Stillbirths, miscarriages and early losses in armed conflict contexts. The modification effect of violence. The Colombian case

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ABSTRACT

Background: Colombia experienced a prolonged armed conflict that affected differently regions and periods. We explored how this regional violence influenced the well-being of newborns, using data from the National Centre of Historic Memory (NCHM) and the Vital Statistics Survey. The NCHM recorded the number of victims, while the Vital Statistics Survey reported data on births, stillbirths, and early losses. **Aim**: We aimed to assess the impact of regional violence on newborns' well-being and to examine whether mothers' university education mitigated these effects. We focused on comparing two periods: 1998–2002 and 2003–2007, and two group of regions which differed in the intensity and distribution of violence.

Methods: We applied a difference-in-differences approach and logistic regression analysis to estimate the odds of stillbirths and miscarriages in regions exposed to violence during the treated regions. We also estimated the interaction effect between treated groups and mothers' university education.

Findings: We found a significant association between living in the most violent regions and having a higher risk of stillbirths, miscarriages, or early losses (OR: 1.721). Women living in less affected regions had a higher probability of giving birth to live babies and preserving the dyad. However, we observed a negative modifier effect of violence on the likelihood of live births for mothers with university education (OR:1.273).

Discussion: We observed that the effect modification points to a higher impact of stress on mothers with university education in violent regions and periods compared to those without higher education. These findings unveil the concealed impact of regional violence, which diminishes the protective influence of maternal education, regardless of the level attained.

Problem: The scarcity of empirical evidence regarding the causa through which violence modify the shield effect of university education in most affected areas.

What is Already Known: When women are able to complete their university education before giving birth, they are better able to have healthier pregnancies and therefore achieve higher levels of well-being for their newborns.

What this Paper Adds: Pregnant women with university education are likely to be experiencing higher levels of stress compared to those mother with no university education within the most violent regions and periods embedded in armed conflict environments/contexts.

1. Introduction

According to the literature, an integral perspective of newborn well-being within war and armed conflict contexts must put emphasis on analyzing stillbirths (SB), miscarriages (MC) and early loses (Valente, 2015). It is recommended to include pregnancies that had these outcomes in order to clearly observe the effect of violence on early well-being. On this basis, between 1998 and 1997, one of the most violent periods in the last six decades of the Colombian Armed Conflict

(CAC), 197,715 women experienced a miscarriage (MC), stillbirth (SB) or early loses. Guainía (10.39%) with a precarious health system, San Andres (14.98%) a pass through narcotrafic routs to Mexico and the North, Antioquia (5.69%) and Tolima (4.87%), both regions historically held by the paramilitary and urban and rural violence, and Huila (4.66%), the poorest region (with a poverty rate of 64.12%) in 2002 and pass through for the guerrillas, were the regions that had the highest rates of SB-MC and early loses. Furthermore, Cordoba (32.87%) highly affected by poverty and forced displacement, Tolima (11.54%) and

Caldas (18.52% - located between Antioquia and Tolima) had the highest rates of violent or inexplicable losses, according to the Vital Statistics Survey.

The scientific community has recognized that an armed conflict context is a threatening and turbulent environment for healthy pregnancies, early childhood well-being, and people's life courses in general (Castro Torres and Urdinola, 2019; Duque, 2017; Hong et al., 2021; Ramos Jaraba et al., 2020; Lee, 2014; Mendoza Tascón et al., 2016). We build upon this sociological premise by examining the case of the turbulent environment reigning in Colombia between 1998 and 2002. During that period, compared to the 121,844 victims between 2003 and 2004, 16,607 more people were victims of one of the eleven (11) categories of violent acts in armed conflict: actions of war, murders, attacks on the population, terrorist attacks, damage to public goods, forced disappearances, mass murders, antipersonnel mines, recruitment of children, kidnappings and sexual violence. Hence, our starting point is the fact that regions and pregnant women were highly exposed to different levels of violence. The combination of war and social inequality in health and education likely led to different but even higher levels of stress manifested in stillbirths, miscarriages (SB-MC) and early loses. Despite the lack of data and the low intensity and reach of the CAC, we show that due to the sharp slope of violence experienced between 1998 and 2002 and the combination of available data, the regional impact of violence on the well-being of newborns could be estimated.

We noticed the existence of several unobserved factors at the regional level and across women that should be included in further explorations, including household living conditions, quality of subnational health systems, maternal clinical stories. Therefore, and because of the structure of the Vital Survey, we approach the issue from a difference in difference fixed effects model adjusting for the standard errors of a cluster of 330 regions-year-violence estimators (one for each of the 33 regions and the 10 years). First, we compute the regression coefficients for a SB-MC comparing two group of regions (Most affected and less affected) in two different periods (1998–2002 and 2003–2007); furthermore we use a matching technique to compare two regions, Meta and Tolima (one highly affected and the other one low affected) in the same periods than in the first model. Both models estimate the interaction and the *modification effect* between regional violence and a mother's university education. We control for other maternal demographic features such as age, area of residence, an approximation of socioeconomic stratification as health insurance, and marital status. We focus on a mother's university educ ation and complement the evidence gathered by other researchers in Colombia (Márquez-Beltrán et al., 2013; Ramos Jaraba et al., 2020) concer ning maternal higher education and outputs related to newborn infants.

2. Stillbirths, miscarriages and early loses

According to the World Health Organization, it is estimated that every year, 2.6 million stillbirths occur. A stillbirth is understood as the death of an unborn baby after 28 weeks of gestation, before birth or during it (Allanson et al., 2016). A miscarriage is understood as when this happens before 28 weeks of gestation. Approximately 40% of all stillbirths occur during the birth process (Allanson et al., 2016; World Health Organization. (n.d, 2023), and between 10% and 15% of miscarriages are experienced by women who knew they were pregnant (Purdie, 2019). The causes explored by medical and health research concern complications in labor, post term pregnancy, maternal infections such as malaria, syphilis and HIV, and maternal conditions, especially hypertension, diabetes, and fetal restriction. Likewise, global research has found that for low and middle income countries, the causes for 43.7% of stillbirths were unexplained, 18.7% were due to an unspecified condition, 13.7% due to a placental condition, 11% due to a specific fetal/pregnancy pathology, 9.1% due to an antepartum hemorrhages, and 3.8% to other known causes (Reinebrant et al., 2018).

Most of the cases of stillbirths (98%) occur in low-income and middle-income countries (Almasi-Hashiani et al., 2017). The consequences go beyond the newborn well-being, and imply psychological consequences for women, especially women in vulnerable conditions in terms of exposure to stress (Allanson et al., 2016).

