all mothers, irrespective of gestational length. This also allows us to circumvent the potential selection bias arising from the circumstance that mothers with shorter gestational length are mechanically exposed to lower homicide rates. Note, however, that because gestational length is estimated using data from 2010 (see footnote 8), this estimate is likely affected by measurement error. To the extent that measurement error is classic, i.e. uncorrelated with the actual gestational length, this should lead to estimates of the impact of homicides on birth outcomes in different trimesters of pregnancy that are, if anything, attenuated, ie. biased towards zero.

5. Empirical Results

5.1 Main results for small municipalities

Table 2 presents estimates of equation (1) for small municipalities (<=5,000 individuals). The table reports, in order, results for average birthweight (in grams) and for the fraction of low, very low, and extremely low-weight births (per 1,000 births). Each row reports separately the effect of homicides in each trimester of pregnancy since conception. Standard errors are clustered by municipality.

Focusing on birthweight (columns 1 to 3), the specification in column (1) only includes municipality and month of conception fixed effects. Results show a clear, precisely estimated, negative effect of the homicide rate in the first trimester of pregnancy on average birthweight, with a coefficient of -0.45. The estimates for the second and third trimester are much smaller in magnitude and not statistically significant at conventional levels. This is in line with evidence from the literature reviewed in Section 2 that the effect of maternal stress on birth outcomes manifests in the first trimester of pregnancy.

These estimates imply that a one standard deviation rise in the homicide rate during the first trimester of pregnancy (4.41, equivalent to one seventh of a homicide in a municipality of this class) leads to a reduction in birthweight of around 2 grams (-0.45 X 4.41).

Column (2) of Table 2 controls for a very rich set of characteristics of the child (race), the pregnancy (dummies for multiple births: singleton, twins, triplet or more), the mother (dummies for age, education and marital status, number of previously born alive and stillborn children) and the municipality (log municipality GDP, log population, log share of public expenditure as a fraction of local GDP, log fraction of local expenditure devoted to health, welfare, education, justice and security and defense, average precipitation and temperature, number of *Bolsa Família* recipients, total amount of *Bolsa Família* payments, number of health institutions and number of nurses). Note that with the exception of precipitation and temperature that vary at the monthly level, all other municipality-level controls only vary at the yearly level.

We also include unrestricted municipality specific month trends (where the latter variable ranges from 1 for the first month of conception observed in our data to 105 for the last month of conception). These subsume unobserved linear trends in homicide rates and birth outcomes across municipalities. We finally include homicide rates in the three trimesters pre-pregnancy and post-birth.

Remarkably, results remain almost unchanged compared to column (1). There is also no evidence of homicides pre- and post-pregnancy significantly affecting birthweight. Both these pieces of evidence speak in favor of our identification assumption that, absent homicides during the first trimester of pregnancy, treatment and control children would have displayed similar birth outcomes.

Finally, column (3) includes additionally municipality-specific calendar month of conception dummies (ranging from 1 to 12) in order to allow for different seasonality patterns in both the outcome variables and the homicide rates across municipalities. Results are effectively unchanged and, if anything, estimates become slightly larger in absolute value relative to columns (1) and (2).

Columns (4) to (12) of Table 2 report regression results for low, very low and extremely low birthweight. Once again, there is evidence that the effects are remarkably consistent across specifications and that homicide rates pre- and post-pregnancy are not significantly correlated with birth outcomes. Again, it appears that only the homicide rate in the first trimester of pregnancy matters for birthweight.

Taking the most saturated specifications in columns (6), (9) and (12), these imply that a unit increase in the homicide rate during the first trimester of pregnancy leads to an increase in the risk of low, very low and extremely low birthweight of respectively 0.24, 0.09 and 0.06. This implies that one standard deviation rise in the homicide rate (4.41) in a small municipality leads to an extra 1.05, 0.40 and 0.26 children out of 1,000 being born low, very low and extremely low birthweight respectively. This is a 1.3, 4, and 6.5 percent increase (relative to a baseline incidence of 0.079, 0.010 and 0.004) respectively.

We have performed a number of robustness checks. As a concern remains that past homicide rates might be affect birth outcomes, for example through fertility (see below), we have also replicated these regressions excluding lagged homicide rates. Results (not reported but available upon request) are effectively unaffected by the exclusion of these variables. A second concern is that homicides affect population growth through selective immigration or emigration. For this reason, we have also re-estimated our model by defining population classes based on population as of 2000 (as opposed to the average over the 2000-2010 period). Results (again not reported) are effectively unchanged. This is suggestive that endogenous population growth is not a source of major concern. We have finally re-estimated our main regression model restricting to singletons. The concern here is that the probability of a multiple birth is itself affected by homicides (see below for evidence against this hypothesis). Results are once more unaffected.

We have also explored the effect of homicides in municipalities other than small ones. Consistent with our hypothesis that municipal-level homicides are imperfect measure of localized violence in larger municipalities, we find no significant effect of homicides during pregnancy on birth outcomes in these municipalities. This is shown in appendix Table A2 where we report regressions for non-small municipalities using the entire set of controls as well as municipality time trends. We only focus on low birthweight (birthweight <2.500 kg) but results for other outcomes (i.e. weight etc.) are similar. Consistently, we fail to find any significant effect of homicides during pregnancy on birth outcomes in larger municipalities.[25] Consistent with this finding we also find (results not reported but available upon request) no effect of homicides rates in neighboring municipalities on the incidence of low birthweight in

[25] We note that homicide rates at 3 out of 24 leads and lags appear to have significant effects, something likely to be ascribed to sampling variability - note that sample sizes are extremely large for large municipalities.

small municipalities. Taken together this evidence suggests that mothers are particularly responsive to very localized shocks in violence.

As a final set of robustness checks, we have also experimented with alternative measures of homicides. These are reported in Appendix Table A3. We report three specifications similar to those in columns (2), (5), (8) and (11) of Table 2. Model 1 includes the homicide rate in the public way (as in Table 2) and controls additionally for the homicide rate computed using all other homicides ("elsewhere"). Model 2 only includes the residual category ("elsewhere"). Model 3 only includes the "overall" homicide rate (public way plus elsewhere). There are three main findings. The inclusion of homicides elsewhere does not affect our results on homicide rates in the public way (see row 1). Homicides elsewhere have typically no statistically significant effect on the outcome variables.[26] The effect of homicides elsewhere is insignificant when included in isolation (model 2). Finally, the effect of the overall homicide rate is similar to the one of homicides in the public way, but typically less precise, consistent with (classical) measurement error. This evidence is consistent with the notion that homicide rates in the public way are a more precise measure, and possibly a more evident form of local violence and hence they are more likely to impact birth outcomes compared to homicides occurring elsewhere.

Figure 5 plots the estimated effect of one homicide in the first trimester of pregnancy on the probability of birthweight being not greater than different thresholds, for 100 grams thresholds between 1 kg and 4 kg. Again we use the most saturated specification as in columns (3), (6), (9) and (12) of Table 2. In the figure we report the estimated proportional change, i.e., the estimated reduction in the probability relative to the incidence in the population, alongside a 90 percent confidence interval. It is clear from the figure that the effect of homicides is effectively zero at high levels of birthweight, implying that the fall in average birthweight documented in columns (1) to (3) of Table 2 is driven by an increased risk of low-birthweight, and that the effect of homicides becomes increasingly larger at lower levels of birthweight.

To put our results in context, Camacho (2008) finds that one landmine explosion during early pregnancy reduces birthweight by 7.5 grams, while Mansour and Rees (2012)

[26] If anything we find, surprisingly, a negative effect on the incidence of extreme low birthweight when we also control for homicides in the public way (model 1). Recall though that homicides exclude those for which the death occurred elsewhere, typically in hospitals in large cities and possibly include those for which the death occurred in a hospital in a small municipality even if the homicide was committed elsewhere. This variable hence is likely to be affected by measurement error of unknown form.

find that an additional non-combatant fatality during the second Intifada reduces the incidence of low birthweight by between 4 to 10 children out of 1,000. Quintana-Domeque and Rodenas (2014) find that one additional bomb casualty reduces birthweight on average by 0.7 grams. All these results point in the direction of a homicide in a small Brazilian municipality producing similar effects to those of more rare, extreme events such as conflict and terrorist attacks.

Table 3 reports regression results for gestational length. Columns (1) to (3) present results for gestational length in weeks, while columns (4) to (12) present results for the probability of being born within 27, 31 and 36 weeks respectively. Results are by and large in line with those in Table 2, with a pronounced negative effect of homicides during the first trimester on average gestational length and, typically, no effect of homicides during other trimesters of pregnancy or in trimesters before and after pregnancy. Again, results are largely robust to the inclusion of additional controls. Once more, results are driven by an increased mass in the lower tail of the distribution.[27] Focusing on the most saturated specifications in columns (3), (6), (9) and (12), these suggest that, in small municipalities, one standard deviation increase in the homicide rate during the first trimester of pregnancy (4.41) leads to a reduction in gestational length of 0.006 (-0.0015 X 4.41) weeks, i.e., around on average one hour, and an increase in the risk of being born before 37, 32 and 28 weeks of 0.91, 0.22 and 0.30 per 1,000 children, i.e. an increase of 1.5, 2.2 and 8 percent respectively.

The results above point in the direction of stress in the first trimester of pregnancy adversely affecting birth outcomes.[28] The effect seems to work through increased risk of

[27] Note that we have some slightly unexpected results for the probability of being born before week 32, with a negative effect of homicide rates in the second trimester of pregnancy and a positive but insignificant effect for homicides in the first trimester.

[28] Although we have no direct way of testing for the effect of homicides on maternal stress due to lack of adequate data, we can however use the mortality micro data to derive measures of the incidence of cardiovascular disease deaths at the level of the municipality. There is evidence from the medical literature of a relationship between premature mortality risk, including due to cardiovascular diseases, and homicide rates (see the meta analysis by Russ et al., 2012). As a placebo test we also examine the effect of homicides on deaths due to the most common causes. We run regression at the level of municipality by trimester as in the other regressions in the paper. Similarly to homicide rates, we standardize the number of deaths to the municipality population (in 100,000) and we run GLS with population as weights. Again we cluster standard errors at the level of the municipality. We use the same specification as in column (2) of Table 2. Our estimates for small municipalities show a positive and statistically significant effect of homicides on the probability of dying from cardiovascular diseases. The coefficient is on the order of 0.07, meaning that one extra homicide leads to 0.07 extra people dying from cardiovascular diseases. It takes effectively 17 homicides for one extra death by cardiovascular diseases to occur. Effects are larger for men compared to women although one cannot reject equality of coefficients across the two groups. We also find no effect on other common causes of deaths, which are unrelated to violence, such as neoplasm, infectious and parasitic diseases, traffic accidents and respiratory diseases. These pieces of evidence appear to be consistent with - although clearly no proof of - mother's stress being a likely pathway for our results.

prematurity and an associated fall in birthweight. In Table 4 we report the effect of homicides on birthweight for pregnancies of normal gestational length (i.e., 37 weeks or more). In this regression and the rest of the analysis we use specifications with all controls plus municipality specific linear time trends (as in column 2 of Table 2).

