Fuel Prices, Gang Violence, and Its Effects on Children's Health: Evidence from Mexico

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Abstract

During Mexico's "war against drugs," homicides and disappearances have surged, driven by organised crime's use of violence to control illicit markets, including fuel theft. The physiological distress resulting from this prolonged security crisis has been largely overlooked. This study examines the impact of prenatal exposure to violence associated with the clandestine tapping of oil and fuel pipelines, or "Huachicol." Leveraging quasi-exogenous variation from georeferenced pipeline networks and a fuel price hike in January 2017, I analysed administrative and pipeline data to assess the effects of this extractive conflict on prenatal and health outcomes. Using a municipal-level difference-in-differences, I found a 22%–38% increase in homicides in areas near pipelines following the price hike, with no significant effects on birth weight or other prenatal outcomes. I explored two potential mechanisms: the income effect stemming from fuel theft and populations' adaptation to prolonged exposure to violence over two decades. Strong evidence for both mechanisms was found using stress-related hospital discharges among women and nightlight data used as a proxy for income. These findings have important policy implications. The lack of severe prenatal health impacts suggests not only a normalisation to high levels of violence but also an adaptation to a shifting economic environment, where cartel activities and local economies become increasingly intertwined, even at the cost of rising homicides.

1 Introduction

The "war against drugs" in Mexico, declared in 2006, has resulted in a substantial impact, marked by approximately 431,644 homicides and 218,885 reported cases of missing individuals since its inception (INEGI, 2022; National Registry of Missing and Unlocated Persons, 2022).

Despite much of the literature focusing on the conflict's direct consequences, there is limited evidence of its physiological effects, particularly for expectant mothers. Stress during pregnancy can

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have long-term impacts on survival, cognitive development, human capital (Conley, Strully, and Bennett, 2006[30]; Currie and Hyson, 1999[33]) and labour market outcomes (Currie and Moretti, 2007[34]). This study explores how stress from illegal fuel extraction affects prenatal and maternal health in Mexico.

Organised crime in Mexico increasingly relies on violence to evade law enforcement and dominate illicit markets, including oil and fuel. Areas with greater cartel competition see more violence (Vivanco et al., 2023 [46]), intensifying stress for residents. Cartel activities have diversified over time, with the theft of oil and fuel from Mexico's 19,000-kilometer pipeline network becoming a significant revenue stream. Between 2009 and 2016. Fuel theft cost the Mexican government an estimated USD 9.28 billion in lost public finances—a sum comparable to the total budget allocated by the Ministry of Public Education for scientific research and technological development during the same period .

To elucidate the effect of stress on health, I used a difference-in-differences strategy, where I leveraged two sources of quasi-exogenous variation – a) the fuel and oil underground pipeline network's geographic distribution across Mexico as a source of increased incidence of conflict (and thus stress), and b) a temporal dimension created by a substantial and exogenous hike in the price of fuel in Mexico. Security experts and academics have stated that price increases in fuel have catalysed its theft since the profit margins are larger in the black market (Navarro, 2018[68]; Leon Saez, 2021[58]; International Crisis Group, 2022[53]).

The identifying assumption in this study is that the presence of pipelines and the fuel price hike, affect prenatal and maternal health outcomes only through their impact on stress, with homicides serving as a proxy. By using a municipal-level difference-in-differences approach, the study isolates this stress effect while controlling for other confounding factors. To investigate the impact of fuel price increases—linked to increased violence—on health outcomes, I use municipal administrative data from birth certificates, prenatal deaths and obstetric hospital discharges.

I find that municipalities with pipelines experience an average increase in violence ranging from 22% to 38% compared to their neighbouring municipalities (without pipelines). This finding is consistent for all homicides accounted together, and also the type of homicides that are correlated with the presence of organised crime, such as firearm homicides of young males. This increase in the number of homicides suggests that cartels are responsive to external market pressures, such as changes in commodity prices (Sobrino, 2019[77]).

Despite the increase in homicides and, therefore, stress, I find null effects on various prenatal health outcomes, including birth weight, in the aftermath (9 months) of the price increase. Additionally, I find temporal increases (but overall null effects) in neonatal deaths and miscarriages 8-9 months after the price increase, and stillbirths show a lower weight, possibly due to prenatal stress.

Finally, there was a slight decline in hospital births, caesarean sections, and abortions nine months after the price increase, suggesting a potential decrease in fertility.

The null effects on birth weight could signal the capacity to adapt to stress from a population exposed to persistent and high levels of violence for almost 20 years. It is also possible that an income effect - as a result of partaking in/ or having network proximity to illicit activity - may be counteracting/ interplaying with the potential adverse effects of stress on health outcomes. I

https://serendipia.digital/investigacion/tomas-clandestinas-disminuyeron-11-por-ciento-durante-2019/

examined both mechanisms and found compelling evidence for each, utilising stress-related hospital discharges among women and nightlight data as a proxy for income.

One of the general objectives of this research is to fill a gap in the literature on the public health impacts of organised crime in Latin American countries, particularly the effects of persistent exposure to violence. Even though much research has focused on outcomes such as homicides in countries like Mexico, Colombia, Brazil, Peru, and Ecuador, the health consequences remain understudied. This paper aims to contribute to two key strands of literature: (a) the effects of maternal stress on birth outcomes and (b) the broader consequences of endemic violence.

Additionally, these findings are relevant for many Latin American countries plagued by homicidal violence, as current policies that focus on militarising the public force exacerbate homicides and neglect the health consequences of persistent conflict.

One study by Brown (2018[24]) examines the impact of Mexico's "war against drugs" on birth outcomes, focusing on the period between 2002 and 2009. His findings show that birth weight decreased by an average of 42 grams, an effect similar in magnitude to those observed during natural disasters, such as earthquakes (see Torche, 2011[79]). However, nearly 20 years later, the situation in Mexico has changed significantly. Today, the combined power of the country's drug cartels makes them the fifth-largest employers in the nation (Prieto-Curiel et al.,2023[72]). Given the prolonged exposure to violence, the question remains: what more can we say about its far-reaching consequences in Mexico after two decades?

In the first section of this paper, I provide an overview of the literature on maternal stress and conflict in section 2, followed by a description of the price increase in section 3. Afterwards, I will describe how pipelines work and their distribution (section 4) as well as fuel theft (section 5). I will describe the identification strategy, threats to identification and empirical strategy in section 6. In section 10, I will describe the data, and in section 11, I will discuss the results. I explore two possible mechanisms which are a possible income effect derived from the profits of fuel theft and resilience to stress in section 12. In the conclusion (section 13), I will discuss my findings, address the policy implications and propose future research inquiries. Specifically, I will discuss how the absence of severe health impacts points to a normalisation of violence and an adaptation to an economy increasingly intertwined with cartel activities, even at the cost of high homicides.

2 Prenatal health and stressful shocks

The "foetal origins" hypothesis posits that the intrauterine environment and various environmental factors have enduring effects throughout an individual's life. This theory has been expanded in economic literature to analyse the consequences of prenatal health on a wide array of outcomes, including low birth weight and developmental delays.

Medical studies provide insight into mechanisms by which prenatal stress affects birth outcomes, emphasizing hormonal and epigenetic pathways. Elevated levels of Corticotrophin-Releasing Hormone (CRH), a hormone that regulates pregnancy length and foetal development, are often induced by prenatal stress, increasing risks for preterm birth and growth restrictions (Wadha et al., 2004

[82]). Another mechanism involves the epigenetic pathway, where exposure to significant maternal distress in the womb increases a baby's reactivity to stress, potentially leading to poor health outcomes((Miller, 2022 [65]). Additionally, there is evidence that health outcomes are particularly sensitive to stress during the early stages of pregnancy (Glynn et al., 2001 [48]) and also could induce pre-term delivery (Copper et al., 1996 [32]).

One of the most reliable measures of foetal health is birth weight, typically assessed within the first few hours after birth. Extensive research across various disciplines highlights the profound short- and long-term impacts of birth weight and preterm delivery on an individual's health trajectory. Birth weight is categorised into several thresholds: low birth weight (LBW) is defined as less than 2500 grams, very low birth weight (VLBW) is defined as less than 1500 grams and extremely low birth weight (ELBW) is defined as less than 1000 grams. On the other end of the spectrum, macrosomia refers to a condition where a newborn's weight exceeds 4000 grams, which is associated with its own set of risks, including complications during delivery and an increased likelihood of metabolic disorders later in life.

LBW could be caused by a preterm birth (pregnancy less than 37 weeks) and/or due to intrauterine growth restriction (IUGR). IUGR is when babies are small relative to what is expected for their gestational term.

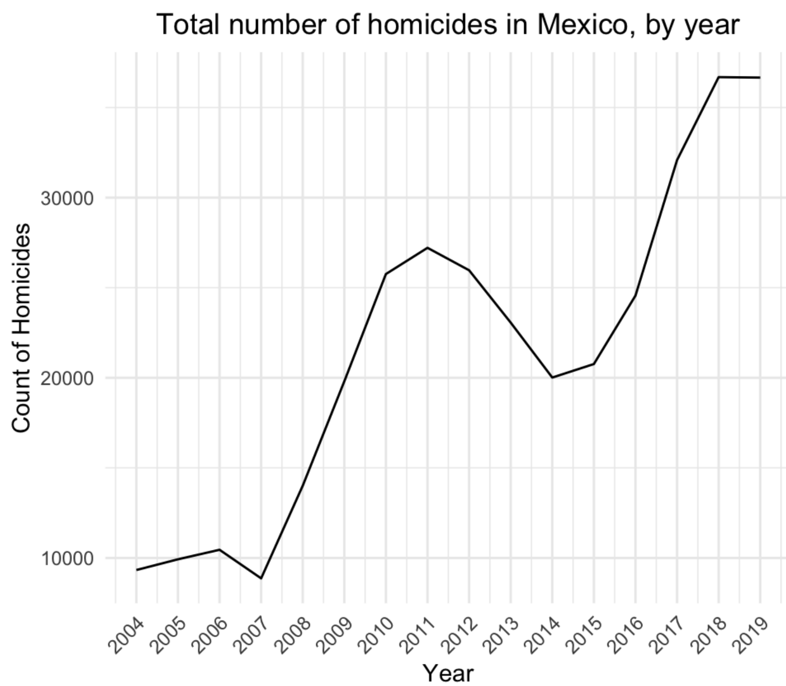
Healthwise, low foetal growth is associated with the risk of infant mortality (Frisbie et al., 1996 [47]), cognitive development (Eves et al. 2023 [41]) and future health outcomes (Hassan et al., 2021 [51]). The consequences of low birth weight are also pervasive in socioeconomic outcomes; there is evidence that found strong correlations between future income outcomes and educational attainment (Currie and Moretti, 2007 [34]; Black et al., 2007 [19]; Oreopoulos et al. 2008 [70]). Furthermore analysis of the "foetal origins" theory has been applied to contexts of economic hardship (Clark et al., 2021 [29], pollution (Molina, 2021 [66]), famine (Scholte et al., 2015 [76]) and conflict (Mansour and Rees, 2011 [63]). There are mostly two approaches when analysing the effects of conflict on prenatal health. One group of papers uses extreme events as catalysers of maternal stress, such as Camacho's (2008 [26]), where she assesses the consequences of random explosions of landmines in Colombia on prenatal outcomes. On a second stream of the literature, there are papers about large increases in violence related to conflict, such as Mansour and Rees's (2012 [63]) research related to the intrauterine exposure to armed exposure of Palestinian mothers.

High homicide rates have become a regularity in Latin America, and they are not derived from a civil war or ethnic conflict but from "crime wars" (Zepeda Gil, 2023 [84]).

In countries experiencing this typology of conflict, such as Mexico, Colombia, Brazil, Peru and recently Ecuador, organised crime strategically employs homicidal violence against security enforcement agents and other criminal organisations, intensifying exposure of the population to conflict.

In the Mexican case, the declaration of the war against drugs by former president Felipe Calderón has kept the country under high levels of violence (see Figure 1). Like many Latin American countries besieged by homicidal violence, the policies created by governments of the region are mostly punitive and have exacerbated homicides (Dell, 2015 [36]; Calderón et al., 2015 [25]; Massa Roldán et al., 2021 [64]; Flores Martinez and Phillips, 2022 [43]). Hence, it is relevant to analyse the effects on health for a population that might be directly or indirectly affected by violence, as homicides can induce distress and anxiety not only through direct exposure but also by witnessing events or encountering news via social media or acquaintances.

Figure 1: Average number of homicides by year



Notes: Homicides from INEGI's mortality records

Rios and Rivera (2018 [73]) found that public displays of violence by Mexican Drug cartels and media coverage experience a self-enforcement mechanism: if media coverage of brutal displays of violence increases, it also increases crime rates and more brutal displays of violence in subsequent periods. This scaling mechanism of severe displays of violence might also increase the distress and anxiety of living in an unsafe municipality and, therefore, affect expectant mothers' well-being. Regarding this, Flores Martinez and Atuesta (2018 [43]), using the MxFLS survey, found that drug-related violence, including narco messages and violent government confrontations, negatively impacts mental health, as indicated by increased depression symptoms reported by individuals.

Moreover, in urban cities in Mexico in 2015, 68% of the population claimed to perceive their city as unsafe (for women, 72.6%). This percentage increase to 73% in 2019 for the overall population but women claimed a 77% .

Mother's indirect exposure to homicides has also been analysed in Latin America. Moscoso (2022 [67]) shows that in Ecuador, newborns exposed to violence show a deficit weight between 20 and 31 grams and that the effect is attenuated if the mother has been exposed to homicides before. Similarly, Koppensteiner and Manacorda (2016 [55]) found a small but significant effect in Brazil in places where violence is rare and where it is endemic.

Mexican evidence of the effects of violence on health is scarce and restricted to the period before

https://www.inegi.org.mx/contenidos/programas/ensu/doc/ensu2019_diciembre_presentacion_ejecutiva.pdf and after 2006. Regarding prenatal health, most of the literature also proposes a stress mechanism as the one directly affecting expectant mothers.

Torche and Villarreal (2014 [78]) found that the security crisis has changed expectant mothers' behaviour by compensating for the stress due to violence by increasing the number of prenatal visits.

Brown (2018 [24]), using the MxFLS survey, analyses the before and after the declaration of the war against drugs and found a substantial decrease in birth weight, particularly for low-income mothers.

3 Fuel price increase: Health and conflict

In 1938, with the nationalisation of the oil industry, this sector became a significant cornerstone for the industrialisation and modernisation of Mexico. The same year, a presidential decree established the creation of the state-owned company Petróleos Mexicanos (PEMEX), which would control all the energy sector activities, such as exploration, production, transportation, refining, and commercialisation. Therefore, for 80 years, PEMEX was the sole entity selling fuel and diesel at regulated retail prices.

From 1938 to 2016, the prices were determined by the Treasure Ministry with no geographical variation; the same prices were fixed throughout the 11,000 gasoline PEMEX stations that only sold PEMEX gasoline (Davis et al., 2019[35]).

