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ORIGINAL RESEARCH

Giving Birth While Facing Death: Cesarean Sections and Community Violence in Latin America

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Abstract

Armed conflict and organized crime are known to be linked to numerous negative maternal and neonatal health outcomes, such as stillbirth, low birth weight, and neonatal mortality. This study investigates how exposure to lethal community violence during pregnancy correlates with Cesarean births in Latin America, a region characterized by high rates of both C-sections and violence. The analysis combines micro-level survey data, covering 123,503 births, with subnational homicide statistics from Colombia, the Dominican Republic, Guatemala, and Mexico. Region-fixed effects linear probability models were used to eliminate geographically varying omitted factors that could potentially confound exposure to violence and health conditions. The findings suggest that the high rates of C-sections in Latin America can partially be attributed to the high levels of violence, due to an increase in both medically unnecessary and emergency procedures. The relationship between exposure to community violence and C-section delivery varied by country, women's socio-demographic characteristics, and the number of antenatal care visits. Exposure to violence during all trimesters correlated with the uptake of C-sections, indicating that violence negatively affects maternal and child health throughout pregnancy. This study enriches our understanding of the social determinants of maternal and child health. The findings can serve to inform comprehensive interventions aimed at reducing excess C-section rates and improving the health of women and newborns in areas affected by violence.

Keywords Maternal health · Infant health · Cesarean section · Violence · Latin America

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Introduction

Billions of people across the globe live in areas affected by fragility, conflict, or organized criminal violence, which considerably constrains development and health (World Bank, 2011). Large-scale deadly community violence generally increases maternal and child health needs both directly, because of battle-related morbidity and stress, and indirectly, due to limited access to food, water, shelter, and preventive care (Jawad et al., 2020; Svallfors, 2021; Svallfors & Billingsley, 2019; Wise, 2017). Past empirical research has revealed a connection between violence and both maternal mortality (Kotsadam & Østby, 2019; Ramos Jaraba et al., 2020) as well as multiple harmful birth outcomes including stillbirth, low birth weight, and perinatal mortality (Brown, 2018; Camacho, 2008; Foureaux Koppensteiner & Manacorda, 2016; Mansour & Rees, 2012; Quintana-Domeque & Ródenas-Serrano, 2017; Svallfors et al., 2022; Torche & Villarreal, 2014; Valente, 2015).

Cesarean sections (C-sections) are an important, yet relatively understudied, indicator of maternal and child health in response to violence. C-sections are on the rise worldwide due to increases in both elective uptake and defensive behavior on the part of obstetricians when there is an indication of birth pathology (Seelbach-Goebel, 2014). The procedure can save lives if conducted due to medically motivated reasons, which usually occur in about 10–15 percent of births. However, medically unnecessary C-sections put both mothers, neonates, and any future children at great risk of short- and long-term health problems such as complications, disability, and death—especially in places without the facilities or capacity to perform surgeries safely and treat surgical complications. Unnecessary C-sections also challenge health systems that are already strained. On the other hand, when medically necessary C-sections cannot be performed, the risk of maternal and neonatal morbidity and mortality increases (WHO, 2015).

A small body of recent literature has observed both positive and negative relationships between C-sections and armed conflict. In Iraq, Lebanon, and Syria, studies have reported an over-recourse to C-sections in response to armed conflict (Balinska et al., 2019; Ekzayez et al., 2021), while in Colombia and Palestine, lower rates of C-sections have been observed in more violent regions (Leone et al., 2019; Ramos Jaraba et al., 2020). Since these studies are mostly based on single case studies using different methods and samples, it is difficult to assess whether the mixed findings are due to methodological decisions or genuine contextual differences. Further, prior research has not considered other sources of violence beyond war. Existing studies have either not directly estimated women's exposure to violence during pregnancy, used nationally representative data controlling for confounding factors, or analyzed the impact of violence on C-sections in population subgroups. As such, our knowledge remains limited of how violence affects C-section rates.

Latin America is a relatively understudied region in terms of health outcomes of violence, not least from a comparative perspective. Violence from both conflict and crime in Latin America has increased dramatically in the past decades, posing a serious challenge to citizen security, democratic governments, civil society, and health (Imbusch et al., 2011). Despite their many differences, Latin American nations share

a common socio-institutional background and similar histories of community violence related to political unrest and organized crime, which enables comparative analyses of context-specific variations as well as generalizations of experiences to the broader region.

Adding to prior literature, the current study investigates the correlation between women's exposure to community violence during pregnancy and whether births were delivered by C-section in Colombia, the Dominican Republic, Guatemala, and Mexico. Any relationship between C-sections and community violence likely operates differently across subgroups of the population. Not least in Latin America, where stark social inequalities create differences in women's and children's health (Perner et al., 2022). The study, thus, considers both universal effects at the population level, as well as heterogeneous effects by socioeconomic characteristics of the mother, sex of the fetus, and healthcare visits during pregnancy, to investigate differential vulnerabilities to violence. Further, following prior literature, the study explores if any impact of violence on the mode of delivery depends on the timing of exposure during pregnancy (Brown, 2018; Camacho, 2008; Foureaux Koppensteiner & Manacorda, 2016; Mansour & Rees, 2012; Torche, 2011; Torche & Villarreal, 2014).

Exposure to community violence is defined in this study as homicides in the regions where women live, regardless of whether the source of violence was related to politics, crime, or personal disputes. This broad definition allows for analyzing the impact of multiple sources of citizen insecurity on women's everyday lives and reproductive health. Moreover, homicides are an appropriate operationalization of community violence since there is generally little underreporting compared to other crimes and the definition generally does not vary between countries and regions (Caudillo & Lee, 2023).