Clearly, some caution in interpreting the coefficients is warranted here, as this sample is selected, given that gestational length is itself affected by birth outcomes. At face value, though, these results suggest that homicides have no effect on birthweight through intrauterine growth retardation and that they affect birth outcomes only through an increased risk of prematurity. This evidence is particularly noteworthy as it tends to rule out that other forces, such as changes in local economic conditions, that might affect child nutrition and via this birth outcomes - and that are known to act in the third trimester by slowing fetal growth even among pregnancies of normal gestational length - are conflating the effect of homicides on birth outcomes.

One channel of potential behavioral adjustment is selective fertility. Mothers exposed to violence might be less likely to initiate a birth or successfully complete a pregnancy due to abortion or miscarriage. Although, most likely, this channel would lead to estimates of homicide rates on birth outcomes that are systematically downward biased - as possibly children at higher risk of low birthweight or prematurity are the ones less likely to survive - it is worth directly investigating this margin of selection. In column (1) of Table 5, we present regression results for the effect of homicides on fertility. For each month and municipality, we compute the number of births initiated in that month and we regress the log number of births on homicides in the three following trimesters. As around 25 percent of municipality X month cells have zero births, we use the logarithm of the number of births plus one.[29] We use the most saturated specification with lagged and leaded homicides rates, all controls and municipality specific linear time trends as in columns (3), (6), (9), (12) of Tables 2 and 3. Coefficients in this column are multiplied by 1,000. We find no evidence of homicide rates in the three months following conception affecting the number of births, suggesting that selective fetus mortality through miscarriage or abortion is unlikely to affect our estimates. We also find no evidence of lagged homicides affecting the number of births initiated in any given month (results not reported in the Table but available upon request). This also rules out fertility responses to past violence.

[29] Results (not reported) are qualitatively similar if we use the square root of the dependent variable.

The remaining columns of Table 5 report results for additional birth outcomes. There is no evidence of violence affecting the probability of a C-section (in column 2), possibly the symptom of complications during pregnancy, or APGAR scores at one and five minutes after birth (columns 3 and 4). Although the latter might be a surprising result, given the effect of homicides on prematurity and low birthweight, APGAR scores are known to be very imprecise measures of health at birth and many studies fail to find effects on APGAR scores even when effects are found on birthweight.

Column (5) of Table 5 investigates the effect of homicides during pregnancy on the number of prenatal visits.[30] Ex-ante, it is difficult to predict if increased violence should lead to more or less prenatal visits. On the one hand, prenatal visits might increase if complications arise during the pregnancy as a result of exposure to violence or if mothers enact behavioral responses aimed at offsetting the effect of violence. On the other hand, violence may deter pregnant women from attending health centers, due to increased safety concerns or just as a result of stress. As prenatal visits, especially during the first trimester of pregnancy, are known to be effective ways to detect and prevent adverse birth outcomes, this might in turn be a contributing factor to the adverse effect of violence on birth outcomes found in Tables 2 and 3. Column (5) though shows no significant effects of homicides at different stages of pregnancy on the number of pre-natal visits. We also do not find that exposure to violence affects the sex ratio at birth, for example through sex specific propensity of miscarriage or abortion (column 6), or the probability of a singleton birth (column 7).

5.2 Main results for Fortaleza

Table 6 presents regression results for the neighborhoods of Fortaleza. We focus on a specification with lagged and leaded homicides rates plus mother, newborn, pregnancy controls and neighborhood controls. Columns (1) to (4) of Table 6 present regression results for birthweight while columns (5) to (8) present results for gestational length. Standard errors in these regressions are clustered by neighborhood.

Despite the different samples (and different sample sizes), point estimates for Fortaleza are remarkably similar to those found for small municipalities, although unsurprisingly slightly less precise, with an effect of the homicide rate in the first trimester on average birthweight of around -0.41 grams, an increase in low birthweight of 0.30 per 1,00

[30] As for gestational length, we convert number of controls in classes into a continuous variable. In particular we assign the values 0, 2, 5 and 7 for 0, 1-3, 4-6 and 7 or more controls respectively.

children and an increase in the probability of being born premature of 0.13 (although the latter effect is statistically insignificant).[31] Again, by and large, we find no statistically significant effects of homicides at other stages of pregnancy or pre- and post-pregnancy on birth outcomes.[32]

Unsurprisingly, as population is much larger in a neighborhood of Fortaleza (average neighborhood population 21,536) compared to the small municipalities, these estimates imply that one extra homicide in the mother's neighborhood of residence leads to an increase in the probability of a child being born low birthweight and premature of around 1 out of 1,000, i.e. around 15 per cent of the effects found in small municipalities. One interpretation for this finding is that greater population density implies that fewer women are affected in Fortaleza compared to small municipalities. However, we cannot rule out alternative interpretations. Potentially, in a setting where homicides are frequent each additional homicide has smaller adverse consequences on birth outcomes than when homicides are rare due to an "adaption" effect. An alternative interpretation is ascribable to spillovers across neighborhoods, whereby homicides in a certain area affect not only those living in that area (treatments) but also those in neighboring areas (controls), leading to a downward bias in the estimates of impact.

Despite the smaller marginal effects in large compared to small municipalities, homicides are much more frequent in the former compared to the latter, meaning that homicides are potentially a much larger contributor to low birthweight and prematurity in Fortaleza compared to small municipalities. We revert to this in the conclusions, where we try to assess the overall contribution of homicides to the incidence of adverse birth outcomes in Brazil.

5.3 Heterogeneous effects by mother's characteristics

In Table 7 we report separate results by mothers and newborns' characteristics. Again we use the same specification as in columns (3), (6), (9), (12) of Tables 2 and 3 and we focus again on small municipalities for which the sample is larger, and hence for which results are more reliable. For brevity, in this table we focus only on the probability of low birthweight (<=2.5 kg) and of prematurity (gestation of less than 37 weeks) and we only present results on first

[31] Results are remarkably robust across specifications. Point estimates are essentially unchanged if we also include neighborhood effects X month of conception, although marginally less precise.

[32] Table A4 also reports similar results to those in Table 5 on additional birth outcomes for the city of Fortaleza. Again, there is no evidence of homicides affecting fertility, prenatal visits or APGAR scores.

trimester exposure (although the regressions also include exposure in subsequent trimesters of pregnancy and in both the pre- and post-pregnancy period). Columns (1) and (2) of Table 7 report separate effects by mother's level of education (up to 7 and more than 7 years of completed education), columns (3) and (4) report separate effects by mother's age (<=24 and 24 or more), while columns (5) and (6) report separate results for non-married (i.e., single, separated and divorced) and married mothers.[33] Columns (7) and (8) report separate results for mothers who had previous birth complications, measured by at least one previous stillbirth, while columns (9) and (10) investigate whether effects differ as a function of the gender of the newborn. Columns (11) and (12) finally examine the effect separately for singletons and multiple births.

Looking at indicators of SES, it appears that the effects are larger among mothers with low levels of education compared to those with high levels of education, although differences across groups are not statistically significant. A possible explanation for these results is that mothers at the top of the SES distribution have ways to buffer the adverse consequences of shocks during pregnancy, although, clearly, an alternative interpretation is simply that, even within the same municipality, less educated mothers are more likely to be exposed to violence.

The results also suggest a possible biological risk factor associated to the probability of delivering a low birthweight and premature child. It appears in particular that the mother's history of stillbirths is a strong predictor of large adverse effects of violence on birth outcomes, with effects five to six times larger than those found at the mean (approximately 1 in column 7 of Table 7 compared to an effect of 0.2 in columns 5 of Tables 2 and 3, although differences across groups are once again not statistically significant),. Given that low-education mothers are at disproportionate risk of previous stillbirths, this effect might again capture a gradient in the response of birthweight to homicides across mothers with different SES levels.[34]

We do not find clear gradients across mother's age, or significant differences between married and unmarried women and between singletons and multiple births. Similarly, and

[33] Since there is evidence for Brazil that it is the presence of a partner to make a substantial difference to children's outcomes (Ayllón and Ferreira-Batista, 2014), we would have ideally liked to have two separate categories for mothers living and not living with a partner, independent of marital status. Unfortunately, though, the data do not allow us separately identify single mothers living on their own from those living with an unmarried partner.

[34] An additional alternative interpretation for this finding is that previous stillbirths are the result of past violence and this itself affects current birth outcomes, although the evidence that we have provide below when we examine fertility does not seem to suggest that this is the case.

despite evidence suggesting that boys are at greater at risk of pre-term delivery and neonatal death (Lawn et al. 2013), we do not find that the effects of violence on birth outcomes are larger for boys compared to girls: if anything the reverse is true (columns 11 and 12).

In sum, both socio-economic and biological factors, such as mothers' low levels of education and previous stillbirths, appear to magnify the adverse consequences of violence on birth outcomes, implying that mother's high socio-economic status acts as a buffer to the effects of violence on birth outcomes and that violence compounds the disadvantage that newborns from low SES already suffer.

6. Concluding remarks

Using a very rich dataset on the universe of births and homicides from vital statistics data over the period 2000-2010, we estimate the effect of in-utero exposure to homicides on a range of birth outcomes in Brazil.

We find a significant negative effect of exposure to violence during the first trimester of pregnancy on birthweight and gestational length. Speculatively, we ascribe this effect to increased maternal stress, which is known to have direct effects on the fetus' development and to lead to increased prematurity and, via this, to lower birthweight (although we cannot rule out that other behavioral mechanisms - such as increased smoking or increased alcohol consumption during pregnancy in response to stress, for which we have no data, act in the direction of magnifying these effects).

These results hold true both across small Brazilian municipalities and in neighborhoods of Fortaleza, one of the most violent cities in Brazil. However, while we find an effect of homicides on birth outcomes in small municipalities - where homicides are rare - that is comparable in magnitude to the effects found by others as a result of large terrorist attacks, landmine explosions or even conflict related deaths, estimates for Fortaleza - where violence is endemic - are significantly smaller (on the order of 15 percent compared to small municipalities). We regard this finding as possibly consistent with our interpretation that violence affects birth outcomes through maternal stress, as homicides are more likely to be stress inducing when they are rare, although an alternative interpretation is that, given the much higher population density in large municipalities compared to small municipalities, the effect of one homicide gets more easily diluted in the former than in the latter.

Clearly, a much higher fraction of pregnant women worldwide are exposed to violence and homicides compared to those who are exposed to terrorist attacks or landmine explosions. While, given their rare nature, these extreme events are not possible contributors to the incidence of low birthweight worldwide, day-to-day violence possibly is.

