Conflicts and Birth Weight

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Abstract

This paper investigates the hidden yet persistent cost of conflict to birth weight outcomes for 53 developing countries experiencing conflict in the past three decades (1990-2018). Exploiting the variation across districts and conception months-years, we find that intrauterine exposure to armed conflict in the first trimester of pregnancy reduces child's weight at birth by 2.8% and raises the incidence of low birth weight by 3.2 percentage points. Infants born to poor and low educated mothers are especially vulnerable to the adverse repercussions of armed conflict. Given the long-lasting consequences of poor infant health over the life cycle, our findings call for global efforts in the prevention and mitigation of conflict. Extra attention should be directed to children and women from disadvantaged backgrounds.

Keywords: Corporal Punishment, Student Achievement, Peer Effects

1 Introduction

Armed conflict remains a threat not only to global peace but also to sustainable development. The world has witnessed an overall upward trend in the number of armed conflicts (Dupuy and Rustad, 2018). Approximately 90% of current conflict-related casualties involve civilians, which mostly consist of women and children (World Bank, 2011). Moreover, Alamir et al. (2018) estimate that, between 1960 and 2014, the global economic loss due to armed conflict accumulates to approximately US$26.8 trillion (in 2010 constant prices), representing 33% of the 2014 global Gross Domestic Product (GDP).

Previous studies show that the costs of armed conflict are atrocious and far-reaching. The apparent cost is the loss of lives and permanent injuries (Dunne et al., 2013). By impeding capital accumulation, armed conflict can also depress production capacity and lower economic growth (Sachs, 2008; Dunne et al., 2013). Conflict can further worsen health outcomes, decrease educational attainment, as well as reduce future earnings for exposed individuals (Bundervoet et al., 2009; Bruck et al., 2019; Le and Nguyen, 2020a). To make matters worse, it is possible for the negative ramifications of armed conflict to be passed on to the second generation. In particular, by imposing acute physical and psychological distress on pregnant women, armed conflict can imperil the babies in utero, leading to poor birth outcomes (Mansour and Rees, 2012; Bruck et al., 2017).

This paper investigates how intrauterine exposure to armed conflict affects infant health proxied by birth weight outcomes for 53 developing countries experiencing conflict during the period of 1990-2018. By examining the intergenerational effects of armed conflict, the study makes three contributions to the literature. First, we estimate the hidden yet persistent cost of conflict, the cost to human capital formation of the future generation, whereas much focus has been placed on individuals directly affected by conflict (Bruck et al., 2017). Second, instead of targeting one single country, we explore the intergenerational consequences of armed conflict in the context of 53 developing countries across five continents over nearly three decades. The wide coverage in both spatial and temporal dimensions lends external validity to our estimated cost of conflict to early human capital. Finally, given the mixed evidence on the relative importance of the exposure timing, we further contribute to the literature by accounting for the timing of utero exposure to armed conflict. Our findings support the importance of the first trimester.

In terms of identification, we adopt the difference-in-differences (DiD) approach across districts and conception months-years to estimate the impacts of utero exposure to armed conflict on birth weight outcomes. In other words, we compare the birth weight outcomes of children born to mothers exposed to armed conflict during pregnancy with those born to mothers unexposed to such events during pregnancy within the same district, relative to the analogous differences for mothers residing in a different district. Our primary data sources are the Uppsala Conflict Data Program Geo-referenced Event Dataset (UCDP-GED) and the Demographic and Health Surveys supplemented with GPS datasets (DHS-GPS). The UCDP-GED is a comprehensive dataset on armed conflict worldwide. The DHS-GPS provides us with rich information on mothers and children as well as their geographic locations.

Our study reaches the following findings. Intrauterine exposure to armed conflict in early pregnancy imposes adverse ramifications on newborn health proxied by birth weight outcomes. Specifically, exposure to armed conflict during the first trimester in utero reduces the child's weight at birth by 2.8% and raises the probability of the infant having low birth weight by 3.2 percentage points.[1] Besides, infants born to poor and low educated mothers are especially vulnerable to the detrimental repercussions of armed conflict. Particularly, poor mothers exposed to armed conflict during the first trimester are more likely to give birth to low birth weight infants by 5.7 percentage points while the effect on non-poor mothers is much smaller in magnitude and statistically insignificant. The incidence of low birth weight is 4 percentage points higher for women with low education (educational attainment is below the secondary level) whereas there is no such negative effect for higher educated women. The results demonstrate the vulnerability to armed conflict of children from disadvantaged backgrounds.

The paper offers meaningful implications for policy. Our findings represent the serious but less visible cost of conflict. Specifically, the deteriorating impacts on birth weight outcomes underline the detrimental ramifications of armed conflict on long-term human capital since poor infant health can leave persistent consequences over the life cycle such as higher susceptibility to diseases, lower educational attainment, and worsening labor market outcome (Reyes and Manalich, 2005; Black et al., 2007; Oreopoulos et al., 2008; Xie et al., 2019). As a result, the paper calls for global efforts in the prevention of conflict. Intervention measures to mitigate the impacts of on-going conflict and post-conflict reconstruction initiatives are also

[1] World Health Organization defines low birth weight as birth weight less than 2.5 kilograms.

important to deal with the cost of conflict. Extra attention should be directed to children and women from disadvantaged backgrounds since this is the most vulnerable group.

The paper proceeds as follows. Section 2 presents the literature review. Section 3 describes our data. Section 4 outlines the empirical methodology. Section 5 reports estimating results. Section 6 concludes the study.

2 Literature Review

Our empirical model to estimate the intergenerational impacts of armed conflict is guided by the theoretical work of Corman et al. (1987). In particular, their model suggests that parents maximize utility in which infant health is one of the arguments. Solving the model gives us infant health as a function of maternal health and prenatal health inputs (e.g. vitamin supplement, vaccine, food, medical services). In our context, armed conflict could affect the infant health production by both deteriorating maternal health and altering prenatal health inputs. Regarding maternal health, not only does armed conflict entail a substantial physical health risk but it also places a tremendous psychological burden on the mother. As for prenatal health inputs, armed conflict can suppress the availability of various nutrition goods and health care services to pregnant women. All these changes are likely to worsen infant health.

