Mapping the mortality impact of drug trafficking on both sides of the United States-Mexico border: fatal overdoses and violence

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Abstract

Homicides driven by drug trafficking and cartel activity have led to declines in life expectancy during the 2000s in Mexico, with homicides peaking in 2020 and remaining extremely elevated during the early 2020s. An increase in drug overdose mortality has also been documented in Mexico. However, previous research has focused on violence and overdoses separately and been limited in its spatiotemporal granularity. In this paper we integrate the study of homicide and drug-related mortality at a fine spatial scale by estimating and mapping the mortality risk from both causes for all municipalities in Mexico and all counties in the United States border states of California, Arizona, New Mexico, and Texas during the 2000-2023 period. Preliminary findings highlight an intensification of both violence and drug-related mortality in northwest Mexico, and a generalization towards the south in the 2020s. Violence and drug overdoses in the US border states were not estimated to be concentrated in border counties, but levels of drug overdose mortality in these states surpassed homicide mortality in Mexico for males in the early 2020s.

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1 Introduction

Homicides and drug overdoses are responsible for more than 2,37 million deaths in the United States of America (U.S.) and Mexico over the last two decades (Institute for Health Metrics and Evaluation 2026). Most of these deaths affected young people and have increased substantially in recent years. At the heart of this crisis are drug trafficking and cartel activity leading to increased violence, particularly in Mexico, and expanded drug supply in the U.S., manifesting in increased overdose deaths (Pájaro 2023; Drugs and Crime 2023).

Mexico's epidemic of violence significantly worsened in 2006 when the military intervened against drug cartels. Since then, homicides rates more than doubled (from 10.82 in 2006 to 27.62 in 2023) and the number of homicides reached record levels in recent years (188,302 homicides between 2019 and 2023) (Institute for Health Metrics and Evaluation 2026). Mexican Male life expectancy has stagnated since 2010 at around 75 years and parts of the country have experienced sharp temporary life expectancy losses due to violence over the last two decades (Canudas-Romo et al. 2017; Aburto and Beltrán-Sánchez 2019; Zazueta-Borboa et al. 2025). In Mexico, most recorded homicide victims are men (around ten times more than women), but recent evidence suggests that increased homicides among women in the Mexican context are an important public health issue.

In parallel, life expectancy in the U.S has stagnated since around 2010. The lack of improvements in cardiovascular mortality (Mehta, Abrams, and Myrskylä 2020) and the unprecedented increase in drug overdose mortality (Barbieri 2019; Alexander, Kiang, and Barbieri 2018; Seltzer 2020; Monnat 2022) contributed to this stagnation. Increased availability of opioids, initially driven by prescription medications and subsequently by the substitution with heroin and fentanyl starting in 2013 drove the increase in drug-related deaths (Ruhm 2018; Seltzer 2020; Shiels et al. 2020). Although the increase in overdose deaths has affected all regions of the United States, studies document wide geographic variations in mortality rates. In general, these deaths are concentrated in locations with the worst economic conditions (Seltzer 2020; Cano et al. 2023; Monnat 2019; Monnat 2022). State policies to prevent overdose deaths, such as naloxone distribution programs, vary geographically, which may influence the observed regional differences in drug mortality (Glei and Preston 2020; Seltzer 2020). Fentanyl-related overdoses initially increased more rapidly in the Northeast and Midwest due to the proximity of these regions to shipping ports; however, with most fentanyl now entering the United States through Mexico, the West and South have begun to receive massive supplies of this drug (Monnat 2019; Monnat 2022).

While several studies have documented the rise of overdoses in the United States and violence in Mexico (Das et al. 2025; Henson et al. 2024), much of this research has been conducted separately, and to our knowledge, no study has explicitly compared the U.S. with Mexico. Our premise is that these two phenomena are intimately linked, since drug cartels in Mexico are involved in both the synthesis and trafficking of fentanyl to the US. Not only are the two causes of death linked, but the increasing presence of fentanyl in Mexico is thought to be driving increases in drug overdose mortality, especially in urban areas near the US border (Henson et al. 2024).

Given these considerations, the objective of this paper is to study the mortality impact of both violence and drug overdoses, in both Mexico and the US border states of Texas, New Mexico, Arizona, and California. We will analyze the time trends of the level of homicide and drug overdose mortality, age patterns and sex differences, and granular spatial patterns.