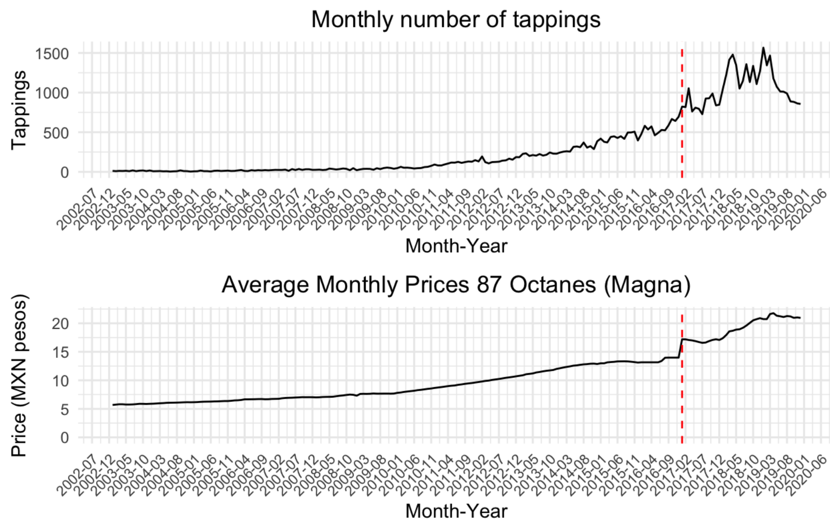
Nevertheless, with the decline of oil production, the pressing international environment and fiscal overload, the Mexican government approved a reform in 2013 that would slowly liberalise the sector. However, due to the oil crisis, the Mexican government changed the liberalisation calendar several times until the Energy Regulatory Commission released the final one on the 20th of December 2016. Later that same month, another announcement surprised the Mexican population with an increase of 20% in fuel prices, the highest increase in history. This price remained the same until February 18th, and since then, the maximum prices were set daily, so each litre of gasoline could be more expensive or cheaper from one day to the other.

Price controls for retail gasoline and diesel began to be removed on March 30, 2017, with a staggered rollout, where price liberalisation started in the north of the country (Baja California and Sonora). Then, they continued to other border states, followed by states farther south. By November 30, 2017, prices were liberalised nationwide.

According to political analysts, this price increase has made the oil/fuel theft industry more lucrative than before by increasing sales on the black market (Navarro, 2018[68]).

I used data obtained through an information request from Mexico's National Institute for Transparency, Access to Information, and Personal Data Protection (INAI) to PEMEX to plot pipeline tappings alongside PEMEX's historical pricing series. Figure 2 shows an apparent increase in pipeline tappings that aligns with the timing of the fuel price hike. Indeed, the total number of illegal fuel tappings increased from 5,972 in 2016 to 9,995 in 2017.

Figure 2: Average monthly tappings and prices



Notes: Monthly tappings and prices. Tappings' data source is from a public information request with folio number 1857200094319. Sources for prices: Energy Information System (before 2016), public information request with folio number (for 2016) and Energy Regulatory Commission (for 2017 onwards). Prices before 2017 are national prices determined by PEMEX and the treasury ministry. Prices are the national average for unlead gasoline (87 octanes-Magna) from 2017 onwards.

Recent literature examines how exogenous income shocks, driven by fluctuations in commodity prices, may influence armed conflict in complex ways. Two mechanisms are identified when the prices of specific goods, such as oil or agricultural products, rise. The first mechanism posits that higher wages decrease the labour supply for criminal activities as legal work becomes more attractive (Becker, 1968 [14]). Conversely, the second mechanism suggests that rising commodity prices can increase the potential returns from predatory activities, thereby escalating conflict (Grossman, 1991 [50]). As a result, evidence regarding the impact of commodity price changes on violence is ambivalent. These mixed findings depend not only on the type of good (e.g., oil, minerals, cocoa) and the specific institutional context of each country but also on the data aggregation level, as within-country heterogeneity is often inadequately captured.

Dube et al. (2013 [39]) provide evidence of the link between price changes and conflict, reporting a positive relationship between oil price hikes and conflict escalation in Colombia, especially in resource-rich municipalities. The capital-intensive nature of the oil sector encourages increased extraction (i.e., rapacity) rather than a shift of labour towards legal sectors. Another example of this mechanism with disaggregated data (grid cells) is provided by Berman et al. (2017[16]), where they show that mining extraction by armed groups in Africa increases the likelihood of violence. Similarly, Axbard et al. (2021 [10]) found that higher mineral prices reduced crime rates, as the mineral sector heavily depends on labour.

Further evidence highlights how commodity prices can influence crime patterns beyond violent conflict. Draca et al. (2019[38]), using a detailed crime dataset from London, demonstrate significant positive crime–price elasticities for a panel of 44 consumer goods, including commodity-related goods like jewellery, fuel, and metal, indicating that changes in goods prices explain a considerable portion of property crime trends. Similarly, Braakmann et al. (2024[23]) provide evidence that temporal variations in the expected returns to crime affect the location of property crimes. Their study on gold prices and burglaries in South Asian neighbourhoods in the UK shows that burglars respond to price fluctuations, targeting geographic locations with higher expected returns.

Meanwhile, research on the relationship between changes in commodity prices and health outcomes has been analysed separately from conflict-related studies. Adhvaryu et al. (2019[2]) found that low cocoa prices at the time of birth in cocoa-producing regions of Ghana increased the incidence of severe mental distress. Their findings suggest that cocoa prices positively impact maternal weight and body mass index, which are closely linked to birth weight and infant health. For the Mexican context, Adhvaryu et al. (2024[3]) demonstrate that adverse rainfall reduces agricultural wages and negatively impacts physical health and how the CCT program PROGRESA helped mitigate these negative effects.

This research aims to connect changes in commodity prices such as fuel, crime and health since this triad is present in low-governance contexts.

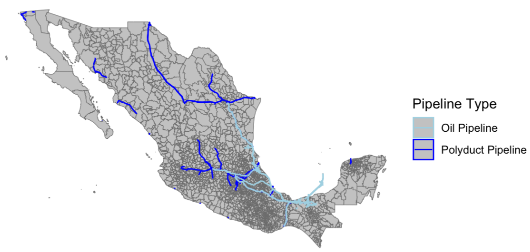
4 Pipelines and tappings

The distribution of hydrocarbons in Mexico is partly done through an intricate pipeline network. The first pipeline was built in 1910 by the Mexican Eagle Petroleum Company and is no longer operational; however, over the past century, Mexico's oil infrastructure has undergone extensive changes, updates, and expansions. The pipelines are usually buried underground and are not located within secure industrial complexes; instead, they stretch across a myriad of territories such as cities, highways, agricultural fields, and natural areas, including private properties, communal lands, and Indigenous territories.

This research analyses two types of pipelines: oil pipelines and "poliductos" which are multipurpose pipelines. Oil pipelines, which stretch a total of 10,006.53 kilometres, transport crude oil from extraction sites to refineries, petrochemical plants, and gas processing facilities. Polyducts primarily transport processed fuels such as gasoline and diesel and are more frequently targeted for fuel theft. Mexico has 9,098.53 kilometres of polyducts.

The Mexican government has not disclosed the exact location of the pipelines due to national security concerns. However, the NGO CartoCritica has published a map that recompiles different sources to map this infrastructure since this consists of old infrastructure built from the 1930s to the 1990s. According to this map, the pipelines traverse 400 out of 2,643 municipalities (in 2017) in 29 out of 32 states. Among these 400 municipalities, 80 have oil pipelines, 164 have only polyducts, and 156 have the presence of both types of pipelines.

(a) Pipelines



(b) CartoCritica

Notes: Map extracted from CartoCritica

Although the Mexican government has not publicly disclosed the precise locations of the pipelines, various media outlets have urged PEMEX, through the Mexican National Institute for Transparency, Access to Information, and Personal Data Protection (INAI), to release data on where illegal taps have occurred to assess the severity of the issue.

The INAI released documents (numbers 1857200016119 and 1857200081419) disclosing the municipalities with tapped pipelines (polyducts and oil pipelines) and the monthly number of tappings from 2000 to 2019. I created a database with the location of the tappings and cross-validated it with the CartoCritica map of oil and polyduct pipelines and found a 98.28% overlap between places with tapped pipelines and municipalities with pipelines (with only seven municipalities without pipeline presence where the Mexican government disclosed a tapping). According to this dataset, 83% of the municipalities with pipelines have experienced at least one tapping from 2000 to 2019.

Other papers use different maps of pipeline infrastructure, like the one used by Vivanco et al. (2023[46]), that show the presence of the pipeline in 285 municipalities. I chose to use the CartoCritica map, which is also used by Lopez and Torrens (2023 [61]) and Battison et al. (2024[11]) due to the high overlap between the disclosed municipalities with tappings and the CartoCritica map.

5 Fuel theft

Yashar (2018[83]) states that illicit markets flourish in regions characterised by illicit political economies, ineffective state security forces, and competitive dynamics among crime organisations seeking control over territorial enclaves. These conditions are evident in Mexico's ongoing fuel theft epidemic, which has become one of the most profitable activities for drug trafficking organisations (DTOs) in the country. This activity has also been present in contexts such as Nigeria, Turkey and the border between Colombia and Venezuela (Saez Leon, 2021[58]).

Since the "war against drugs" was declared, increased militarisation has prompted DTOs to diver-

sify their activities into black markets. This diversification became necessary to maintain profits as drug trafficking grew increasingly violent and risky due to competition and state crackdowns.
The profitability of fuel theft has attracted criminal organisations such as the Zetas, Caballeros Templarios, and Cártel Jalisco Nueva Generación (CJNG). Smaller regional groups, particularly in states like Puebla, manage operations under the authority of larger cartels (Navarro, 2018 [68]). The competition for fuel has turned areas with pipelines into battlegrounds.
Fuel theft is a complex crime that relies on insider knowledge of PEMEX operations, particularly the exact locations of its underground pipelines, which can be buried up to 30 meters deep and are often hidden from view. Because of national security concerns, the Mexican government has classified the specific locations of these pipelines, making it challenging for outsiders to obtain this information. As a result, organized crime groups often target PEMEX employees and officials with bribery, extortion, and threats to gather details about not only where the pipelines are located but the pressure within them and the types of substances being transported, including various refined fuels like diesel and unleaded gasoline.
In an anonymous interview a person involved in fuel theft stated that such operations typically require between 10 to 20 people, sometimes including an engineer or technician. The same interviewee also declared that fuel theft is more profitable than being a member of one of Mexico's most prominent cartels, Los Zetas. Fuel theft can yield up to 250,000 pesos (13,317 USD) every two weeks, though this amount varies.
Between 2009 and 2016, the Mexican government lost 159,957 million pesos (9.28 billion USD) in public finances due to fuel theft. In terms of volume, estimates reveal that the lost amount totals 14,652 million litres, equivalent to up to 250 fuel tanker trucks daily . Additionally, PEMEX had to spend nearly 1.8 billion pesos (95 million USD) to repair the tapped pipelines. Moreover, the federal energy regulatory agency (Comisión Reguladora de Energía, CRE) found that between 2009 and 2016, fuel thieves tapped PEMEX's pipeline network on average every 1.4 kilometres.
According to in-depth research on oil theft by Leon Saez (2021[58], 2022[57]), the first evidence of this crime appeared in the 1980s with small-scale operations. In 2004, police detected specialised groups with sophisticated networks for robbery and distribution in Tlaxcala, Estado de Mexico, Tamaulipas, Queretaro, Oaxaca, and Sinaloa. During this period, oil theft was usually carried out directly at oil terminals by colluding with or coercing PEMEX staff. It was not until President Felipe Calderón's term (2006-2012) and the declaration of the "war against drugs" that fuel theft via pipeline tapping significantly increased.
Between 2007 and 2008, the number of pipeline tappings saw its first significant increase, suggesting the entry of new organised crime actors into an already expanding black market. Since 2013, PEMEX has enlisted the help of the Mexican army and the Marines to combat fuel theft.
Qualitative evidence describes an increase in violence in places where tappings occurred; however, the quantitative evidence regarding violence provoked by the potential tapping of pipelines is limited but growing.

https://vanguardia.com.mx/noticias/nacional/huachicolero-confiesa-robar-pemex-es-mas-redituable-que-ser-zeta-IPVG3435728

https://elpais.com/internacional/2017/05/05/mexico/1493959583_187590.html

https://www.animalpolitico.com/2017/02/robo-combustible-ductos-pemex-gobierno-pena

López and Torrens (2023[61]) modelled competition behaviour amongst cartels and found that when the government cracks down on drug trafficking, it triggers criminal diversification into other illegal activities like fuel theft. Because fuel theft opportunities are geographically dispersed and do not align with the drug trafficking areas, organised crime spreads to new locations. López and Torrens (2023[61]) also found an increase in homicides in places with pipelines.

On a similar note, Vivanco et al. (2023 [46]) show that an increase in international oil prices is associated with higher homicide rates in municipalities with pipelines. Lastly, Battiston et al. (2024 [11]) found that municipalities with pipelines experienced a significant increase in cartel presence compared to those without pipelines. They also found that among municipalities with pipelines, there are more illegal taps in areas where the political party supporting anti-drug trafficking policies narrowly won local elections. However, they did not find an increase in homicides.

I show that violence increased in areas with pipelines from 2016 to 2017 by 22% to 38% to probe whether places with pipelines have become more stressful to live in.

6 Identification strategy

This study analyses the effect of stress due to violence on various health outcomes, focusing on the context of Mexico, where homicides have been on the rise since the declaration of the war against drugs in 2006. Homicide counts are among the most reliable crime data in Mexico, despite the serious problem of underreporting, and can serve as a proxy for measuring stress. However, the persistent level of violence across municipalities is not exogenous.

To address this challenge, one strategy is to examine health outcomes before and after the 2006 declaration of the war against drugs using the MxFLS survey whose temporal variation allows to explore this time frame (see Alamir, 2023 [5], Tsaneva and Gunes, 2020 [81], Brown, 2018 [24] and Flores Martinez and Atuesta, 2018 [42]). This type of analysis is not plausible using birth certificate records since relevant health data such as birth weight were only consistently documented starting in 2008. Furthermore, given almost two decades of ongoing conflict, it is crucial to investigate whether the population has normalised stress or if changes in the geographical distribution of crime, and consequently homicides, have affected health outcomes.

Therefore, I leverage quasi-exogenous variation from the pipeline network's geography and a significant 2017 fuel price hike derived from a presidential decree. Thus, my design will consist of municipalities with pipelines used as treatment units, and the control units will consist of adjacent municipalities (first-order neighbours) to guarantee that both groups are overall comparable. To enhance my empirical design, my data is not only disaggregated at the municipal level but also accounts for the monthly variation of my outcome variables.

Furthermore, the location of the pipelines is unrelated to the current violence in Mexico, as the infrastructure was constructed between the 1930s and early 1990s, well before the onset of the "war against drugs" policy.