Indeed, our exercise allows us to derive an estimate of the effect of homicides on birth outcomes in Brazil. While in small municipalities of Brazil, where homicides are rare, homicides cannot possibly account for the incidence of low birthweight, back-of-the-envelope calculations suggest that in Fortaleza, where violence is endemic, homicide rates can account for around 1 percent of the incidence of low birthweight and 3.5 percent of the incidence of extremely low birthweight.[35]

This is possibly one factor contributing to rationalize the evidence that we have provided in the paper that, while mothers' living standards are higher (and the provision of health care services better) in large areas compared to small municipalities, children in large urban areas tend to suffer from poorer health at birth.

Our estimates are likely to be conservative estimates of the effect of violence on birth outcomes as we only restrict to homicides for which the death occurred in the street (hence excluding homicides for which the death happened elsewhere, in particular in health establishments in larger municipalities) and we clearly exclude other forms of violence and violent crime, although the latter are known to be strongly correlated with homicides.

Although our estimates refer to Brazil, results clearly have the potential to extend to other settings where violence is endemic. In particular middle and low-income countries in Latin America and Africa display among the highest rates of homicide in the world and our study sheds light on one, yet largely ignored, additional cost of violence in these countries.

[35] The main regressor in the equations is the homicide rate in the first trimester of pregnancy. This is a quarterly rate (i.e. total number of homicides in the first trimester of pregnancy divided by population). At a yearly homicide rate of 12.85 per 100,000 population (see Table A1), this implies approximately 3.3 homicides rates per 100,000 population in the first trimester of pregnancy. If we multiply this by the coefficients of interest from Table 6, 0.3017 and 0.0892 respectively for low birthweight and for extreme low birthweight, this gives respectively 1 and 0.28 extra children per 1,000 being born low birthweight and extreme low birthweight as a result of homicides. As there are 90 children born low birthweight out of 1,000 this explains around 1 percent of the incidence of low birthweight. For extreme low birthweight this is 0.28 divided by 8, i.e. 3.5 percent.

References

Aizer, A., 2011. Poverty, Violence and Health: The Impact of Domestic Violence during Pregnancy on Newborn Health. Journal of Human Resources. 46(3), 518-38.

Aizer, A., Stroud, L., Buka, S., 2015. Maternal Stress and Child Well-Being: Evidence from Siblings. Journal of Human Resources. Forthcoming.

Almond, D., 2006. Is the 1918 Influenza Pandemic Over? Long-term Effects of In Utero Influenza Exposure in the Post-1940 U.S. Population. Journal of Political Economy. 114, 672-712.

Almond, D., Currie, J., 2011. Human Capital Development before Age Five. In: O. Ashenfelter and D. Card (eds), Handbook of Labor Economics. 4,1315-1486.

Almond, D., Mazumder, B., 2011. Health Capital and the Prenatal Environment: The Effect of Ramadan Observance during Pregnancy. American Economic Journal, Applied Economics. 3, 56-85.

Almond, D., Chay, K., Lee, D., 2005. The Costs of Low Birthweight. The Quarterly Journal of Economics. 120(3), 1031-83.

Almond, D., Hoynes, H., Whitmore Schanzenbach, D., 2011. Inside the War on Poverty: The Impact of Food Stamps on Birth Outcomes. The Review of Economics and Statistics. 93(2), 387-403.

Amarante, V., Manacorda, M., Miguel, E.,Vigorito, A., 2015. Do Cash Transfers Improve Birth Outcomes? Evidence from Matched Vital Statistics, Social Security and Program Data'. American Economic Journal: Economic Policy. Forthcoming.

Andalón, M., Azevedo, J., Rodríguez-Castelán, C., Sanfelice, V., Valderrama, D., 2014. Weather Shocks and Health at Birth in Colombia. World Bank Policy Research Working Paper WPS7081, Washington D.C.

Ayllón, S., Ferreira-Batista, N., 2014. Mommy, I Miss Daddy. The Effect of Family Structure on Children's Health in Brazil. Economics and Human Biology. Forthcoming.

Becker, G., 1968. Crime and Punishment: An Economic Approach. Journal of Political Economy. 76, 169-217.

Black, S., Devereux, P., Salvanes, K., 2007. From the Cradle to the Labor Market? The Effect of Birth Weight on Adult Outcomes. Quarterly Journal of Economics. 122(1), 409-439.

Black, S., Devereux, P., Salvanes, K., 2015. Does Grief Transfer across Generations? In-Utero Deaths and Child Outcomes. American Economic Journal: Applied Economics. Forthcoming.

Bozzoli, C., Quintana-Domeque, C., 2014. The Weight of the Crisis: Evidence from Newborns in Argentina. Review of Economics and Statistics. 96 (3), 550-562.

Brown, R., 2014. The Mexican Drug War and Early-Life Health: The Impact of Violence Crime on Birth Outcomes. Mimeo, Duke University.

Camacho, A., 2008. Stress and Birthweight: Evidence from Terrorist Attacks. American Economic Review. 98(2), 511-15.

Citizens' Council for Public Security and Criminal Justice, 2014. *Seguridad, Justizia Y Paz.* Accessed online on 12/12/2014 at: http://goo.gl/4Som2e.

Currie, J., Schwandt, H., 2015. The 9/11 Dust Cloud and Pregnancy Outcomes: A Reconsideration. Journal of Human Resources. Forthcoming.

Currie, J., Walker, R., 2011. Traffic Congestion and Infant Health: Evidence from E-ZPass. American Economic Journal: Applied Economics. 3, 65-90.

Currie, J., Greenstone, M., Moretti, E., 2011. Superfund Cleanups and Infant Health'. American Economic Review. 101, 434-441.

Dube, O., Vargas, J., 2013. Commodity Price Shocks and Civil Conflict: Evidence from Colombia. Review of Economic Studies. 80, 1384-1421.

Dustmann, C., Fasani, F., 2015. The Effect of Local Area Crime on Mental Health. Economic Journal. Forthcoming.

Eccleston, M., 2012. In Utero Exposure to Maternal Stress: Effects of 9/11 on Birth and Early Schooling Outcomes in New York City. Mimeo. Cambridge, United States: Harvard University.

Eskenazi, B., Marks, A., Catalano, R., Bruckner, T., Toniolo, P., 2007. Birthweight in New York City and Upstate New York Following the Events of September 11^{th}. Human Reproduction. 22, 3013-3020.

Figlio, D., Guryan, J., Karbownik, K., Roth J., 2014. The Effects of Poor Neonatal Health on Children's Cognitive Development. American Economic Review. 104(12), 3921-3955.

Glover, V., O'Connor, T., O'Donnell, K., 2010. Prenatal Stress and the Programming of the HPA Axis. Neurosciences & Biobehavioural Reviews. 35, 17-22.

Harris, A., Seckl, J., 2011. Glucocorticoids, Prenatal Stress and the Programming of Disease. Hormones and Behavior. 59, 279-289.

Harville, E., Savitz, D., Dole, N., Herring, A., Thorp, J., 2009. Stress Questionnaires and Stress Biomarkers During Pregnancy. Journal of Women's Health. 18, 425-1433.

Heinemann, A., Verner, D., 2006. Crime and Violence in Development: A Literature Review of Latin America and the Caribbean. World Bank Policy Research Working Paper 4041. Washington, DC, United States: World Bank.

Hobel, C., Dunkel-Schetter, C., Roesch, S., 1998. Maternal Stress as a Signal to the Fetus. Prenatal and Neonatal Medicine. 3, 116-120.

Hsiang, S., Burke, M., Miguel, E., 2013. Quantifying the Influence of Climate on Human Conflict. Science. 341: 1212-1228.

Kramer, M., 1987. Determinants of Low Birth Weight: Methodological Assessment and Meta-Analysis. Bulletin WHO.

Latendresse, G., 2009. The Interaction Between Chronic Stress and Pregnancy: Preterm Birth from a Biobehavioral Perspective. Journal of Midwifery and Women's Health. 54, 8-17.

Latinobarometer, 2010. Annual Report. Latinobarómetro Corporation, Santiago, Chile.

Lawn, J., Blencowe, H., Darmstadt, G., Bhutta, Z., 2013. Beyond Newborn Survival: The World You are Born into Determines Your Risk of Disability-free Survival. Pediatric Research. 74, 1-3.

Lin, M., 2008. Does Unemployment Increase Crime?: Evidence from U.S. Data 1974-2000. Journal of Human Resources. 20, 413-436.

Mansour, H., Rees, D., 2012. Armed Conflict and Birthweight: Evidence from the al-Aqsa Intifada. Journal of Development Economics. 99, 190-99.

Matsuura, K., Willmott, C., 2012. Terrestrial Air Temperature and Precipitation: 1900-2010 Gridded Monthly Time Series. Version 3.02. University of Delaware.

McLean, M., Bisits, A., Davies, J., Woods, R., Lowry, P., Smith, R., 1995. A Placental Clock Controlling the Lengths of Human Pregnancy. Nature Medicine. 1, 460-463.

Miguel, E., Satyanath, S., Sergenti, E., 2004. Economic Shocks and Civil Conflict: An Instrumental Variables Approach. Journal of Political Economy. 112, 725-753.

Mulder, E., Robles de Medina P., Huizink, A., Van den Bergh, B., Buitelaar, J., Visser, G., 2002. Prenatal Maternal Stress: Effects on Pregnancy and the (Unborn) Child. Early Human Development. 70, 3-14.

Pike, I., 2005. Maternal Stress and Fetal Responses: Evolutionary Perspectives on Preterm Delivery. American Journal of Human Biology. 17, 55-65.

Quintana-Domeque, C., Rodenas, P., 2014. Fear in the Womb: The Effects of Terrorism on Birth Outcomes in Spain. Mimeo. University of Oxford.

Raphael, S., Winter-Ebmer, R., 2001. Identifying the Effect of Unemployment on Crime. Journal of Law and Economics. 44, 259-283

Reichenheim, M., Ramos de Souza, E., Leite Moraes, C., de Mello Jorge, M., Passos da Silva, C., Minayo, M., 2011. Violence and Injuries in Brazil: the Effect, Progress Made, and Challenges Ahead. Lancet. 377, 1962-75.

Reynolds, R., Labad, J., Buss, C., Ghaemmaghami, P., Raikkonen, K., 2013. Transmitting Biological Effects of Stress in Utero: Implications for Mother and Offspring. Psychoneuroendocrinology. 38, 1843-1849.

Rocha, R., Soares, R., 2015. Water Scarcity and Birth Outcomes in the Brazilian Semiarid. Journal of Development Economics. 112, 1843-1849.

Rossin, M., 2011. The Effects of Maternity Leave on Children’s Birth and Infant Health Outcomes in the United States. Journal of Health Economics. 30, 221-239.