This study is the first to explore the relationship between C-sections and community violence across multiple countries based on nationally representative survey data. The cross-comparative design allows for studying context-specific variations and similarities without running the risk of different data or method choices that make findings incomparable. Investigating the impact of community violence on maternal and child health outcomes such as C-sections contributes to our broader understanding of the structural determinants of maternal and child well-being. The real costs of violence cannot be understood or addressed without knowledge about how it affects civilian lives (Iqbal, 2010). Analyses of individual-level health outcomes of violence are thus crucial to developing comprehensive interventions in affected settings.

C-Sections in Latin America

Between 1990 and 2014, the share of births delivered by C-section increased in Latin America from 23 to 42 percent, but with substantial variations between and within countries (Betrán et al., 2016). More than 43 percent of births were delivered by C-section in Colombia, the Dominican Republic, and Mexico during 2012–2013;

in Guatemala, 16 percent of births were delivered by C-section in 2008 (Betrán et al., 2016).

Both emergency and planned C-sections occur more often in cases of pre-existing health conditions and birth complications (Adu-Bonsaffoh et al., 2022; Edelblute & Altman, 2021; Harrison et al., 2021b; Leone et al., 2008; Roldán et al., 2020). Underuse of C-sections among women with lower socioeconomic status (SES) coexists with unnecessary use among those with higher SES (Perner et al., 2022). Richer, more educated, and older women who give birth in private facilities are generally more likely to deliver by C-section, likely reflecting medically unnecessary elective procedures (Alzate et al., 2019; Edelblute & Altman, 2021; Harrison et al., 2021b; Leone et al., 2008; Roldán et al., 2020). Research on Mexico further indicates that the likelihood of delivery by C-section depends on hospital characteristics such as maternal unit size, the complexity of caseloads, and reimbursement incentives (Taljaard et al., 2009), as well as attitudes among obstetricians, for example, with respect to the perceived safety of various delivery modes and support of women's right to choose their preferred delivery mode (Vallejos Parás et al., 2018). In sum, C-section uptake across the four countries under study varies by differential health, SES, facility, and provider factors.

Community Violence in Colombia, the Dominican Republic, Guatemala, and Mexico

The four countries under study each have unique dynamics of violence shaped by their sociohistorical and political contexts. In Colombia, the armed conflict that ignited in the mid-twentieth century involved the government, left-wing guerrillas, right-wing paramilitary groups, and organized crime cartels. Even after the peace accords signed by the government and the largest guerrilla FARC in 2016, land disputes related to narcotrafficking have continued to cause high levels of deadly violence (Bergquist et al., 2001; Ramos Jaraba et al., 2020). The Guatemalan genocide of the Mayan population by the military regime during the civil war 1960–1996 precedes the period analyzed here, but "international drug traffickers, domestically based organized crime syndicates, and youth gangs […] have dramatically expanded their operations since the 1990s" (Brands, 2010, p. v). The Dominican Republic had a brief civil war in 1965 that ended with US military intervention, followed by repressive rule under President Joaquín Balaguer on and off until 1978. Recently, the country has become a corridor for drug trafficking and money laundering by Colombian cartels. Violence also spills over from neighboring Haiti (Ortiz Rodríguez, 2019). Finally, in Mexico, rivaling crime cartels and the US-funded War on Drugs policy adopted by President Felipe Calderón in 2006 have created a war-like situation after previously stable trends, with high levels of deadly violence, extortion, kidnapping for ransom, human trafficking, and publicized violence such as the displaying of tortured and dismembered bodies to induce fear (Rios, 2013).

While the actors, dynamics, and temporalities of violence differ across the four countries, there are also noteworthy similarities. The various sources of violence can be traced to a historical legacy of colonialism, social inequality, and the emerging

political economy of drug trafficking. Deadly violence has been mostly concentrated among young men. The lack of security is a continuous threat to the quality of life, which is why many leave the most violent communities in search of more peaceful places (Imbusch et al., 2011). Different repertoires of violence in different settings might not contribute to C-sections in the same way, although the definition of homicides is the same. Given the similarities as well as unique country features, the analyses will thus explore each of the four countries separately.

Conceptualizing C-Sections in Response to Community Violence

Hypothetically, the uptake of C-sections may either increase or decline in response to community violence, as reported in the literature (Balinska et al., 2019; Ekzayez et al., 2021; Leone et al., 2019; Ramos Jaraba et al., 2020). Multiple potential pathways could explain such shifts, as suggested by previous research. Those pathways are described under separate subheadings below. While most mechanisms are not directly testable with the available data, they are useful for outlining expected findings and interpreting results.

Gender-Based, Structural, and Obstetric Violence (Involuntary Increase or Decrease)

The overall literature on gender and war indicates that large-scale violence tends to disempower women and increase multiple forms of violence against them, including sexual violence as a military strategy and intimate partner violence (Svallfors, 2023a, b, c). Scholarships on obstetric violence and structural violence suggest that women face harm from intersecting colonial, sexist, and classist structures (Nagle & Samari, 2021; Sadler et al., 2016; Solnes Miltenburg et al., 2018). C-sections administered against women's will could increase in tandem with other forms of structural and gender-based violence due to insecurity.

Over-Medicalization (Voluntary or Involuntary Increase)

Medically unnecessary C-sections may increase with structural sexism leading to an over-medicalization of women's bodies (Nagle & Samari, 2021), as patriarchal gender norms often become exacerbated in settings of protracted violence (Svallfors, 2023a). It is not clear from the literature whether these factors would primarily incentivize women to elect C-sections, or for health workers to administer them.