Recently, a ten-country case study presented insights concerning women's and children's health services in armed conflict contexts such as Afghanistan, Colombia, Democratic Republic of the Congo, Mali, Nigeria, Pakistan, Somalia, South Sudan, Syria, and Yemen (Singh et al., 2021). They found that despite the variations in policies and local conflict dynamics, in all the contexts, the health measures present included the following: antenatal care, basic emergency obstetric and newborn care, comprehensive obstetric and newborn care, immunization, infant and young child feeding and nutrition, treatment of common childhood illness, and screening (Singh et al., 2021). The study presented evidence to recognize that armed conflict contexts are a complex scenario in terms of variables linked to data concerning women's and children's health, and other contextual and demographics considerations. Nevertheless, health science studies make it clear that one common issue in terms of health policy was that in the ten countries, the women's and children's health services lack tools specifically designed to help women and children, or interventions to address stillbirths and they are often included in general reproductive, newborn, and adolescent health services (Singh et al., 2021).

3. Maternal university education

Beyond the medical and health causes of well-being distress during the in-utero, antenatal, and pregnancy period, there are other demographic factors that are likely to impact women's pregnancies that drive the newborn well-being. Empirical research conducted in Iran presented evidence about the probabilities of stillbirths when considering parental demographic features such as education or age (Almasi-Hashiani et al., 2017). There was a significant increase in the odds for stillbirths for mothers between 15 and 25 years of age, and for those with lower economic status (Almasi-Hashiani et al., 2017). Complementary research conducted in Canada has shown evidence of the protective effect of maternal education to avoid stillbirths (Luo et al., 2006). Along the same lines, other research in Australia has shown the high distribution of stillbirths among mothers with lower levels of education and those with public health insurance (Journal of Pediatrics and Child Care, 2019). For instance, the literature suggests that socioeconomic inequality in terms of access to higher levels of education and health services are likely to diminish in-utero well-being. Complementary to this, there is scientific evidence that leverages the direct and significant correlation between university education and antenatal tests and pregnancy monitoring. This finding, among the widely acknowledged of socioeconomic benefits for having university education, make it plausible that levels of knowledge about pregnancy and birth might be correlated to the mother's higher educational profile or higher educational levels, thus leading to those with a university education taking more care of their health during their pregnancies. Nevertheless, it is also recognized that war, armed conflict and high levels of social inequality open up a completely different scenario in terms of obtaining a university education.

On the other hand, scholars have noticed the negative and significant correlation between vectors of violence and a mother's university education. In the CAC, the more violent the region or municipality, the fewer the mothers with a higher education (Duque, 2017). Even though there are health and demographic studies available on newborn health, specifically for Colombia, it has been impossible to find any relevant quantitative evidence when considering the number of SB-MC and maternal demographic features such as maternal university studies. This, according to literature is a critical point if we really aim to assess the impact of violence on newborn well-being in such turbulent, violent and unequal contexts as Colombia in 2002.

4. A turbulent environment for in-utero well-being

Defining the Colombian context as a fragile one leverages the coexistence of diverse violent dynamics across regions (Echandía Castilla, 2006). Along these lines, scholars suggest that because of the CAC, access to basic health and university education remains worsen in some regions and overall in rural areas (Pacheco, 2020). More importantly, respect for the rights of children and the development of their capabilities decreases in these more fragile contexts (Pómez Rueda and Sánchez Pómez, 2011). Families and entire municipalities have been the target of violence all through history (Arias Nieto et al., 2009). For instance, in some regions the positive correlation between fertility and armed conflict evinces sexual harassment as a practice of terror within war. Hence, the terrible consequences for women and newborn infants (Castro Torres and Urdinola, 2019). Deprivation can start in the mother's womb for the children of women living in the most affected regions, as a result of potential rapes and violence (Castro Torres and Urdinola, 2019). Other evidence strongly suggests that during pregnancies, families and mothers living in municipalities and towns exposed for prolonged periods to violent dynamics and social inequality are transferring traumas and deprivation to their children, causing neurological and developmental delays (Duque, 2017). Specifically, in turbulent environments, families might be buffering the violence that is everywhere by increasing physical aggression to their children (Ramos Jaraba et al., 2020). Fortunately, according to the literature, this transmission of inequality through the mechanisms of antenatal stress could be prevented, or at least tackled, if families and pregnant women could be taught how to manage stressful situations and have access to antenatal medical care. For instance, by practicing meditation or mindfulness. As shown by some scholars (Urizar et al., 2019), prenatal cognitive-behavioral stress management (CBSM) interventions are likely to improve stress outcomes among low-income pregnant women and perhaps infant health outcomes in the short and long term.

5. The period of 1998 and 2002

Between 1998 and 2002, the military reform carried out by the Pastrana government, although inconclusive, prevented the FARC from fulfilling their "strategic plan," which would have allowed the guerrilla group to transition to another phase of the war and expand its territorial dominance significantly(Echandía and Cabrera, 2017). Despite the Armed Forces' regaining their combat capabilities lost in the previous four years, the actions of the guerrilla escalated at a higher proportion, resulting in an unfavorable balance of forces in the confrontation for the State (Echandía and Cabrera, 2017). Additionally, it is important to note that paramilitary groups contributed to containing the guerrilla's advancement and, in many regions, pushed them back. Particularly in the northern part of the country, paramilitary organizations occupied territories, assassinated suspected sympathizers and militants of the insurgency, and resorted to terror to intimidate the population (Echandía and Cabrera, 2017). The following Fig. 1 shows better the high violent activity within this period. As depicted in Fig. 1, when instrumenting our regional violence indicator, it becomes evident that there is a clear upward trend in the national mean between 1998 and 2002, followed by a declining trend between 2003 and 2007. This rising trend between 1998 and 2002 coincide with violent acts a dynamics entitled in the FARC's greatest success in executing its "strategic plan", precisely during the peace process with the.