Our paper is closely related to empirical studies on the intergenerational effects of violent conflict (Ghobarah et al. 2004; Devakumar et al., 2014; Bruck et al., 2017).[2] Prior studies suggest that conflict can impede human capital of the future generation (in the form of unfavorable birth outcomes) through the imposition of both physical and psychological trauma on pregnant women. First, during conflict, women are usually the target of physically violent incidents such as rape and trafficking, which is clearly a threat to the babies in utero (Bruck et al., 2017). With limited access to prenatal care and deficient nutrition during the period of conflict, the health of the infants can further be jeopardized (Mansour and Rees, 2012; Bruck et al., 2017).

Second, besides the immense physical risks, conflict can inflict pregnant women with substan-

[2] The study also complements the literature on the direct impacts of conflict on the economy and individuals. For example, conflict imposes apparent costs such as the loss of lives and the devastation of production capacity (Dunne et al., 2013). Conflict also destroys human capital accumulation such as worsening health outcomes and lowering educational attainment for exposed individuals (Bundervoet et al., 2009; Le and Nguyen, 2020a).

tial psychological distress, which in turn negatively affects infant health (Mansour and Rees, 2012; Sherrieb and Norris, 2013; Quintana-Domeque and Rodenas-Serrano, 2017; Brown, 2020). For example, intrauterine exposure to the 9/11 WTC attacks in New York City and the 2004 train bombings in Madrid raises the incidence of low birth weight, mainly through increased maternal stress during pregnancy (Sherrieb and Norris, 2013; Brown, 2020). By imposing acute psychological damage on pregnant women, the Al-Aqsa Intifada (i.e. the intensified IsraeliPalestinian violence period) worsens birth outcomes in terms of birth weight in the context of Palestine (Mansour and Rees, 2012).

Despite an overall consensus on the detrimental effects of utero exposure to negative shocks on infant health outcomes, there exists conflicting evidence for the relative importance of the exposure timing in both medical and economics literature. Regarding nutrition, Lunney (1998) finds that restricted maternal nutrition in the third trimester worsens birth outcomes whereas nutritional deprivation during the first trimester does not. Regarding maternal stress, while several medical studies document the negative association between stress during the second trimester and birth weight (Field et al., 2006; Field and Diego, 2008), others point to the importance of the first-trimester exposure to mental distress (Schneider et al., 1999; Van den Bergh et al., 2005). In the economics literature, the majority of works uncover that utero exposure to adverse events during the first trimester of pregnancy leads to poor infant health outcomes (Torche, 2011; Mansour and Rees, 2012; Quintana-Domeque and Rodenas-Serrano, 2017; Brown, 2020).

3 Data

Our primary data sources are the Uppsala Conflict Data Program Geo-referenced Event Dataset (UCDP-GED) and the Demographic and Health Survey (DHS). The UCDP-GED is a dataset on armed conflict worldwide since the beginning of 1989. The DHS provides us with information on birth weight and the various characteristics of women as well as their children since 1986. We describe each dataset in more detail below.

3.1 Data on Conflict

Information on armed conflict is taken from the latest version (version 19.1) of the UCDP-GED, a global dataset that records armed conflict since the beginning of 1989. UCDP-GED is developed by the Department of Peace and Conflict Research of Uppsala University. The focus of UCDP-GED is conflict or armed violence. The smallest unit of observation in the

UCDP-GED is the event, which refers to "an individual incident (phenomenon) of lethal violence occurring at a given time and place" (Sundberg and Melander, 2013; Stina, 2019). To be counted as an event, the incident needs to (i) involve the use of arms (e.g. weapons) by an "organized actor" against another "organized actor" or against civilians and (ii) lead to at least one direct death. UCDP-GED defines "organized actor" as a government of an independent state, a formally organized group, or an informally organized group. For each event, the UCDP-GED records the place of occurrence (identified by one pair of latitude and longitude coordinates) as well as the date of occurrence. The lowest administrative level that coordinates fall into is the village/town (administrative level 3) and the lowest temporal level is the day.

3.2 Data on Child Outcomes

Information on birth weight outcomes and a variety of mother/child characteristics are drawn from the Demographic and Health Surveys. The DHS program is funded by the United States Agency for International Development (USAID) along with other sponsors such as the United Nations Children's Fund (UNICEF), the United Nations Population Fund (UNFPA), the World Health Organization (WHO), and the Joint United Nations Program on HIV and AIDS (UNAIDS). The DHS, administered in over 90 developing countries since 1986, is a rich dataset focusing on women and children. We mainly rely on the Woman's Questionnaire which concentrates on women in reproductive ages (15-49). These women were asked questions on their demographic backgrounds, health, fertility, birth weight and the birth date of their children, among others.[3]

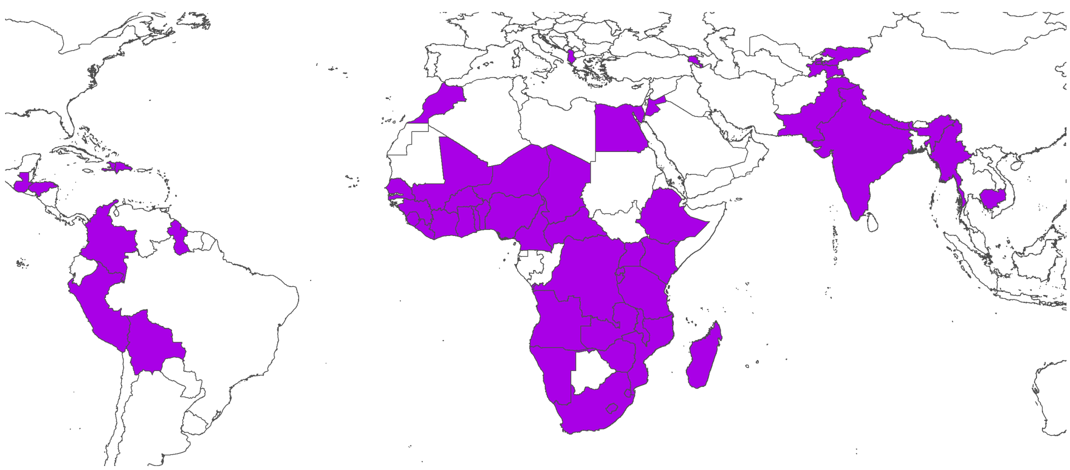
In order to match with the UCDP-GED, we need the geographic locations of the mothers and children. Therefore, we utilize the DHS surveys where GPS datasets are available (DHS-GPS). In these surveys, participating households are geo-referenced. In other words, the geographic location of the household's residential cluster can be identified by one pair of latitude and longitude coordinates. The lowest administrative level that coordinates fall into is the district (administrative level 2).