Royer, H., 2009. Separated at Girth: U.S. Twin Estimates of the Effects of Birthweight. American Economic Journal: Applied Economics. 1(1), 49-85.

Russ, T., Stamatakis, E., Hamer, M., Starr, J., Kivimäki, M., Batty, D., 2012. Association Between Psychological Distress and Mortality: Individual participant Pooled Analysis of 10 Prospective Cohort Studies. British Medical Journal. 345, 1-14.

Skogan, W., Maxfield, M., 1981. Coping with Crime: Individual and Neighborhood Reactions. Beverly Hills, CA, Sage Publications.

SSPDS (Secretaria de Segurança Pública e Defesa Social), 2014. Crime Statistics 2014. Fortaleza.

Torche, F., Villarreal, A., 2014. Prenatal Exposure to Violence and Birth Weight in Mexico: Selectivity, Exposure, and Behavioral Responses. American Sociological Review, 79(5), 966-992.

UNICEF, 2006. Low Birthweight: Country, Regional and Global Estimates. Geneva, Switzerland: United Nations Children’s Fund.

UNODC, 2005. Country Report Brazil 2005. Regional Office Brazil. Brasilia, Brazil: United Nations Office on Drugs and Crime.

UNODC, 2011. 2011 Global Study on Homicide. Trends, Contexts, Data. Vienna, Austria: United Nations Office on Drugs and Crime.

UNODC, 2013. Homicide Statistics 2013. Vienna, Austria: United Nations Office on Drugs and Crime.

Vinkelsteijn, A., Struijk, P., Ursem, N., Hop, W., Wladimiroff, J., 2004. Fetal Heart Rate and Umbilical Artery Flow Velocity Variability in Intrauterine Growth Restriction: a Matched Controlled Study. Ultrasound in Obstetrics and Gynecology. 23, 461–465.

Wadhwa, P., Culhane, J., Rauh V. et al., 2001. Stress, Infection and Preterm Birth: a Biobehavioural Perspective. Paediatric and Perinatal Epidemiology. 15, 17-29.

Waiselfisz, J., 2013. Homicídios e Juventude no Brasil. Mapa do Brasil 2013. Secretaria-Geral da Presidência da República, Brasília.

Warr, M., 2000. Fear of Crime in the United States: Avenues for Research and Policy. Criminal Justice. 4, 451-489.

World Bank, 2006. Crime, Violence and Economic Development in Brazil: Elements for Effective Public Policy. Poverty Reduction and Economic Management Sector Unit. Washington D.C., United States: World Bank.

Data appendix

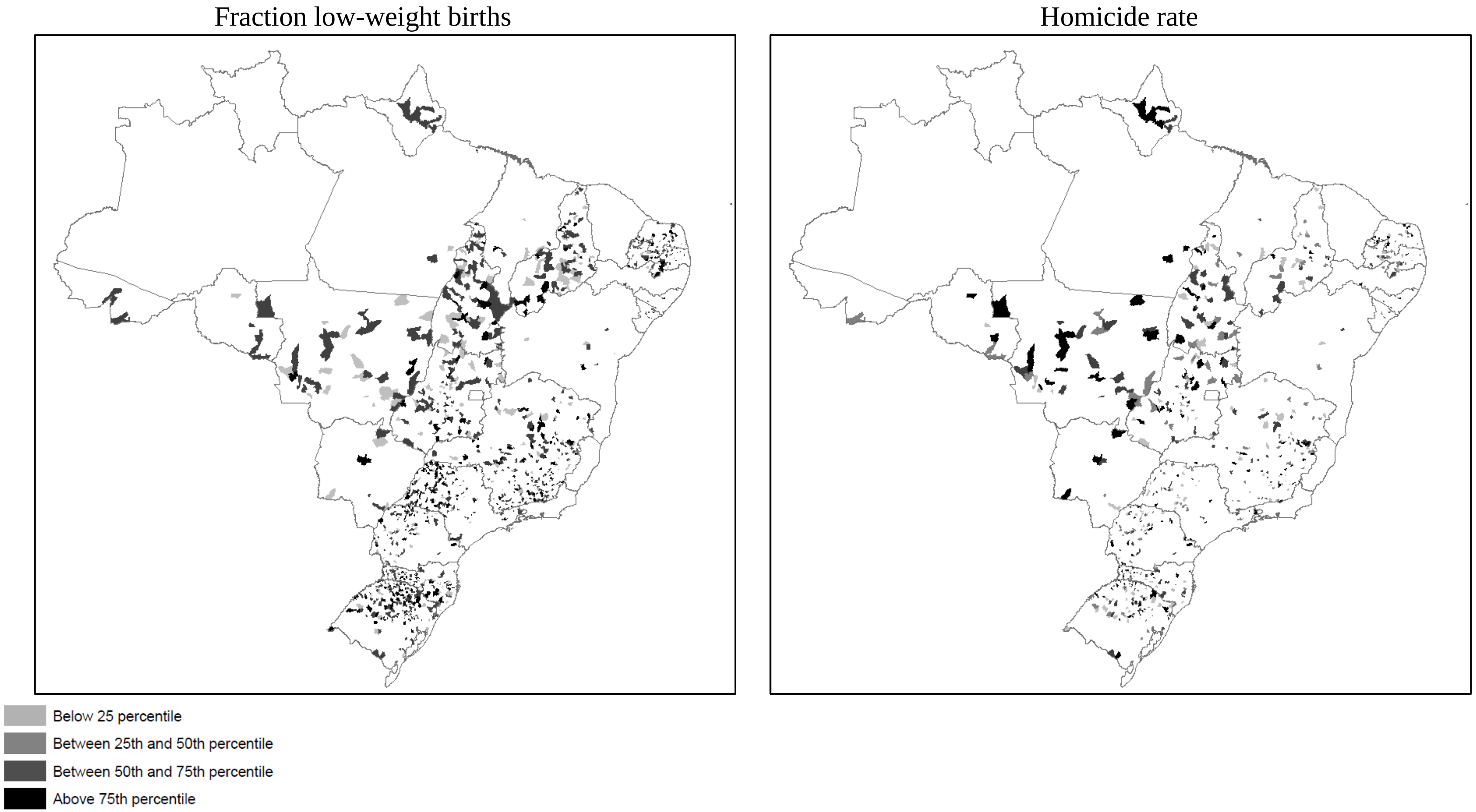
Variable	Notes	Source	Link	Frequency
GDP	Municipality gross national product at current prices (R$)	SIDRA/IBGE	http://goo.gl/OpQffe	Annual
Municipality spending	Total local government (municipality) expenditure at current prices (R$)	IPEADATA, Ministry of Finance	http://goo.gl/lSI3nz	Annual
Welfare spending	Local government (municipality) expenditure on assistance and welfare at current prices (R$)	IPEADATA, Ministry of Finance	http://goo.gl/lSI3nz	Annual
Education spending	Local government (municipality) expenditure on education and culture at current prices (R$)	IPEADATA, Ministry of Finance	http://goo.gl/lSI3nz	Annual
Health spending	Local government (municipality) expenditure on health and sanitation at current prices (R$)	IPEADATA, Ministry of Finance	http://goo.gl/lSI3nz	Annual
Judicial spending	Local government (municipality) judicial expenditure at current prices (R$)	IPEADATA, Ministry of Finance	http://goo.gl/lSI3nz	Annual
Security spending	Local government (municipality) expenditure on national security and public defense at current prices (R$)	IPEADATA, Ministry of Finance	http://goo.gl/lSI3nz	Annual
Health institutions	Number of public health institutions per 1,000 population, including general and specialized hospitals, policlinics, health centers (*posto de saúde*), basic health centers (*unidade básica de saúde*)	CNES/ DATASUS	http://goo.gl/tdwW	Annual
Nurses	Number of qualified hospital nurses according to the Brazilian Classification of Professions (CBO-2002) per 1,000 population	CNES/ DATASUS	http://goo.gl/tdwW	Annual
Bolsa Família recipients	Number of Bolsa Família recipients per 1,000 population	DATASUS	http://goo.gl/tdwW	Annual
Bolsa amount	Average Bolsa Família amount per recipient at current prices (R$)	DATASUS	http://goo.gl/tdwW	Annual
Precipitation	Monthly precipitation in mm at the 0.5° x 0.5° grid level.	Matsuura and Willmott (2012): Terrestrial Air	http://goo.gl/Fdqjrp	Monthly

		Temperature and Precipitation: Monthly and Annual Time Series (1940 - 2010), version 3.02		
Temperature	Monthly average temperature in degree Celsius at the 0.5° x 0.5° grid level.	Matsuura and Willmott (2012): Terrestrial Air Temperature and Precipitation: Monthly and Annual Time Series (1940 - 2010), version 3.02	http://goo.gl/Fdqjrp	Monthly