2 Data and methods

Data

For Mexico, we obtained data on deaths and population from the national statistical office (Instituto nacional de estadística y geografía (INEGI)). We conduct our analysis at the municipal level; Mexico is divided in 2,462 municipalities which are the second administrative division after states in Mexico. The individual level mortality data contains information on sex, age, year of death, municipality of residence and occurrence of death, and cause of death by the International Classification of Diseases 10th revision (ICD-10) code. The mortality data we have is for the period 2000–2023. We also have municipal mid-year population estimates by age and sex for the period 2000–2019, and official projections for 2020–2023.

For the US border states, we used the Centers for Disease Control (CDC) WONDER underlying cause of death data series, which contain information on number of deaths and population by state, county, age, sex, and cause of death according to the ICD-10. The CDC WONDER suppresses death counts and population sizes less than 10, so county-level tabulations contained some suppressed cells. However, the state level tabulations did not have suppressed cells, so from the state totals we were able to estimate the number of missing deaths from the county level suppressed cells. We redistributed the missing deaths to the suppressed cells proportionally according the county population sizes.

For overdose mortality, we used the ICD-10 codes following Henson et al. (2024). For homicides, we

used X86–X99, Y00–Y09, Y35, and Y36.

Methods

First, we aggregated death counts and population at the country level and computed yearly death rates for ages 15-64 by sex for both causes of death. We restrict our analysis to ages 15-64 because the vast majority of homicide and overdose deaths occur in this range. We also computed age-specific death rates for 5-year age groups to see how the age pattern of mortality has evolved over time.

We also analyzed spatiotemporal patterns by modeling the 15-64 death rate in US counties and Mexican municipalities. Small or zero death counts at the municipal/county level are quite noisy and made modeling necessary to extract spatiotemporal patterns and granular estimates of year and area specific mortality risk. In a Poisson regression framework, we modeled the log mortality rates as a smooth function of space and time, plus additional area and year specific terms not constrained to be smooth (Perperoglou and Eilers 2010; Lee and Durbán 2011; Martin and Camarda 2025). This allowed us to borrow strength over space and time while also allowing for sharp breaks from the spatiotemporal pattern. This is especially important when analyzing violence, as where localized hotspots can depart significantly from a smoother underlying spatial pattern. The full model specification is in the appendix. We performed all modeling independently by cause of death, country, and sex.

Limitations

Our primary limitation relates to the mortality data and cause of death classification. Death registration in both Mexico and the US is generally good (United Nations Statistics Division 2023), but cause-specific counts are likely subject to underreporting due to misclassification. In Mexico, homicides may never be registered in the first place, given the widespread prevalence of enforced disappearances and clandestine graves. Also, both homicides and overdoes could be misclassified as ill-defined or other causes. For overdoses, the absence of systematic testing for substances in Mexico means it is likely that the Mexican data underreports deaths due to drugs (Henson et al. 2024).

Another limitation is the comparability of spatial units in the geographic analysis. Both the Mexican municipalities and the US counties vary in population and geographic area. This is not a problem in itself but caution should be exercised when interpreting mapped results as different areas may represent very different population sizes. Although the Mexican municipalities and US counties are similar territorial aggregations,

the Mexican municipalities offer a higher granularity than the US counties. Thus, in our maps spatial patterns will be less detailed in the US.

3 Results

Figure 1 presents the overdose and homicide death rates for ages 15-64 by sex and country. The Mexican overdose death rates stay much lower than overdoses in the US border states and homicides in both countries, but show an increasing trend since 2015. These results reproduce the trends found by Henson et al. (2024); however, their analysis was restricted to the post-2005 period, and we observe here that overdose death rates stood at a higher level in 2000. Overdose death rates in the US border states were higher than homicides or overdoses in either the US or Mexico for females for the entire study period, and for males they were only surpassed by homicides in Mexico for some years. Both male and female overdose death rates rose exponentially towards the end of the study period.

Homicide rates for males in Mexico were at their lowest in 2007 before increasing dramatically to triple the 2007 rate in 2010. The rates declined until 2014 before rising again to even higher levels in the late 2010s. In 2023, the male homicide rate remained elevated compared to the first 5 years of the study period, with the death rate still almost triple the lowest rate registered in 2007. Female homicide rates in Mexico follow a similar temporal trend, albeit at a lower level. In the US, homicide rates for both sexes were actually higher than in Mexico at the beginning of the study period. Female homicide mortality in the US border states was surpassed by Mexico in 2010, but levels remained comparable between the two countries from 2010 onwards. Male homicide remained substantially higher in Mexico than in the US border states after 2008.