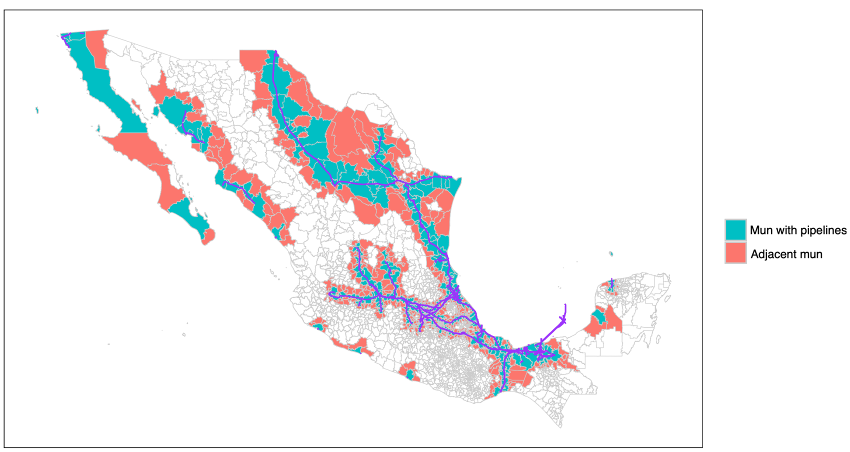
The design exploits a price hike, which could raise concerns about its exogeneity. However, the source of the shock is exogenous as people expected the liberalisation of prices at some point in 2017 (the final calendar was realised on the 20th of December 2016). Still, the population did not expect the rise of prices of 20% announced on the 28th of December 2016 and to be enacted on the first of January 2017.

The surprise and discontent caused by this measure were also due to the government communicating during the approval of the reform that among the benefits of price liberalisation was a decrease in fuel prices, which did not occur. This caused the president's approval to drop to 12%, the lowest approval a Mexican president has ever had.

To claim that places with pipelines are more violent and, therefore, more stressful, it is first necessary to show that there are indeed more homicides in places with pipelines compared to places without pipelines. Hence, the design in Figure 4 is implemented, comparing places with pipelines to their first-order neighbours, as these areas have, on average, shared similar characteristics. This approach allows for a comparison of the effects of homicides in municipalities where they are presumably unexpected and potentially more traumatic than in municipalities where homicides are frequent.

Having defined the identification strategy, I show that after the price increase, homicides increased in places with pipelines. A first insight into the increasing number of homicides is given by comparing both trends (Figure 7). Nevertheless, by conducting an event study and employing differences-in-differences designs, it is confirmed that there is a clear rise in homicides after the price increase. This provides an opportunity to elucidate the impact of stress due to homicidal violence perpetrated by drug trafficking organisations (DTOs) on prenatal and other health outcomes.

Figure 4: Municipalities with pipelines vs first-order neighbours



Notes: Municipalities with pipelines in green, first-order neighbours in orange. Information from the location of the pipelines was extracted from the CartoCritica map.

7 Threats to identification

Exposure to conflict and high levels of violence can significantly alter population behaviour, particularly affecting women's fertility decisions and motivating expectant mothers to relocate due to safety concerns. Consequently, internal migration and selective fertility are two mechanisms that could confound my estimates.

Examining fertility trends over time revealed no statistically significant changes in any period. Difference-in-differences (DiD) estimates also showed no significant effects. Recognising that fertility responses may vary across different groups, I did a separate analysis on a sample of women with more schooling years, as suggested by Pop-Eleches (2010 [71]), who argues that these women are more likely to use birth control effectively. Also, this subgroup encompasses 14.94% of the sample, which might proxy high-skilled workers who are most likely to move (Aldeco et al. 2022[6]). For this group of women, the event study's point estimates are not statistically significant from zero and show no pretrends. Nevertheless, the DiD coefficient shows a slight decrease in fertility at the 10% level of significance for this group of women (see Appendix).

Assessing internal migration is challenging due to the lack of comprehensive data tracking population movements. The scarce data regarding migration is contained in the decennial Censuses (2010 and 2020) and an Intercensal Survey (2015), where both datasets are representative at the municipal level. The 2020 Census asks if the person resides in the same state from 2015 to 2020. The Intercensal survey (2015) asks if the person resided in the same municipality in the previous five years (2010).

The Intercensal survey shows that overall, 82% of inhabitants live in the same municipality in the period 2010-2015, but this percentage is higher (92%) for women in their fertile age (15 to 49). Particularly, for municipalities with pipelines, the percentage of the population that remained living in the same municipality is 83 %, whereas for their neighbouring municipalities is 84.33%. For women in their fertile age, the share of those remaining in the same municipality is 90.81%, whereas for the neighbouring municipalities is 91.8%.

Hence, due to the lack of administrative data at the municipal level and for the years of my analysis (2016 and 2017), I used a geospatial strategy to revise possible internal migration close to the pipelines. This approach allows observing population dynamics beyond municipal boundaries, offering a clearer picture of potential internal migration and growth near polyduct and oil pipelines. The data is analysed through buffers of varying distances (5 km to 20 km), using high-resolution GeoTIFF files to estimate population counts within each buffer zone (See the Appendix for the complete analysis).

Following this strategy, I found a slight but statistically significant increase in population between 2016 and 2017 for areas near both types of pipelines that align closely with national and urban growth rates (1.1% and 1.4%, respectively). This increase suggests that the observed population changes are more reflective of Mexico's general demographic trends rather than internal migration triggered by security concerns or other local factors. The stable growth pattern across different buffer distances further supports the theory that the presence of pipelines has not significantly influenced migration patterns. This also confirms that the pipelines link urban centres although they pass by different kinds of territories.

In conclusion, internal migration and selective fertility do not threaten my identification strategy.

8 Time frame

To assess the impact of pipelines on homicides and stress, I divided the outcome data into two different time frames. This division allows for a distinct evaluation of in-utero stress effects on perinatal outcomes compared to obstetric hospital discharges and homicides. This time distinction is made because perinatal outcomes are evaluated across the gestational period. Nevertheless, both sets of outcomes are analysed using an event-study framework and a difference-in-differences design. The analysis accounts for monthly variation, being municipalities the geographic unit of analysis.
Obstetric hospital discharges, as well as homicides, are analysed directly by examining the effects nine months before (April 2016) and after the price increase. Accordingly, hospital discharges and homicide analyses follow the timeline outlined in Figure 5. Any effects attributable to the price increase are expected to manifest after the reference period, December 2016 (zero), starting from January 2017.

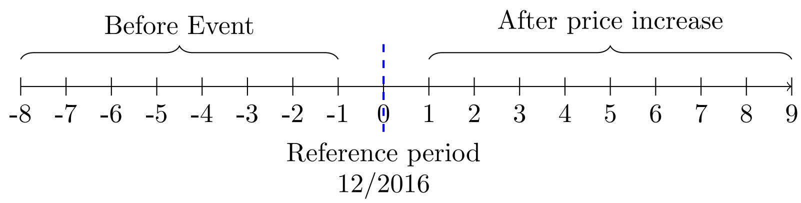


Figure 5: Timeline centred around December 2016

For perinatal outcomes, I use birth certificates and neonatal mortality records. Both datasets include the date of birth and gestational age, enabling the estimation of conception dates for each birth. This allows for aggregating outcome data by month, year, and municipality. To assess prenatal stress exposure, I selected March 2016 as the reference period, one month before conception, ensuring that infants born in January 2017 had at least one month of prenatal stress exposure. Consequently, the analysis of perinatal outcomes (Figure 6) covers the nine months following conception and the nine months following the price increase. If the rise in violence triggered by price changes affected perinatal outcomes, I should observe this impact in births between January 2017 and October 2017.

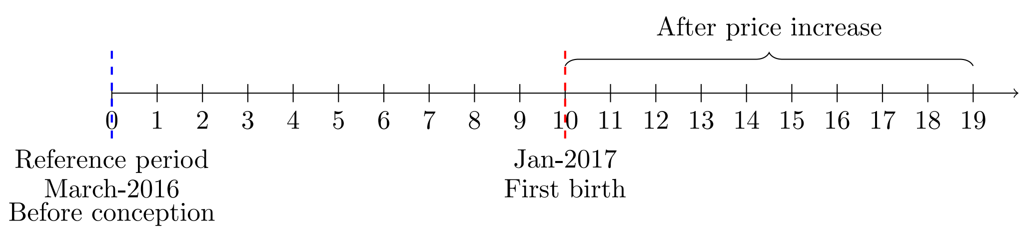


Figure 6: Timeline starting from zero with Reference Period and 01/2017 onwards

9 Event study design

I use an event-study design to measure the impact of pipelines and violence on the two sets of health outcomes. For the obstetric discharges for women of fertile age and homicides, I follow the timeline outlined in Figure 5.

Hence for a set of i outcomes, outcome Y_i by municipality j and time (month-year) t, I estimate the following specification:

$$Y_{jt} = \mu_0 + \beta_0 \cdot \text{Pipeline}_{jt} + \sum_{k=-8, k\neq 0}^{9} \beta_k \cdot \text{Pipeline}_{jt} \cdot \mathbb{1}[\tau = k] + \eta_j + \delta_t + \varepsilon_{jt} \tag{1}$$

The term $Pipeline_{jt}$ is a dummy variable that takes the value of "1" when there is a pipeline in the municipality and "0" if the municipality is the first-order neighbour. The reference period ($Time_t = 0$) is set in December 2016, just before the price increase.

The analysis considers a pre-event window t, $k = \{-8, -7, -6, -5, -4, -3, -2, -1\}$ in 2016 and an after-event period ($k = \{1, 2, 3, 4, 5, 6, 7, 8, 9\}$) from January 2017 onward. Each estimate β_k represents the change in outcome Y for municipalities with pipelines compared to their neighbours after the price increase.

The event study also incorporates time-fixed-effects δ_t (month and year) to account for seasonal fluctuations and municipality fixed-effects η_j to control for non-invariant geographical characteristics. Standard errors are clustered by municipality (Abadie et al., 2022 [1]). Additionally, difference-in-differences (DiD) designs were employed to assess aggregate effects before and after the price increase.

For the set of perinatal outcomes Y_i by the municipality of residence of the mother j and time (month-year) t, I estimate the specification 2 that follows the timeline in Figure 6, with the reference period "0" set as one month before conception in March 2016.

$$Y_{jt} = \mu_0 + \beta_0 \cdot \text{Pipeline}_{jt} + \sum_{k=0, k\neq 0}^{19} \beta_k \cdot \text{Pipeline}_{jt} \cdot \mathbb{1}[\tau = k] + \rho_j + \gamma_t + \varepsilon_{jt} \tag{2}$$

Hence the pre-event study window t, $k = \{1, 2, 3, 4, 5, 6, 7, 8, 9\}$ is from April to December 2016 and an after-event period and an after-event period ($k = \{10, 11, 12, 13, 14, 15, 16, 17, 18, 19\}$) from January 2017 to October 2017. This period corresponds to the gestational period of babies exposed throughout their entire gestation to the price increase.

The variable $Pipeline_{jt}$ serves as a dummy variable, taking the value of 1 when a pipeline is present in the municipality. To control for potential common time shocks affecting outcomes, fixed effects for the time of conception (month-year) γ_t and municipality ρ_j are included. Standard errors are clustered at the mother's municipality of residence to account for any correlation within municipalities.

10 Data and variable definitions

I use the above-mentioned empirical strategy on an array of different health outcomes. All the outcome data comes from administrative registers collected by the National Institute of Statistics and Geography, INEGI (in Spanish) for all 2463 municipalities.

10.1 Health outcomes

This research focuses mainly on perinatal health; hence, I analyse two different datasets: birth certificates and neonatal mortality registers. Both datasets represent a contrast between more "resilient" pregnancies that managed to reach their full term as well as to characterise the ones that could not make it.

Data on birth certificates is based on administrative records from civil registry certificates that provide insights into common maternal ages at conception, timing and completeness of birth registrations and distribution of births based on the size of the mother's usual place of residence, among other factors.

Neonatal mortality records are obtained from Death and Foetal Death Certificates, which capture both deaths at birth and the loss of a product of conception before it is fully expelled or extracted from the mother's body, regardless of the duration of the pregnancy. This administrative dataset compiles all Death Certificates, as required by the Civil Registry.

The homicides were obtained from INEGI's mortality records that provide key characteristics covered, including age, sex, and underlying cause of death. In this case, it was selected "Homicide" as the sole cause of death. However, it was analysed other outcomes like stress-related mortality causes, suicides and infant mortality without finding statistically significant results.

INEGI collects data from hospital discharges through the National Health Information System, which compiles information from forms completed by doctors at the end of hospital stays in public health facilities. This dataset includes the primary diagnosis and the patient's sex, along with a subsection for obstetric visits that records births in hospitals, caesarean sections, and abortions.

Table 1: Outcome variables

Reference Period	Type of Data	Outcome	Source (INEGI)
December 2016	Homicides	All homicides	Mortality registers
(Month before the price increase)		Male homicides	
		Firearm homicides	
		Young men (14 to 45) homicides	
		Male and firearm homicides	
		Young male homicides with firearm	
		Female homicides	
December 2016	Obstetric hospital discharges	Rate of abortion	Hospital discharges
(Month before the price increase)		Rate of use contraceptives	
		Rate of C-sections	
		Rate of Dystocic pregnancies	
		Rate of births	
March 2016	Neonatal mortality	Rate of prenatal deaths	Mortality registers
(Month before conception)		Rate of complications during pregnancy	
		Rate of stillbirths	
		Rate of death during birth	
		Gestational age	
		Weight	
		Rate of death of male fetus	
		Rate of miscarriages	
		Rate of death due to violence	
		Prenatal care (number of visits)	
March 2016	Birth certificates	Birth weight	Birth certificates (SINAC)
(Month before conception)		Gestational age	
		Percentage of low birth weight (less than 2500g)	
		Percentage of very low birth weight (less than 1500g)	
		Percentage of macrosomia (more than 4000g)	
		Prenatal care (number of visits)	
		Percentage premature	
		Apgar	
		Low Apgar (below 7)	
		Fertility rate	
		Sex ratios	
		Percentage of teenage mothers	
		Percentage of anomaly	

Outcome data sources related to violence and health indicators

10.2 Birth certificates

The birth certificate dataset has been collected since 1986, however, for this analysis, I will only focus on the period from March 2016 to October 2017. This dataset includes detailed information on newborns, such as weight (collected since 2008), gestational age, and sex, as well as maternal characteristics like age, education, and municipality of residence. I studied all births (2,823,800) during this period and collapsed the data by month, year, and municipality. I calculated various metrics such as averages of the following variables: birth weight (in grams), gestational age (in weeks), mother's age, number of prenatal visits, and Apgar scores. Additionally, I estimated the percentages of premature births (less than 37 weeks), percentage of teenage mothers, percentage of babies born with anomalies, sex ratios, and low Apgar scores (less than 7).
Data inconsistencies, such as babies weighing less than 500 grams and mothers over 60 years old, were excluded to ensure data accuracy.
The descriptive statistic table shows very similar weights at birth from both kinds of municipalities; however, after the 2017 price increase, the birth weight dropped for both groups. The percentage

of low-birth babies, as well as the average gestational age, are also very similar.