Weather data

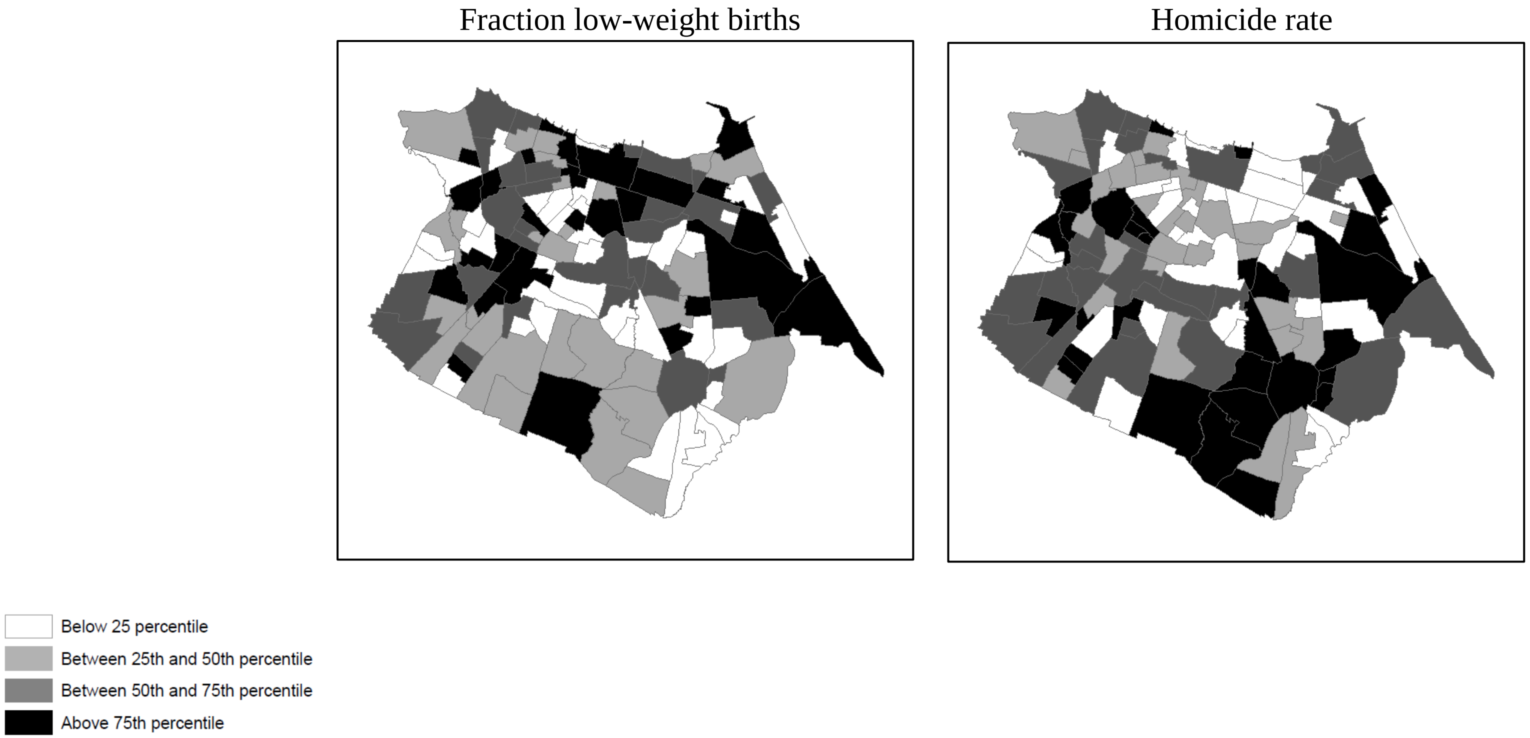
For the creation of the weather data we follow closely Rocha and Soares (2015). We use *Terrestrial Air Temperature and Terrestrial Precipitation: 1900-2010 Gridded Monthly Time Series*, version 3.03 (Matsuura and Willmott 2012). The Matsuura and Willmott data provide averages of monthly air temperature in degree Celsius and precipitation in mm at a 0.5° x 0.5° grid, where the data for each node is based on the average of the 20 closest weather stations. We identify the four nodes closest to the centroid of each municipality and construct a municipality monthly series of temperature and rainfall using the weighted average from the four closest nodes, with weights inversely proportional to the distances to each node. We then standardize the (log) of temperature and precipitation in each municipality computed using this procedure to the historic annual average calculated for the period 1940 to 2010.

Figure 1: Distribution of low birthweight and homicides across small Brazilian municipalities



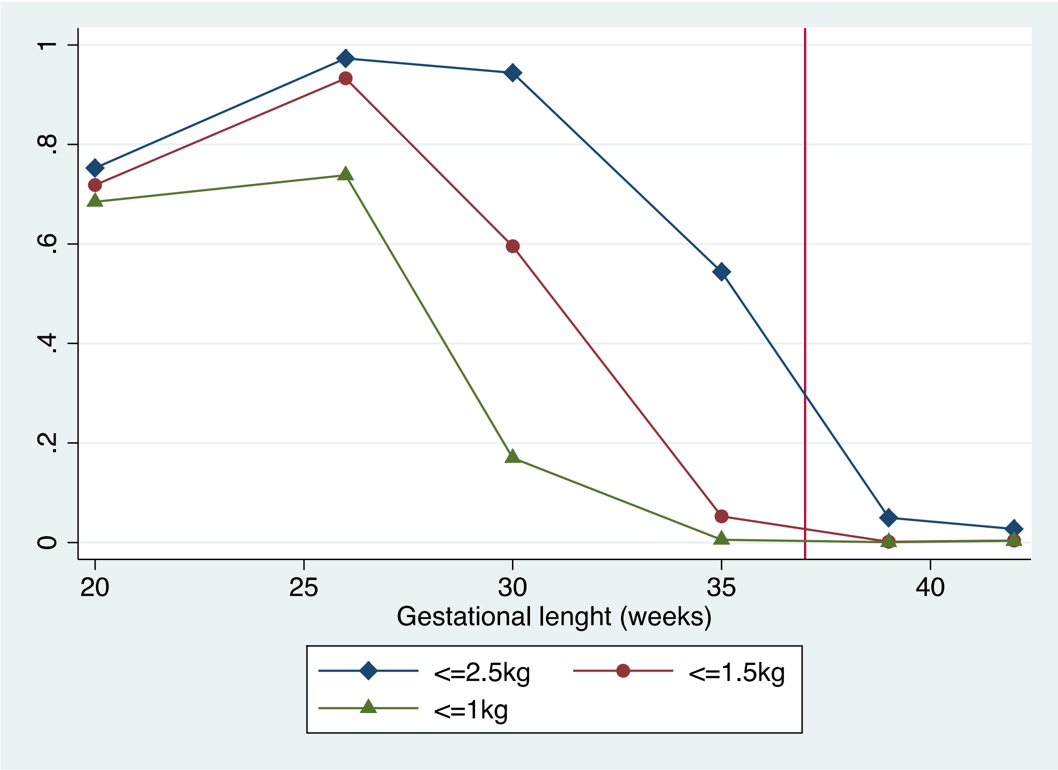
Notes: The figures report, respectively, the average fraction of low-weight births (<2.5 kg) and the homicide rate in the public way across Brazilian municipalities for small municipalities (population up to 5,000).

Figure 2: Distribution of low birthweight and homicides across neigbhorhoods of Fortaleza



Notes: The figures report, respectively, the average fraction of low-weight births (<=2.5 kg) and the homicide rate in the public way across neighborhoods of Fortaleza.

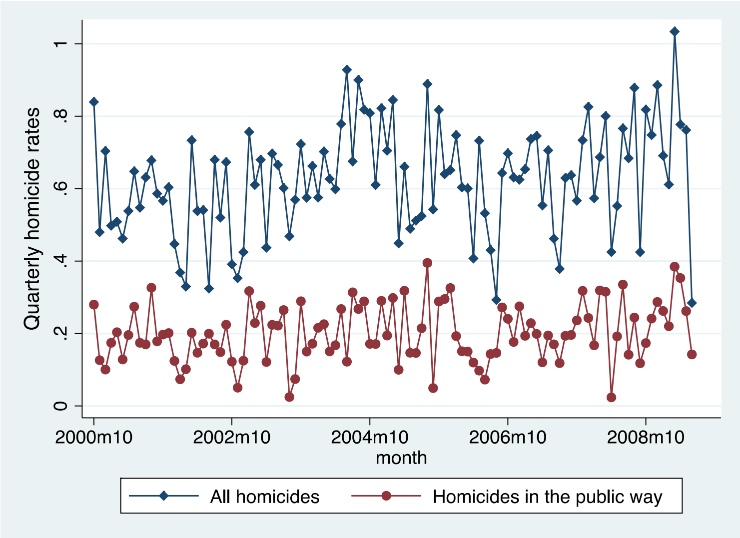
Figure 3: Association between low birthweight and gestational length



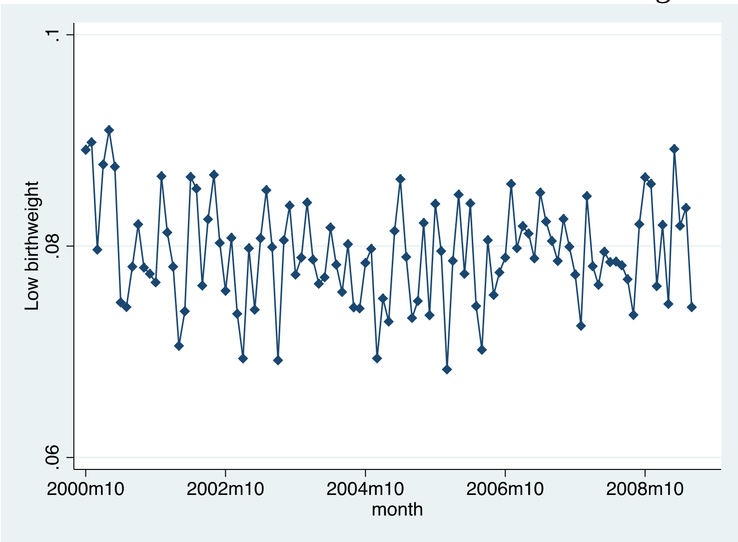
Note. The figure reports the fraction of low weight births as a function of gestational length. Gestational length is expressed in intervals (<22, 22-27, 28-31, 32-36, 37-41, 42 or more). Average gestational length for each interval is reported on the horizontal axis (20, 26, 30, 35, 39, 42). The data refer to all births that occurred in Brazil between 2000 and 2010.

Figure 4: Trends in homicide rates and in the incidence of low birth weight in small municipalities - by month

Panel A: Homicide rates

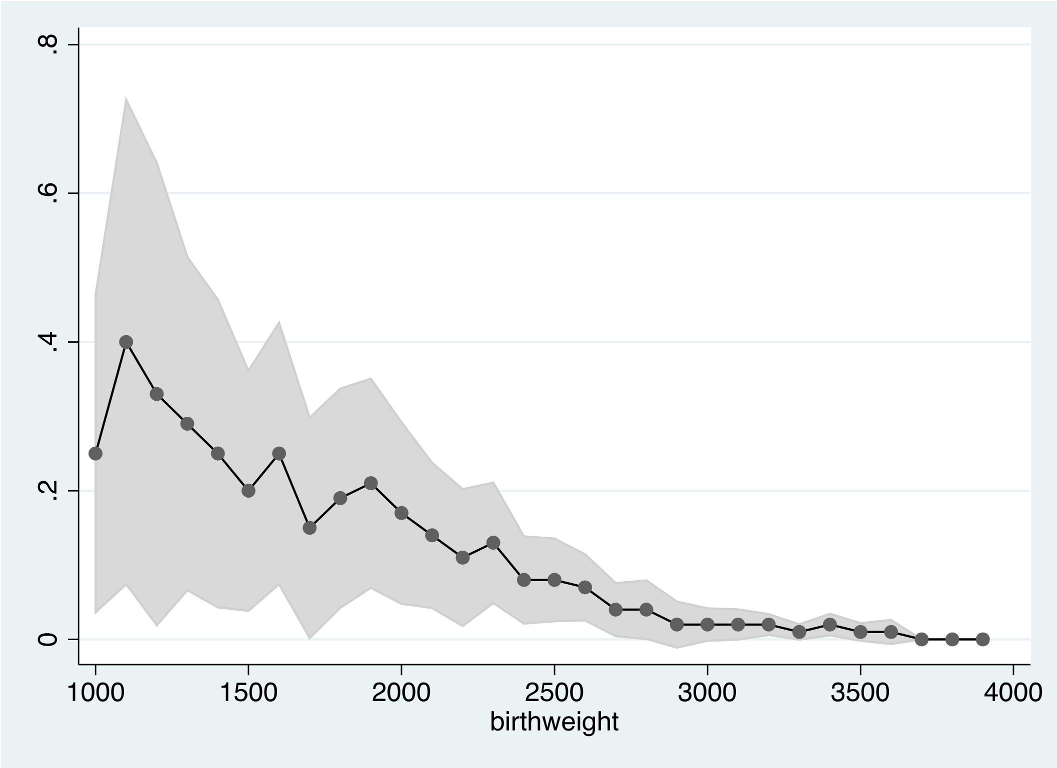


Panel B: Fraction of children born low birthweight



Note. The figure reports the monthly homicide rate (panel A) as a function of the month of occurrence and the fraction of children born with low birthweight (panel B) as a function of the month of conception in small municipalities (population up to 5,000).