In Figure 2 we map our estimates for drug overdose mortality in the US counties and Mexican municipalities. As these are modeled estimates, they should be interpreted as the underlying mortality risk from overdose, rather than representative of the actual number of recorded deaths. We map the estimates for four selected years: three inflection points during Mexico's epidemic of violence, and the last year for which we had data. Overdose drug mortality was highest in the north of Mexico, especially in several clusters of municipalities on the border. In the US border states, the level of overdose mortality was higher in almost all counties than in Mexico, creating a visibly distinguishable border on the maps. However, for males, drug mortality in northern Mexican municipalities approached the levels estimated in neighboring US counties, blurring the border in some areas, especially the northwestern border with Arizona. In addition to the border municipalities in northern Mexico, we estimated clusters of higher male drug overdose mortality on the

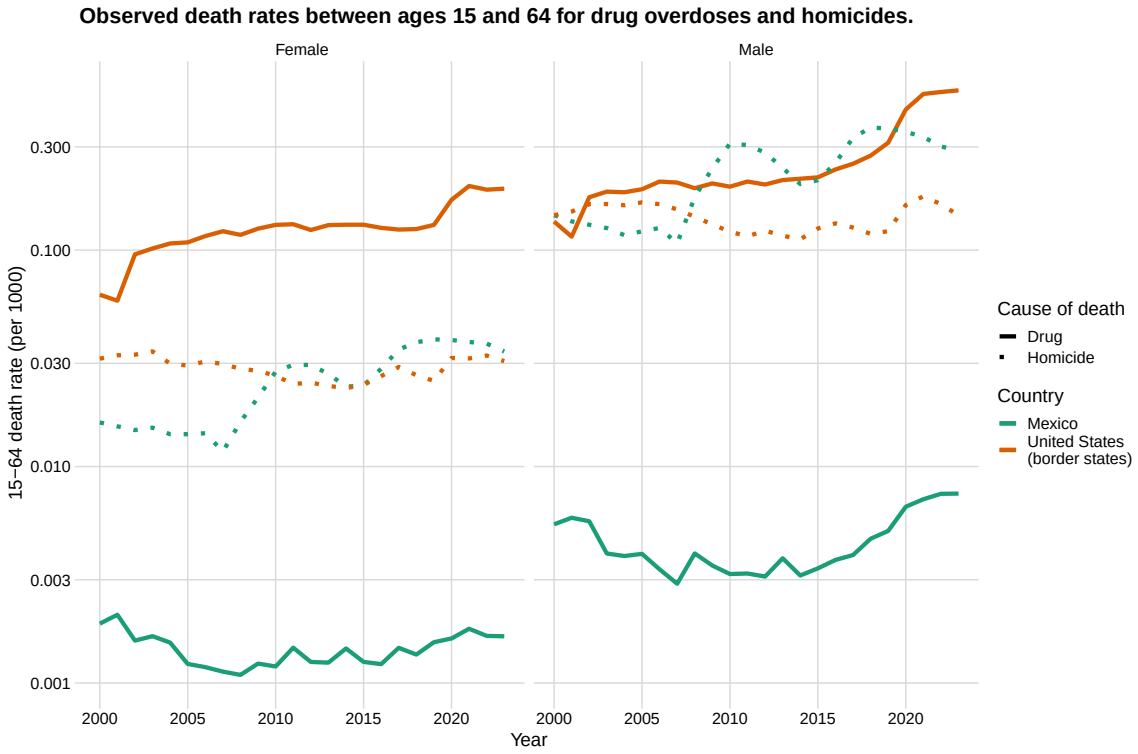

Figure 1: Observed homicide and drug overdose mortality rates for ages 15-64 in Mexico and the US border states.

southern and western coasts. In contrast to Mexico, in the US border states we did not estimate the highest levels of overdose mortality to be in counties on the border. Instead, the highest mortality risk was estimated in northern New Mexico for males.

Figure 3 shows the estimated homicide mortality risk for the same four years. In Mexico, the geographic pattern of violence generalized to higher levels and more clusters present throughout the country, especially in the south. Levels of homicide mortality in Mexico remained high along the border for the whole study period. The geographic patterns for males and females are highly similar, though at a much lower level for females. In the US border states, in contrast to Mexico, our county-level estimates did not necessarily show higher homicide mortality concentrated in border counties. Instead, we estimated the highest rates in 2023 in non-border counties of New Mexico.