Table 2: Descriptive Statistics

	Pre-price increase		Post-price increase	
Variable	Control	Treatment	Control	Treatment
Birth weight (grams)	3153.03	3151.71	3141.69	3142.64
Mean gestational age (weeks)	38.80	38.76	38.76	38.70
% of low birth weight	5.75	5.75	6.19	6.40
% of very low birth weight	.59	.56	.60	.67
% of macrosomia	2.85	2.89	2.87	2.89
Mean prenatal care	7.39	7.72	7.42	7.71
% premature	6.32	6.22	6.26	6.43
Mean Apgar	8.89	8.90	8.89	8.90
% low Apagar	.97	.83	.99	.86
Fertility rate (per 1000)	4.44	4.24	5.12	4.51
Sex ratio	1.04	1.01	1.05	1.02
Mother's age	24.78	24.84	25.23	25.29
% anomaly	6.40	5.11	4.54	3.86

Notes: Descriptive statistics of birth certificate data from INEGI. These descriptive statistics encompass March 2016 to October 2017.

10.3 Neonatal mortality

This dataset records the characteristics of the products of conception (POC). For neonatal mortality, I included an array of outcomes aggregated by municipality, month, and year that includes rates such as complications during pregnancy, deaths at birth and pregnancy, neonatal deaths of male fetuses, miscarriages, and deaths due to violence. These rates were calculated by dividing the number of cases by the total number of women in their childbearing years in the municipality in that specific month and year times 1000. More details about the population counts are provided in the Appendix. As the birth certificate sample, the dataset spans from March 2016 to October 2017. The descriptive statistics show that, on average, there are more prenatal deaths in places without pipelines. After the price increase, this percentage remained constant, whereas it increased in places with pipelines. Moreover, adjacent municipalities decreased the rate of complications during pregnancy, death during pregnancy and miscarriages, but places with pipelines experienced an increase.

Table 3: Descriptive statistics of neonatal mortality

	Pre-price increase		Post-price increase	
Variable	Control	Treatment	Control	Treatment
Rate of prenatal deaths	.019	.011	.22	.012
Rate of complications during pregnancy	.047	.02	.04	.029
Rate of death during pregnancy	.110	.06	.010	.076
Rate of death during birth	.019	.011	.022	.012
Average gestational age (weeks)	27.81	27.49	27.66	27.32
Average weight (grams)	1488.61	1426.94	1439.29	1403.49
Rate of death of male fetus	.076	.04	.075	.049
Rate of miscarriages	.029	.017	.027	.019
Rate of death due to violence	.0003	.0001	.0001	.000099
Prenatal care	7.4	6.81	6.44	7.02

Notes: Descriptive statistics of neonatal deaths from INEGI. The rates were obtained by dividing the number of cases by the women in their childbearing age population in the municipality. These descriptive statistics encompass March 2016 to October 2017.

10.4 Obstetric hospital discharges

The National Health Information System relies on hospital discharge statistics compiled from forms completed by doctors at the end of hospital stays. This data undergoes thorough review, coding, and processing to provide insights into healthcare demand and epidemiological trends. These statistics encompass discharges from both general and specialised hospitals. Diagnoses are categorised based on the primary condition treated or diagnosed at discharge using ICD codes, with priority given to conditions that require the most resources.

These administrative records include a section on obstetric hospital discharges that encompasses data on hospital births, caesarean sections, abortions, and the use of contraceptives such as intrauterine devices, patches, or hormonal methods. To obtain the rate of obstetric hospital discharges per category, the data was aggregated by month, year, and municipality, divided by the population of women of reproductive age, and multiplied by 1000.

The obstetric discharges dataset can provide valuable information regarding any behavioural changes in women in their reproductive age due to violence and stress. This dataset includes variables like births at the hospital, C-sections, dystocic births (refers to difficult or abnormal childbirth), abortion and receiving contraceptives.

The data shows a decrease in births after the price increase, with no substantial changes in the rate of dystocic pregnancies. However, there is a noticeable decrease in the contraceptive rate, which consists of hospital appointments for contraceptives such as oral hormonal, monthly and bimonthly injectable, subdermal implants, intrauterine devices (IUD), female condoms, male condoms and medicated IUDs.

Table 4: Descriptive statistics of obstetric hospital discharges

	Pre-price increase		Post-price increase	
Variable	Control	Treatment	Control	Treatment
Birth rate	2.71	2.35	2.07	1.68
C-sections rate	.99	.87	.75	.61
Dystocic rate	.28	.25	.29	.24
Contraceptive rate	1.99	1.92	.965	.90
Abortion rate	.28	.25	.29	.26

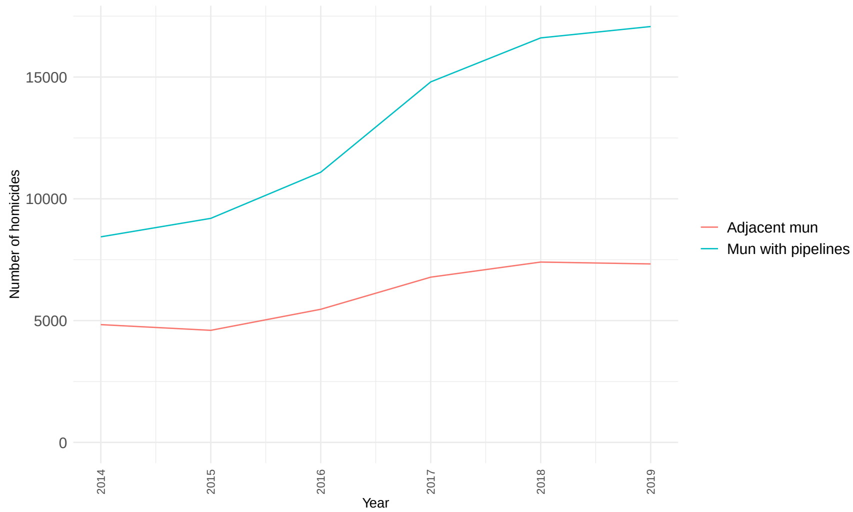
Notes: Descriptive statistics of women's obstetric hospital discharges from INEGI. The variables include births at hospitals, C-sections, dystocic births, contraceptives and abortions. The rates were obtained by dividing the total number of women patients by the women in their fertile age population in the municipality and multiplied by 1000. These descriptive statistics encompass April 2016 to September 2017.

10.5 Homicides

The homicide data comes from the mortality counts done by the Mexican National Institute of Statistics and Geography (INEGI). INEGI registers homicides by using death certificates, which I am collapsing by municipality, month and year of occurrence. Within the category of "homicides", there are subcategories such as firearm homicides as well as the age and sex of the victim, which allows a more detailed analysis of this cause of death.

In Figure 7, it can be observed the differences between the number of homicides by month and year and how they followed a similar trajectory until 2017. After 2017, the municipalities with pipelines show a noticeable change in the slope, whereas the adjacent municipalities (first-order neighbours) remain constant.

Figure 7: Number of homicides in municipalities with pipelines vs. first-order neighbours



Notes: Homicides in municipalities with pipelines in green, first-order neighbours in orange. Information from the location of the pipelines was extracted from the CartoCritica map. Homicides are from INEGI's mortality records. These descriptive statistics encompass April 2016 to September 2017.

11 Baseline results

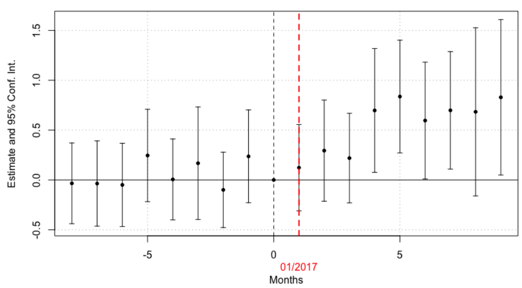
This section shows the event study design that compares places with pipelines (treated) vis-a-vis neighbouring municipalities (control) amid the fuel price increase in January 2017.
Firstly, I show that places with pipelines are, on average, more violent than places without them. For the rest of the outcomes, I will only display those statistically significant results from the health outcomes.

11.1 Are there more homicides in places with pipelines?

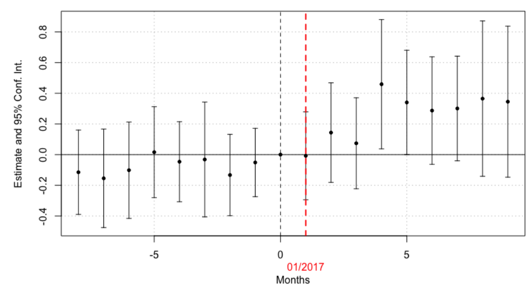
As observed in other Latin American countries, Mexico's geography of violence has changed substantially in the last years due to the reallocation of crime in places where there is profit (Yashar, 2018 [83]). This stylised fact, jointly with the State's limited capacity to enforce the law, has transformed regions where these groups compete for goods such as fuel in places where homicidal violence is extreme.
Given the above scenario, firstly, I aim to test if places with pipelines became more stressful to live in, it is necessary to check if they became more violent. A way to measure the latter is to verify if homicides, which is the most reliable proxy of violence in Mexico, did increase in places with pipelines.
Using the research design (Figure 5) and an event study (based on Eq.1), I analysed homicides nine months before and after the 2017 price increase, using the reference period as December 2016.

In Figure 8a, the event study shows that homicides started increasing in April 2017 and remained positive and significant in the subsequent months. For firearm homicides of young men (Figure 8b), I found the same persistent increase in April 2017. In the DiD estimates, I observe an increase of 38% in all types of homicides in comparison to the average.
Similarly, for the firearm homicides of young men (14 to 49), a type of homicide correlated with organised crime, I found an increase of almost 22%. All corresponding regression tables are available in the Appendix.

(a) Effect of price increase in all homicides



(b) Effect of price increase in young male homic. with firearm



Notes: Results from estimating equation 1, where the dependent variables are the number of homicides and firearm homicides of young men (14 to 45 years old) from INEGI's mortality population counts from April 2016 to September 2017, therefore 9 months before and after the price increase. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the number of homicides. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

I observed a similar pattern in the event studies and DiD estimates for firearm, male and young male homicides when analysed separately (see Appendix). For female homicides, I do observe an increase after the price increase but with pre-trends.
These findings reinforce the idea that Drug Trafficking Organizations adjust their strategies in response to external market pressures and new avenues of profit. These results are in line with Sobrino's (2019[77]) study, which investigated the demand shock for heroin resulting from the 2010 OxyContin reformulation. Sobrino found that an increase in the number of cartels entering a geographically defined market, such as opium poppy cultivation, is associated with rising homicide rates in that region.
Battinson et al. (2024[11]), analysed cartel competition in the context of fuel theft and found that the 2006 war against drugs (government crackdowns on drug-related violence and drug-trafficking routes) pushed cartels into this illegal activity without finding an increase in homicides during the 2000-2014 period. Nevertheless, the evidence presented in this paper suggests that the 2017 price shock motivated cartels to compete aggressively against each other for this good.

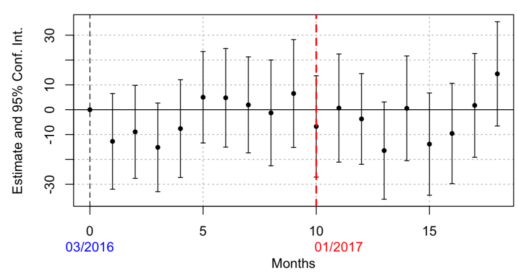
11.2 Perinatal health results

This section presents the results for perinatal outcomes from birth certificates and neonatal mortality records. The analysis follows the time frame outlined in Figure 6 and the specification described in equation 2, including time and municipality fixed-effects.

The event studies begin one month before conception (March 2016, indicated by the blue dashed line) for those affected by the price increase. The first babies impacted by the price increase should be born starting in month 10 (January 2017, indicated by the red dashed line) and continue through the end of the 9-month time frame in October 2017. Only relevant outcomes are reported.

Figure 9a shows the results for all births. The event-study plot shows a pre-trend and a negative and statistically different from zero point estimate in April 2017, the month homicides increased; however, there is no clear pattern. Additionally, the DiD estimate (see Appendix) reveals that the combined effect of a price increase and the presence of a pipeline does not have any effect on birth weight.

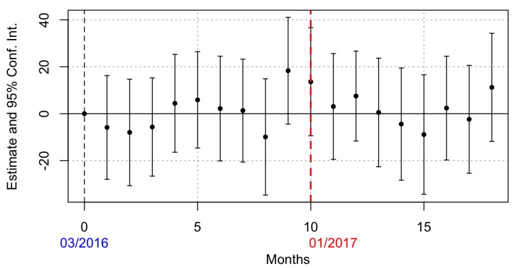
(a) Effects of the price increase on birth weight



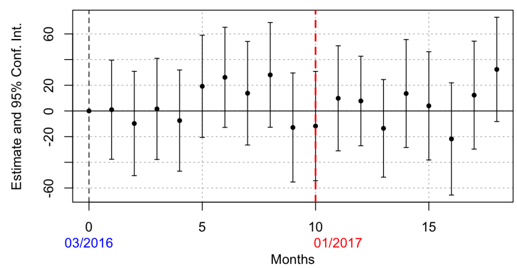
Notes: Results from estimating equation 2, where the dependent variable is birth weight from March 2016 to October 2017, both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the weight in grams. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

This lack of effect can also be observed if I split urban and rural localities—a smaller geographic unit contained in municipalities—aggregated at the municipality level. The effects on both types of environment are null, although they seem less volatile.

(a) Effects of the price increase on urban birth weight



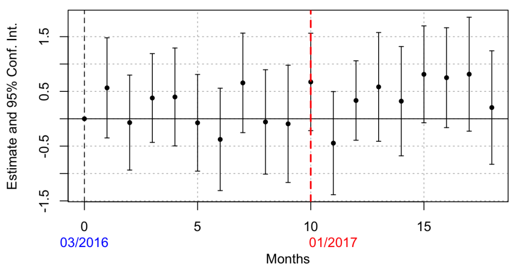
(b) Effects of the price increase on rural birth weight



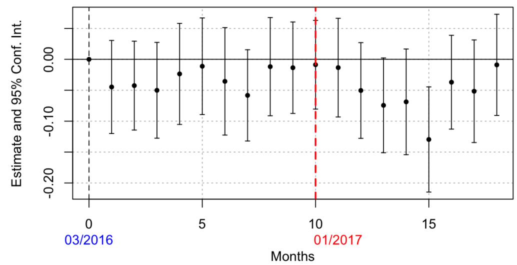
Notes: Results from estimating equation 2, where the dependent variables are birth weight in urban and rural environments from March 2016 to October 2017, both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the weight in grams. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

I compare the estimated (Figure 9a) confidence intervals with others from the consulted literature, to see how well-estimated are the null effects. Koppensteiner and Manacorda (2016[55]) report a confidence interval spanning from 2,046.61 to 4,436.59 grams when assessing the effect of homicides on birth weight. My analysis follows with a slightly narrower confidence interval, from 2,101.82 to 4,396.98 grams (see DiD estimates in the Appendix).
It is also observed that, when accounting for all births, the percentage of low birth weight increased slightly and gestational age decreased from January to June 2017.