Birth Planning and Avoidance of Healthcare (Voluntary Increase or Involuntary Decrease)

Elective C-sections may increase if women are worried about the timing of their childbirth, thus preferring to have a planned C-section in avoidance of unpredictable security conditions during their labor. Women generally become more

risk-averse when faced with crisis than men (Hanaoka et al., 2018) and sometimes adopt health-protective behaviors when faced with violence (Svallfors, 2022; Torche & Villarreal, 2014), which might extend to medically unnecessary C-sections. It is also possible that insecurity deters women from seeking care altogether for similar reasons.

Depletion of Health System Resources (Involuntary Increase or Decrease)

Health systems tend to be strained by large-scale violence and other crises, because of resources being directed towards other initiatives, health workers being reluctant to work in violent areas, and tactical or accidental attacks against healthcare facilities, personnel, and shipments (Franco et al., 2006; Rubenstein, 2021; Svallfors et al., 2023c; Svallfors & Billingsley, 2019). Research on C-sections and health systems suggest that obstetricians might opt for this procedure in cases of high-risk pregnancies due to a lack of collegial support in decision-making and pressure from colleagues (Litorp et al., 2015), factors that could become more common as health systems become more strained due to community violence.

Medically necessary C-sections and other forms of emergency obstetric care might also become more scarce following health system deteriorations (Brentlinger et al., 2005; Varley, 2010).

High-Risk Pregnancies (Involuntary Increase)

Acute C-sections could increase with other obstetric risks due to several factors. Stress during pregnancy has been related to several deleterious health outcomes of community violence in Latin American settings (Brown, 2018; Camacho, 2008; Foureaux Koppensteiner & Manacorda, 2016; Svallfors et al., 2022; Torche & Villarreal, 2014). Relatedly, community violence has been linked to women's increased victimization of intimate partner violence (Østby et al., 2019; Svallfors, 2023b; Torrisi, 2023), which places both mother and fetus at risk.

Women may avoid seeking antenatal and delivery care due to fear of battle attacks on the way to or in clinics (Brentlinger et al., 2005; Rubenstein, 2021). The availability of such services may also be impaired, thus hindering screening and early intervention for high-risk pregnancies (Chukwuma & Ekhator-Mobayode, 2019; Østby et al., 2018; Price & Bohara, 2013).

Selection into Live Birth (Involuntary Decrease)

Decreases in the probability of C-sections could reflect selection into a live birth. Community violence is a known driver of pregnancy loss, reducing the number of high-risk pregnancies resulting in live births that would have been delivered by C-section in a counterfactual scenario (Valente, 2015).

Heterogeneous and Trimester-Specific Effects

This study explores if and how the correlation between exposure to violence during pregnancy and C-sections varies by women's residence, education and age, sex of the fetus, and antenatal care (ANC) visits. Exposure to violence may be a driver of elective C-sections foremostly among high-SES women, while low-SES women may be more at risk of intimate partner violence, limited access to healthcare, and other factors that may put them at risk of pregnancy complications requiring acute C-sections (Perner et al., 2022; Trujillo et al., 2014). Adolescents generally suffer from obstructed labor from pelvic bone immaturity, but have overall lower rates of C-sections compared to adult mothers (Conde-Agudelo et al., 2005; Ganchimeg et al., 2014). Males are often more sensitive to intrauterine shocks and may thus be more at risk of pregnancy complications requiring C-sections compared to females (Quintana-Domeque & Ródenas-Serrano, 2017; Valente, 2015). Finally, distinct patterns in the relationship between violence and C-sections by the number of ANC visits can indicate differential access to care, health-seeking behaviors, and high-risk pregnancies (Price & Bohara, 2013).

Moreover, the study uses trimester-specific indicators of violence to explore whether any relationship between violence and the likelihood of C-sections depends on the timing of exposure during pregnancy. Prior research on infant health has mostly identified the first trimester as being particularly sensitive to intrauterine shocks, including exposure to violence (Brown, 2018; Camacho, 2008; Foureaux Koppensteiner & Manacorda, 2016; Mansour & Rees, 2012; Torche, 2011; Torche & Villarreal, 2014).

Research Design

Data and Sample

Data from individual-level surveys were combined with vital statistics to explore the relationship between exposure to community violence during pregnancy and C-sections in the four Latin American countries.

The study sample was derived from the nationally representative cross-sectional Demographic and Health Surveys (DHS) in Colombia, the Dominican Republic, and Guatemala and the National Survey of Demographic Dynamic (ENADID) in Mexico. All surveys sampled women aged 15–49. The Colombian DHS also sampled girls aged 13–14 from 2004 and onwards, and the Mexican ENADID also included women aged 50–54. The DHS contain retrospective information about whether respondents' births during the preceding five years were delivered by C-section. In Mexico, ENADID provided information about whether a women's births were delivered by C-section, regardless of how long ago it took place (ICF International, 2018; INEGI, 2018). Women's live births during the five years before the surveys were retained in the main sample, while sensitivity analyses included only the latest recorded births in the past five years for countries sampled by the DHS and the latest recorded births in Mexico.

Table 1 Overview of surveys

Country	Source	Survey year/s	Number of births (by women)	Response rate (%)
Colombia	DHS-IV	2004/05	14,621 (11,320)	92
	DHS-V	2009/10	17,756 (14,185)	94
	DHS-VII	2015/16	11,759 (9,976)	94
Dominican Republic	DHS-VI	2013	3,708 (2,963)	94
Guatemala	DHS-VII	2014/15	12,426 (9,537)	97
Mexico	ENADID	2014	32,070 (32,070)	88[a]
	ENADID	2018	31,163 (31,163)	96
Total			123,503 (111,214)	

[a]Household response rate; the other response rates represent the individual women's survey

Monthly data on homicides were drawn from cause-of-death registers in vital statistics reported by each country's statistical agency. These were linked to survey data by the administrative subregion (municipalities in Colombia and Mexico, departments in Guatemala, and provinces in the Dominican Republic, referred to as region throughout the manuscript for reasons of parsimony) where respondents resided at the survey interview, for nine months preceding the birth of each child due to the lack of information about the gestational length of pregnancies (following, e.g., Brown, 2018; Valente, 2015).