Pastrana government, with the backing of broad sectors of society who saw negotiation as the only way to contain the guerrilla's advance over national territory (Echandía and Cabrera, 2017). In November 1998, Mitú, the capital of Vaupés department, was taken by assault, resulting in the death of 16 members of the security forces and the kidnapping of 61 more. It is noteworthy that while the assault on Mitú
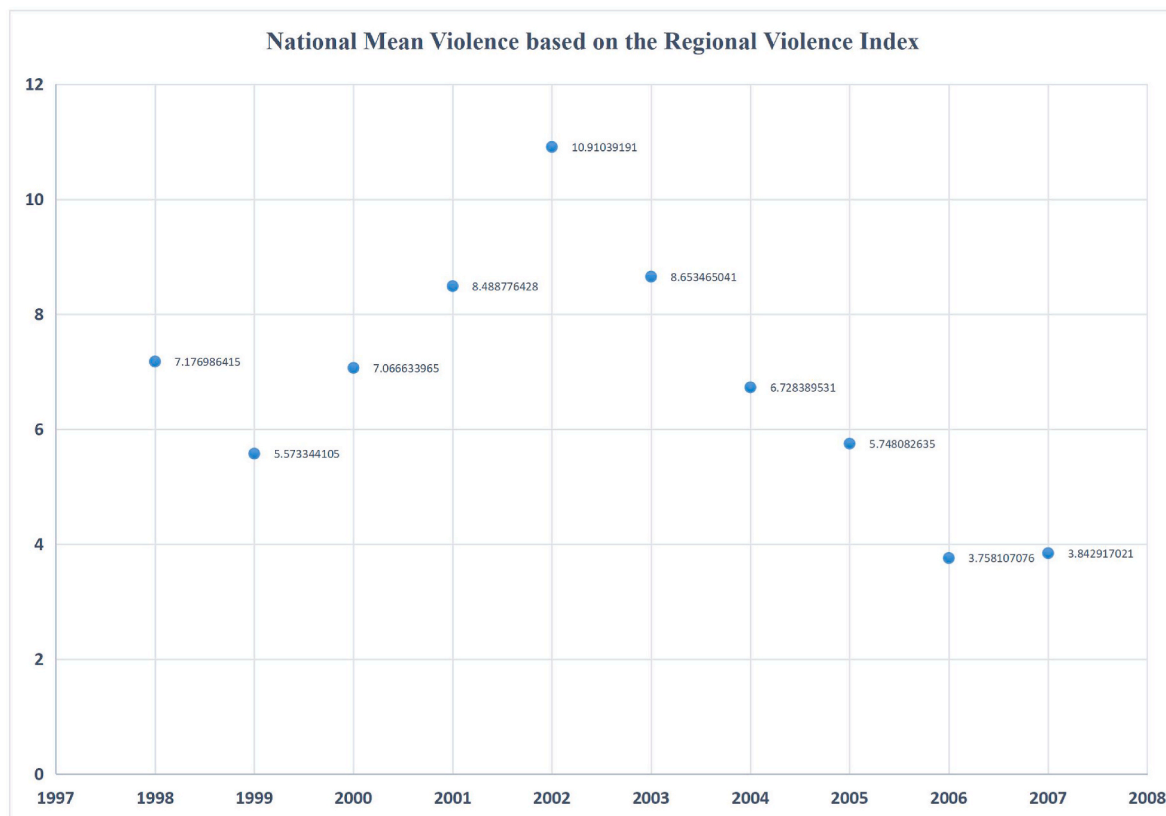

Fig. 1. Human Victims INDEX as approx of regional violence for the period of (1998 - 2007). Source: Own elaboration on National Centre of Historic Memory (NCHM) data bases on the eleven categories of violent acts plus the forced displacement databases of the Victims Unit.

represented the most significant achievement for FARC, its subsequent recapture in a joint operation by the Police and the Army marked the beginning of a series of successful operations against the guerrilla, resulting from a military transformation process with the cooperation of the United States (Echandía and Cabrera, 2017). The military reform which strengthened the Colombian state institutionally, doctrinally, and technologically to confront irregular groups frustrated FARC's goal of achieving strategic balance and tactically using the scenario for peace negotiations in the municipalities of San Vicente Caguán (Caquetá) and Uribe, Mesetas, Vista Hermosa, and La Macarena (Meta) (Echandía and Cabrera, 2017).

As evidenced by the available data of tha NCHM, during the negotiations with the Pastrana government, the FARC escalated their armed actions, mainly in the departments of Arauca, Caquetá, Putumayo, Meta, Cundinamarca, Nariño, Cauca, Valle, Chocó, Magdalena, and the Montes de María region located between the departments of Sucre and Bolívar. In 2002, when the peace process broke down, the FARC reached its peak in terms of violent activities (Echandía and Cabrera, 2017). On the other hand, during this period, the ELN conducted the highest number of actions in its history, mainly in the departments of Arauca, Santander, Antioquia, Magdalena, Norte de Santander, and Casanare, seeking to pressure the demilitarization of a zone for peace negotiations with the government (Echandía and Cabrera, 2017). Additionally, the Armed Forces engaged in increasingly frequent combat with both the FARC and the ELN. The State's major efforts in the fight against armed groups are evident in the fact that combats surpassed the actions carried out by guerrilla groups in Meta, La Guajira, Guaviare, Quindío, Córdoba, Guainía, and Vaupés, as shown in the attached graph and map. The declaration of the Montes de María region and the Arauca department as priority zones for the "Policy of Defense and Democratic Security" in September 2002 marked a turning point in the dynamics of armed confrontation, ultimately contributing decisively to creating the necessary conditions for achieving negotiated peace with the FARC (Echandía and Cabrera, 2017).

6. Hypotheses

6.1. (Regional violence)

Exposure to high levels of violence during pregnancy increases the risk of stillbirths and miscarriages. Hence, women who lived in the most affected regions within the most violent period of the Colombian Armed Conflict were more likely to loss their babies.

6.2. (The modifier effect)

University education is a protective factor for newborn well-being during pregnancy, as it increases the odds of having a live birth. However, regional violence reduces this protective effect and affects more severely those mothers with university education or not informed educational level.

7. Data

Our data has a multilevel structure, with pregnant women/newborn infants nested in 33 regions, including Bogota, and 10 years. Although the survey has a multilevel structure, our quantitative technique of analysis enables us to estimate the impact of violence while accounting for the standard error between regions and accounting for the weight of regions within the Vital Statistics Surveys. Thus adjusting for standard errors across the 330 regional clusters.