(a) Effects of the price increase on % low birth weight



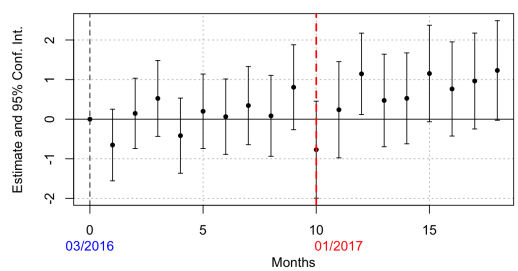
(b) Effects of the price increase on gestational age



Notes: Results from estimating equation 2, where the dependent variables are the percentage of low birth weight and average gestational age (weeks) from March 2016 to October 2017, both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the weight in grams. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

A sustained increase in the percentage of babies born with anomalies has also been observed. Nevertheless, the DiD estimates for the percentage of low birth weight, gestational age (weeks), and anomalies are non-statistically significant.

(a) Effects of the price increase on % of anomalies



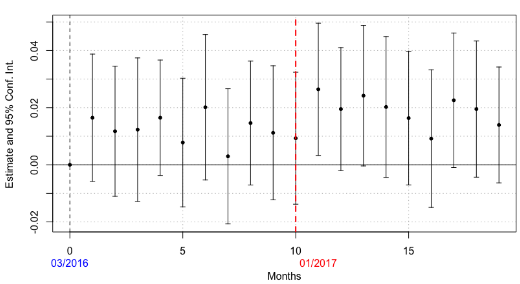
Notes: Results from estimating equation 2, where the dependent variable is the percentage of anomalies from March 2016 to October 2017, both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the weight in grams. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

No effects were found for the mother's age, Apgar score and the percentage of low Apgar (less than 7). Pre-trends were detected for prenatal care (despite having a negative and statistically significant coefficient), percentage of teenage pregnancies, percentage of very low birth weight, percentage of macrosomia and sex ratios. I also do not find any differences between male and female fetuses.

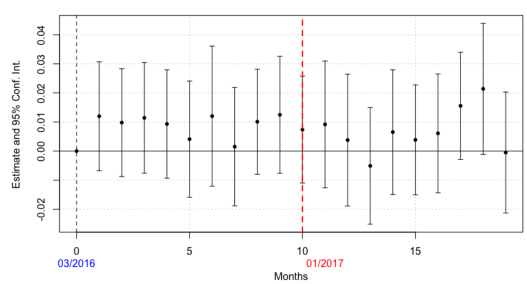
Having established that in-utero exposure to the price increase and pipelines does not have any effect on birth weight, I next examined whether this configuration affected a different sample of pregnant women who could not carry their pregnancies to term.

For neonatal death, there was an increase in stillbirths (after 20 weeks of pregnancy) in the first months after the price increase. For miscarriages, positive and statistically significant point estimates were observed in August and September 2017.

(a) Effects of the price increase on stillbirths rate among women



(b) Effects of the price increase miscarriage rate among women

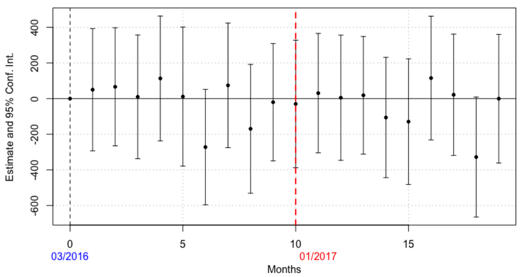


Notes: Results from estimating equation 2, where the dependent variables are the rate of stillbirths in that municipality that presented a neonatal death and the rate of miscarriages in that municipality that had a miscarriage from March 2016 to October 2017 both outcomes from INEGI's neonatal mortality dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the rates. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

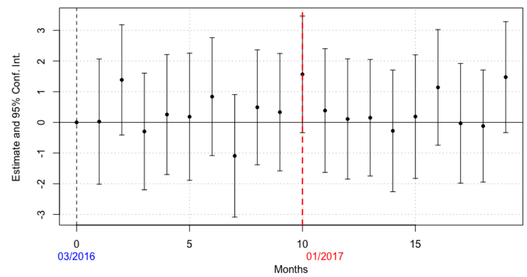
No statistically significant changes and no pre-trends are observed in the total number of prenatal deaths (although the point estimate is positive), complications during pregnancy, prenatal care, and death at birth. Additionally, there is no increase in the percentage of neonatal deaths among male fetuses, who are generally more biologically fragile than females (Kraemer, 2000 [56]). Although the point estimates in the event study appear volatile, they do not indicate a significant trend.

However, there is a non-significant increase in gestational age accompanied by a drop in weight in September 2017. This may be due to intrauterine growth restriction, a condition where the fetus does not grow at a normal rate inside the womb (Fowden, 2017 [45]). Such growth restriction can result from stress, physiological changes, reduced placental blood flow, increased inflammation, and adverse health behaviours. Consequently, it is plausible that this condition is present in POC exposed in the aftermath of the price increase.

(a) Effects of the price increase on average weight



(b) Effects of the price increase on gest. age



Notes: Results from estimating equation 2, where the dependent variables are the average weight and gestational age (weeks) of POC from March 2016 to October 2017, both outcomes from INEGI's neonatal mortality dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the averages. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

In conclusion, there are no effects on birth weight, although there are transitory effects on the percentage of low birth, gestational age, and anomalies. By analysing prenatal deaths and, hence, a different sample of mothers, I found slight increases in stillbirths and a transitory increase statistically different from zero in miscarriages.

Despite finding an increase in homicides and contrary to what has been found in the literature, there is no effect on birth weight. It is plausible that other forces at interplay neutralise the adverse effect. In another section, I will discuss two plausible mechanisms: high resilience to stress and an income effect derived from fuel theft that might improve prenatal conditions.

11.3 Hospital discharges

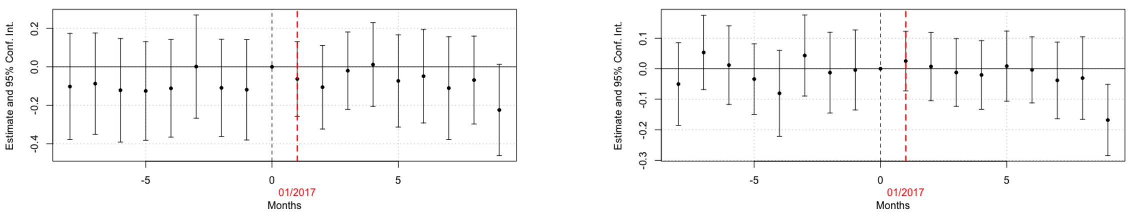
I study obstetric visits of women in their fertile age (15 to 44) to observe any changes in healthcare usage and or behaviour, including abortion, contraceptives, dystocic pregnancies, and C-sections. As in previous sections, only statistically significant results are reported.

For obstetric discharges, significant decreases are observed in the last analysed period (September 2019) in the rates of C-sections and hospital births among women of reproductive age. Specifically, abortion rates decreased in March 2017, with a further (non-significant) decline in the last observed period. When comparing the abortion rate to hospital birth rates in March 2017 (Figure 15a), no significant changes are evident. However, when contrasted with fertility rates (Figures 20a and 20b), there is a non-significant decline, suggesting a potential reduction in births during that month.

No effects are observed on the rate of dystocic pregnancies, and the lack of observations for contraceptives after 2017 makes the estimates unreliable.

(a) Effects of the price increase on birth rate among fertile women

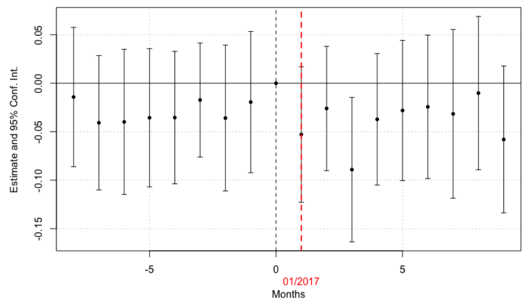
(b) Effects of the price increase on C-section rate among fertile women



Notes: Results from estimating equation 1, where the dependent variable is the rate of births and C-sections from April 2016 to September 2017, therefore 9 months before and after the price increase. The data source is the obstetric hospital discharge records by INEGI. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the rate. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

It is also noticeable that births, C-sections, and abortions dropped during the same period. Although the decrease in C-sections could be mechanical, resulting from a decrease in births, this might indicate a future trend in fertility. Despite no statistically significant changes in fertility (figure 20a) within the study's time frame, the negative point estimates after the price increase might hint at a slow change in trend. Previous studies by Brown (2018 [24]) and Floridi et al. (2023 [44]) found no evidence of selective fertility due to violence; nevertheless, these studies used data from the MxFLS covering the same period (2002-2009) across the entire country. Further research is needed to evaluate if contemporary Mexico's constant exposure to violence has affected fertility rates.

Figure 16: Effects of the price increase on abortion rate among women



Notes: Results from estimating equation 1, where the dependent variable is the abortion rate from April 2016 to September 2017, 9 months before and after the price increase. The data source is the obstetric hospital discharge records by INEGI. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the rates. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

12 Mechanisms

In this section, I discuss two potential mechanisms that may explain the absence of adverse effects on birth weight despite the rise in homicides: adaptive behaviours in response to stressful living conditions and an increase in local income driven by fuel theft activities.

12.1 Adaptative behaviour

Community violence can impact various health outcomes by triggering physiological stress responses and possibly modifying habits and behaviours among residents (Ahern et al., 2018 [4]). In Mexico, a lack of data hampers understanding the general stress levels of the population due to violence. Furthermore, there is no timely available information regarding mental health or other indicators that could inform policymakers about this critical issue.

Therefore, to gauge the impact of increased violence on stress, I analyse data from stress-related hospital discharges using an event-study type of model established in Equation 1. The focus is primarily on female patients of all ages.

Monthly stress-related hospital discharge rates are calculated by aggregating data by municipality, adjusting for the female population (see Appendix to see how population counts are obtained), and scaling by 1,000. This analysis includes anxiety and substance use disorders, as well as a selection of stress-related heart and cerebrovascular diseases (see Appendix for ICD classification).

Table 5: Outcome variables

Reference Period	**Type of Data**	**Outcome**	**Source (INEGI)**
December 2016	Stress related hospital discharges	Anxiety Disorders	Hospital discharges
(Month before the price increase)		Substance Use Disorders	
		Heart Diseases	
		Cerebrovascular Diseases	

Data sources of stress-related hospital discharges

The descriptive statistics from these hospital discharges show an overall decrease in anxiety disorders during the period before the price increase. Nevertheless, there is an increase in substance use disorders and heart-stress-related conditions.

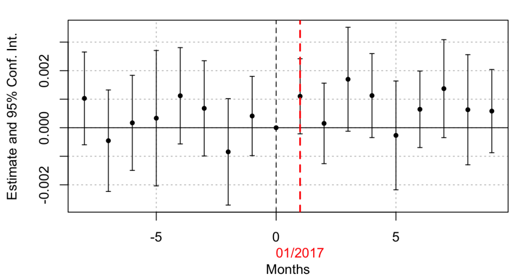
Table 6: Descriptive statistics of stress-related hospital discharges

	Pre-price increase		Post-price increase	
Variable	Control	Treatment	Control	Treatment
Anxiety disorders	.00069	.00051	.00047	.00049
Substance use disorders	.00061	.00076	.00071	.00084
Heart diseases	.0127	.0116	.0126	.0118
Cerebrovascular diseases	.0087	.0078	.0067	.0071

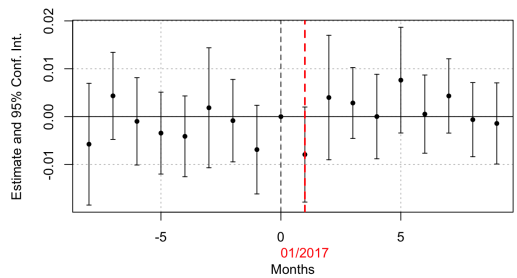
Notes: Descriptive statistics of women's hospital discharges related to stress. This data is collected by INEGI and includes anxiety and substance disorders and heart and cerebrovascular stress-related diseases. The rates were obtained by dividing the total number of women patients by the women's population in the municipality and multiplied by 1000. These descriptive statistics encompass April 2016 to September 2017.

For anxiety disorder discharges, it can be observed an increase statistically different from zero only in March and April of 2017.
Despite the event study's point estimates being not statistically significant from zero for cerebrovascular-stress diseases, the DiD interaction term is positive and statistically significant at the 10% level. This means that the aggregated effect after the price increase is positive and equivalent to an overall rise of 18.45% in cerebrovascular disease rate (compared to the pretreatment period mean of the treated group). Nevertheless, it is essential to note that, whilst stress can contribute to risk factors for cerebrovascular diseases (like high blood pressure), these conditions might also be influenced by various factors, including genetics, lifestyle, and other health conditions. Therefore, they may also hint at changes in lifestyle and diet as a coping mechanism for stress.

(a) Effects of the price increase on anxiety disorders rate among women



(b) Effects of the price increase on cerebrov.-stress diseases rate among women



Notes: Results from estimating equation 1, where the dependent variables are the rate of anxiety disorders and cerebrovascular-stress-related diseases among women from April 2016 to September 2017, therefore 9 months before and after the price increase. The data source is the hospital discharge records by INEGI. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the rates. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

No significant effect is found for heart-related stress conditions or substance use disorders. It is important to remark that hospital discharge data may reflect a lower bound for these conditions, particularly for anxiety and substance use disorders, as they likely capture only severe cases requiring hospitalisation. As a result, the findings may represent a conservative estimate of changes in health behaviours related to coping with stress or hospitalisations due to anxiety disorders.

12.2 Income effect: Nighttime light

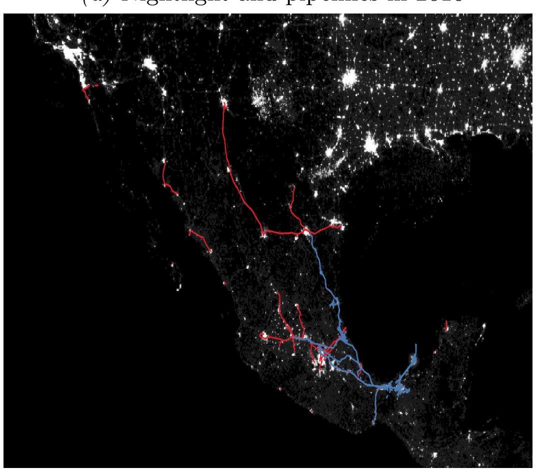
Due to the localised nature of fuel and oil theft, it is plausible that income increases close to pipeline areas may be linked to the proceeds of such activities. For example, individuals involved in fuel theft might invest in local businesses, purchase goods, or build infrastructure. This increase in income could also translate into better prenatal conditions, which could neutralise the adverse effects of stress due to homicides.

In Mexico, as in many countries, obtaining detailed annual income data is challenging. One alternative is to assess income growth in areas near pipelines by analysing satellite images of nighttime light intensity.