The harmonized dataset covered 123,503 births by 111,214 women, born during 1999–2016 in 1,122 Colombian municipalities, 2009–2015 in 22 Guatemalan departments, 2008–2013 in 31 Dominican provinces, and during 2009–2018 in 2,470 Mexican municipalities. Table 1 displays an overview of the included surveys by country, year of data collection, number of births (after removing missing values on relevant variables), and response rate. Table A in the Online Supplementary Information displays the number of children born each year during observation.

Variables

The dependent variable measured whether women's births were delivered by *C-section*.

The key independent variables assessed women's *exposure to community violence*, operationalized as homicides recorded in the respondent's home region in the months preceding birth—during each of the three trimesters, and throughout the full pregnancy.[1] These four approximated timeframes were used to identify the stage of pregnancy when exposure to community violence most impacts the mode of delivery. Measures of the actual number of homicides were preferred over rates due to

[1] Exposure to community violence was measured, respectively, during 9–7 months, 6–4 months, 3–1 months, and 9 months preceding birth to represent the first, second, third trimester, and full pregnancy.

incomplete data on inhabitants per municipality in Colombia. As mentioned, home region refers to municipalities in Colombia and Mexico, departments in Guatemala, and provinces in the Dominican Republic. These units of analysis were chosen because they are roughly comparable in scale.

Akaike's Information Criterion (AIC) tests assessed the model fit of various functional forms of the exposure variables: continuous, logged measures based on the inverse hyperbolic function, or categorical measures based on terciles or quartiles in each country.[2] The indicators contributing most to model fit were quartile measures distinguishing between low, lower-mid, upper-mid, or high levels of community violence. Using a categorical measure of exposure to violence is useful for investigating non-linear relationships with C-sections.

All models controlled for time-varying variables: *birth order*, *child's birth year*, and whether it was a *multiparous birth* (i.e., more than one child). The latter is a crucial confounder since C-sections are becoming increasingly common worldwide to mitigate health risks related to multiparous pregnancies, especially in low- and middle-income countries (Seelbach-Goebel, 2014).

The respondent's birth year was excluded as a control to avoid a collinearity bias with age and birth year of the child (Wilson et al., 2021). Indicators of family income or wealth were omitted from the models due to the lack of time-varying information. Father's characteristics, while unavailable, tend to be less relevant for pregnancy outcomes than maternal characteristics (Shah, 2010).

To investigate heterogeneous effects, the models were partitioned by the *mother's residence* (urban or rural),[3] *mother's age at birth* (≤ 19, 20–34, ≥ 35), *mother's education* (primary or lower, secondary, or tertiary[4]), *sex of the fetus* (male or female), and the number of *ANC visits* (<8 or ≥ 8 following WHO (2016) guidelines).

Statistical Model

Linear probability models, with births as the unit of analysis, estimated the probability of delivery by C-section in relation to women's exposure to regional homicide violence during pregnancy. Linear models are valuable for cross-model comparisons and coefficient interpretability when the event is not rare. In comparison, estimates from binary logistic regressions are not as straightforward and susceptible to omitted

[2] Dummy indicators could not be used because all pregnancies in Guatemala were exposed to violence.

[3] The definition of urban/rural differs between countries. Urban is defined as a locality of >1500 inhabitants in Colombia, administrative centers of *comunas* and municipal districts in the Dominican Republic, centers of municipalities in Guatemala (Montgomery et al., 2003, pp. 490–491), and a locality of >2500 inhabitants in Mexico (INEGI, 2018).

[4] Approximated from age the highest level of education achieved at the time of the interview, the respondent's age, and the typical age at graduation. The time-varying educational variable comes with some limitations, as it assumes a quite rigid educational system with no study breaks, repeating of school years, or earlier/postponed entries into the school system, and thus provides a lower bound of educational attainment.

variable bias, but such models typically work better for rare-outcome models (Allison, 1999; Mood, 2010; Wooldridge, 2009).

While the association between community violence and health outcomes is a critical concern, it is empirically challenging to identify. Women from the same region are likely to experience similar levels of violence and exhibit similar socio-demographic characteristics compared to those in other regions due to a range of omitted factors. To address this issue, region- and year-fixed effects and region-clustered standard errors were deployed, examining changes in community violence within the same region over time while controlling for time-invariant regional characteristics and a shared time trend. This approach helps identify whether there is an association between community violence and C-sections that is not explained by characteristics of regions that do not vary over time (e.g., historical legacies of state neglect in certain areas leading to pervasive deficits in healthcare services and other resources, a weak monopoly on violence, as well as the presence of organized armed groups (Imbusch et al., 2011)) or by common changes over time (e.g., national standards of obstetric care (Antoine & Young, 2021)).

Results

Descriptive Statistics

Descriptive statistics of the sample population are displayed in Table 2. The share of births delivered by C-section was 31%, 54%, 27%, and 45% in Colombia, the Dominican Republic, Guatemala, and Mexico, respectively. Distributions were similar across all four countries in terms of multiparous births (1–3%), sex of fetus (51% males), and age at birth (19–25% teenage fertility). Mothers with primary or lower education comprised 45%, 47%, 76%, and 29% of the population in each country, respectively, while those with tertiary education comprised 12%, 17%, 3%, and 29%. In Guatemala, 34% of mothers resided in urban areas, compared to around 70% in the other three countries. The share of women with at least eight ANC visits comprised around half in Colombia and Guatemala and around three-quarters in the Dominican Republic and Mexico.