Figure 5: Effects of homicides in the first trimester on the probability of being below specific levels of birthweight



Notes. The figure plots the estimated effect of one extra homicide in the first trimester of pregnancy on the probability of birthweight being not greater than different thresholds, for 100 grams thresholds between 1 kg and 4 kg. Specification as in columns (3), (6), (9) and (12) of Table 2 used. The figure reports the estimated proportional change, i.e., the estimated reduction in the probability relative to the incidence in the population, alongside a 90 percent confidence interval. See also notes to Table 2.

Table 1: Descriptive Statistics - Brazilian municipalities

	Municipalities by population class					Fortaleza
Birth outcomes	1-5,000	5,001-20,000	20,000-100,000	100,000-500,000	>500,000	
Birthweight	3,212	3,223	3,208	3,164	3,151	3,217
Low birthweight	0.079	0.079	0.082	0.090	0.094	0.083
Very low birthweight	0.010	0.010	0.010	0.013	0015	0.014
Ext. low birthweight	0.004	0.004	0.004	0.005	0.006	0.006
Weeks gestation	38.752	38.755	38.749	38.657	38.612	38.682
Weeks gestation<37	0.059	0.058	0.055	0.070	0.079	0.064
Weeks gestation<32	0.010	0.010	0.010	0.012	0.013	0.011
Weeks gestation<28	0.003	0.003	0.004	0.004	0.005	0.004
Newborn characteristics						
Female	0.485	0.487	0.487	0.488	0.488	0.486
White	0.571	0.450	0.435	0.519	0.423	0.092
Black	0.020	0.023	0.020	0.018	0.019	0.004
Asian	0.005	0.005	0.004	0.002	0.002	0.003
Mixed	0.356	0.472	0.489	0.387	0.395	0.568
Indigenous	0.010	0.012	0.008	0.002	0.001	0.002
Birth and pregnancy characteristics						
C-section	0.434	0.360	0.393	0.476	0.505	0.495
Multiple birth	0.019	0.018	0.018	0.019	0.021	0.020
Prenatal visits	5.801	5.433	5.438	5.865	5.925	5.426
Mother characteristics						
Age	25.716	25.863	25.535	25.855	26.518	26.902
Single	0.442	0.517	0.545	0.516	0.548	0.595
No ed.	0.030	0.048	0.039	0.012	0.008	0.015
Years of ed.: 1-3	0.137	0.168	0.144	0.074	0.055	0.075
Years of ed.: 4-7	0.391	0.389	0.366	0.313	0.270	0.302
Years of ed.: 8-11	0.319	0.281	0.319	0.431	0.446	0.396
Years of ed.: >=12	0.103	0.086	0.105	0.150	0.197	0.158
Born alive children>0	0.621	0.658	0.653	0.614	0.589	0.675
Born alive children	1.231	1.434	1.385	1.161	1.055	1.278
Still births	0.097	0.111	0.116	0.105	0.104	0.084
Births	528,089	3,896,949	7,733,470	6,301,984	7,190,636	333,927
Municipality characteristics						
Homicide rate	7.186	10.848	17.509	31.233	41.132	31.599
Homicide rate - Public way	2.285	4.159	7.734	14.267	16.470	14.428
Homicide rate - Residence	2.090	2.483	2.835	3.336	2.750	3.189
Homicide rate - Health inst.	0.219	0.831	2.985	9.279	18.163	9.864
Homicide rate - Elsewhere	2.301	2.949	3.397	3.906	3.384	2.697
Population (,000)	3.418	10.807	39.460	204.562	1487.057	2341.745
Municipalities	1,341	2,653	2,653	216	35	1

Notes: The table report descriptive statistics by groups of municipalities defined based on population size. Observations refer to all births conceived between October 2000 and June 2009. The last column refers to the municipality of Fortaleza. Homicide rates are expressed as a fraction per 100,000 people. Categories of variables might not add up to 100 due to missing values. Municipality characteristics are obtained as population weighted averages across all municipalities in each size class.

Table 2: The effect of homicides during pregnancy on birthweight - Small municipalities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Trimester	Birthweight			Low birthweight			Very low birthweight			Extremely low birthweight		
-3 (pre-conception)		-0.0439	-0.0412		0.0071	-0.0071		-0.0220	-0.0121		-0.0412**	-0.0330
		(0.1901)	(0.2031)		(0.0976)	(0.1028)		(0.0361)	(0.0376)		(0.0204)	(0.0217)
-2 (pre-conception)		-0.1870	-0.0751		0.1146	0.1023		-0.0044	-0.0150		0.0062	-0.0022
		(0.1847)	(0.1950)		(0.0926)	(0.0985)		(0.0324)	(0.0349)		(0.0221)	(0.0246)
-1 (pre-conception)		0.2086	0.1087		-0.0302	-0.0008		0.0056	0.0062		0.0071	0.0057
		(0.1902)	(0.2003)		(0.0888)	(0.0932)		(0.0355)	(0.0368)		(0.0240)	(0.0244)
1	-0.4465**	-0.5167***	-0.5659***	0.1342	0.2038**	0.2441**	0.0705*	0.0798**	0.0863**	0.0519*	0.0545**	0.0649**
	(0.1794)	(0.1794)	(0.1821)	(0.0890)	(0.0864)	(0.0895)	(0.0390)	(0.0386)	(0.0412)	(0.0277)	(0.0277)	(0.0290)
2	0.0048	-0.0675	0.0056	0.0507	0.1040	0.0429	-0.0279	-0.0240	-0.0265	-0.0129	-0.0127	-0.0169
	(0.2075)	(0.2021)	(0.2161)	(0.1003)	(0.0982)	(0.1056)	(0.0344)	(0.0345)	(0.0358)	(0.0216)	(0.0220)	(0.0246)
3	0.1347	-0.0335	0.0380	-0.0862	0.0168	-0.0134	0.0228	0.0307	0.0205	0.0139	0.0148	0.0073
	(0.2083)	(0.2011)	(0.2106)	(0.0910)	(0.0919)	(0.0975)	(0.0414)	(0.0401)	(0.0408)	(0.0316)	(0.0296)	(0.0280)
4 (post-birth)		-0.1480	-0.1542		0.1276	0.1192		0.0385	0.0413		0.0220	0.0259
		(0.1900)	(0.1973)		(0.0914)	(0.0969)		(0.0378)	(0.0395)		(0.0287)	(0.0295)
5 (post-birth)		0.0936	0.0166		-0.0116	0.0597		-0.0462	-0.0469		-0.0162	-0.0150
		(0.1745)	(0.1778)		(0.0873)	(0.0912)		(0.0316)	(0.0348)		(0.0208)	(0.0233)
6 (post-birth)		-0.0705	-0.0017		0.0781	0.0555		-0.0022	-0.0068		0.0233	0.0212
		(0.1877)	(0.2030)		(0.0942)	(0.1036)		(0.0297)	(0.0319)		(0.0228)	(0.0241)
Additional controls		Yes	Yes		Yes	Yes		Yes	Yes		Yes	Yes
Municip. X linear month		Yes	Yes		Yes	Yes		Yes	Yes		Yes	Yes
Municip. X calendar month dummies			Yes			Yes			Yes			Yes

Notes. The table reports the estimated effect of the quarterly homicide rates in different trimesters since the month of conception on birthweight in Brazilian municipalities with population up to 5,000. Low, very low and extremely low birthweight denote birthweight up to 2.5, 1.5 and 1 kg respectively. Coefficients in columns (4) to (12) are multiplied by 1,000. All specifications include municipality of residence and month fixed effects. Additional controls include: child race, dummies for singleton, twins, triplet or more, dummies for mother's age, education and marital status, number of previously born alive and born dead children and municipality characteristics (log municipality GDP, log population, log share of public expenditure as a fraction of local GDP, log fraction of local expenditure devoted to health, welfare, education, justice and security and defense, average precipitation and temperature, number of Bolsa Família recipients, total amount of Bolsa Família payments, number of health institutions and number of nurses). Columns (2), (5), (8) and (11) also include the interaction between municipality fixed effects and a linear month of conception trend (running from 1 to 105). Columns (3), (6), (9) and (12) finally include the interaction of municipality X calendar month effects. Clustered standard errors by municipality of residence in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Number of observations: 505,253.

Table 3: The effect of homicides during pregnancy on gestational length - Small municipalities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Trimester	Weeks gestation			Week gestation<37			Weeks gestation<32			Weeks gestation<28		
-3 (pre-conception)		0.0008	0.0006		-0.1452*	-0.1535*		-0.0237	0.0000		-0.0076	0.0010
		(0.0005)	(0.0006)		(0.0817)	(0.0884)		(0.0370)	(0.0386)		(0.0189)	(0.0205)
-2 (pre-conception)		0.0003	0.0004		-0.1415*	-0.1489*		-0.0223	-0.0233		0.0245	0.0154
		(0.0005)	(0.0005)		(0.0806)	(0.0865)		(0.0340)	(0.0362)		(0.0202)	(0.0220)
-1 (pre-conception)		0.0003	0.0003		-0.0207	0.0060		-0.0319	-0.0512		0.0082	0.0009
		(0.0005)	(0.0005)		(0.0900)	(0.0946)		(0.0339)	(0.0357)		(0.0220)	(0.0226)
1	-0.0012**	-0.0013**	-0.0015**	0.2063**	0.2031**	0.2187**	0.0449	0.0500	0.0547	0.0472**	0.0605***	0.0724***
	(0.0006)	(0.0006)	(0.0006)	(0.0901)	(0.0866)	(0.0943)	(0.0380)	(0.0372)	(0.0380)	(0.0238)	(0.0233)	(0.0244)
2	0.0006	0.0005	0.0008	0.0025	-0.0101	-0.0581	-0.0578*	-0.0588*	-0.0596*	-0.0118	-0.0023	-0.0034
	(0.0005)	(0.0005)	(0.0006)	(0.0780)	(0.0786)	(0.0859)	(0.0348)	(0.0343)	(0.0360)	(0.0208)	(0.0216)	(0.0241)
3	-0.0003	-0.0006	-0.0004	0.0063	0.0429	0.0049	0.0367	0.0496	0.0432	-0.0161	0.0002	-0.0052
	(0.0005)	(0.0005)	(0.0005)	(0.0816)	(0.0806)	(0.0850)	(0.0368)	(0.0368)	(0.0385)	(0.0199)	(0.0201)	(0.0219)
4 (post-birth)		-0.0003	-0.0003		0.1011	0.1110		-0.0188	-0.0238		0.0055	0.0027
		(0.0005)	(0.0005)		(0.0882)	(0.0898)		(0.0312)	(0.0334)		(0.0186)	(0.0200)
5 (post-birth)		0.0004	0.0000		-0.0490	0.0180		-0.0314	-0.0214		-0.0084	-0.0011
		(0.0005)	(0.0005)		(0.0807)	(0.0875)		(0.0320)	(0.0324)		(0.0173)	(0.0194)
6 (post-birth)		0.0000	0.0001		-0.0788	-0.0869		0.0055	0.0078		0.0435**	0.0411*
		(0.0005)	(0.0005)		(0.0747)	(0.0842)		(0.0311)	(0.0336)		(0.0218)	(0.0231)
Additional controls		Yes			Yes	Yes		Yes	Yes		Yes	Yes
Municip. X linear month		Yes	Yes		Yes	Yes		Yes	Yes		Yes	Yes
Municip. X calendar month dummies			Yes			Yes			Yes			Yes

Notes. The table reports the estimated effect of homicide rates in different trimesters since the month of conception on gestational length in small Brazilian municipalities (population up to 5,000). Coefficients in columns (4) to (12) are multiplied by 1,000. See also notes to Table 2. Number of observations: 505,253.