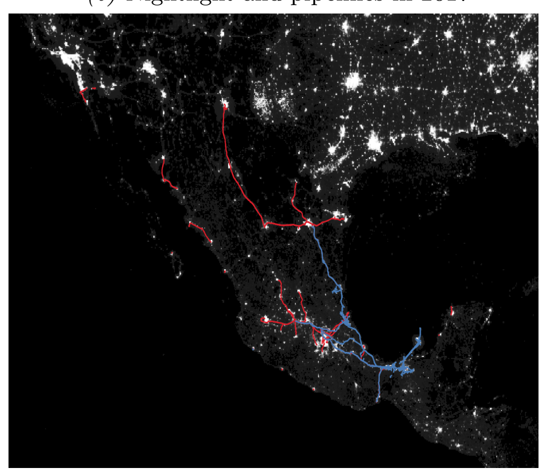
Economists have used satellite light data to supplement official income growth measures, especially in regions lacking comprehensive statistics (Henderson et al., 2012[52]). Nighttime light serves as a proxy for economic activity, based on the assumption that lighting, like consumption, reflects income levels (Donaldson and Storeygard, 2016[37]). Henderson, Storeygard, and Weil (2012[52]) found a lights-GDP elasticity of 0.28 to 0.32 in global data from 1992 to 2008, with a strong correlation in long-term changes. Although their study focused on country-level data, subsequent research has applied light data to smaller regions where traditional economic data is scarce. Therefore, increased

luminosity indicates economic development, often linked to a higher income. If this illicit income boosts local spending, it is expected to see a corresponding increase in light intensity.
To investigate this, I will use VIIRS (Visible Infrared Imaging Radiometer Suite) data from the Colorado School of Mines. The VIIRS dataset integrates nighttime light data from two sources: the Defense Meteorological Satellite Program/Operational Linescan System (DMSP/OLS), which collected data from 1992 to 2013, and the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership satellite, which provided data from 2012 to 2018. This integration creates a unified global dataset of nighttime lights.
The data is provided in GeoTIFF format, a raster file type that records annual average light intensity. This dataset captures nighttime radiance, measured in $W/m^2/sr$ (watts per square meter per steradian). This unit quantifies the intensity of electromagnetic energy emitted by a surface area (in square meters) per unit of solid angle (in steradians). Radiance values can range from 0.01 $W/m^2/sr$ in dark, remote areas to over 10 $W/m^2/sr$ in brightly lit urban regions.
Therefore, the analysis involves assessing changes in light luminosity from satellite-derived TIFF files that contain the average light intensity for the years 2016 (Figure 18a) and 2017 (Figure 18b), focusing on their proximity to pipeline infrastructure.

(a) Nightlight and pipelines in 2016



(b) Nightlight and pipelines in 2017

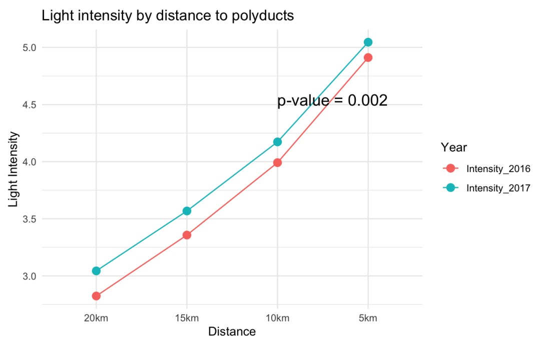


Notes: GeoTIFF files (raster image file types) with light intensity (radiance) by year with polyducts or multipurpose pipelines in red and oil pipelines in blue. Source: VIIRS (Visible Infrared Imaging Radiometer Suite) data from the Colorado School of Mines.

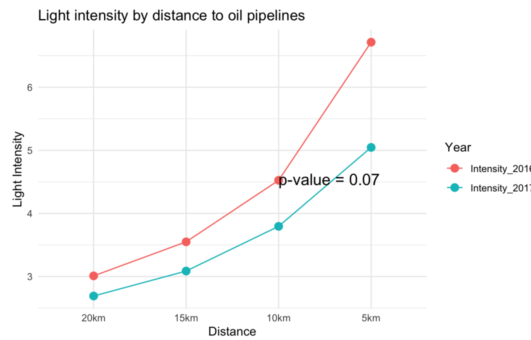
I split the analysis into both types of pipelines, polyduct and oil, and by using satellite data, I clipped buffer zones around the pipelines at varying distances (20 km, 15 km, 10 km, and 5 km). The buffer zones extend equally on both sides of each pipeline. So, when it is specified a buffer width of, for example, 5 kilometres, it means the buffer will be 5 kilometres on both sides of the pipeline. Hence a width of 10 kilometres across the buffer zone, centred on the pipeline.
The mean light intensity within each buffer zone is calculated for both years per bandwidth.
The results with the average intensity per bandwidth and per type of pipeline can be found in

Figure 19a and 19b. I found that regardless of the pipeline type, the light intensity increases when the distance to the pipeline diminishes. Nevertheless, for polyduct pipelines, the light intensity increased in 2017 with respect to 2016. The paired t-test between both years' intensities per buffer zone suggests that there was a statistically significant increase in light intensity from 2016 to 2017 (.002).
For oil pipelines, the light intensity was higher in 2016 than in 2017, and the difference between the two years was not statistically significant. This difference in both pipelines could be due to polyduct pipelines being more subject to tappings since they transport fuel and diesel which is easier and more profitable to sell.

(a) Ligh intensity polyduct



(b) Light intensity oil pipeline



Notes: Map extracted from CartoCritica

The increase in birth weight could be an unintended consequence of the increased income, indicating that whilst some aspects of local well-being might improve, the underlying cause—fuel theft—poses significant legal, environmental, and social risks, mostly at the expense of an increase in homicides.

13 Conclusion

This paper presents a systematic analysis of the effects of conflict on prenatal health, using granular monthly data and two sources of quasi-exogenous variation: the underground location of fuel pipelines and a fuel price increase. I document a significant increase in homicides (22.6%-38%) in municipalities with pipelines following the price hike. Yet, despite this substantial rise in violence, my findings show largely null or transitory effects on prenatal health outcomes, which contrasts with existing literature.
Specifically, I observe no significant changes in overall birth weight and only temporary increases in the percentage of low birth weight. Gestational age experiences a brief decline, though without an increase in premature births, and there is a short-term rise in the incidence of congenital anomalies. Additionally, neonatal mortality records show an increase in stillbirths shortly after the price

increase and a rise in miscarriages in August and September 2017. Likewise, it was not observed any significant changes in women's obstetric health care usage.

These largely null effects may reflect the presence of palliative mechanisms. I explore two potential explanations: an income effect from the proceeds of fuel theft and an adaptive response to prolonged exposure to violence. Analysis of nightlight data around pipeline areas indicates a significant increase in light intensity following the price increase, suggesting an income effect tied to fuel theft. In terms of adaptive behaviour, stress-related hospital discharges show no major stress-related health impacts, except for an uptick in cerebrovascular diseases and anxiety disorders among women, hinting at future health risks such as higher disease incidence, increased hospitalisations, and reduced quality of life.

The slight decline in births and abortions is an area for further investigation, especially given the long-term decreasing trend in fertility, as prior research has found no evidence of conflict affecting fertility decisions in Mexico before and after 2006.

These findings have important policy implications. The lack of severe prenatal health impacts suggests not only a normalisation to high levels of violence but also an adaptation to a shifting economic environment, where cartel activities and local economies become increasingly intertwined, even at the cost of rising homicides.

Moreover, the results accentuate the shortcomings of militarised strategies, which intensify violence while neglecting its indirect health repercussions. To foster long-term stability, policymakers should prioritise interventions that mitigate the public health effects of persistent stress and tackle the structural factors sustaining cartel-driven economies.

14 Appendix

Population Adjustment Methodology

Population data by municipality is limited to the availability of the Mexican Census every 10 years and an Intercensal Census (Encuesta Intercensal) in 2015. To estimate the population for 2016 and 2017, I used linear interpolation using census data from 2010, 2015, and 2020. Data regarding the total number of women by municipality and in their fertile window (15 to 45 years) comes from the Intercensal Census 2015. I obtained the percentages of women per municipality from this sample and imputed them with the same linear interpolation method. To improve my population measurements, I subtracted the number of homicides from monthly population counts. Thus, for all the municipalities' populations, I subtracted all homicides; for the female population, I subtracted the number of all female homicides; and for women in their reproductive age counts, I subtracted female homicides in the same range of age.

Threats to identification: Fertility and migration

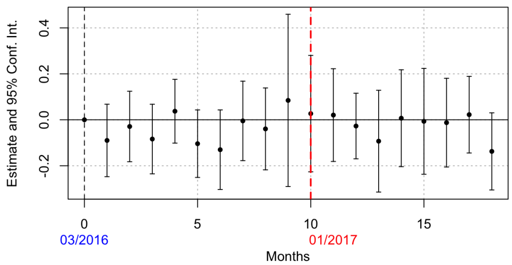
One potential threat to the validity of my previous analysis is the assumption that mothers changed their behaviour in response to the price increase and subsequent violence, which could be influencing the relationship between health and local violence. This behaviour change could be selective fertility or migration to "safer" places. I tested these threats using an event study of fertility and satellite data that proxy population counts.

14.1 Fertility

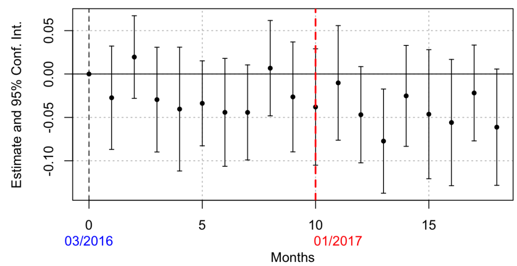
I challenge my results by analysing fertility over time using event-study type analysis and difference-in-differences estimates. I calculate the fertility rate by using the total number of births divided by the number of women of fertile age in each municipality. The event study and the DiD show no effects or pretrends on fertility, suggesting that this variable did not change during the study period, conditional on all the fixed effects.

I conducted the same analysis on a subsample of women with undergraduate education or higher (almost 15% of the sample), who typically have better adherence to birth control and are more likely to relocate (Aldeco et al. 2022[6]). This subsample showed a slight decrease statistically different from zero in the point estimate in April 2017 (see Figure 20b).

(a) Effects of the price increase on fertility rate



(b) Effects of the price incr. on fert. rate of highly edu.



Notes: Results from estimating equation 1, where the dependent variable is the fertility rate and fertility rate with women with more schooling years (completed undergraduate education and beyond) from March 2016 to October 2017, therefore nine months before and after the price increase. The data source is the birth certificate data from INEGI and the adjusted population counts. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the rate. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

As previously mentioned, the DiD estimates are not statistically significant for overall fertility. However, for highly educated women, there is a slight decrease in fertility that is statistically significant at the 10% level.

Table 7: Effects of the price increase in fertility

	(1)	(2)
	Fertility	Highly educated fert.
DD price	-0.0560	-0.0208*
inc.*pipeline	(0.0323)	(0.0102)
Munic. F.E.	Yes	Yes
Time F.E.	Yes	Yes
Adjust R2	0.980	0.899
N	19021	19021
AIC	66575.0	14568.9

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Results from estimating a version of equation (1) where instead of interacting the treatment group with time dummies (by month and year), I replace them by an $\text{AfterPrice}_\text{t}$ indicator, which takes the value of one at January 2017. The outcome variable analysed is Fertility, which is a rate created by the total number of births divided by the women in their childbearing years living in the municipality. I include time and municipality-fixed-effects. Specifications have clustered standard errors at the municipality level in parentheses.

14.2 Migration

There is a lack of data documenting internal migration in Mexico. The Mexican census, conducted every ten years, shows that in 2020 only 4% of the population reported moving due to security concerns. Still, they do not ask for more information, such as the exact origin and final locations. Additionally, population data is limited since it is contained at the municipal level in the decennial Censuses (2010 and 2020) and the Intercensal Survey (2015). In previous sections, I use these data sources to impute population to estimate the rates of different outcomes, but this data falls short of providing a clearer picture regarding migration.

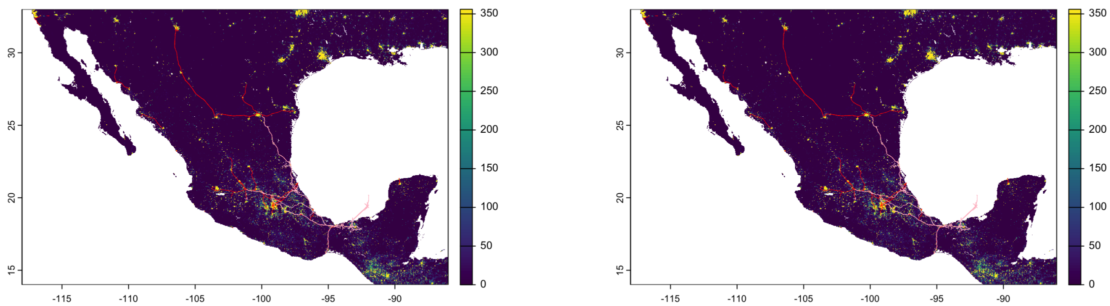
Due to the lack of administrative data, I used a geospatial strategy to revise possible internal migration close to the pipelines. This approach provides a glimpse of population dynamics beyond municipal administrative borders. If violence influences migration decisions, a decline in population close to pipelines would be expected.

I analysed the spatial distribution of populations near polyduct and oil pipelines in Mexico using GeoTIFF population data from the GlobPOP (Liu et al., 2024[60]), a gridded dataset with 30 arc-second resolution, available in population count and density formats.

To estimate the population within proximity to pipelines, I created buffers at distances of 5 km, 10 km, 15 km, and 20 km around the pipelines and applied them to the GlobPOP dataset. Using the population counts per grid, I calculated the mean population per grid cell within each buffer. After determining the area of each buffer, I used these mean values to estimate the total population in

each proximity zone.
Figure 21a and figure 21b, show the population distribution in 2016 and 2017. It is observed that the pipeline network in central Mexico passes by important urban centers such as part of Mexico City whereas the Northern part of the country is less populated.

(a) Gridded population 2016 *(b)* Gridded population 2017

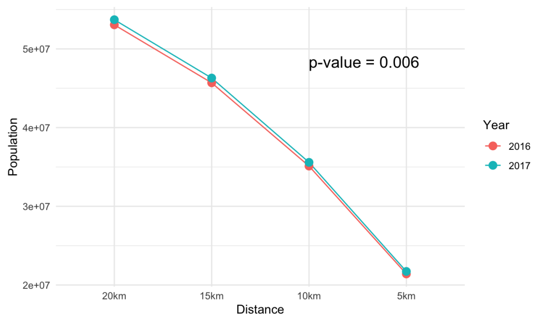


Notes: Population Distribution across Mexico in 2016 and 2017 (Rescaled for Mexico's minimum and maximum values per grid cell), based on GlobPOP global gridded population data with a 30-arcsecond (1 km^2) resolution. The dataset provides population counts for each grid cell. Source: GlobPOP Global gridded population) from Liu et al.,2024. Red pipelines correspond to polyducts and pink are oil pipelines.