Figure 4 maps the ratio of female to male estimated homicide rates. Except for three counties in west Texas, we estimated the female homicide risk to be lower than the corresponding male risk for all years. Overall, the female homicide rates are closer to the male rates in the US. In Mexico, the ratios of rates are highly variable in both space and time. In 2023, the Mexican municipalities with the highest ratio of female to male homicide rates were concentrated in the states of Michoacán, Jalisco, and Coahuila.

4 Discussion

Increasing overdose mortality in Mexico

Our results confirm the work of Henson et al. (2024), showing steadily rising overdose rates since 2010 in Mexico. The timing of this rise mirrors the the beginning of the third or fentanyl wave of overdose mortality in the United States in 2013. Henson et al. (2024) and numerous newspaper articles (Linthicum, Blakinger, and Sheets 2023; Grant 2024) in the last few years have brought attention to rising fentanyl mortality in northern border cities, especially Mexicali and Tijuana. Our high-resolution analysis identified other municipalities on the Texas border and in southern Mexican states showing elevated overdose mortality. These results indicate that more sparsely-populated areas may be affected by high burdens of drug overdose mortality risk, even if the number of yearly recorded deaths remains small. Additionally, the results further demonstrate the need for better data collection and monitoring in all municipalities in Mexico to detect areas in which overdoses have an increasingly important impact on public health.

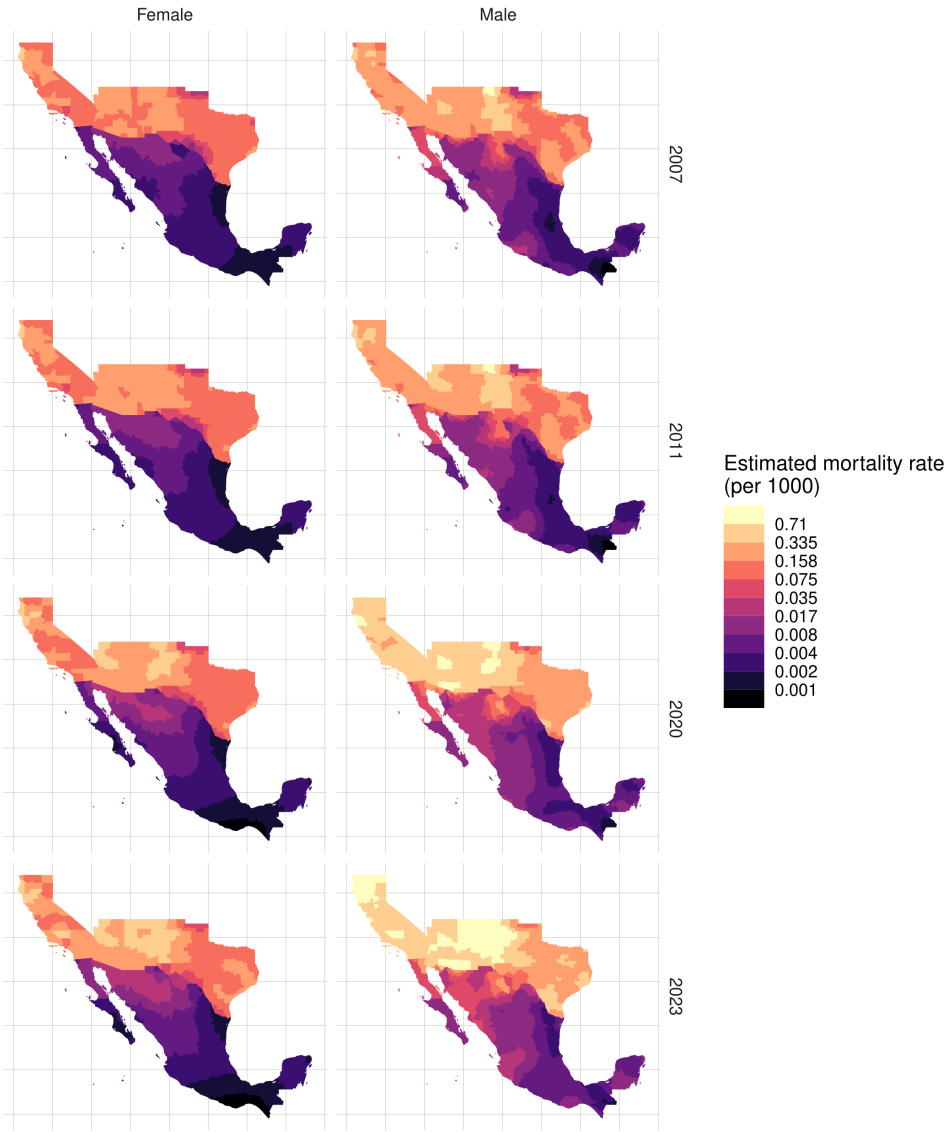

Figure 2: Estimated drug overdose mortality risk for ages 15-64 for selected years.