Figure 1 illustrates the number of homicides (left Y-axis, black lines) and proportions of births delivered by C-section (right Y-axis, gray lines) by the years of observation. After a peak in homicides in Colombia in the early 2000s, violence decreased steadily until 2016 (when the peace accords between the government and FARC were signed). In Mexico, homicide violence followed an inverse U-shape during observation, while in Guatemala and the Dominican Republic trends have been largely stable. In all countries except Mexico, the share of C-sections has increased over time but with varying levels and slopes. At the country level, there was no clear relationship between homicides and C-sections.

Figure 2 displays maps of the spatial distribution of community violence, where darker colors indicate regions with a higher number of homicides. The maps show substantial regional variation in women's exposure to violence, supporting the choice of a fixed effects model.

Table 2 Descriptive statistics of the sample population

	Colombia		Dominican Republic		Guatemala		Mexico	
Variable	*n*/mean	%/SD	*n*/mean	%/SD	*n*/mean	%/SD	*n*/mean	%/SD
C-section								
No	30,320	68.70	1,714	46.22	9,084	73.10	34,790	54.75
Yes	13,816	31.30	13,816	53.78	3,342	26.90	28,756	45.25
Child's birth year	2007	4.28	2010	1.48	2012	1.46	2013	2.58
Birth order	1.20	0.45	1.22	0.46	1.26	0.49	2.11	1.24
Multiparous pregnancy								
No	43,464	98.48	3,624	97.73	12,209	98.25	61,368	96.57
Yes	672	1.52	84	2.27	217	1.75	2,178	3.43
Mother's residence								
Urban	29,407	66.63	2,590	69.85	4,268	34.35	45,482	71.57
Rural	14,729	33.37	1,118	30.15	8,158	65.65	18,064	28.43
Mother's age at birth								
≤19	10,580	23.97	916	24.70	2,547	20.50	12,188	19.18
20–34	29,040	65.80	2,531	68.26	8,494	68.36	45,031	70.86
≥35	4,516	10.23	261	7.04	1,385	11.15	6,327	9.96
Mother's educational level								
Primary or lower	19,911	45.11	1,751	47.22	9,421	75.82	18,545	29.18
Secondary	18,792	42.58	1,327	35.79	2,608	20.99	26,704	42.02
Tertiary	5,433	12.31	630	16.99	397	3.19	18,297	28.79
Sex of fetus								
Male	22,555	51.10	1,896	51.13	6,438	51.81	32,229	50.72
Female	21,581	48.90	1,812	48.87	5,988	48.19	31,317	49.28
Antenatal care visits								
<8	20,354	46.11	940	25.35	5,869	47.23	21,951	68.45
≥8	23,782	53.88	2,768	74.65	6,557	52.77	10,119	31.55
Exposure to community violence (number of homicides)								
First trimester	221.74	336.97	36.92	53.03	120.87	193.99	12.16	55.76
Second trimester	220.00	335.04	36.78	52.53	119.93	191.75	12.09	53.83
Third trimester	218.09	332.07	36.66	52.06	119.01	189.01	11.98	53.47
Full pregnancy	707.13	1177.60	110.36	156.64	359.95	573.04	36.23	158.46
Total	44,136	100.00	3,708	100.00	12,426	100.00	63,546	100.00

Associations Between C-Sections and Community Violence

Table 3 presents results from four separate linear probability models of the relationship between C-sections and women's exposure to community violence during each trimester as well as throughout the full pregnancy, in each of the four countries. The Online Supplementary Information contains models with alternative specifications of community violence (Table B).

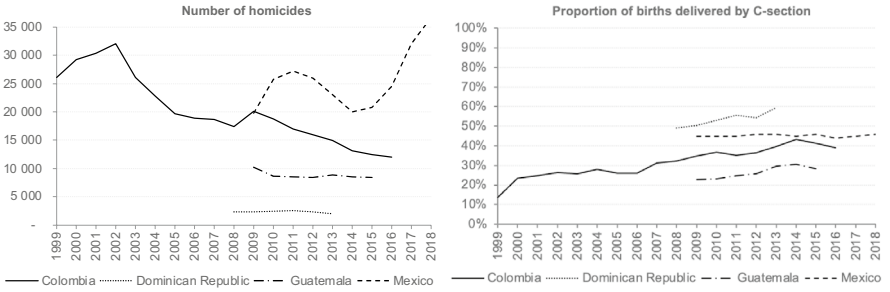

Fig. 1 Number of homicides (left) and proportion of births delivered by C-section (right) over time in Colombia, the Dominican Republic, Guatemala, and Mexico