As previously mentioned, the paper uses secondary data sources from the Vital Statistics Surveys (VSS) between 1998 and 2007, which are a cross-sectional surveys that has been conducted annually since 1998 for the National Statistics Department of Colombia (DANE). The VSS has been used extensively to examine the characteristics of key events

regarding newborn infants' health. The survey aims to collect information concerning certain events which occur in the event of giving birth to a baby. The data collection is based on formats that have been designed according to international standards and country characteristics. The process involves sub-national entities and sub-national health dependencies. Once the "vital statistics register" for each newborn has been generated within each region, the information is collected by the DANE. As per international standards, the survey is randomized and passes through a rigorous statistical quality control. Even though there are more recent VSS, the period of analysis was selected to take into account considerations regarding violence and high levels and low levels of violence in two diferent periods. This makes up the specific scenario for our experiment. Thirty-three (33) regions were surveyed in ten (10) years, including Bogota which had the largest sample, with 16.40% of the total, followed by Antioquia with 13.88%. The other regions had less than 6% of the sample, except for Valle del Cauca (8.56%). The model was enhanced by incorporating a weighting command.

We computed a human victims' index by merging data on Colombian Armed Conflict and regional violence, based on the databases from the National Centre for Historic Memory (NCHM's) that record the human victims of eleven violent acts from 1998 to 2007. These databases are organized by region and by year. This allowed us to estimate the level of regional violence.

8. Methods

We applied the methodological approach of (Cozzani et al., 2022), which measured the effect of the Madrid train bombings on pregnancy outcomes using a difference-in-difference technique. We assessed the impact of regional violence on the odds of having a miscarriage or stillbirth, controlling for the interaction between the treatment status and maternal education. We compared the risk of women living in regions with high and low exposure to the violence. We also contrasted Meta and Tolima, two regions with similar characteristics and survey weights but different levels of violence.

For the estimation of the regional level of violence index we divided the number of human victims by each region's population in that specific year. Thus, to be able to compute the rate of violence by region by assessing the number of victims and its weight based on each region population. The eleven documented categories of violence include actions of war, kidnappings, mines, selective murders, mass murders, damage to public goods, population attacks, death of civilians by armed actions, sexual harassment, forced disappearances, children in war and terrorist attacks. It is essential to mention that all actions have equal weighting in the computation of the indicator. We embed this regional index of violence in the VSS of unborn babies SB-MC and early losses, as well as in the VSS of newborn infants.

Our response variable Y will be a binary indicator that takes the values 0 and 1. The "logit" model is a model for the log-odds of the probability that $Y = 1$. Thus, the log-odds to $Y = 1$. We will be then computing the odds for being an unborn baby, or early lost (0 = Live birth; 1 = SB-MC and early loss). The explanatory variables used by our research are the DID estimator and the mothers' university education level, and their interaction coefficient. We include an educational category for mothers who did not disclose their educational level in the survey. The reason for this was to have a reference line compared to those for whom we were sure did or did not have university education. Even though we could not know their educational level, we do acknowledge the fact that in this violent context, the information collected reflects unobservable individual and administrative factors and reasons, which in this case are clearly affected by regional violence in different ways. Hence, having a different category in which we do not know a respondent's education level allows us to observe reasons other than education level. Mainly, within the VSS for unborn babies, 19,0.71% of the women did not disclose their education levels in the survey. This must be explored in further research, delving into the

Table 1
Difference in Difference logistic regression coefficient estimates and standard errors on the log of odds of stillbirth or miscarriage.

	Log odds for a SB-MC Regions most Affected N = 5,778,397		Log odds for a SB-MC Meta and Tolima N = 381,823	
	1a	1 b	2a	2 b
Violent Period (1998–2002)	- 0.5308 *** (0.0728)	- 0.5299*** (0.07283)	−0.3645*** (0.1044)	−0.3651*** (0.1048)
Treated Regions	−0.4653*** (0.0849)	−0.4650*** (0.0848)	−0.760*** (0.0066)	−0.076*** (0.0065)
University Education	−0.7023 *** (0.0216)	−0.6902*** (0.0230)	- 0.6491 (0.0454)	−0.6326 (0.0461)
Not informed	3.5012*** (0.4462)	3.5862 *** (0.5081)	2.046*** (0.45)	1.992*** (0.456)
Married or Having a Partner	−0.5485*** (0.0182)	−0.5485*** (0.0182)	−0.5148*** (0.0242)	−0.5147*** (0.02427)
Average Age in Years	1.0362*** (0.0011)	- 1.036*** (0.0011)	−1.039*** (0.0014)	1.039*** (0.0014)
Urban Housing	1.2375*** (0.0496)	1.2376*** (0.0496)	1.7517*** (0.095)	1.7516*** (0.095)
Health Regime and formal Job Status				
Contributor - earning at least 1 MLWS	base line	base line	base line	base line
Subsidized - no income or under 1 MLWS	1.5941*** (0.0948)	1.5932*** (0.0946)	2.727*** (0.287)	2.723*** (0.286)
Beneficiaries - by couple or parent	2.1027*** (0.1656)	2.1013*** (0.1653)	3.246*** (0.4198)	3.242*** (0.4193)
Particular or no job - paying	−0.7347 (01423)	−0.7370 (0.1427)	2.063 (0.9358)	2.053 (0.9327)
None	6.170*** (0.7652)	6.1684*** (0.0.7646)	4.9647*** (1.809)	4.9563*** (1.805)
DID - Difference in Difference Estimator	1.6899*** (0.3787)	1.721961*** (0.3824)	4.000*** (1.093)	3.7689*** (1.068)
Interaction Effect (DID - UNIVERSITY)		1.273** (0.115)		1.8621*** (0.2356)
University				
Not infomed		−8097 (0.1333)		1.680*** (0.4360)
Intercept/Constant	0.00932*** (0.0009)	0.00932*** (0.0.0009)	0.0123*** (0.0011)	0.0123*** (0.0011)

Own elaboration, based on the National Health Statistics Survey of 1998–2007, and National Centre of Historic Memory databases.
Coefficients Standard errors in parentheses - Significance, ***p < 0.01, **p < 0.05, *p < 0.1.
Marginal effects on the log of odds are constant, while the predicted probabilities are not. Thus, we choose a baseline for each variable, computed as a value that is covariant to the output.
Note: control variables are Health Regime, Marital Status, Age and Urban location.

reasons why there are a great number of mothers who did not disclose their educational levels.

To examine the impact of regional and temporal violence, we employ a Difference-in-Differences (DID) estimator. For our comprehensive analysis, we focus on newborns born between 1998 and 2007 in the 32 regions. We categorize them into four groups. The first two groups are based on treatment periods: i) Newborns and losses during the most violent period between 1998 and 2002, and ii) Newborns and losses after the most violent period, from 2003 to 2007. The second set of groups focuses on treated regions: i) Regions heavily affected by violence, as indicated by the regional violence index (Antioquia, Guaviare, Norte de Santander, Choco, Putumayo, Meta, Caquetá, Casanare, Arauca, Cesar, La Guajira, Magdalena, and Vaupez), and ii) Less affected regions excluding Bogota (Amazonas, Atlantico, Bolivar, Boyaca, Caldas, Cauca, Cordiba, Cundinamarca, Guainia, Huila, Nariño, Quindio, Risaralda, Santander, Sucre, Tolima, Valle del Cauca, San Andres). In a separate model, we narrow our focus to Meta and Tolima regions and employ the same methodology.