[3] Unfortunately, the DHS does not collect the information on gestational age. Therefore, we cannot examine the impacts on premature birth.

3.3 Estimation Sample

We first restrict our sample to DHS-GPS surveys with information on birth weight. Then, we merge the UCDP-GED with the DHS-GPS datasets. Because the smallest geographic unit DHS-GPS coordinates fall into is the district (subnational administrative level 2) while the lowest administrative level that UCDP-GED coordinates fall into is the village/town (subnational administrative level 3), we need to aggregate the armed conflict events in the UCDP-GED to the district level. With the geographic details, we can identify whether the mothers' district of residence experienced the armed conflict or not. Given that the timing of conflict is available from UCDP-GED and the child's birth date is present in the DHS-GPS, we can calculate whether a child was exposed to armed conflict in utero. In other words, with the spatial and temporal information, we can identify the timing of exposure to armed conflict for mothers and children in our sample.

Figure 1: Geographic Coverage



Note: The shaded regions illustrate the geographic coverage of our sample.

There are three main explanatory variables in our analysis, including Tri_1, Tri_2, and Tri_3. They are one-zero indicators taking the value of one if the mother experienced armed conflict in her residence district during the first, second, and third trimesters of pregnancy, respectively, and zero otherwise.[4] For example, let us consider a child born in September 2005. If armed conflict occurred in February (or any time between January and March), the child was exposed to the conflict in the first trimester ($Tri_1 = 1$, $Tri_2 = 0$, and $Tri_3 = 0$). If there

[4] Based on Mansour and Rees (2012), we define trimesters as follows. The first trimester is defined as 6-9 months before birth. The second trimester refers to a period of 3-5 months before birth. The third trimester refers to the period of 0-2 months before birth. Similarly, conception month can be calculated as 9 months prior to the birth date.

was another conflict in May, then the child was exposed in the first and second trimesters ($Tri_1 = 1$, $Tri_2 = 1$, and $Tri_3 = 0$).

Table 1: Summary Statistics

	All	Exposed	Unexposed
	Mean (Standard Deviation)		
	(1)	(2)	(3)
Panel A: Dependent Variables			
Birth Weight (kg)	3.104	3.017	3.104
	(0.679)	(0.694)	(0.679)
Low Birth Weight	0.112	0.133	0.112
(Birth Weight < 2.5 kg)	(0.316)	(0.339)	(0.315)
Panel B: Explanatory Variables			
Birth Interval (months)	43.093	42.540	43.097
	(27.231)	(25.351)	(27.245)
Mother's Age at Birth	28.213	27.856	28.216
	(5.719)	(5.494)	(5.720)
Mother's Education	0.183	0.170	0.183
(at least Secondary)	(0.387)	(0.376)	(0.387)
Male Child	0.517	0.520	0.517
	(0.499)	(0.500)	(0.500)
Plural Birth	0.013	0.017	0.013
	(0.115)	(0.130)	(0.115)
Birth Order	3.503	3.330	3.505
	(1.856)	(1.695)	(1.857)
Observations	293,997	2,319	291,678

Note: Birth weight is measured in kilograms (kg). Low birth weight is defined as birth weight less than 2.5 kg. Mother's Education in an indicator taking the value of one if mother completes at least secondary education. Birth interval is the interval (in months) between current birth and the preceding one.

Our sample consists of 293,997 children across 53 countries where pregnant women were exposed to armed conflict between 1990 and 2018. The list of countries is provided in Table A1 in the appendix. Figure 1 illustrates the geographic coverage of our sample. The proportion of women subject to armed conflict by country is reported in Table A2. The descriptive statistics for our outcome and control variables are presented in Table 1 for the entire sample and disaggregated by the conflict utero exposure status.[5] As shown in Column 1 of Panel A, the average birth weight is 3.1 kilograms (kg). According to WHO, "low birth weight" is defined as weighing less than 2.5 kg. In our sample, approximately 11.2% of children weighing

[5] The exposed group consists of children born to mothers experiencing armed conflict during pregnancy. The unexposed group comprises children born to mothers not experiencing armed conflict during pregnancy, which includes (i) mothers exposed to armed conflict prior to conception, (ii) mothers subject to armed conflict after the delivery, and (iii) mothers unexposed to armed conflict. Details are provided in Section 4.

less than 2.5 kg at birth, i.e. considered low birth weight. As shown in Columns 2 and 3 of Panel A, the average birth weight is lower for children exposed to armed conflict in utero than the unexposed ones. Consistently, the fraction of low birth weight is higher for infants exposed to armed conflict in utero.

Summary statistics of control variables are provided in Panel B. Birth interval takes the mean value of approximately 43 months for the full sample and it is slightly longer for children in the unexposed group. Mothers in the unexposed group are somewhat older at childbirth and tend to have more education. The fraction of male newborns is higher in the exposed group. In Table A3, we test the differences in these baseline characteristics (birth interval, mother's age at birth, mother's education, child gender, birth plurality, and birth order) between the exposed and the unexposed groups. Specifically, we regress each of these characteristics on an indicator Expose that takes the value of one if the mother was exposed to armed conflict when she was pregnant, zero otherwise, conditioning on district fixed effects, conception month-year fixed effects, and the country-specific linear time trend at the conception month-year level. As shown in Table A3, none of the point estimates is statistically significant, pointing to the non-existence of the differences in these characteristics between the two groups.