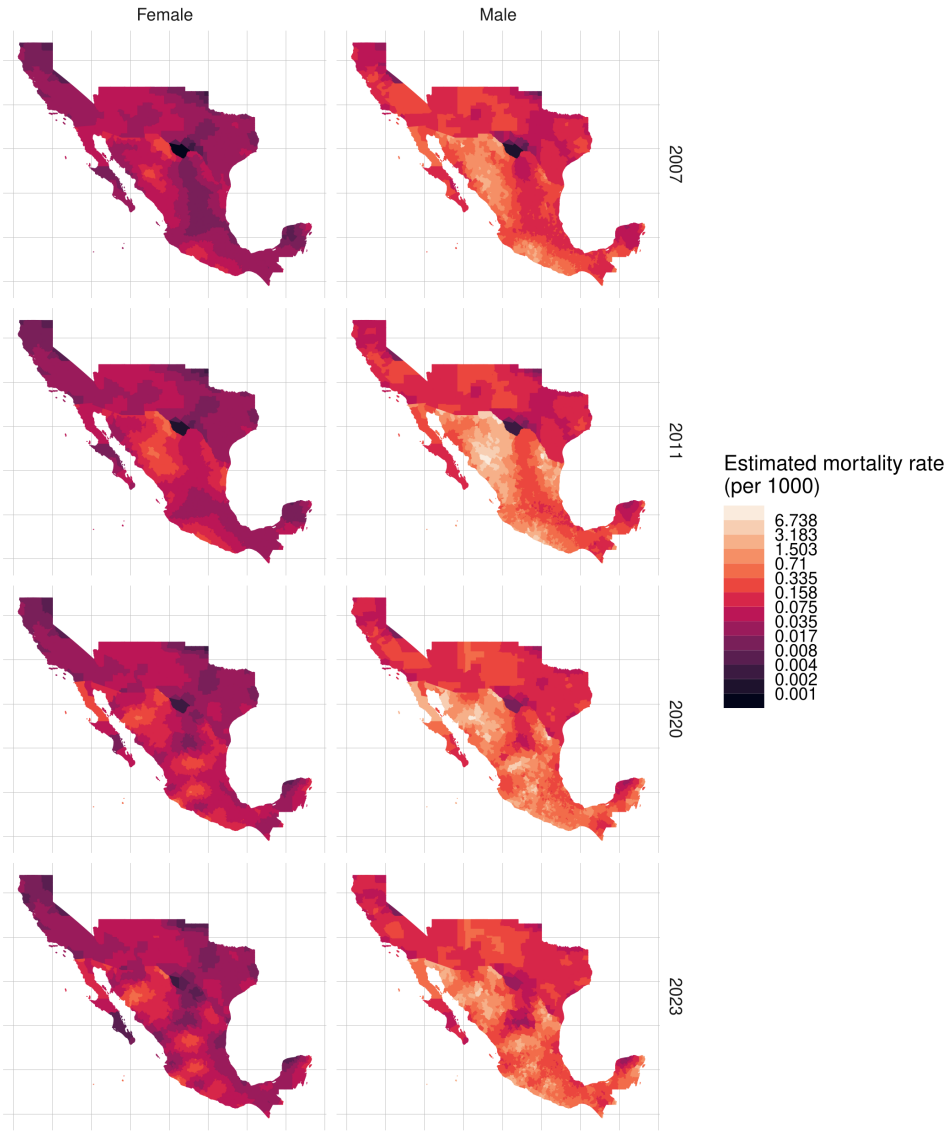

Figure 3: Estimated homicide mortality risk for ages 15-64 for selected years.