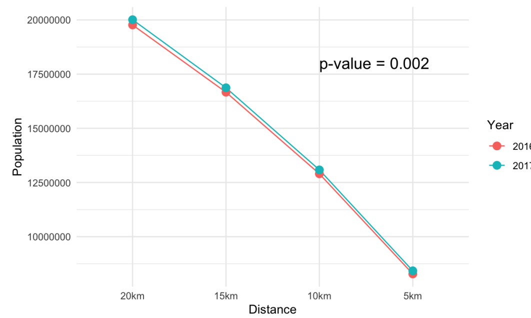
The main concern of internal migration, in the results, is that the population, particularly women, are migrating to "safer" places to avoid stress exposure due to homicides. As mentioned, I estimated the average population counts per bandwidth and found that places close to pipelines are very populated. The average population in the 5-kilometre bandwidth (so in a vicinity of 10 kilometres) is 21 million inhabitants for polyducts and 8 million inhabitants for oil pipelines. I also found that the population slightly increased in places closer to both pipelines from 2016 to 2017.

To improve accuracy, I addressed overlapping buffers by merging them into non-overlapping areas and recalculating population sums for these adjusted zones.

(a) Polyduct estimated population counts



(b) Oil estimated population counts



Notes: Average population counts per type of pipeline (polyduct and oil), estimated by calculating the mean population per grid cell within each buffer zone (5 to 20 kilometres) based on GlobPOP global gridded population data with a 30-arcsecond (1 km^2) resolution. The dataset provides population counts for each grid cell. Source: GlobPOP Global gridded population) from Liu et al.,2024.

The population increase from 2016 to 2017 is statistically significant for both types of pipelines. This growth may be attributed to Mexico's demographic trends during that period, with a national growth rate of 1.1% and an urban growth rate of 1.4%, and not due to internal migration.
To investigate this hypothesis, I compared the actual population counts for 2017 with the expected counts based on two growth rates: the national growth rate of 1.1% and the urban growth rate of 1.4%.).
Based on the results shown in Table 8, it can be observed that the actual populations for both the national and urban areas were quite close to the expected values based on the growth rates of 1.1% for national and 1.4% for urban populations. This suggests that the growth rates for estimating the expected populations were reasonable and reflective of actual demographic trends. This conclusion is further supported by earlier results indicating that fertility and birth rates have not increased.

Table 8: Comparison of Actual and Expected Population Counts Around Pipelines

Bandwidth (km)	2016 Population	2017 Population	Expected Growth Comparison		Urban Expected Growth Comparison	
			Expected (1.1%)	Diff. (%)	Expected (1.4%)	Diff. (%)
Polyduct Pipelines						
20	53,058,202	53,707,070	53,639,844	+0.13	53,889,525	+0.35
15	45,687,443	46,295,688	46,190,005	+0.23	46,153,417	+0.31
10	35,110,679	35,582,500	35,497,897	+0.24	35,442,143	+0.40
5	21,405,432	21,723,173	21,641,892	+0.38	21,547,273	+0.82
Oil Pipelines						
20	19,768,913	20,010,341	19,986,371	+0.12	20,030,519	-0.10
15	16,665,529	16,870,163	16,849,850	+0.12	16,874,350	-0.02
10	12,900,558	13,080,928	13,042,465	+0.30	13,025,892	+0.42
5	8,280,840	8,424,488	8,371,929	+0.63	8,320,218	+1.26

Comparison of population estimates for different bandwidths around pipelines. It contrasts the actual population counts for 2016 and 2017 with the expected counts for 2017 based on two growth rates: the national growth rate of 1.1% and the urban growth rate of 1.4%. The percentage differences between the actual and expected populations are provided, highlighting how closely the observed values align with demographic expectations.

Furthermore, the consistency of the results across different bandwidths (20km, 15km, 10km, and 5km) indicates that the growth patterns are stable regardless of the distance from the pipelines. This uniformity might suggest that the impact of pipelines on population growth or internal migration is minimal. However, it is important to note that pipeline location is quite heterogeneous since it passes quite populated areas such as central Mexico and historically empty ones, like the northern part of the country.

15 ICD codes

Table 9: Outcome variables

Category	ICD Code	Disease Name
Anxiety Disorders (F40-F48)	F40	Phobic anxiety disorders
	F41	Other anxiety disorders
	F42	Obsessive-compulsive disorder
	F43	Reaction to severe stress, and adjustment disorders
	F44	Dissociative (conversion) disorders
	F45	Somatoform disorders
	F48	Other neurotic disorders
Substance Use Disorders (F10-F19)	F10	Mental and behavioural disorders due to use of alcohol
	F11	Mental and behavioural disorders due to use of opioids
	F12	Mental and behavioural disorders due to use of cannabinoids
	F13	Mental and behavioural disorders due to use of sedatives or hypnotics
	F14	Mental and behavioural disorders due to use of cocaine
	F15	Mental and behavioural disorders due to use of other stimulants, including caffeine
	F16	Mental and behavioural disorders due to use of hallucinogens
	F17	Mental and behavioural disorders due to use of tobacco
	F18	Mental and behavioural disorders due to use of volatile solvents
	F19	Mental and behavioural disorders due to multiple drug use and other psychoactive substances
Heart Diseases Related to Stress	I20	Angina pectoris
	I21	Acute myocardial infarction
	I10	Essential (primary) hypertension
	I47	Paroxysmal tachycardia
	I48	Atrial fibrillation and flutter
	I42	Cardiomyopathy
	I50	Heart failure
	I51.81	Takotsubo cardiomyopathy
Cerebrovascular Diseases (I60-I69)	I60	Subarachnoid hemorrhage
	I61	Intracerebral hemorrhage
	I62	Other nontraumatic intracranial hemorrhage
	I63	Cerebral infarction
	I64	Stroke, not specified as haemorrhage or infarction
	I65	Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction
	I66	Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction
	I67	Other cerebrovascular diseases
	I68	Cerebrovascular disorders in diseases classified elsewhere
	I69	Sequelae of cerebrovascular disease

Diseases Related to Stress by General Category

16 Homicides results

This section shows the results from the difference-in-differences estimates in all homicides, male homicides, homicides with a firearm, young male homicides, homicides of young males with a firearm and female homicides. The interaction coefficients are all statistically significant.

Table 10: Regression table with the effects of the price increase in homicides

	(1)	(2)	(3)	(4)	(5)	(6)
	All hom.	Male hom.	Hom. firearm	Young male hom.	Firearm hom. young male	Female hom.
DD price	0.740**	0.672**	0.551**	0.539**	0.419**	0.0638*
incr.*pipeline× tube	(0.247)	(0.225)	(0.201)	(0.186)	(0.157)	(0.0254)
Municipality F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Adjust R2	0.814	0.809	0.770	0.787	0.747	0.572
N	29736	29736	29736	29736	29736	29736
AIC	144489.5	138913.7	132152.2	126820.5	117458.6	46725.0

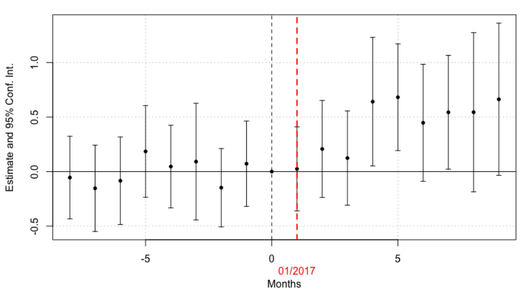
Clustered Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

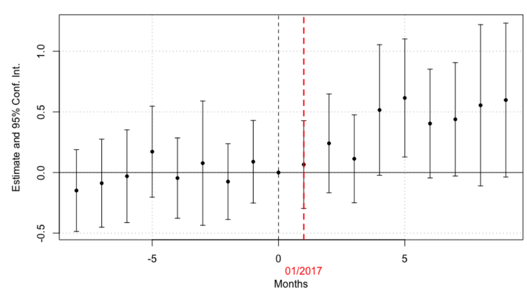
Notes: Results from estimating a version of equation (1) where instead of interacting the treatment group with time dummies (by month and year), I replace them by an $\text{AfterPrice}_{\text{t}}$ indicator, which takes the value of one at January 2017. I include time and municipality-fixed-effects. Specifications have clustered standard errors at the municipality level in parentheses.

Furthermore, I include the event studies of the rest of the types of homicides that serve as a robustness check of how the price increase increased homicides in places with pipelines in comparison to its first-order neighbours.

(a) Effects of the price increase male homicides

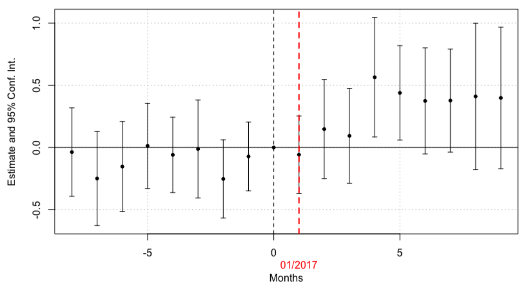


(b) Effects of the price increase hom. firearm

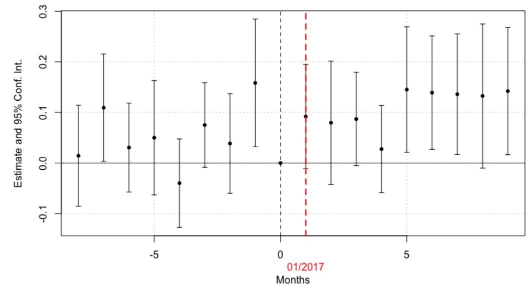


Notes: Results from estimating equation 1, where the dependent variables are the number of male homicides and firearm homicides from INEGI's mortality population counts from April 2016 to September 2017, therefore nine months before and after the price increase. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the number of homicides. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

(a) Effects of the price increase young male homicides



(b) Effects of the price increase female homicides



Notes: Results from estimating equation 1, where the dependent variables are the number of young male (14 to 44 years old) homicides and female homicides from INEGI's mortality population counts from April 2016 to September 2017, therefore nine months before and after the price increase. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the number of homicides. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

17 Health outcomes results

In this section, I present the results from the difference-in-differences estimates and event studies for prenatal outcomes from birth certificates.
The DiD estimates were split into two different tables.

17.1 Birth certificate outcomes

Table 11: Regression table part 1 with the effects of the price increase in birth outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Birth weight	% low bw	% vlbw	% macros	Gest. age	% premature
DD price	1.469	0.243	0.0893	-0.0248	-0.0161	0.268
inc.*pipeline	(3.559)	(0.171)	(0.0590)	(0.148)	(0.0138)	(0.201)
Munic. F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Adjust R2	0.242	0.046	0.008	0.079	0.139	0.051
N	20111	20111	20111	20111	20111	20111
AIC	252171.7	130913.7	87399.6	120295.0	26879.4	133733.3

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Results from estimating a version of equation (2) where instead of interacting the treatment group with time dummies (by month and year), I replace them by an Post_t indicator, which takes the value of one at January 2017. Our outcome variables were the several prenatal outcomes. The data was obtained from the birth certificate registers collected by INEGI from March 2016 to September 2017. I include time and municipality-fixed-effects. Both specifications have clustered standard errors at the municipality level in parentheses.

Table 12: Regression table part 2 with the effects of the price increase in birth outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	% teen	Prenatal care	Sex ratio	Apgar	% low Apgar	% anomaly
DD price	0.0530	-0.0495*	-0.420	-0.00417	0.00585	0.590
inc.*pipeline	(0.390)	(0.0264)	(1.775)	(0.00669)	(0.0833)	(0.359)
Adjust R2	0.143	0.501	0.019	0.169	0.104	0.310
N	20111	20111	20111	20111	20111	20111
AIC	155253.3	49075.2	218121.2	-7848.8	94591.0	134753.8

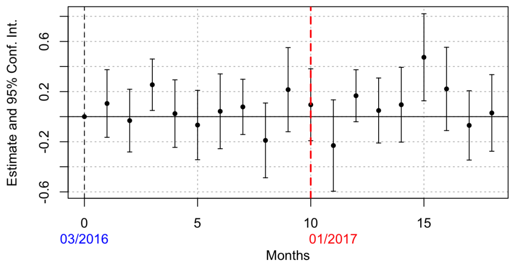
Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

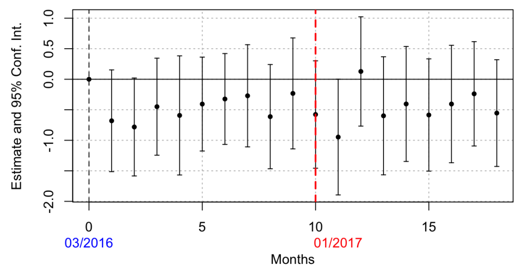
Notes: Results from estimating a version of equation (2) where instead of interacting the treatment group with time dummies (by month and year), I replace them by an Post_t indicator, which takes the value of one at January 2017. The outcome variables were the several prenatal outcomes. The data was obtained from the birth certificate registers collected by INEGI from March 2016 to September 2017. I include time and municipality-fixed-effects. Both specifications have clustered standard errors at the municipality level in parentheses.

In this section, I will report the event studies with null effects or those that presented pretrends.