4 Empirical Methodology

To estimate the effects of exposure to armed conflict during pregnancy on birth weight outcomes and tackle the lack of consensus on the relative importance of the exposure timing (Lunney, 1998; Field et al., 2006; Field and Diego, 2008), we adopt the difference-in-differences (DiD) model, given by,

$$Y_{idct} = \beta_0 + \beta_1 Tri_{1,dct} + \beta_2 Tri_{2,dct} + \beta_3 Tri_{3,dct} + X'_{idct}\Omega + \lambda_d + \delta_t + \gamma_c \times t + \epsilon_{idct} \quad (1)$$

where the subscript i, d, c, and t correspond to child, district of residence, country, and conception month-year. The outcome variable, Y_{idct}, is the health measures of the child at birth, namely weight at birth (in log form) and whether the child has a low weight at birth (defined as birth weight less than 2.5 kg). As we want to explore exposure to armed conflict in which stage of pregnancy affects birth weight outcomes, we include trimester-specific exposure indicators as our key explanatory variables, $Tri_{1,dt}$, $Tri_{2,dct}$, and $Tri_{3,dct}$, taking the value of one if the mother is exposed to armed conflict in her residence district during the first, second, and third trimester of pregnancy, respectively, and zero otherwise.

Vector X'_{idct} denotes mother and child characteristics including mother's education, mother's age at birth, child's sex, birth interval, child's birth order, and birth plurality. The terms λ_d and δ_t represent district fixed effects and conception month-year fixed effects, respectively. We denote by $\gamma_c \times t$ the country-specific linear time trend at the conception month-year level and ϵ_{idct} the idiosyncratic error term. Our coefficients of interest are β_1, β_2, and β_3 which captures the impacts on birth weight outcomes of armed conflict in each of the pregnancy trimesters. Standard errors throughout the paper are clustered at the district level.

In this DiD setup, we compare the birth weight outcomes of children born to mothers exposed to armed conflict during pregnancy with those born to mothers unexposed to such event and mothers subject to such event before conception as well as after birth delivery within the same district, relative to the analogous differences for mothers residing in a different district. In other words, our treatment group consists of mothers exposed to armed conflict during any trimester of pregnancy. The control group in our main specification includes (i) mothers exposed to armed conflict prior to conception, (ii) mothers subject to armed conflict after the delivery of the baby, and (iii) mothers unexposed to armed conflict. Because prior studies suggest that one control group could be better than the other (Persson and Rossin-Slater, 2018; Currie et al., 2019), we later show in the robustness checks that our results are insensitive to different categorizations of the control group. With this setup, our identifying assumption underlying the DiD framework is that the timing of armed conflict is unrelated to within district unobserved factors that could potentially affect birth weight outcomes.

5 Results

5.1 Main Results

We present our estimates of the effects of exposure to armed conflict on birth weight outcomes in Table 2. The structure is as follows. Results on birth weight (in log form) and low birth weight indicator are provided in Columns 1-3 and Columns 4-6, respectively. Columns 1 and 4 provide our most parsimonious specification where we only control for district fixed effects and conception month-year fixed effects. In Columns 2 and 5, we introduce mother and child characteristics, including mother's education, mother's age at birth, child's sex, birth interval, child's birth order, and birth plurality, into our regressions. Finally, Columns 3 and 6 report our most extensive specifications with all fixed effects, a full set of controls, and the country-specific linear trend (at the conception month-year level).

Starting with the most parsimonious specifications, we find that first-trimester utero exposure to armed conflict decreases child's weight at birth by 2.7% (Column 1) and increases the incidence of low birth weight by 3.3 percentage points (Column 4). The effects of exposure during the second and the third trimesters are statistically insignificant and very small in magnitude. Controlling for mother and child characteristics leaves our estimates virtually unchanged (Columns 2 and 5). Results from our most extensive specifications (Columns 3 and 6) suggest that exposure to armed conflict during the first trimester in utero reduces the child's weight at birth by 2.8% and raises the probability of the infant having low birth weight by 3.2 percentage points. These estimates are both statistically and economically significant. Taking the fraction of babies weighing less than 2.5 kg among the control group as the benchmark (Table 1), the estimate in Column 6 implies an average increase in the incidence of low birth weight by 28.6%. These estimates can be considered economically significant because poor infant health could leave long lasting consequences such as raising the susceptibility to diseases, lowering educational attainment, and worsening labor market outcome (Reyes and Manalich, 2005; Black et al., 2007; Oreopoulos et al., 2008; Xie et al., 2019).

Table 2: Impacts of Exposure to Armed Conflict on Birth Weight Outcomes

	Y=Log Birth Weight			Y=Low Birth Weight (Birth Weight<2.5 kg)		
	(1)	(2)	(3)	(4)	(5)	(6)
Exposed 1st Trimester	-0.027***	-0.027***	-0.028***	0.033***	0.032***	0.032***
	(0.008)	(0.008)	(0.008)	(0.013)	(0.012)	(0.012)
Exposed 2nd Trimester	-0.008	-0.006	-0.008	-0.007	-0.011	-0.010
	(0.012)	(0.012)	(0.012)	(0.012)	(0.011)	(0.011)
Exposed 3rd Trimester	-0.017	-0.015	-0.017	-0.002	-0.003	-0.004
	(0.013)	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)
Observations	293,997	293,997	293,997	293,997	293,997	293,997
Country-Specific Linear Trend	·	·	✓	·	·	✓
Mother & Child Characteristics	·	✓	✓	·	✓	✓
Conception Month-Year FE	✓	✓	✓	✓	✓	✓
District FE	✓	✓	✓	✓	✓	✓

Note: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each column represents coefficients in a separate regression. Dependent variables are the child's weight at birth in log form (Columns 1-3) and an indicator for the child having low weight at birth (Columns 4-6). Birth weight is in kilogram. Low birth weight is defined as birth weight being less than 2.5 kg. Mother and child characteristics include mother's education, mother's age at birth, child's sex, birth interval, child's birth order, and birth plurality. Robust standard errors are clustered at the district level.