The estimation of DID parameters is conducted using logistic probability models with fixed effects for regions and years. Specifically, we employ a logistic difference-in-differences (DID) model to assess the causal impact of the treatment on the log odds for a SB-MC. In this model, the treatment variable, denoted as Treated_R, indicates whether the mother belongs to the treatment group or not. The time variable, Time, distinguishes observations within the violent period from those outside it. The DID variable captures the average treatment effect on the treatment group in the violent period. To account for potential confounding factors, we include additional covariants that may influence the outcome, such as University, Health, Age, Couple, and Urban. Moreover, we introduce an interaction term between DID and University to examine whether the treatment effect varies based on the mother's educational level.

In this general logistic model, *Y* is the log odds of the baby being born alive or not, *i* is the newborn/pregnant women living in region *j*. The first component of the model, β_0, is the intercept or the mean value of the log odds when all explanatory variables are zero. β_1 is the average effect of the violence on the treatment group before the intervention.; β_2 is the effect of violent period on the log odds.; β_3 is the average effect of regional violence on the most affected regions during the most violent period. This is the parameter of interest that measures the causal impact of the treatment. β_4 is the effect of the mother's educational level on the log odds; β_5 is the interactive effect between treatment and mother's educational level on the log odds; β_6 is for her health insurance regime (based on Law 100 of 1993, five inferred categories of income and health access); β_7 is the mother's age (on average 12, 17, 22, 32, 37, 42, 47 or 52 years old); β_8 for her marital status (having a partner/husband or not); β_9 is the effect of urban or rural municipal location on the log odds. Finally, u is the error term that captures variations not explained by the model. We are weighting observations by Region, and clustering standard errors by 330 measures of violence, one for region in each year, which represents region-year pairs. This implies that we are assuming that there is heterogeneity in treatment effects across regions and correlation in errors within each region-year. We conduct two models: i) comparing two group of regions, most affected (above the regional mean violence) and less affected (under the mean); and ii) comparing Meta and Tolma. This is due to the similarity and weight of those regions within the surveys and their opposite level of violence.

9. Results

Table 1 presents the coefficient and the standard errors for the two pair of models. All the range of variables were included in the four logistic regression models. However, only models 1 b and 2 b included the estimation of the interaction effect between the DID coefficient and the

$$\text{Log Odd Prob}\left(Y_{ij}\right) = 1 = \beta_0 + \beta_1\left(Treated_j\right) + \beta_2\left(Time\right) + \beta_3\left(DID_j\right) + \beta_4\left(University\right) + \beta_5\left(DID_j \times University\right) + \beta_6\left(Health\right) + + \beta_7\left(Age\right) + \beta_8\left(Couple\right) + \beta_9\left(Urban\right) + u$$

mother's university education level.

In four models, we observe that the (DID) estimator significantly amplifies the negative impact on newborn well-being, as indicated by an increased log odds of not being born alive (OR: 1.6889 in 1a and OR: 4.00 in 2a), and (OR: 1.7219 in 1 b and OR: 3.678 in 2 b). These findings provide support for our initial hypothesis regarding the detrimental effect of high levels of violence during pregnancy on fetal outcomes. Even the coefficients for the interaction term were indicating the worsen conditions within those contexts (Models 1 b and 2 b). Hence, women residing in regions heavily affected by the CAC were at a heightened risk of experiencing stillbirths and miscarriages, as our first hypothesis of regional violence state.

Concerning mother's university education, the log of odds for SB_MC in four models was indicating always significantly improving the newborns well-being (OR: −0.7023; OR: −0.6902; OR: −0.649; OR: −0.632). Mothers who did not disclose their education level showed a disadvantage in four models (OR: 3.50; OR: 3.58; OR: 2.04; OR: 1.99). This suggests that a university education significantly increases the log of odds of a respondent's pregnancy resulting in a live birth, when the interaction effect is zero (0). Hence, proving the previous findings regarding the advantage of maternal university education for newborns well-being, without considering the impact of violence.

In models (2a and 2 b), we conduct a comparative analysis between Meta (highly affected) and Tolima (low affected) using a matching strategy that took into account survey weights and socioeconomic conditions and development features between the two regions. The aim was to assess more clearly the impact of violence and the influence of maternal university education in two similar regions with oposite levels of violence, Tolima (5.4) and Meta (14.7). Our findings reveal that the (DID) estimator significantly amplifies the negative impact on newborn well-being, with mothers in Meta, being more susceptible to experiencing stillbirths or miscarriages (Or: 3.7 in model 2 b).

In both models (1 b and 2 b), when considering the interaction effect, the effect of a mother's university education is modified by the DID estimator variable (regional-period of violence) and strongly in the matching model for case of Meta. This is statistically known as the *effect modification* (Pekka et al., 2004). In this case, regional violence modifies the effect of a mother having a university education on the log of odds of experiencing a stillbirth, miscarriage (SB-MC) or early loss. As mentioned before, for all four models, the regression coefficient indicates that having a university education reduces the risk of losing the baby while not considering the *effect modification*. However, the interaction implies the opposite, thus diminishing/modifying the protective/shielding effect of a university education (OR: 1.27 in 1 b and OR: 1.86). For women who did not informed their education level (OR: 0.80 not significant in 1 b and OR: 1.68 singnificant in 2 b). We noticed that when computing the interaction, the effect on newborn well-being of their mother having a university education depends on violence (i.e., the effect is not always the same, but changes according to the degree of regional violence and period of exposure). Across the two models (1 b and 2 b), the interaction shows the effect modification as mothers with university education, but greater in magnitude in 2 b. A mother's university education is modified by DID, regional-period violence.