(a) Effects of the price increase on % very low birth weight

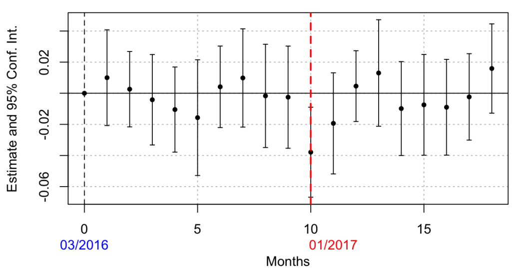


(b) Effects of the price incr. on % of macrosomia

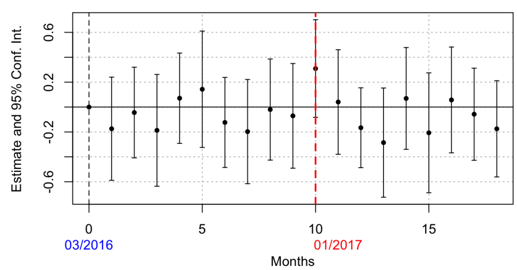


Notes: Results from estimating equation 2, where the dependent variables are the percentage of very low birth weight (vlbw) and percentage of babies with macrosomia from March 2016 to October 2017 both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the average score of the percentage. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

(a) Effects of the price increase on Apgar

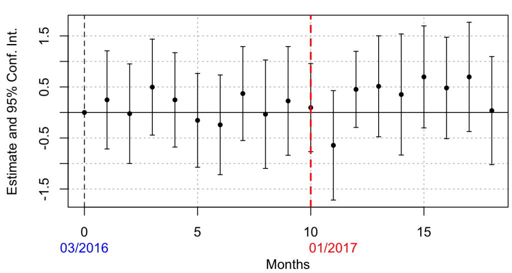


(b) Effects of the price incr. on % low Apgar

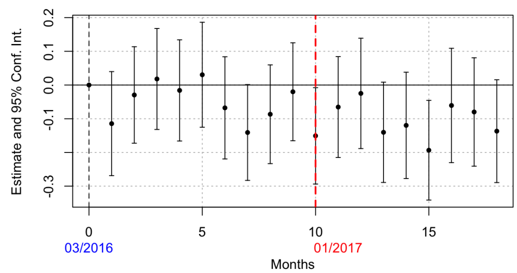


Notes: Results from estimating equation 2, where the dependent variables are the percentage of Apgar score and percentage of low Apgar (5 or less) from March 2016 to October 2017 both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the average score of the percentage. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

(a) Effects of the price increase on the percentage of premature babies

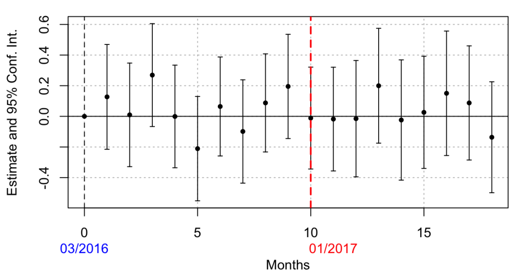


(b) Effects of the price incr. on average prenatal care

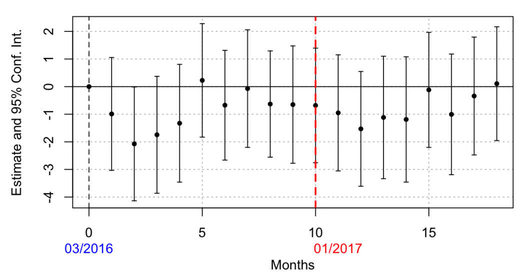


Notes: Results from estimating equation 2, where the dependent variables are the percentage of premature babies and average prenatal care (total number of visits) from March 2016 to October 2017, both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the percentages or average outcomes. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

(a) Effects of the price increase on mother's age

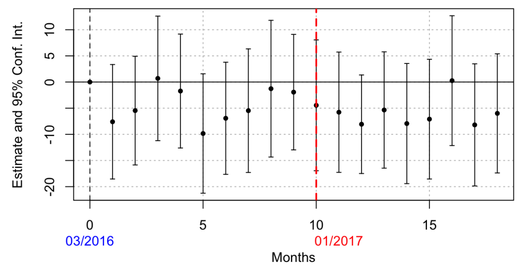


(b) Effects of the price incr. on % teen mothers



Notes: Results from estimating equation 2, where the dependent variables are the average mother's age and percentage of teenage mothers (less than 20 years old) from March 2016 to October 2017 both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the outcomes. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

(a) Effects of the price increase on mother's age



Notes: Results from estimating equation 2, where the dependent variable is sex ratio (birth of girls divided by the birth of boys) from March 2016 to October 2017 both outcomes from INEGI's birth certificates dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the ratio. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

17.2 Neonatal mortality outcomes

In this section, I include the difference-in-differences estimates and event studies of the outcomes from prenatal mortality records that did not show any statistically significant effect. The array of outcomes consists of the following: number of deaths, rate of complications during pregnancy, rate of death during pregnancy, rate of death during birth, gestational age of the POC, weight of the POC, rate of death of male fetuses, rate of death due to violence and prenatal visits.

In this section, I will report the event studies with null effects or those that presented pretrends.

Table 13: Regression table Part 1 with the effects of the price increase in mortality outcomes

	(1)	(2)	(3)	(4)	(5)
	N. deaths	Complic	Preg. death	Birth death	Gest. age
DD price	0.00240	0.00384	0.00412	-0.00183	-0.0974
inc.*pipeline	(0.00241)	(0.00297)	(0.00297)	(0.00224)	(0.320)
Munic. F.E.	Yes	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes	Yes
Adjust R2	0.809	0.348	0.691	0.239	0.131
N	5884	5884	5884	5884	5884
AIC	-20273.5	-18039.0	-18188.9	-21827.9	37136.7

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Results from estimating a version of equation (2) where instead of interacting the treatment group with time dummies (by month and year), I replace them by an $\mathrm{Post_t}$ indicator, which takes the value of one at January 2017. The outcome variables were neonatal mortality. The data was obtained from the Death and Foetal Death Certificates collected by INEGI from March 2016 to September 2017. I include time and municipality-fixed-effects. Both specifications have clustered standard errors at the municipality level in parentheses.

Table 14: Regression table Part 2 with the effects of the price increase in mortality outcomes

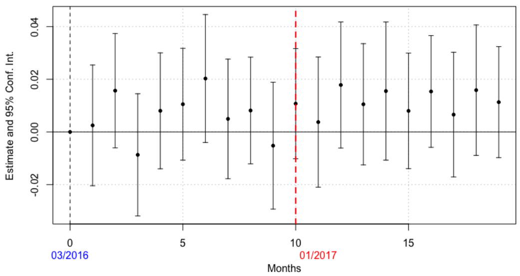
	(6)	(7)	(8)	(9)	(10)
	Weight	Rate male	Rte misc.	Violence	Prenat. visits
DD price	9.369	0.00357	-0.00140	0.000205	0.849
inc.*pipeline	(54.39)	(0.00342)	(0.00264)	(0.000192)	(0.644)
Munic. F.E.	Yes	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes	Yes
Adjust R2	0.111	0.505	0.248	0.051	0.059
N	5884	5884	5884	5884	5884
AIC	97375.1	-16900.2	-19926.3	-49037.7	44878.7

Standard errors in parentheses

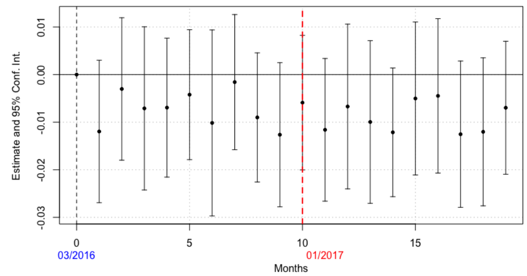
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Results from estimating a version of equation (2) where instead of interacting the treatment group with time dummies (by month and year), I replace them by an $\mathrm{Post_t}$ indicator, which takes the value of one at January 2017. The outcome variables were neonatal mortality. The data was obtained from the Death and Foetal Death Certificates collected by INEGI from March 2016 to September 2017. I include time and municipality-fixed-effects. Both specifications have clustered standard errors at the municipality level in parentheses.

(a) Effects of the price increase on complication during pregnancy rate among fertile women

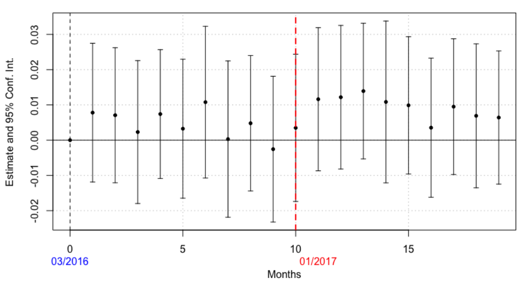


(b) Effects of the price increase on death at a birth rate among fertile women

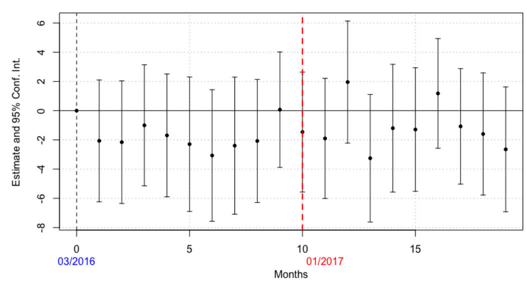


Notes: Results from estimating equation 2, where the dependent variables are the rate of women in that municipality who presented complications during pregnancy and those who suffered the death of the baby at birth from March 2016 to October 2017 both outcomes from INEGI's neonatal mortality dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the rates. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

(a) Effects of the price increase on prenatal death rate among fertile women

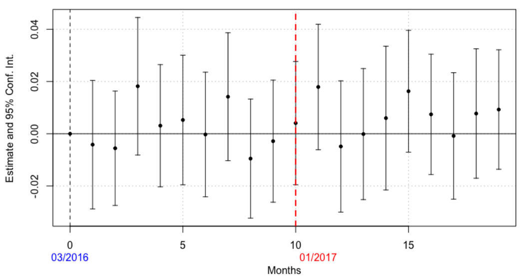


(b) Effects of the price increase on prenatal care visits

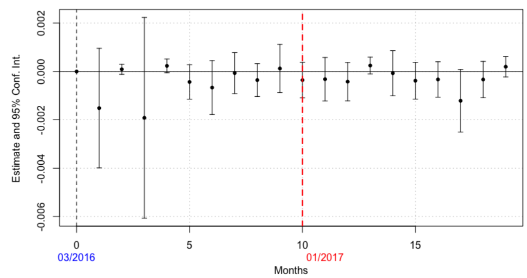


Notes: Results from estimating equation 2, where the dependent variables are the percentage of women in that municipality that suffered a prenatal death and the average prenatal care (number of visits to the doctor) of women in that municipality from March 2016 to October 2017 both outcomes from INEGI's neonatal mortality dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the rates. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

(a) Effects of the price increase on the male POC rate among fertile women



(b) Effects of the price increase on death due to violence rate among fertile women



Notes: Results from estimating equation 2, where the dependent variables are the number of male POC deaths divided by the number of women in that municipality multiplied by 1000. Similarly, the outcome of death to violence is the number of neonatal deaths due to domestic or another kind of violence divided by the number of fertile women in that municipality from March 2016 to October 2017, both outcomes from INEGI's neonatal mortality dataset. The X-axis represents the months. The reference period is March 2016, a month before the conception of babies affected by the price increase in January 2017. The plot shows the β_k coefficients that capture the rates. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

17.3 Stress-related hospital discharges

In this section, I will report the results from the DiD interaction term for every stress-related hospital discharge for women residents in the selected municipalities as well as the event studies of stress-related substance use disorders and stress-related heart diseases.
For all discharges, except for cerebrovascular diseases, DiD interaction coefficients are non-statistically significant.

Table 15: Regression table with the effects of the price increase in hospital discharges

	(1) Anxiety	(2) Substance use	(3) Heart	(4) Cerebrovascular
DD price inc.*pipeline	0.000396	-0.0000226	0.000674	0.00291*
	(0.000324)	(0.000383)	(0.00203)	(0.00157)
Munic. F.E.	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes
Adjust R2	0.026	0.061	0.110	0.034
N	16328	16328	16328	16328
AIC	-104976.7	-100461.5	-44603.4	-48821.3

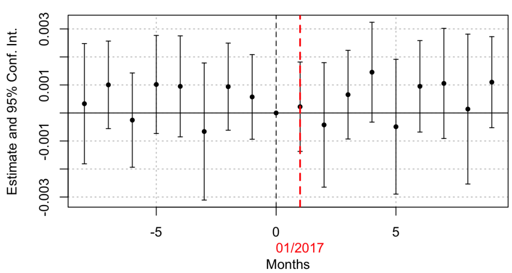
Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

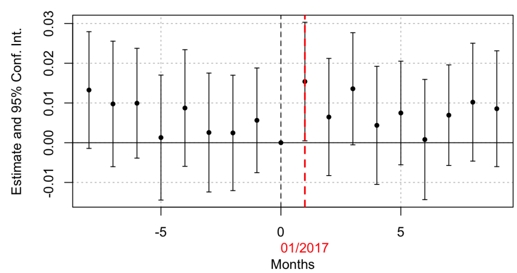
Notes: Results from estimating a version of equation (1) where instead of interacting the treatment group with time dummies (by month and year), I replace them by an Post_t indicator, which takes the value of one at January 2017. The outcome variables were stress-related hospital discharges. The data was obtained from INEGI from March 2016 to September 2017. I include time and municipality-fixed-effects. Both specifications have clustered standard errors at the municipality level in parentheses.

The event study plot for substance use disorders shows point estimates small in magnitude and non-statistically different from zero before and after the price increase.
For heart diseases, it was observed a pretend in April 2016 hence the DiD interaction coefficient is questionable.

(a) Effects of the price increase on substance use disorders rate among women



(b) Effects of the price increase on heart disease rate among women



Notes: Results from estimating equation 1, where the dependent variables are the rate of substance use disorders and heart-stress-related diseases from April 2016 to September 2017, therefore nine months before and after the price increase. The data source is the hospital discharge records by INEGI. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the rates. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

17.4 Obstetric hospital discharges

In this section, I will report the results from the DiD interaction term for every obstetric hospital discharge for women in their fertile years who are residents in the selected municipalities.

I also include the event-study type of analysis of those variables that were not significant or with pretrends.

Table 16: Regression table with the effects of the price increase in obstetric hospital discharges

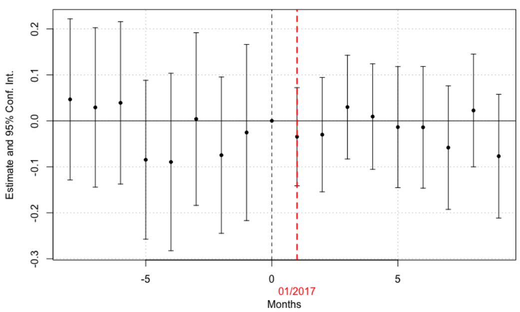
	(1) Abortion	(2) Contracep.	(3) C-sect	(4) Dystocic	(5) Birth
DD price	-0.00591	0.00286	-0.0141	-0.00595	0.0267
inc.*pipeline	(0.0129)	(0.0651)	(0.0354)	(0.00684)	(0.0821)
Munic. F.E.	Yes	Yes	Yes	Yes	Yes
Time F.E.	Yes	Yes	Yes	Yes	Yes
Adjust R2	0.169	0.488	0.349	0.077	0.526
N	16650	16650	16650	16650	16650
AIC	11385.2	42763.0	32487.0	-18445.1	54108.8

Standard errors in parentheses

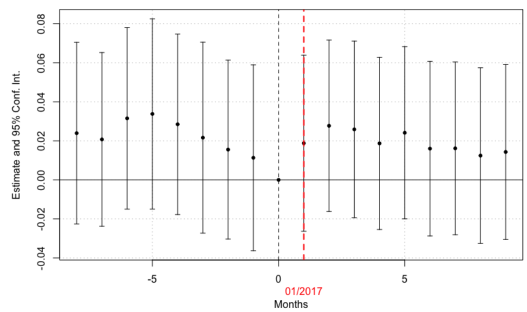
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Results from estimating a version of equation (1) where instead of interacting the treatment group with time dummies (by month and year), I replace them by an $\mathrm{Post_t}$ indicator, which takes the value of one at January 2017. The outcome variables were obstetric hospital discharges. The data was obtained from INEGI from March 2016 to September 2017. I include time and municipality-fixed-effects. Both specifications have clustered standard errors in parentheses.

(a) Effects of the price increase on contraceptive rate among fertile women



(b) Effects of the price increase on dystocic birth rate among fertile women



Notes: Results from estimating equation 1, where the dependent variable is the rate of contraceptive use and dystocic births from April 2016 to September 2017, therefore 9 months before and after the price increase. The data source is the obstetric hospital discharge records by INEGI. The X-axis represents the months. The reference period is December 2016, a month before the price increase in January 2017. The plot shows the β_k coefficients that capture the rate. I control for time (month and year) and municipalities fixed-effects. Confidence interval 95% based on standard errors clustered at the municipality level.

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