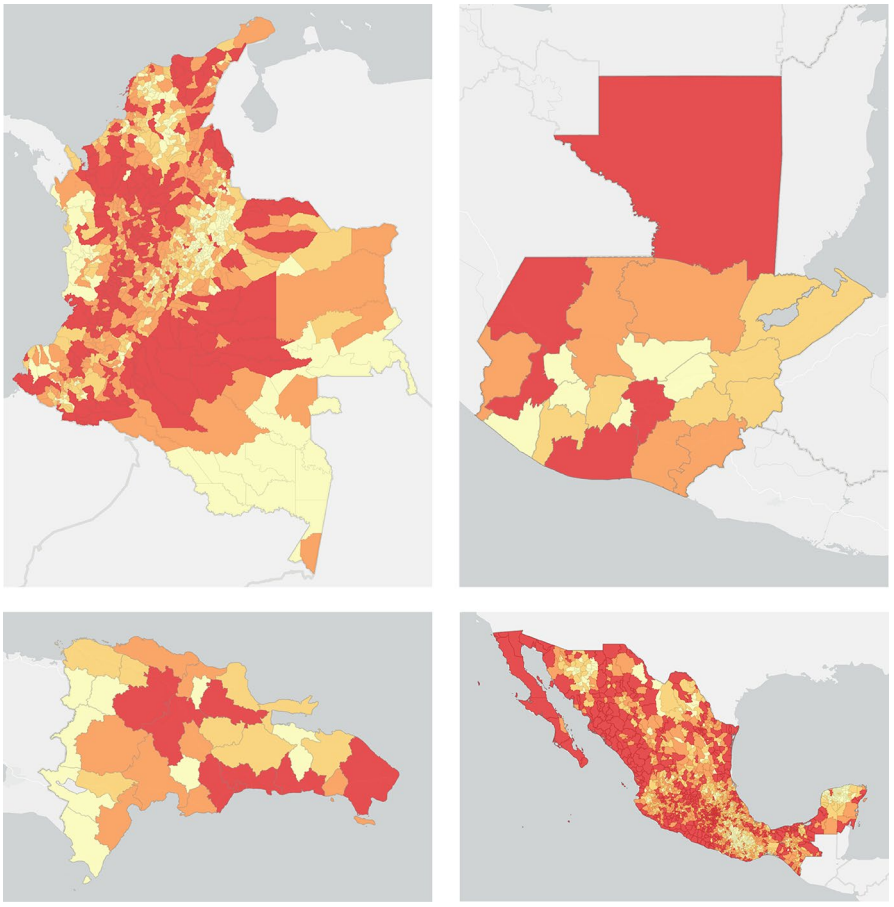

Fig. 2 Spatial distribution of violence in Colombia, Guatemala, the Dominican Republic, and Mexico. Darker colors indicate regions with more homicides. Attribution: Esri, HERE, Garmin, FAO, NOAA, USGS. (Color figure online)

Table 3 Region-fixed effects linear probability models of the relationship between C-sections and community violence in four Latin American countries

	Model 1 trimester 1		Model 2 trimester 2		Model 3 trimester 3		Model 4 full pregnancy	
	B	SE	B	SE	B	SE	B	SE
Colombia ($n=44{,}136$)								
Exposure to community violence[a]								
Low mid	0.03*	(0.01)	0.02*	(0.01)	0.02**	(0.01)	0.03*	(0.01)
High mid	0.09***	(0.01)	0.09***	(0.01)	0.08***	(0.01)	0.09***	(0.01)
High	0.10***	(0.01)	0.10***	(0.01)	0.11***	(0.01)	0.11***	(0.02)
Constant	− 25.14***	(3.80)	− 25.28***	(3.80)	− 25.31***	(3.86)	− 25.49***	(3.81)
AIC	52,729.64		52,703.72		52,747.73		52,720.65	
R2	0.05		0.05		0.05		0.05	
Rho	0.06		0.06		0.06		0.06	
Dominican Republic ($n=3{,}708$)								
Exposure to community violence[a]								
Low mid	0.01	(0.03)	− 0.01	(0.04)	− 0.02	(0.04)	0.01	(0.04)
High mid	0.04	(0.03)	− 0.03	(0.05)	− 0.01	(0.04)	0.07	(0.07)
High	0.15***	(0.04)	0.07	(0.05)	0.01	(0.05)	0.16*	(0.07)
Constant	− 13.28	(11.99)	− 12.78	(11.66)	− 11.55	(11.64)	− 15.10	(11.99)
AIC	5075.64		5076.77		5079.01		5074.45	
R2	0.02		0.01		0.01		0.01	
Rho	0.08		0.08		0.08		0.08	
Guatemala ($n=12{,}426$)								
Exposure to community violence[a]								
Low mid	0.002	(0.02)	0.02	(0.02)	0.002	(0.01)	0.02	(0.02)
High mid	0.03	(0.02)	0.02	(0.02)	0.01	(0.01)	0.03	(0.02)
High	0.004	(0.02)	0.00	(0.03)	− 0.02	(0.02)	0.02	(0.03)
Constant	− 8.84	(5.75)	− 9.24	(5.74)	− 9.64	(5.86)	− 9.60	(5.63)
AIC	14,011.36		14,014.33		14,013.16		14,014.08	
R2	0.03		0.03		0.03		0.03	
Rho	0.05		0.05		0.05		0.05	
Mexico ($n=32{,}070$)								
Exposure to community violence[a]								
Low mid	− 0.02	(0.01)	0.0001	(0.01)	− 0.01	(0.01)	− 0.01	(0.01)
High mid	− 0.03*	(0.01)	− 0.002	(0.01)	− 0.01	(0.01)	− 0.02	(0.02)
High	− 0.03	(0.02)	0.01	(0.02)	− 0.01	(0.02)	− 0.01	(0.02)
Constant	− 2.73	(2.21)	− 2.18	(2.22)	− 2.29	(2.22)	− 2.39	(2.22)
AIC	86,142.96		86,146.89		86,144.92		86,145.84	
R2	0.02		0.02		0.02		0.02	
Rho	0.20		0.20		0.20		0.20	

Region-fixed effects and controls for child's birth year, birth other, and multiple birth are included. Each column displays a separate model