Collectively, we find that utero exposure to armed conflict, especially during the first trimester, imposes adverse ramifications on newborn health proxied by birth weight outcomes. As suggested in prior literature, the potential explanation could be the release of stress hormones, such as norepinephrine and cortisol, during the exposure to traumatic events. Such stress hormones can damage fetal growth, which is notably pernicious in the early stage of pregnancy (Gluckman and Hanson, 2004; Quintana-Domeque and Rodenas-Serrano, 2017). Therefore, psychological stress due to armed conflict can leave deteriorating effects on infant health. Besides, psychological stress can weaken the immune system and make pregnant women susceptible to illnesses, thus aggravating their physical health. Moreover, as women are more likely to be targeted with violent incidents (Usta et al., 2008; Shemyakina, 2011), it is possible for such physical risks to imperil babies in utero (Bruck et al., 2017). Another possibility could be the lack of access to prenatal care or limited nutrition engendered by armed conflict (Mansour and Rees, 2012). However, prenatal care and nutrition seem to be more important in the later stages of pregnancy (Grossman and Joyce, 1990; Lunney, 1998; Jewell and Triunfo, 2006; Wehby et al., 2009), making them potentially less relevant in our context.

Our results are consistent with the literature on the intergenerational consequences of conflict. In general, conflict generates both the physical and psychological health risks for women, which could be passed onto the second generation through utero transmission (Ghobarah et al. 2004; Devakumar et al., 2014; Bruck et al., 2017). For example, women experiencing terrorist attacks during pregnancy tend to give birth to low birth weight infants because these women are more likely to suffer from psychological trauma during such events (Eskenazi et al., 2007; Sherrieb and Norris, 2013; Brown, 2020).

In terms of the relative importance of early and late pregnancy exposure to negative shocks, the findings are in line with several studies that uncover the association between utero exposure during the first trimester and infant health outcomes. Camacho (2008) shows that landmine explosions during a womans first trimester of pregnancy decrease the child's birth weight in the context of Colombia. Mansour and Rees (2012) find that Palestinian pregnant women experiencing the intensified Israeli-Palestinian violence period in the first trimester are more likely to give birth to low birth weight infants. Quintana-Domeque and Rodenas-Serrano (2017) and Brown (2020) uncover that first-trimester utero exposure to terrorist attacks reduces the weight at birth of Spanish and American newborns. Together with these studies, our findings provide evidence supporting the importance of the first trimester. Nevertheless, our presented results stand in contrast with papers pointing to the effects of intrauterine exposure to adverse events during the second and the third trimesters (Lunney, 1998; Field et al., 2006; Field and Diego, 2008).

Our results represent the serious but less visible cost of conflict. Specifically, the deteriorating impacts on birth weight outcomes underline the detrimental ramifications of armed conflict on long-term human capital, given that poor infant health can leave lasting consequences over the life cycle such as higher susceptibility to diseases, lower educational attainment, and worsening labor market outcome (Reyes and Manalich, 2005; Black et al., 2007; Oreopoulos et al., 2008; Xie et al., 2019). As a result, the paper calls for global efforts in the prevention and reduction of conflict. Our study also emphasizes the importance of mitigation strategies in on-going armed conflicts as well as post-conflict reconstruction initiatives to minimize the cost of conflict.

Last but not least, we acknowledge that there are two shortcomings in our analysis. First, we choose to ensure the external validity of our estimates at the expense of a more detailed measure of conflict. Specifically, to increase the generalizability of our results to out-of-sample countries, we have to rely on a global dataset that records armed conflict over a large time span (the UCDP-GED). Nevertheless, the UCDP-GED does not provide detailed information on conflict intensity, which is the tradeoff for its spatially and temporally wide coverage. Given that conflict of varying intensity levels might affect infant health differentially, our estimates fail to capture the intensive margin of the impacts of armed conflict.[6] The second limitation is that our estimates only capture the impacts on live births. It is possible that conflict might have led to the worst pregnancy outcomes such as fetal death, miscarriage, or maternal death. We acknowledge that by not accounting for such scenarios due to data unavailability, our estimates represent the lower bound of the true effects of armed conflict.

[6] Prior studies that quantify the effects of conflict intensity tend to focus on one particular event. For example, within the context of the allied bombing of Vietnam, several studies employ the unique bombing mission dataset and utilize the total quantity or total weight of bombs to capture the intensity of bombing (Miguel and Roland, 2011; Le and Nguyen, 2020a). Exploring World War II destruction in Germany, Akbulut-Yuksel (2014) uses a unique destruction dataset and employ the volume of rubble as the intensity measure.

5.2 Heterogeneity Analyses

In this section, we explore the heterogeneous effects of utero exposure to armed conflict on birth weight outcomes along the lines of family, mother, and child characteristics, using our most extensive specifications (similar to Columns 3 and 6 of Table 2). The estimating results are presented in Table 3. Dependent variables are the child's birth weight in log form (Panel A) and low birth weight indicator (Panel B). Each column represents a separate regression, and the column headings specify subgroup levels.