When considering the control variables, the health insurance regime as an approximation of socioeconomic status and inequality (i.e., whose health insurance is subsidized by the state due to their vulnerable economic status, such as not having a job or earning less than the minimum wage), shows that was always better to have a job thus belonging to the Contributive regime (the base line category), The most affected women were those women who did not belong to a health regime or had any health insurance (OR: 6.1 for model 1 b and OR: 4.47 for model 2 b). According to the results, mothers who were married or living with a partner were significantly more prone to having a live birth and avoid a SB-MC (OR: 0.548 in 1 b and OR: 0.51 in 2 b)). For those women living in and urban settlement, the odds of SB-MC were always and significantly higher compared to those living in rural areas (OR: 1.23 in 1 b and OR:

1.75 in 2 b). Likewise mother's age, an increment in the log of odds of experience a SB-MC (OR: 0.36 in 1 b and OR: 0.39 in 2 b). Fig. 1 illustrates the marginal effect of maternal education over the predicted probability of SB-MC by regions and university education levels. It also shows the variation by the categories of the DID estimator.

Fig. 1 highlights the stronger effect modification of the DID estimator on the correlation between mother's education and newborns' well-being. This effect is particularly pronounced for mothers with university education residing in the most affected regions between 1998 and 2002, including Antioquia, Guaviare, Arauca, Norte de Santander, Cesar, Meta, Casanare, Caquetá, Magdalena, La Guajira, Vaupez, and Putumayo. In these regions, the marginal effect on the predicted mean of mother's university education substantially decreases due to the heightened levels of violence.

Consistent with our second hypothesis, we observe that pregnant women with university education who lived in regions that were less affected by violence and between 2003 and 2007, such as Tolima, Huila, Nariño, Cundinamarca, Boyacá, or Atlántico, were more likely to effectively cope with and reduce the harmful residual effects of violence on their stress levels compared to those residing in the most affected regions during the earlier period of 1998 and 2002. These findings provide valuable insights into the differential impact of violence on pregnancy well-being and suggest the significance of region-specific interventions in promoting better health outcomes during pregnancy. In Fig. 2, we apply a similar approach as in the previous analysis but now with the matching strategy for models 2a and 2 b, which involves comparing the regions of Meta and Tolima. Notably, the DID estimator correlation coefficients exhibit a stronger effect modification on university education for women residing in Meta, as opposed to those living in Tolima, during the treated period of 1998 and 2002. This finding sheds light on the differential impact of the conflict on maternal well-being and educational attainment in these two regions.

The three categories of women with varying education were differently modified by regional violence, suggesting that mothers with university education were also highly impacted by regional violence, reducing their educational advantages. Furthermore, when computing the interaction coefficient for Meta and Tolima, the effect modification was high enough to erase the shielding and protection effect of having a university education from those who did not have university education but no from those with unknown education. Hence, we suggest that there are unobserved factors within the category of women that have not disclosed their level of education, mainly in the VSS for unborn babies, stillbirths, miscarriages and early losses.

The cause of this effect modification may be caused by the lack of state presence and capacity to make those regions safe and invest in the more severely affected regions to improve macroeconomic features such as employment or even access to higher education. Here, the effect modification leverages the diminishing trend of university education shielding newborn well-being, which is slightly decreasing due the higher levels of regional violence during that period (1998–2002). The effect modification of regional-period violence reduced the shielding/protective effect of university education on the log of odds for newborn well-being. Proving our second part of the first hypothesis. As mentioned above, between 1998 and 2002 those regions that were most affected by violence were highly turbulent for pregnant women with a university education. In contrast, within regions less affected by violence between 2003 and 2007, such as Tolima, Atlántico, Cundinamarca, Nariño, and Huila, we observe that mothers with university education were more successful in protecting the dyad and ensuring newborn well-being. Furthermore, our analysis indicates that regional violence had a more pronounced effect on women with university education compared to those who did not disclose their education levels or had no university education.

Given these significant findings, further research is needed to comprehensively understand the complex interplay between regional violence, maternal educational levels, and its impact on maternal and
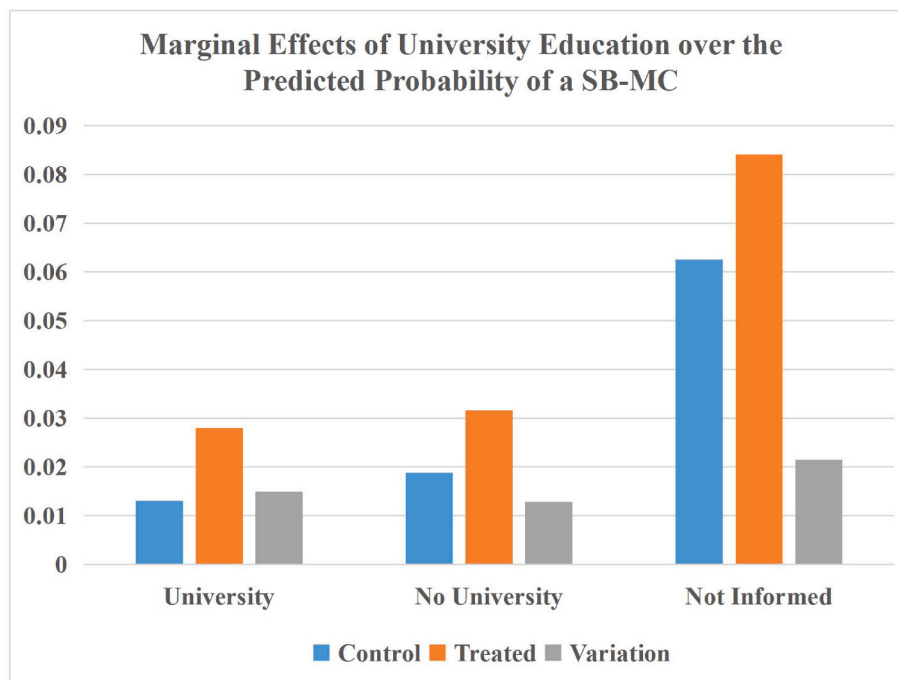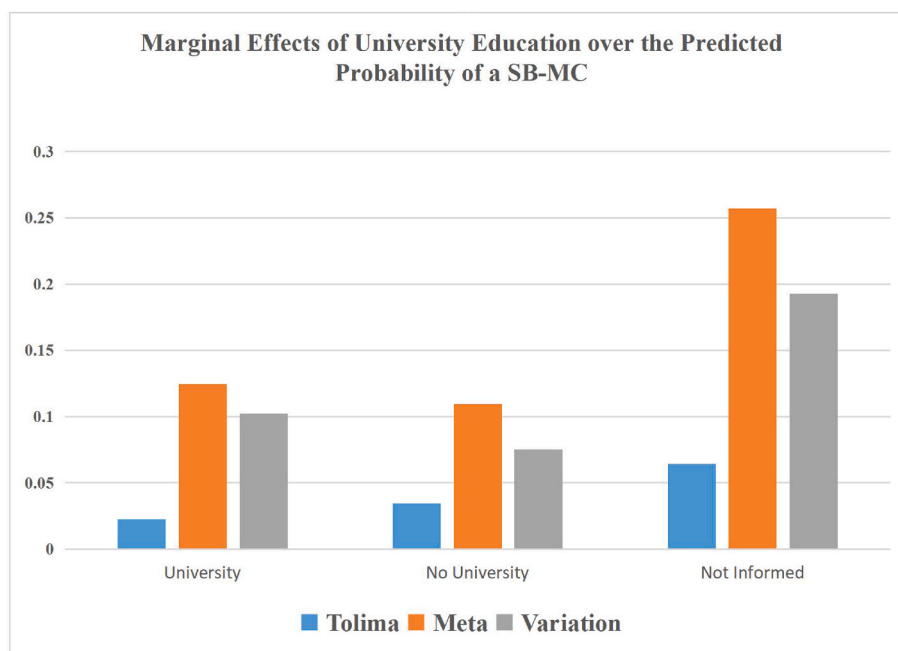
Fig. 2. Marginal effects on the log of odds are constant, while the predicted probabilities are not. Thus, we choose a baseline for each variable, computed as a value that is covariant to the output in Table 1 (Model 1 b).
Source: own elaboration, based on the coefficients of Model 6 in Table 1