B probability, *SE* region-clustered standard errors

*$p<0.05$, **$p<0.01$, ***$p<0.001$

[a]Reference is low

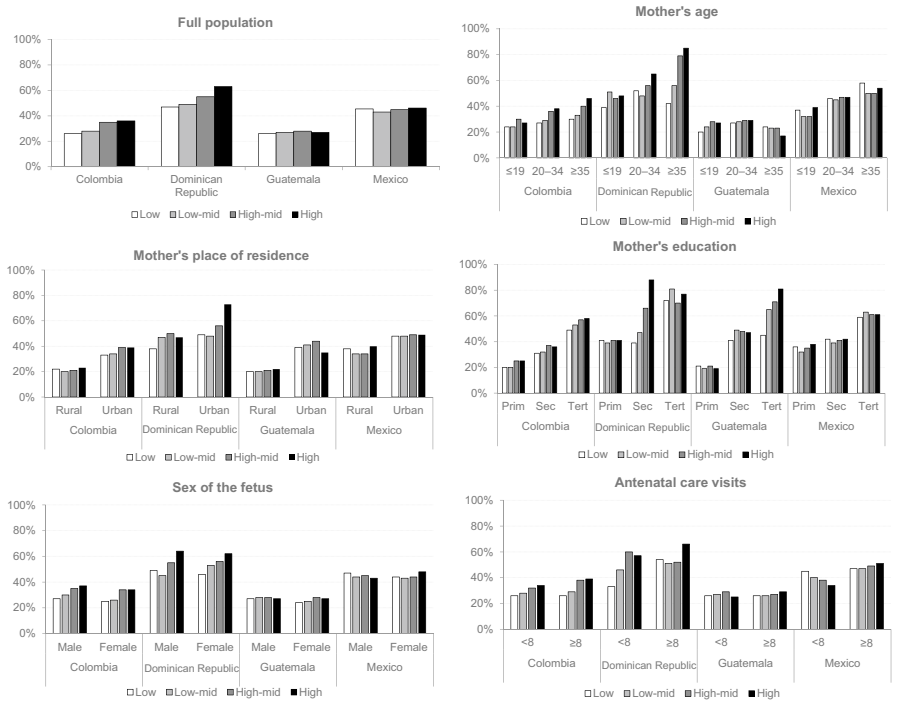

Fig. 3 Predicted probabilities of C-section delivery in relation to women's exposure to community violence during pregnancy, in the full population and disaggregated by the mother's age, residence, and education, sex of the fetus, and antenatal care visits

In Colombia, women exposed to low mid-levels of community violence during pregnancy were 2–3 percentage points (pp) more likely to deliver their births by C-section, compared to those with low levels of exposure, while those exposed to high mid or high levels had a 08–11 pp higher probability. Coefficients were similar across all trimesters. In the Dominican Republic, high levels of exposure to violence were associated with a 15–16 pp increase, in the first trimester and throughout the full pregnancy. In Mexico, high mid-levels of violence were linked to a lower probability of having a C-section by 3 pp. There were no significant relationships between exposure to violence and the probability of C-sections in the overall population in Guatemala.

Based on these exercises, average marginal effects were used to generate predicted probabilities of C-section delivery, accounting for the child's birth year, birth order, and multiparous pregnancy as observed in the samples (top-left panel of Fig. 3). There were notable positive trends in C-sections across levels of violence in Colombia and the Dominican Republic. The probability of delivering by C-section varied little by women's exposure to violence during pregnancy in Guatemala and Mexico.

Heterogeneous Effects

Next, models were partitioned by women's SES, the sex of the fetus, and the number of ANC visits, in order to investigate the heterogeneity in the relationship between C-sections and exposure to violence during pregnancy (see Tables C1–G4 in the Online Supplementary Information). Predicted probabilities based on these models are displayed in Fig. 3 (for trimester-specific exposures, refer to Figures A–C in the Online Supplementary Information).

In Colombia and the Dominican Republic, older women who were exposed to more violence during pregnancy exhibited a higher probability of C-section delivery. Conversely, slight negative gradients were found among mothers aged 35 or above in Guatemala.

Exposure to violence was also linked to a higher probability of C-sections among urban women in Colombia and the Dominican Republic, women of all educational levels in Colombia, and women with tertiary education in Guatemala. The steepest gradient in relation to violence was observed among women with secondary education in the Dominican Republic.

No differences were observed in the probability of C-sections across different levels of violent exposure based on whether the fetus was male or female, except in Mexico, where there was a slight negative trend across levels of violence for males, and conversely, a slight positive trend for females.

Differences in the predicted probability of C-section delivery in relation to the number of ANC visits and exposure to violence were evident only in the Dominican Republic and Mexico. However, among those who made fewer visits and were exposed to more violence, Dominican women showed a higher probability of having a C-section, while this probability was lower among Mexican women, when compared to their less exposed counterparts. The trend observed among Dominican women was primarily driven by exposure during the first trimester. However, a higher exposure in the third trimester was linked to a reduced probability of having a C-section in this population (see Figures A and C in the Online Supplementary Information).

Discussion

C-sections serve as a crucial indicator of maternal and neonatal health. With their increasing prevalence in Latin America and elsewhere, their significance cannot be overlooked (Betrán et al., 2016; Seelbach-Goebel, 2014; WHO, 2015). Previous studies have reported varying trends in C-section procedures globally in response to armed conflict, with both increases and declines noted (Balinska et al., 2019; Ekzayez et al., 2021; Leone et al., 2019; Ramos Jaraba et al., 2020). Building on this research, this study investigated the impact of community violence on C-sections in Latin America, a region marked by the coexistence of high rates of C-sections and homicides.

Overall, the relationship between exposure to community violence and C-section delivery ranged from null to positive—varying by country, population subgroup, and

trimester—which suggests that community violence is contributing to the high rates of C-sections in Latin America. The greater propensity for C-section delivery in violent circumstances could indicate a surge in obstetric violence, birth planning, pregnancy complications, and/or an over-medicalization of birthing processes. Whether the increased uptake of C-sections is a result of elective or emergency procedures, it emerged as an indirect and unforeseen repercussion of community violence, posing a considerable risk to women's and children's well-being in Latin America. Consequently, this study enriches existing knowledge on the adverse maternal and neonatal health outcomes linked to armed conflict and organized crime, in Latin America and beyond (Brown, 2018; Camacho, 2008; Foureaux Koppensteiner & Manacorda, 2016; Kotsadam & Østby, 2019; Østby et al., 2018; Quintana-Domeque & Ródenas-Serrano, 2017; Torche & Villarreal, 2014; Valente, 2015).