Table 4: The Effect of homicides during pregnancy on birthweight - Small municipalities
Only pregnancies of normal gestational length

	(1)	(2)	(3)	(4)
Trimester	Birthweight	Low birthweight	Very low birthweight	Extremely low birthweight
1	-0.2339	0.1056	-0.0155	-0.0109
	(0.1672)	(0.0737)	(0.0115)	(0.0100)
2	-0.0929	0.0825	0.0067	0.0027
	(0.1858)	(0.0796)	(0.0150)	(0.0117)
3	0.0825	-0.0720	-0.0069	0.0024
	(0.1911)	(0.0791)	(0.0209)	(0.0203)

Note: The table reports the same specifications as those in Table 2, column (2), (5), (8) and (11) only for pregnancies of normal length (37 weeks or more). Number of observations: 475,383. See notes to Table 2.

Table 5: The Effect of Homicides during pregnancy on additional outcomes - Small municipalities

Trimester	(1) Fertility	(2) C-section	(3) APGAR 1 minute	(4) APGAR 5 minutes	(5) Prenatal Visits	(6) Female	(7) Singletons
1	0.0318	-0.0001	-0.0002	-0.0000	0.0004	-0.0001	0.0000
	(0.0326)	(0.0002)	(0.0006)	(0.0004)	(0.0007)	(0.0002)	(0.0000)
2	-0.0438	0.0000	0.0004	0.0003	0.0006	0.0002	-0.0000
	(0.0341)	(0.0002)	(0.0005)	(0.0004)	(0.0007)	(0.0002)	(0.0000)
3	-0.0379	-0.0000	-0.0008	-0.0002	0.0005	-0.0001	-0.0000
	(0.0358)	(0.0002)	(0.0005)	(0.0004)	(0.0006)	(0.0002)	(0.0000)

Notes. Column (1) of the table reports the effect of homicide rates on fertility. This is calculated as the log number of pregnancies initiated in any given month that led to a birth (plus one in order to account for zeros). Coefficients are multiplied by 1,000. Columns (2) to (7) report specifications similar to those as in columns (2) of Tables 2 and 3 for additional outcomes. All specifications include homicide rates pre- and post-pregnancy, municipality and month of conception fixed effects, municipality controls and municipality fixed effects X month of conception. Columns (2) to (7) additionally control for mother, newborn and pregnancy characteristics. Number of observations in column (1) 142,728. See also notes to Table 2.

Table 6: The effect of homicides during pregnancy on birth outcomes - Neighborhoods of Fortaleza

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Trimester	Birthweight	Low birthweight	Very low birthweight	Extremely low birthweight	Weeks gestation	Week gestation<37	Weeks gestation<32	Weeks gestation<28
-3 (pre-conception)	0.2512	-0.0651	0.0203	0.0119	-0.0010	0.1721	0.1175	-0.0496
	(0.2856)	(0.1161)	(0.0983)	(0.0762)	(0.0010)	(0.1202)	(0.1110)	(0.0517)
-2 (pre-conception)	0.3302	0.0712	0.0525	0.0263	0.0007	-0.1262	0.0012	-0.0083
	(0.2232)	(0.1855)	(0.0703)	(0.0506)	(0.0009)	(0.1425)	(0.0597)	(0.0430)
-1 (pre-conception)	0.3217	-0.0760	-0.0734	0.0250	0.0003	-0.0780	-0.0040	0.0283
	(0.4304)	(0.2036)	(0.0936)	(0.0590)	(0.0012)	(0.1718)	(0.0818)	(0.0559)
1	-0.4105**	0.3017**	0.0963	0.0892**	-0.0013*	0.1369	0.0506	0.0878**
	(0.2068)	(0.1382)	(0.0708)	(0.0441)	(0.0008)	(0.1244)	(0.0561)	(0.0419)
2	-0.1659	-0.0173	0.0197	0.0975***	-0.0013	0.2102	0.0341	0.0958**
	(0.2552)	(0.1575)	(0.0549)	(0.0357)	(0.0009)	(0.1379)	(0.0474)	(0.0372)
3	-0.0105	0.0625	0.0732	0.1001**	-0.0007	-0.0543	0.0801	0.0839**
	(0.2196)	(0.1188)	(0.0564)	(0.0425)	(0.0006)	(0.0901)	(0.0502)	(0.0345)
4 (post-birth)	0.2261	0.2171	-0.0025	-0.0013	0.0002	0.0634	-0.0199	-0.0475
	(0.3492)	(0.1790)	(0.0502)	(0.0340)	(0.0008)	(0.1116)	(0.0548)	(0.0309)
5 (post-birth)	-0.1675	0.3083***	0.0634	0.0625	-0.0011	0.1846	0.0177	0.0368
	(0.2319)	(0.1119)	(0.0679)	(0.0662)	(0.0009)	(0.1145)	(0.0778)	(0.0558)
6 (post-birth)	-0.3131	0.2262*	0.0333	0.0469	-0.0007	0.0461	0.0899*	0.0230
	(0.2587)	(0.1314)	(0.0761)	(0.0429)	(0.0008)	(0.1123)	(0.0522)	(0.0584)

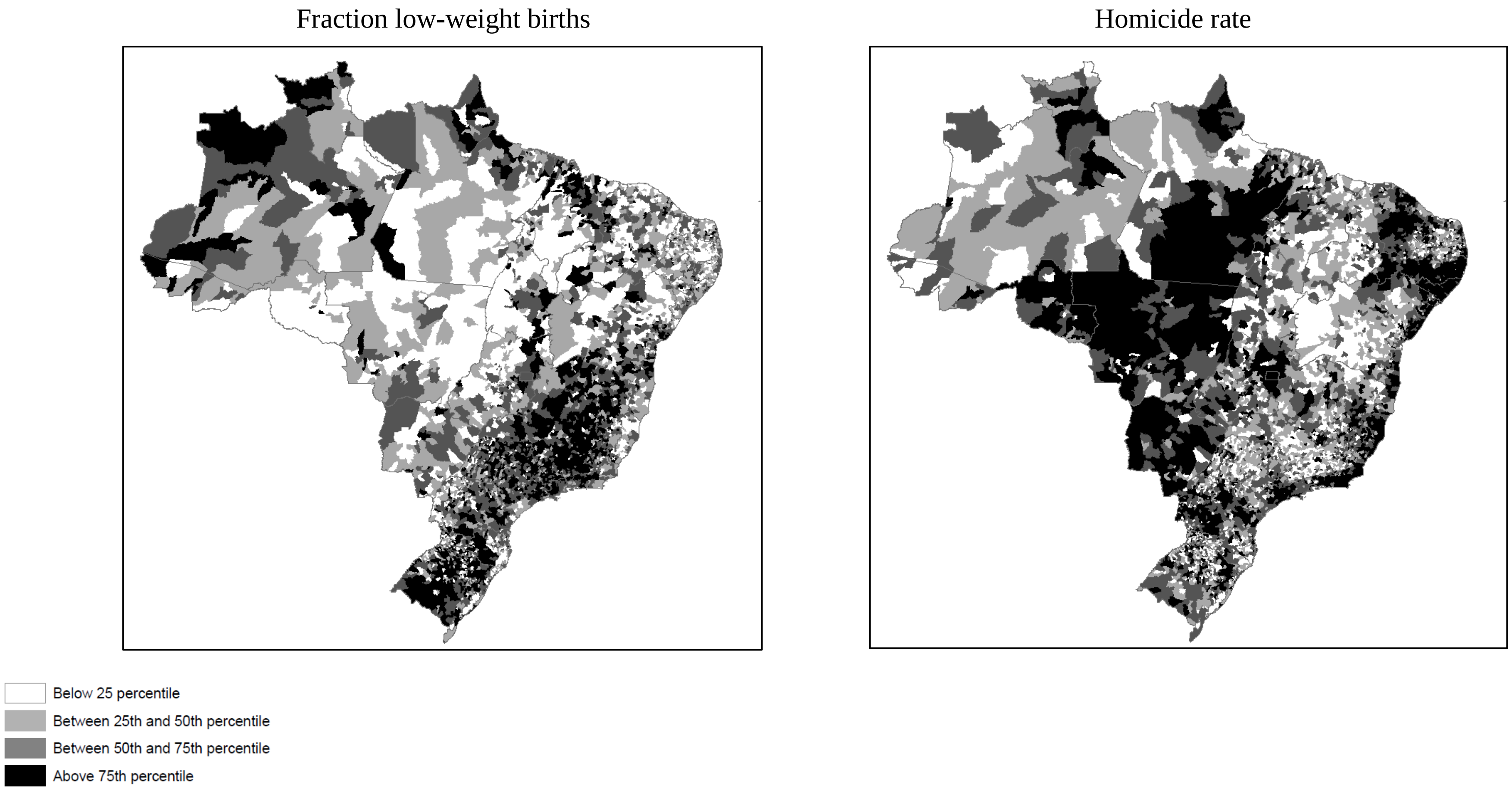
Notes. The table reports the estimated effect of homicide rates in different trimesters since the month of conception on birthweight (columns 1 to 4) and gestational length (columns 5 to 8) in the city of Fortaleza. All specifications include neighborhood and month of conception fixed effects plus neighborhood controls (log population, fraction of households with access to waste collection, fraction of individuals by gender X 10-years age groups. Standard errors clustered by neighborhood. Number of observations 100,814. See also notes to Table 2.