Table 3: Heterogeneity by Family, Mother, and Child Characteristics

	Poor Households	Non-poor Households	Low Education	High Education	Short Birth Interval	Long Birth Interval
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Y=Log Birth Weight						
Exposed 1st Trimester	-0.034***	-0.023**	-0.032***	-0.010	-0.041***	-0.016
	(0.012)	(0.011)	(0.009)	(0.017)	(0.012)	(0.010)
Exposed 2nd Trimester	-0.006	-0.011	-0.012	0.006	-0.022	0.008
	(0.012)	(0.019)	(0.014)	(0.017)	(0.020)	(0.012)
Exposed 3rd Trimester	0.000	-0.029	-0.019	-0.010	-0.023	-0.008
	(0.015)	(0.019)	(0.016)	(0.017)	(0.021)	(0.014)
Observations	107,546	186,451	240,096	53,901	148,511	145,486
Panel B: Y=Low Birth Weight (Birth Weight<2.5 kg)						
Exposed 1st Trimester	0.057***	0.013	0.040***	-0.004	0.036*	0.028
	(0.021)	(0.015)	(0.013)	(0.029)	(0.019)	(0.018)
Exposed 2nd Trimester	0.000	-0.016	-0.008	-0.026	-0.019	-0.005
	(0.020)	(0.015)	(0.013)	(0.026)	(0.018)	(0.016)
Exposed 3rd Trimester	-0.025	0.006	-0.002	-0.014	-0.002	-0.005
	(0.021)	(0.016)	(0.014)	(0.031)	(0.018)	(0.020)
Observations	107,546	186,451	240,096	53,901	148,511	145,486

Note: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each column represents coefficients in a separate regression. The column headings indicate the dimensions of heterogeneity. Dependent variables are child's weight at birth in log form (Panel A) and low birth weight indicator (Panel B). Birth weight is in kilogram. All regressions control for district of residence fixed effects, conception month-year fixed effects, mother and child characteristics, as well as country-specific linear trend. Robust standard errors are clustered at the district level.

We first examine whether the effects of utero exposure to armed conflict differ by household wealth (Columns 1 and 2, Table 3). Poor households are defined as households in the bottom and second quintiles of the wealth index distribution. Likewise, non-poor households are those in the third, fourth, and fifth quintiles. We find that mothers from both poor and non-poor households who experience armed conflict during the first trimester of pregnancy give birth to lower birth weight babies. Specifically, infants born to poor mothers exposed to armed conflict during the first trimester weigh 3.4% less while the reduction for those born to non-poor mothers having the same experience is only 2.3% (Columns 1 and 2, Panel A). Poor mothers exposed to armed conflict during the first trimester are more likely to give birth to low birth weight infants by 5.7 percentage points while the effect on non-poor mothers is smaller and statistically insignificant (Columns 1 and 2, Panel B). These results suggest that a more advantaged socio-economic background can buffer the negative shocks of armed conflict.

Next, we explore whether women with low educational levels and those with higher educational attainment are distinctively impacted by armed conflict (Columns 3 and 4). Low education refers to women whose educational attainment is below the secondary level. High education refers to women who complete at least secondary education. Evident from Table 3, infants of low education mothers tend to be more vulnerable. Particularly, newborns of low education mothers exposed to armed conflict during the first trimester of pregnancy weigh 3.2% less whereas the impact on infants born to high education mothers subject to such adverse event is small in magnitude and statistically insignificant (Columns 3 and 4, Panel A). Women with low education experiencing armed conflict during the first trimester are 4 percentage points more likely to give birth to low birth weight infants while there is no such adverse effect on higher educated women (Columns 3 and 4, Panel B). Given the importance of maternal education in health outcomes of children (Currie and Moretti, 2003; Grytten et al., 2014; Le and Nguyen, 2020b), these estimating results further highlight the role of mother's education in counteracting the consequences of adverse events.

Since birth spacing is a potential factor affecting infant health (CondeAgudelo et al., 2012; Fotso et al., 2013), we now proceed to examine the potential differential effects of utero exposure to armed conflict by birth interval (Columns 5 and 6). Birth interval refers to the interval between the birth of one newborn and the birth of the preceding one. The short birth interval is defined as less than or equal to the mean interval of the sample while the long birth interval is defined as greater than the mean. We find that utero exposure to armed conflict during the first trimester makes newborns in short birth intervals weigh 4.1% less while the effect is almost nonexistent for infants in longer birth intervals (Columns 5 and 6, Panel A). Infants in shorter birth intervals are also 3.6 percentage points more likely to be categorized as low birth weight babies if their mothers experience armed conflict during the first trimester of pregnancy whereas the effect on newborns in long birth intervals is smaller and statistically insignificant (Columns 5 and 6, Panel B). It is possible that the detrimental consequences of armed conflict tend to concentrate on infants in shorter birth intervals.

5.3 Robustness Checks

Explanatory Variable and Sample Restrictions – Next, we proceed to provide additional evidence for the robustness of our results by imposing various variable and sample restrictions in Table 4. Estimates in Table 4 come from our most extensive specifications. Each column represents a separate regression and the column headings indicate the variable and sample restrictions. Columns 1 through 3 report the results for the log of birth weight while Columns 4 through 6 provide the results for the low birth weight indicator.

As suggested in prior literature, exposure to adverse events during pregnancy could result in the reduction of male births, making the child's sex as a bad control (Catalano et al., 2006; Sanders and Stoecker, 2015). Therefore, we exclude the child's sex from our regressions and re-estimate the most extensive DiD model. Evident from Columns 1 and 4, the exclusion of the child's sex leaves our estimates virtually unchanged. We still find significant effects of utero exposure during the first trimester on birth weight outcomes, specifically the 2.7% reduction in birth weight and a 3.2 percentage point increase in the incidence of low birth weight.

Besides, it is documented that early age at childbirth such as teen pregnancy is associated with poor birth outcomes (Chen et al., 2007; Gibbs et al., 2012). To probe with the concern that our estimated impacts of armed conflict are prompted by teenage mothers, we only consider mothers aged 20 and above at childbirth. As shown in Columns 2 and 5, utero exposure to armed conflict in the first trimester is linked with deteriorating birth weight outcomes. The magnitude is a 2.6% decrease in child's weight at birth and a 3.3 percentage point increase in the incidence of low birth weight.

Because multiple pregnancy babies are faced with a higher risk of low birth weight than single pregnancy ones (Blondel et al., 2002), prior studies on infant health only include singleton births in their models (Ludwig and Currie, 2010; Currie and Rossin-Slater, 2013). Although we already control for multiple births in our main specification, we now exclude multiple pregnancy babies and re-estimate the impacts of utero exposure to armed conflict. Evident from Columns 3 and 6, our results are insensitive to the exclusion of multiple births. We continue to find that fetuses exposed to armed conflict during the first trimester are born into lower birth weight infants.