This study is particularly significant in its examination of the heterogeneous—rather than just universal—effects across population subgroups. Such an analysis can better guide our understanding of the mechanisms underpinning the relationship between C-sections and community violence.

Women who were highly educated and living in urban areas generally demonstrated a higher likelihood of delivering by C-section when exposed to violence. This suggests a surge in elective rather than urgent C-sections, which could be driven by birth planning or over-medicalization (Nagle & Samari, 2021; Torche & Villarreal, 2014). The stronger correlations between violence and C-sections among older women might indicate either more agency to adopt health-protective behaviors through birth planning or the presence of pregnancy complications necessitating emergency or precautious C-sections. Indeed, C-sections requested by the mother are generally more common in older, more educated women and those with hypertension in many low- and middle-income countries (Harrison et al., 2021a, 2021b).

The likelihood of C-section delivery did not significantly vary based on the sex of the fetus, diverging from existing literature which often suggests that males are more sensitive to shocks (Foureaux Koppensteiner & Manacorda, 2016; Quintana-Domeque & Ródenas-Serrano, 2017; Valente, 2015). This may imply that the increased probability of C-sections in response to community violence is related to behavioral—not biological—factors, or the health conditions of the pregnant person rather than the child.

The results indicated diverging trends based on the frequency of ANC visits in the Dominican Republic and Mexico. Dominican women who attended fewer ANC visits were more likely to deliver by C-section when exposed to more violence, potentially due to an increase in pregnancy complications and urgent C-sections. In Mexico, however, women with fewer ANC visits were less likely to have a C-section, pointing to a decrease in access to overall maternal healthcare, potentially due to a depletion of health system resources or avoidance of care during periods of intense violence (Chukwuma & Ekhator-Mobayode, 2019; Østby et al., 2018; Price & Bohara, 2013).

Significant correlations were observed in all trimesters, although there were variations among different population subgroups and countries, implying that exposure to violence at any stage of pregnancy adversely affects maternal and child health. This finding contrasts prior research on infant health, which typically

identifies the first trimester as being particularly sensitive to intrauterine exposure to shocks (Brown, 2018; Camacho, 2008; Foureaux Koppensteiner & Manacorda, 2016; Mansour & Rees, 2012; Torche, 2011; Torche & Villarreal, 2014).

Strengths, Limitations, and Sensitivity Analyses

This study, based on a cross-national comparison, served to align inconsistent findings in the literature and provide benchmarks for when community violence is a determinant of maternal and child health. Consequently, the varying findings across the four countries studied here should not be attributed to different methodological decisions. While being the first study to consider community violence and C-sections cross-comparatively at the population level, certain limitations remain.

The available data did not differentiate between voluntary and involuntary C-sections, pre-labor and intrapartum C-sections, or low-risk and high-risk pregnancies. Nevertheless, the findings suggested that the likelihood of both medically unnecessary and emergency procedures increases in relation to community violence. There was no information available regarding the role of prior C-sections and insurance status, two known determinants of the probability that a birth will be delivered by cesarean (Antoine & Young, 2021; Nagle & Samari, 2021; Schantz et al., 2019). Data on C-sections were only available for live births and women who survived pregnancy, excluding the pregnancies at the highest risk. There was also no information about the content or quality of ANC visits (Benova et al., 2018). Women may wish to leave more violent areas, but the DHS did not include migration histories. Consequently, the estimates presented in this study likely suffer from survivorship bias and should therefore be considered as floor—not true—effects.

Exposure assignment was based on assumed nine-month gestations due to a lack of data regarding the duration of pregnancies. However, community violence is a recognized determinant of preterm birth (Foureaux Koppensteiner & Manacorda, 2016). The findings remained robust to assuming seven-month gestations. Additionally, gestational age is often imprecisely measured (Reichman & Hade, 2001; Roohan et al., 2003).

Findings were also robust to selecting only the most recent birth of each woman in Colombia, the Dominican Republic, and Guatemala, and to including births occurring earlier than five years prior to the survey in Mexico. The time series available were longer in Colombia, but the results remained consistent when limiting the sample to only the most recent survey round from 2015/2016.

The findings were robust to the exclusion of multiparous births, and to estimating exposure to violence before conception and throughout gestation (15 months before birth) to account for endogenous fertility responses. However, using mixed effects or logit instead of linear regressions resulted in positive correlations between exposure to violence and the probability of C-section in Mexico. This suggests that the results for Mexico were less stable. These sensitivity analyses are provided in the Online Supplementary Information.

Implications

In conclusion, this study highlights the significant impact of exposure to community violence during pregnancy on the health of pregnant women and their newborns in Latin America. The findings suggest that the high rates of C-sections in Latin America can, in part, be attributed to the high rates of violence, due to an increase in both medically unnecessary and emergency procedures.

It is essential for governments, health system managers, healthcare professionals, and other relevant entities to prioritize resources to support pregnant women in highly violent settings. This would ensure access to medically necessary C-sections while discouraging unmotivated ones. Randomized control trials in Latin America have demonstrated success in preventing medically unnecessary C-sections by introducing mandatory second opinions from other physicians. Other trials have shown effectiveness in scaling up interventions to prevent maternal and child mortality, thereby reducing the need for emergency C-sections (Althabe et al., 2004; Arnesen et al., 2016). Ultimately, maternal and child health clearly benefits in more peaceful settings, underscoring the need for policies and interventions that promote human security, restorative justice, and gender-sensitive demobilization programs for armed groups and organized crime networks (Ní Aoláin, 2009).

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Declarations

Competing Interests None to declare.

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