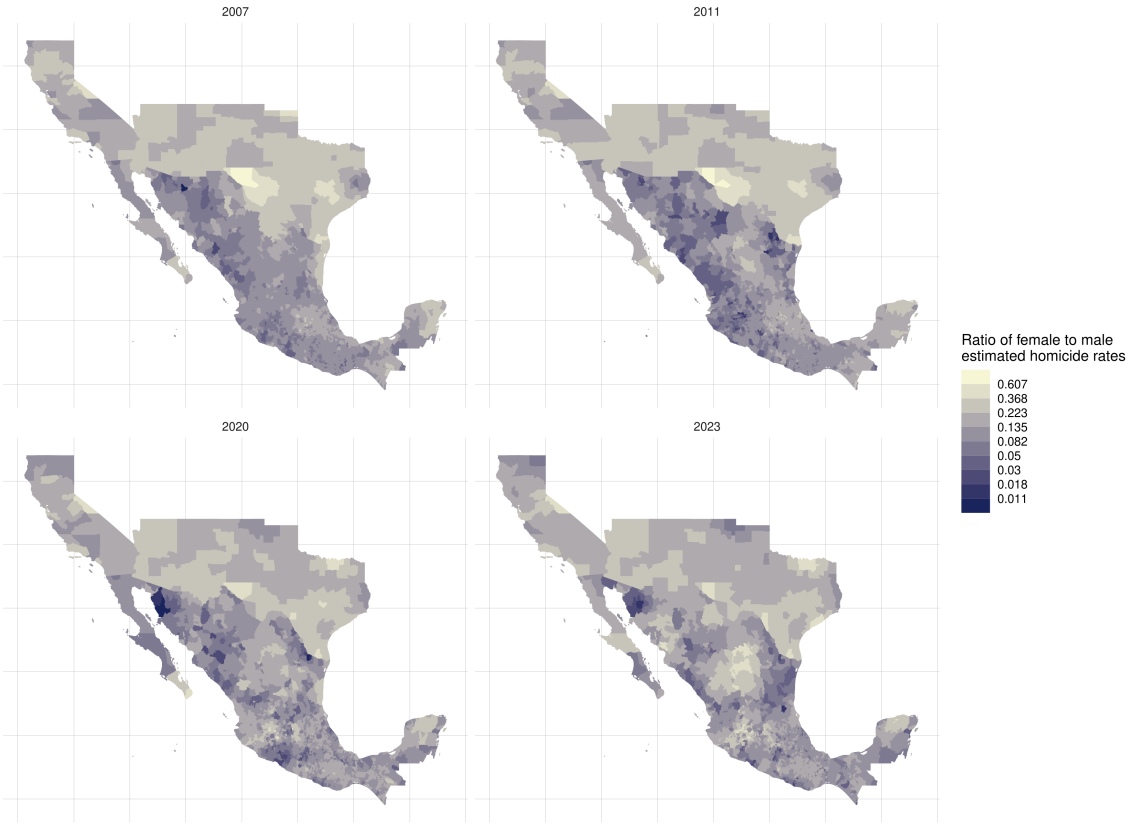

Figure 4: Ratio of female to male estimated homicide rates for selected years.

Changing spatial patterns of violence

The geographic patterns and overall level of homicide mortality in the US border states remained quite stable during the study period. In Mexico, however, the national homicide rates rose and fluctuated dramatically, and the three or four main clusters of violence present in 2007 changed into many different clusters covering a much larger area of the country. Thus, levels of violence both rose and spread within the country so that a larger number of municipality suffered an elevated risk of homicide mortality.

Our results show more gendered patterns of violence in Mexico than the United States. In the US border states, county-level female homicide rates were closer to the corresponding male rates than in Mexico. The geography of these gendered differences also remained mostly the same in the US but not in Mexico. In Mexico, female and male homicide rates become more similar in municipalities in the states of Michoacán, Jalisco, and Coahuila. More research is needed to understand these changes and the relationship between gender-related killings and cartel-related homicides.

Directions for future research

In future research, we plan to expand this idea to other Latin American countries. In Brazil, the number of overdose fatalities increased by more than 5 times between 2000 and 2021 (Bianco et al. 2023). In Colombia, nonfatal drug overdoses have also dramatically risen since 2010 (Santaella-Tenorio et al. 2024). Combined with the evidence from Mexico, this points to an emerging public health threat in Latin America. Thus, we plan to perform similar fine-grain analyses of overdose mortality in Brazil, Colombia, Argentina, Uruguay, Ecuador, and Chile. Many of these countries are also seriously implicated in the global trafficking of illicit substances and have experienced some of the highest homicide mortality in the world.

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