Table 4: Robustness Checks - Explanatory Variable and Sample Restrictions

	Y=Log Birth Weight			Y=Low Birth Weight (Birth Weight<2.5 kg)		
	Not Control for Child's Sex	No Teenage Mothers	Only Singleton Births	Not Control for Child's Sex	No Teenage Mothers	Only Singleton Births
	(1)	(2)	(3)	(4)	(5)	(6)
Exposed 1st Trimester	-0.027***	-0.026***	-0.027***	0.032***	0.033**	0.032***
	(0.008)	(0.008)	(0.008)	(0.012)	(0.013)	(0.012)
Exposed 2nd Trimester	-0.007	-0.005	-0.009	-0.011	-0.012	-0.008
	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)	(0.011)
Exposed 3rd Trimester	-0.017	-0.017	-0.018	-0.004	-0.006	-0.002
	(0.013)	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)
Observations	293,997	285,429	290,075	293,997	285,429	290,075

Note: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each column represents coefficients in a separate regression. Dependent variables are the child's weight at birth in log form (Columns 1-3) and an indicator for the child having low weight at birth (Columns 4-6). Birth weight is in kilogram. Low birth weight is defined as birth weight being less than 2.5 kg. All regressions control for district of residence fixed effects, conception month-year fixed effects, mother and child characteristics, as well as country-specific linear trend. Robust standard errors are clustered at the district level.

Different Categorizations of Control Group – Recall that in our main specification, the control group consists of (i) mothers exposed to armed conflict prior to conception, (ii) mothers subject to armed conflict after the delivery of the baby, and (iii) mothers unexposed to armed conflict. In this section, using our most extensive specification, we first show in Table 5 that our results are robust to different categorizations of the control group. Each column in Table 5 represents a separate regression and the column headings indicate the names of different control groups. Columns 1 through 3 report the results for the log of birth weight while Columns 4 through 6 provide the results for the low birth weight indicator.

As argued in Currie et al. (2019), women exposed to the adverse event before conception can be comparable to those exposed during pregnancy. Therefore, in Columns 1 and 4, our control group (CG-1) includes women experiencing armed conflict up to 10 months prior to conception. We find that exposure to armed conflict during the first trimester decreases the child's weight at birth by 2.5% and raises the incidence of low birth weight by 4.8 percentage points. The effects of exposure during the remaining trimesters are close to zero and statistically insignificant.

In Columns 2 and 5, following Persson and Rossin-Slater (2018) and Matsumoto (2018), we choose the control group as mothers exposed to armed conflict after birth delivery (CG-2). Exposure after delivery should not affect the birth outcomes for these women. Particularly, our control group comprises women experiencing armed conflict up to 12 months after giving birth. With this control group, we continue to detect the adverse effects of first-trimester utero exposure to armed conflict on birth weight outcomes. Specifically, exposure during the first trimester is associated with the reduction in birth weight by 2.7% and the increase in the probability of low birth weight by 3 percentage points. There is not enough evidence for the impact of exposure during the second or the third trimester of pregnancy.

Table 5: Robustness Checks - Different Categorizations of Control Group

	Y=Log Birth Weight			Y=Low Birth Weight (Birth Weight<2.5 kg)		
	CG-1	CG-2	CG-3	CG-1	CG-2	CG-3
	(1)	(2)	(3)	(4)	(5)	(6)
Exposed 1st Trimester	-0.025**	-0.027**	-0.036***	0.048***	0.030*	0.038***
	(0.010)	(0.011)	(0.009)	(0.017)	(0.017)	(0.014)
Exposed 2nd Trimester	-0.010	-0.013	-0.013	0.011	-0.001	-0.010
	(0.015)	(0.013)	(0.013)	(0.017)	(0.016)	(0.013)
Exposed 3rd Trimester	-0.013	-0.012	-0.019	0.007	-0.003	-0.006
	(0.013)	(0.014)	(0.013)	(0.018)	(0.019)	(0.015)
Observations	4,759	5,311	194,287	4,759	5,311	194,287

Note: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. CG-1 denotes control group 1 which consists of mothers exposed to armed conflict up to 10 months prior to conception. CG-2 denotes control group 2 which consists of mothers exposed to armed conflict up to 12 months after delivery. CG-3 denotes control group 3 which consists of mothers exposed to armed conflict either prior to conception or after delivery. Each column represents coefficients in a separate regression. Dependent variables are the child's weight at birth in log form (Columns 1-3) and an indicator for the child having low weight at birth (Columns 4-6). Birth weight is in kilogram. Low birth weight is defined as birth weight being less than 2.5 kg. All regressions control for district of residence fixed effects, conception month-year fixed effects, mother and child characteristics, as well as country-specific linear trend. Robust standard errors are clustered at the district level.

Finally, we incorporate women exposed to armed conflict either before conception or after delivery into our control group (CG-3). As shown in Columns 3 and 6, we still find the detrimental effects of first-trimester utero exposure to armed conflict. Intrauterine exposure to such adverse events within the first three months after conception decreases the child's weight at birth by 3.6% and raises the probability of the child having low birth weight by 3.8 percentage points.

Boundary Issues − Thus far, we have based our analysis on armed conflict exposure at the district level. Particularly, the treatment group consists of mothers residing in a district where the conflict occurred at any time during her pregnancy period. There are two boundary issues associated with this approach. First, the wide dispersion in the size of administrative districts means that the proximity of armed conflict can vary considerably. Let us consider a conflict that broke out in a very large district. Mothers living in that district but far away from the occurrence place of the conflict are still assigned to the treatment group although they were barely affected. Second, mothers living around district borders could be inaccurately assigned the treatment/control statuses. These mothers could experience no conflict in their own district but might be affected by armed conflict in the neighboring district. In our current setup at the district level, they are still considered the control group despite being exposed to armed conflict. The two above-mentioned boundary issues can bias our estimated impacts of armed conflict toward zero.[7] A common method to address these issues is to employ the buffer zone approach. In particular, we create buffers around the mothers' place of residence with a particular radius. Then, we only consider a mother to be exposed to armed conflict if the event occurs within the buffer zone.