newborn health outcomes. These insights can pave the way for targeted interventions and policies to safeguard the well-being of pregnant women and newborns in regions affected by violence.

9.1. Testing the cross-level interaction, modifier effect of violence on maternal education

Fig. 3 presents the results of the interaction and effect modification between treated regions-periods (DID estimator) and mothers' educational level. For this, we obtained the marginal effects of the interaction effect on the probabilities of experience a stillbirth or miscarriage in the DID logistic model.

Regardless of the mothers' university education, the level of regional violence will always marginally decrease the probability of being born alive. However, in the (Not mentioned) category, the significance levels of the cross-level interaction effect modifier are way higher. That is,

Fig. 3. Marginal effects on the log of odds are constant, while the predicted probabilities are not. Thus, we choose a baseline for each variable, computed as a value that is covariant to the output in Table 1 (Model 2 b).
Source: own elaboration, based on the coefficients of Model 6 in Table 1

those mothers who did not report their educational level were the mothers who were most affected by the level of violence. Despite this finding, we must say that although the shielding effect of university education was affected by the effect modification of violence shows a steeper slope than those mothers with no university education (see Fig. 4), it is also true that those mothers with a university education continue having marginally more likely to give birth to an alive son/ daughter, as shown in, the red line, which is under the blue line (no university education) and the green line (Not mentioned) (see Fig. 4). However, in the matching models of Meta and Tolima this is not the case (see Fig. 5). Fig. 5 illustrates the detrimental trend due to the modification effect of violence over mother's university education when comparing Tolima and Meta.

Here in Fig. 4, the interaction between the DID estimator and university education for pregnant women residing in the Meta region compared to those living in Tolima evidence the higher impact of the modification effect of violence over mother's university education thus on newborns well-being. This matching technique allows us to clearer observe the impact of violence on newborns' well-being by diminishing the protective effect of university education during pregnancy in preventing stillbirths and miscarriages. Our findings suggest that the effect modification has a more significant impact on women with university education, evidenced in the steeper slope and increased marginal effects of experiencing a stillbirth or miscarriage compared to women without university education living in the same region, specifically in the case of Meta.

10. Discussion

The results suggest that mothers with university education were more likely to have a live birth than those with no university education and those with unknown education level when the effect modification of violence was not estimated. Nevertheless, when considering the interaction between the DID estimator and mother's education level, we tested that the effect modification of violence on the correlation between maternal university education and newborns well. being. We noticed that a diminishing in the shield/protective effect of university education

making it practically insignificant compared to those mothers without university education. For the case of Meta and Tolima this effect modifier transform the advantage of having university education in a disadvantage. Previous findings should be further explored, considering potential correlations between the mother's demographic features and other contextual variables such as poverty, unemployment and the performance of health services. Nevertheless, it is aligned with previous research in terms of the impact of violence in newborn outputs considering the high levels of stress occasioned by violence but differ in terms of socioeconomic stratification spread marginal effects (Cozzani et al., 2022; Duque, 2017; Jaraba et al., 2020; Lee, 2014; Valente, 2015).

However, we suggests that the effect modification of violence increases for mothers with university education, primarily due to significant mismatches between the region's socioeconomic and demographic reality and women's expectations. Additionally, in most affected regions there are potential obstacles to employability and investment in highly skilled work due to the lack of security and state presence in those regions affected by violence. The prevalence of high levels of violence makes it more challenging for highly educated women to find suitable employment during periods of armed conflict. Moreover, regions with less violence tend to experience less migration of investments due to safer conditions for businesses, leading to a higher likelihood of finding employment for individuals with sophisticated knowledge. Furthermore, in regions and periods of high violence, the odds of completing university studies before giving birth might be significantly lower compared to regions that are less affected by violence, such as Tolima. This results in a lack of opportunity to face adversity more effectively and achieve progress by having university studies before giving birth and during the first year of a newborn. This is worse in highly privatized higher education systems such as the one in place in Colombia, were student's loans are the general condition to access to university education. However, after the test of the interaction effect, we state that mothers who have university education were more able to tackle adversity in the group of regions treated, thus shielding the dyad, overall, when they were living in regions that were less affected by the armed conflict. This was not the case for the matching model between Meta and Tolima, were women with uniersity education passed to be
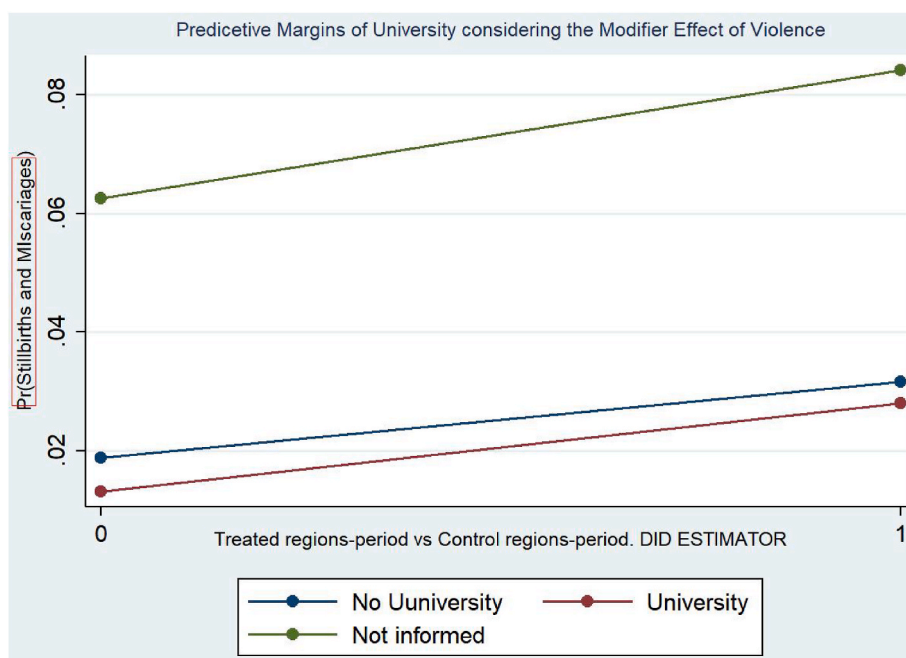