Table 7: The Effect of homicides during the first trimester of pregnancy on birth outcomes - Heterogeneous effects by mother and newborn's characteristics

	(1)	(3)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	By mother's years of education		By mother's age		By mother's marital status		By mother's birth history		By newborn's gender		By number of offspring	
Trimester	<=7	>7	<=24	>24	Not married	Married	Still-births	No Still-births	Male	Female	Singletons	Multiple births
					Low birthweight							
1	0.2541**	0.1329	0.2020	0.2195*	0.2419*	0.1885	1.1483***	0.0786	0.1664	0.2306*	0.2101**	0.2018
	(0.1271)	(0.1365)	(0.1258)	(0.1295)	(0.1268)	(0.1327)	(0.3252)	(0.1008)	(0.1217)	(0.1258)	(0.0854)	(2.312)
P-value	0.5386		0.9261		0.7762		0.0017		0.7164		0.9971	
Observations	281,513	213,814	278,286	226,480	228,529	230,332	42,810	395,935	259,727	245,235	495,503	9,477
					Weeks gestation <37							
1	0.2448**	0.1449	0.1805	0.2159*	0.2028	0.2077	0.9666***	0.0368	0.1271	0.2473**	0.2315***	-1.0769
	(0.1164)	(0.1325)	(0.1238)	(0.1257)	(0.1301)	(0.1262)	(0.3103)	(0.0941)	(0.1195)	(0.1217)	(0.0843)	(2.0415)
P-value	0.5670		0.8435		0.9783		0.0041		0.4700		0.5219	
Observations	281,513	213,814	278,286	226,480	228,529	230,332	42,810	395,935	259,727	245,235	495,503	9,477

Notes. The table reports the effect of homicide rates on birth outcomes in small Brazilian municipalities (population up to 5,000) separately for births defined based on different characteristics of the mother and the newborn. Specifications are the same as those in columns (2), (5), (8) and (11) of Tables 2 and 3. P-values refer to a test of equality of coefficients across groups. See also notes to Table 2.

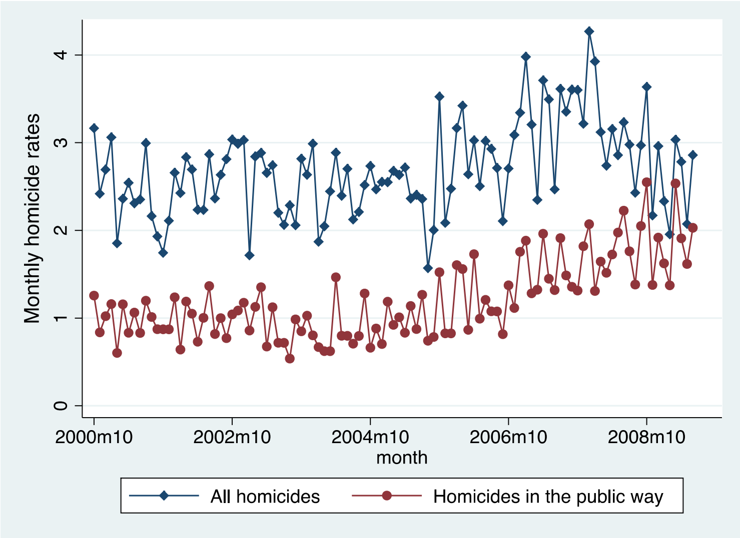
Figure A1: Distribution of low birthweight and homicides across Brazilian municipalities



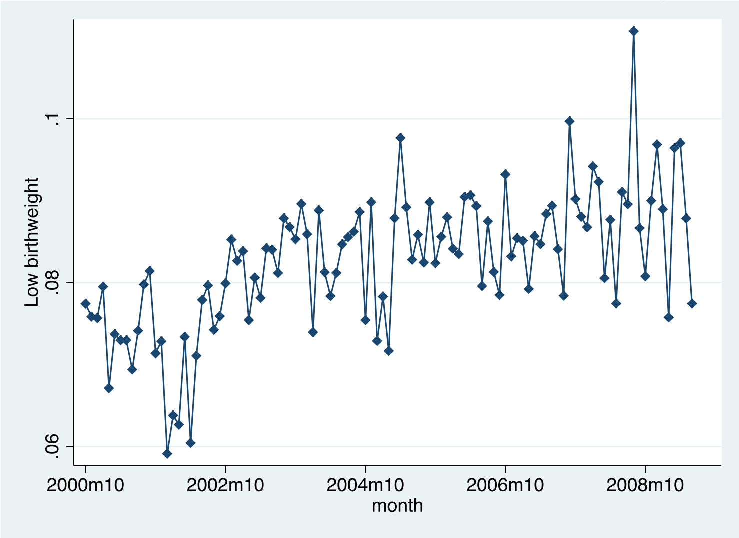
Notes: The figures report, respectively, the average fraction of low-weight births (<2.5 kg) and the homicide rate in the public way across Brazilian municipalities.

Figure A2: Trends in homicide rates and in the incidence of low birth weight in Fortaleza - by month

Panel A: Homicide rates



Panel B: Fraction of children born low birthweight



Note. The figure reports the monthly homicide rate (panel A) as a function of the month of occurrence and the fraction of children born low birthweight (panel B) as a function of the month of conception in the city of Fortaleza.

Table A1: Descriptive statistics - Neighborhoods of Fortaleza

	Fortaleza
Birth outcomes	
Birthweight	3,199
Low birthweight	0.091
Very low birthweight	0.017
Ext. low birthweight	0.008
Weeks gestation	38.628
Weeks gestation<37	0.071
Weeks gestation<32	0.013
Weeks gestation<28	0.006
Newborn characteristics	
Female	0.486
White	0.053
Black	0.002
Asian	0.001
Mixed	0.584
Indigenous	0.000
Birth and pregnancy characteristics	
C-section	0.554
Multiple birth	0.021
Prenatal visits	5.413
Mother characteristics	
Age	25.914
Single	0.668
No ed.	0.009
Years of ed.: 1-3	0.055
Years of ed.: 4-7	0.256
Years of ed.: 8-11	0.453
Years of ed.: >=12	0.189
Born alive children>0	0.613
Born alive children	1.119
Still births	0.054
Observations	100,814
Municipality characteristics	
Homicide rate	17.234
Homicide rate - Public way	12.850
Homicide rate - Residence	2.173
Homicide rate - Hospital	-
Homicide rate - Elsewhere	2.301
Population (,000)	21,536
Neighborhoods	109

Notes. Observations refer to all births conceived between January 2006 and December 2008 and to births and homicides for which an indicator for the mother's neighborhood of residence and the neighborhood of occurrence of the homicide respectively are available. See also notes to Table 1.

Table A2: The effect of homicides during pregnancy on the probability of low birthweight - Municipalities of different sizes

	(1)	(2)	(3)	(4)
	5,001-20,000	20,000-100,000	100,000-500,000	>500,000
-3 (pre-conception)	-0.0319	-0.0164	0.0145	-0.0636
	(0.0458)	(0.0489)	(0.0438)	(0.0522)
-2 (pre-conception)	-0.0324	0.0142	-0.0246	0.0172
	(0.0448)	(0.0589)	(0.0430)	(0.0547)
-1 (pre-conception)	0.0625	0.0989*	0.0471	0.0221
	(0.0446)	(0.0543)	(0.0444)	(0.0570)
1	0.0038	-0.0472	0.0187	0.0541
	(0.0447)	(0.0561)	(0.0431)	(0.0640)
2	-0.0278	-0.0497	-0.0735	-0.0242
	(0.0427)	(0.0465)	(0.0453)	(0.0657)
3	0.0035	-0.0234	0.0217	0.0501
	(0.0420)	(0.0473)	(0.0437)	(0.0705)
4 (post-birth)	0.0608	0.0411	0.0978**	0.0373
	(0.0432)	(0.0478)	(0.0404)	(0.0682)
5 (post-birth)	0.0294	-0.0253	0.0586	0.0280
	(0.0432)	(0.0457)	(0.0436)	(0.0651)
6 (post-birth)	-0.0352	-0.1708***	0.0157	0.0289
	(0.0427)	(0.0458)	(0.0407)	(0.0716)
Additional controls	Yes	Yes	Yes	Yes
Municip. X linear month	Yes	Yes	Yes	Yes

Notes. The table reports similar regressions to those in Table 2, column (5) for municipalities of different sizes. See also notes to Table 2.

Table A3: The effect of homicides during pregnancy on birthweight - Small municipalities - Alternative definitions of homicide

	(1)	(2)	(3)	(4)
	Birthweight	Low birthweight	Very low birthweight	Extremely low birthweight
Model 1				
Public way	-0.5105***	0.2014**	0.0796**	0.0545**
	(0.1776)	(0.0864)	(0.0386)	(0.0278)
Elsewhere	-0.1067	-0.0366	-0.0094	-0.0008
	(0.1144)	(0.0608)	(0.0233)	(0.0149)
Model 2				
Elsewhere	0.0111	0.0109	-0.0313	-0.0269*
	(0.1232)	(0.0642)	(0.0225)	(0.0150)
Model 3				
All	-0.2299**	0.0388	0.0191	0.0166
	(0.0959)	(0.0492)	(0.0199)	(0.0137)
Additional controls	Yes	Yes	Yes	Yes
Municip. X linear month	Yes	Yes	Yes	Yes

Notes. The table reports regressions similar to those in columns (2), (5), (8) and (11) of Table 2 using different definitions of homicide. Regressions include also leads and pre-conception and post-birth measures of homicides, although coefficients are not reported for brevity. Model 1 includes the homicide rate in the public way (as in Table 2) and controls additionally for the homicide rate computed using all other homicides ("elsewhere"). Model 2 only includes the residual category ("elsewhere"). Model 3 only includes the "overall" homicide rate (public way plus elsewhere). See also notes to Table 2.

Table A4: The Effect of homicides during pregnancy on additional outcomes - Neighborhoods of Fortaleza

	(1)	(2)	(3)	(4)	(5)	(6)
	Fertility	C-section	APGAR	APGAR	Prenatal	Female
Trimester			1 minute	5 minutes	visits	
1	-0.1278	-0.0003	-0.0001	-0.0002	0.0006	-0.0001
	(0.1355)	(0.0002)	(0.0005)	(0.0003)	(0.0007)	(0.0002)
2	-0.0571	0.0003	-0.0001	-0.0005**	-0.0002	-0.0006***
	(0.0809)	(0.0002)	(0.0005)	(0.0003)	(0.0011)	(0.0002)
3	-0.0456	-0.0001	0.0011**	-0.0001	0.0007	0.0005**
	(0.0751)	(0.0002)	(0.0005)	(0.0004)	(0.0007)	(0.0002)

Notes. Number of observations in column (1): 3,891. See also notes to Tables 4 and 5.