For example, if the buffer zone of a mother's residential area is 5 kilometers (km), then the mother is only considered to be exposed to conflict if the conflict occurred less than 5 km away from her residential area. In other words, the maximum influenced zones of conflicts are 5 km. Figure A1 in the Appendix illustrates the idea of buffer zone by zooming into Cote d'Ivoire. The black and gray lines represent the country and district borders, respectively. The blue points are the coordinates of residential clusters. The blue regions circling around the blue points are the buffer zones of 5 km for the clusters. The red arrows point to the locations of all armed conflicts during the period of 1990-2018.

We conduct the sensitivity exercise with various ranges of the buffer zone. Specifically, we create buffers with a radius of 5, 25, and 100 km. One might expect that the estimate should be the largest for the 5 km buffer and the smallest for the 100 km buffer. It is because the closer the proximity to armed conflict, the greater the impacts. The results of this exercise are presented in Table 6. Estimates come from our most extensive specifications. Each

[7] The unaffected mothers would be imprecisely assigned to the treatment group in the first issue. The affected mothers could wrongly be placed into the control group in the second issue. In either cases, our estimates would be biased toward zero because the magnitude of the DiD estimates will be smaller than the actual differences between the treatment and control groups.

column represents a separate regression and the column headings indicate different buffer zones corresponding to different treatment groups. Columns 1 through 3 report the results for the log of birth weight while Columns 4 through 6 provide the results for the low birth weight indicator. As evident from Table 6, utero exposure to armed conflict during the first trimester reduces the child's weight at birth and raises the incidence of low birth weight. Coefficient estimates on the first-trimester exposure indicator are close in magnitude to those in the main results reported in Table 2. The estimates are statistically insignificant and smaller in magnitude for the remaining trimesters.

Table 6: Robustness Checks - Buffer Zone Approach

	Y=Log Birth Weight			Y=Low Birth Weight (Birth Weight<2.5 kg)		
	5 km (1)	25 km (2)	100 km (3)	5 km (4)	25 km (5)	100 km (6)
Exposed 1st Trimester	-0.034***	-0.029***	-0.028***	0.036**	0.034***	0.033***
	(0.010)	(0.008)	(0.008)	(0.015)	(0.013)	(0.012)
Exposed 2nd Trimester	-0.006	-0.007	-0.008	-0.007	-0.011	-0.01
	(0.015)	(0.012)	(0.012)	(0.013)	(0.011)	(0.011)
Exposed 3rd Trimester	-0.014	-0.018	-0.017	-0.001	-0.002	-0.004
	(0.016)	(0.013)	(0.013)	(0.016)	(0.014)	(0.013)
Observations	293,997	293,997	293,997	293,997	293,997	293,997

Note: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each column represents coefficients in a separate regression. Dependent variables are the child's weight at birth in log form (Columns 1-3) and an indicator for the child having low weight at birth (Columns 4-6). Birth weight is in kilogram. Low birth weight is defined as birth weight being less than 2.5 kg. Mother and child characteristics include mother's education, mother's age at birth, child's sex, birth interval, child's birth order, and birth plurality. Robust standard errors are clustered at the district level.

Taken together, our estimated intergenerational impacts of armed conflict are robust to various variable and sample restrictions, different categorizations of the control group, and the employment of the buffer zone approach to resolve the boundary issues.

6 Conclusions

This paper contributes to the literature by estimating the hidden yet persistent cost of conflict to early human capital formation for 53 developing countries experiencing conflict between 1990 and 2018. Drawing from a comprehensive dataset on armed conflict worldwide (UCDP-GED) and a global dataset on child outcomes (DHS-GPS), we employ the DiD approach across districts and conception months-years to estimate the impacts of utero exposure to armed conflict on birth weight outcomes.

We find that intrauterine exposure to armed conflict in early pregnancy imposes adverse ramifications on newborn health proxied by birth weight outcomes. Particularly, experiencing armed conflict during the first trimester of pregnancy induces the mother to give birth to an infant weighing 2.8% less and makes her 3.2 percentage points more likely to give birth to a low birth weight infant. There is not enough evidence for the impacts of exposure during the second and third trimester. Our results are insensitive to various robustness checks.

Exploring the heterogeneity in the intergenerational impacts of armed conflict, we uncover that infants born to poor and low educated mothers are the most vulnerable group. Specifically, poor mothers exposed to armed conflict during the first trimester are more likely to give birth to low birth weight infants by 5.7 percentage points while the effect on non-poor mothers is smaller in magnitude and statistically insignificant. The incidence of low birth weight is 4 percentage points higher for low educated women whereas there is no such negative effect for higher educated women.

Our findings highlight the critical but less apparent cost of conflict. As the negative effects of poor infant health persist into adulthood (Reyes and Manalich, 2005; Black et al., 2007; Oreopoulos et al., 2008; Xie et al., 2019), the adverse impacts detected in this paper emphasize the detrimental ramifications of armed conflict on long-term human capital. As a result, policy interventions before, during, and after the occurrence of conflict are needed to minimize the tremendous cost of conflict. First, the paper calls for global efforts in the prevention of conflict. Investment in peacekeeping troops and the implementation of various economic sanctions as well as aids that are intended to place pressure on the protagonists before military interventions are crucial to prevent the breakout of armed conflict (Dunne et al., 2013). Second, our findings highlight the role of mitigation strategies in ongoing armed conflict. Specifically, the development of non-military forces such as polices, technicians, doctors, etc. could help deal with the immediate cost of conflict. Interventions that seek to raise the nutritional intake of low-income pregnant women who suffer from armed conflict can avert the unfavorable birth outcomes. Third, the study further underlines the importance of post-conflict reconstruction initiatives. Public assistance that aims to improve the welfare of conflict-inflicted children, especially those from disadvantaged backgrounds, should be one of the top priorities. For instance, nutrition assistance programs, free health care for children, reduced school fees can help to partially offset the human capital consequences of utero exposure to armed conflict.