Fig. 4. Marginal effects on the log of odds are constant, while the predicted probabilities are not. Thus, we choose a baseline for each variable, computed as a value that is covariant to the output in Table 1 (Model 1 b).
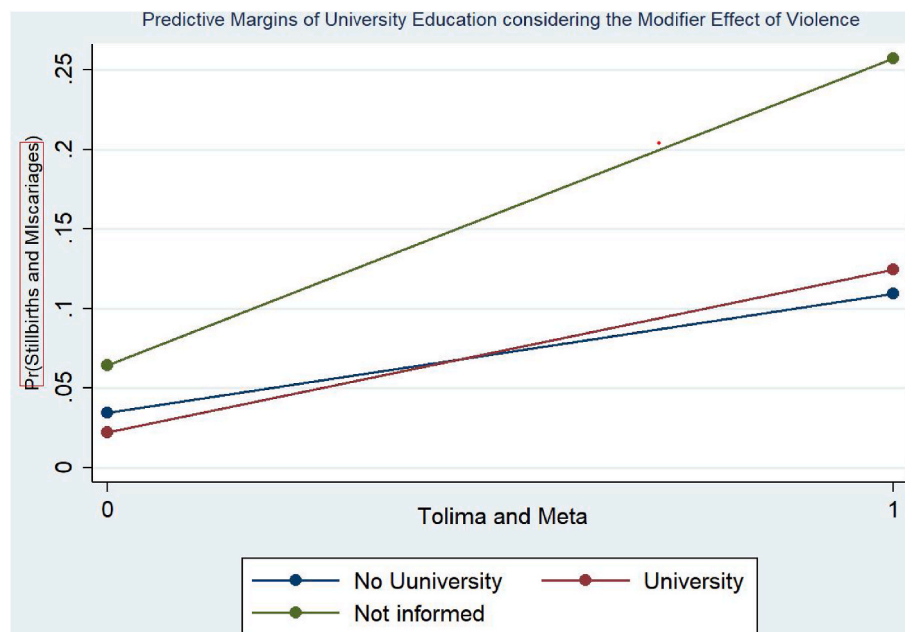Source: own elaboration, based on the coefficients of Model 6 in Table 1

Fig. 5. Marginal effects on the log of odds are constant, while the predicted probabilities are not. Thus, we choose a baseline for each variable, computed as a value that is covariant to the output in Table 1 (Model 2 b).
Source: own elaboration, based on the coefficients of Model 6 in Table 1

more affected by the effect modification of violence.

Our findings add more evidence of the effect of regional violence on newborn health, beyond violence at the municipal level (Duque, 2017). We have gone further in exploring this paradoxical relationship by considering the protective/shielding effect of a mother's educational level in terms of reducing the harmful effect of violence on newborn well-being. Furthermore, in testing the impact of violence over mother's education and newborns' well-being. Other demographic features should be taken into account in further research, such as ethnic background, medical background, occupation, life stories, household dynamics, family environment, and others which according to the Ecological Theory of Urie Bronfenbrenner (1979) reinforce their roles within the dyad and might be correlated with pregnancy outcomes. We also add evidence to earlier findings in the Vital Statistics descriptive and empirical research in Colombia (Márquez-Beltrán et al., 2013; Ramos Jaraba et al., 2020). One of these pieces of medical and population research analyzed 14,520 women included in the 2010 Demographic Health Survey and, through bivariate analyses, binomial regression and stratified models by age showed a negative and significant correlation between higher levels of regional violence and newborn outcomes (Ramos Jaraba et al., 2020). Regardless of these findings, the present research has obtained significant evidence of the shielding effect of a mother's university education for having a live birth when regional violence is low. This is clearly a step forward from earlier paradoxical results obtained by previous researchers in terms of newborn weight and the odds of being preterm.

11. Future research

In multilevel settings, research questions generally involve several levels (e.g., the effect of various regional contextual factors potentially affecting a mother's socioeconomic and psychological situation, and thus newborn outputs). Multilevel data entails a complex variance-covariance structure; in further research we should consider using more complex multilevel models such as slopes models with covariants. For instance, Bronfenbrenner's concept of the mesosystem comprises the interrelations among two or more settings such as, for a pregnant woman, the relationships between home, family, work, and social life. In

the words of Bronfenbrenner, this is a system of microsystems, and it is drawn up whenever a person moves to a different setting. Therefore, our aim is to estimate those interrelations in a wide spectrum of observation by estimating the interaction between levels of violence in a region and a mothers' education level.

On the other hand, it was impossible for us to identify mothers who were running from violence, were on holiday, or were visiting relatives. We assume that the region where mothers were living at the time was the same as the one where they have spent the previous nine months of their pregnancies. Other data restrictions prevented us identifying ethnic origins. This lack of input should be addressed in following papers, and similarly, the lack of regional macroeconomic information for the eight regions not included in the regression analysis models.

Author contributions

Statistical evidence of the impact of armed conflict violence over the pregnant woman/newborn's health wellbeing even when woman could achieve university studies. This one we compute the interaction effect. In addition the design of a Regional Violence Index to measure regional violence.

Ethical statement

The present manuscript respect the epistemology and linguistic roots of concepts related to the field of knowledge of Women's Health Issues. I am aware of the relevance of terminology related to humanity, progress, equity and social justice for marginalized populations, moreover within fragile contexts such as Colombia.

Data availability

Data will be made available on request.

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