BMC Women's Health

RESEARCH

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The impact of social determinants of health on feminicide in the second-largest state of the Brazilian Amazon: a spatial epidemiological analysis

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Abstract

Introduction Despite global advancements in gender equality and legal frameworks, feminicide remains a persistent issue worldwide. Spatial analysis is a powerful tool to use in obtaining evidence-based recommendations for more effective policies to fight it. In Brazil the state of Pará was highlighted with the sixth highest increase in the feminicide rate between 2019 and 2022. In this study, we spatially analyzed feminicide rates in Pará, from 2016 to 2021, employing spatial distribution and autocorrelation, spatio-temporal, and geographically weighted regression (GWR) techniques.

Methods Annual number of feminicide incidents from all municipalities in Pará were provided by Secretariat of Intelligence and Criminal Analysis of Pará. Municipalities crude feminicide rates were calculated and analyzed using spatial distribution and spatial autocorrelation (Getis-Ord G analysis) to identify areas with a high burden of feminicide. Spatio-temporal risk analysis was employed to assess the influences of policies and social factors on feminicide trends over space and time. GWR was used to evaluate the influence of social determinants of health in the spatial variability of feminicide rates.

Results During the study period, feminicide rates expanded spatially in Pará, with municipalities in Belem metropolitan area and in the northeast, southeast and southwest mesoregions of Pará being the most affected. Between 2016 and 2018, there was a hotspot cluster (neighbor municipalities sharing high feminicide rates) located in southwest and southeast of Pará. From 2019 to 2021, this hotspot contracted, and a new one appeared in the northeast. The spatio-temporal risk zone comprised municipalities situated in the northeast, southeast, and southwest mesoregions of Pará from 2018 to 2021. The spatial variability of feminicide was promoted by the "high school pass rate," the "youth homicide rate," and "primary healthcare services coverage."

Conclusion Our findings highlight the need for policy interventions, including increased investment in women's shelters, expanded access to legal and psychological support for victims of gender-based violence, and the integration of gender equality education into school.

Keywords Women, Feminicide, Social determinants of health, Brazil, Spatial analysis

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Introduction

Despite global advancements in gender equality and legal frameworks, feminicide— the gender-related killing of women and girls—remains a persistent issue worldwide. Feminicide originates in male chauvinism, which has been perpetuated in its most archaic and perverse version and gained strength through the fear of female empowerment throughout human history [1]. In 2022 alone, approximately 48,800 women and girls were intentionally murdered by partners worldwide, with an average of 133 women killed per day [2]. In Brazil, in 2022, the number of feminicide cases increased by 10.8% compared to that in 2019, with an average of four women killed per day [3].

Despite multiple strategies to combat feminicide, progress has been slow, and rates continue to rise in several countries, such as the United States, Italy, and Mexico [4–6]. In some countries, feminicide is not explicitly categorized as a crime in the penal code, the effectiveness of legal and policy responses [4, 5].

To fight feminicide Brazil has implemented 1) the Sentinel Departments within the Unified Health System, which mandate the reporting of partner-related violence [7]; 2) the National Policy for Comprehensive Attention to Women's Health, which aims to consolidate advances in the field of sexual and reproductive women's rights [8]; 3) the Women's Service Center Dial 180, which enables individuals to report gender-based violence and directs cases to appropriated authorities [9]; 3) the Maria da Penha Law, (Law No. 11,340) [10], which criminalizes all forms of gender-related violence; 4) the National Policy to Combat Violence against Women, which defines various forms of gender-based violence and establishes guidelines for prevention, victim assistance, and the protection of women's rights [11]; and 6) several other agencies, including the Specialized Reference Center for Social Assistance (CREAS), the State Reference and Support Center for Women (CREAM), and the Reference Center for Social Assistance (CRAS) [12].

In 2015, Brazil legally classified feminicide as a heinous crime under the Law No. 13,104 [13], and in 2023, Law No 14,541 was enacted to ensure uninterrupted service at women's police stations [14]. However, despite these legal advancements, feminicide rates continue to rise, particularly in northern Brazil. A temporal study between 2000 and 2019 in Brazil reported that northern region stood out with a greater upward trend in lethal violence rates among 15–59 years-old women (Mean annual increase/decrease—Northern = + 0.33, Northeast = + 0.26, Midwest = + 0.06, Southeast = −0.20, South = + 0.08) [15]. Between 2019 and 2022, Pará, in northern Brazil, had the sixth highest increase (55%) in the number of reported feminicide (2019 = 18 cases, 2022 = 28 cases) [3].

Feminicide incidence varies across geographic regions due to differences in social determinants of health (SDH)—non-medical conditions in which people live that impact their health situation [16]. For example, in Mexico, municipalities with higher homicide rates among men and women were those having lower social conditions [17]. In Milwaukee, Wisconsin, the likelihood of battery or assault against women was significantly higher in neighborhoods with higher poverty rates [18]. Another spatial study in the municipalities of Uttar Pradesh, India, revealed temporal and spatial variations in the risk of homicide for young women that could be associated with policy changes that influenced societal attitudes [19]. These findings underscore the role of social determinants in shaping feminicide patterns and highlight the potential of spatial analysis in identifying high-risk areas and assessing the effectiveness of policies.

Despite the growing evidence linking feminicide to social determinants of health, this relationship remains underexplored in research. To our knowledge, this is the first study to conduct a spatial analysis of feminicide in northern Brazil. To address this gap, this study employs spatial analysis techniques to examine feminicide rates in Pará between 2016 and 2021, assessing their association with key SDH indicators. This study provides evidence to inform more efficient policies to prevent and improve protective mechanisms for women in vulnerable contexts.

Methods

Study design and settings

This is an ecologic study that used secondary data on feminicides in Pará, obtained from the Integrated Public Security System (SISP-WEB), which are made available by the Secretariat of Intelligence and Criminal Analysis (SIAC), linked to the Secretariat of Public Security of the State of Pará.

Pará is the second-largest state in the Brazilian Amazon with a territorial area of 1,245,871 km^2. It comprises seven mesoregions (Lower Amazonas, Marajó, Belem Metropolitan Area, Northeast, Southeast, and Southwest) and 144 municipalities (Fig. 1). In 2022, Pará had a population of 8,116,132, of which 50.1% of whom were women [20].

Pará ranks fourth among the Brazilian states in terms of the lowest Human Development Index (HDI = 0.69) [20] and has only 24 Women's Police Stations (DEAM), 21 Specialized Social Assistance Reference Centers (CREAS), and 9 State Reference and Support Centers for Women for its 144 municipalities [21, 22]. These services are mainly concentrated in the Belem Metropolitan Area and the Northeast and Southeast mesoregions (Fig. 2).

Fig. 1 Location of Pará and its mesoregion divisions: Low Amazonas, Marajo, Metropolitan of Belem, Northeast, Southeast, and Southwest

The study population included all cases of reported cases of feminicide in Para between 2016 and 2021, where victims' residences were identified within the state. Data were organized in Microsoft Excel and double-checked to eliminate redundancies.

Data analysis

To account for year-to-year variations and to analysis the increasing of areas affected by feminicide, rates were calculated for three-year periods: 2016–2018 and 2019–2021. These periods were chosen due to the political changes in Brazil in which the right-wing extremists took power in 2019 with Jair Bolsonaro as president.

To calculate the feminicide rates, the number of feminicides was divided by the average projected female population, obtained in DATASUS (http://tabnet.datasus.gov.br/cgi/deftohtm.exe?ibge/cnv/projpopuf.def), for the respective three years period in each municipality. The

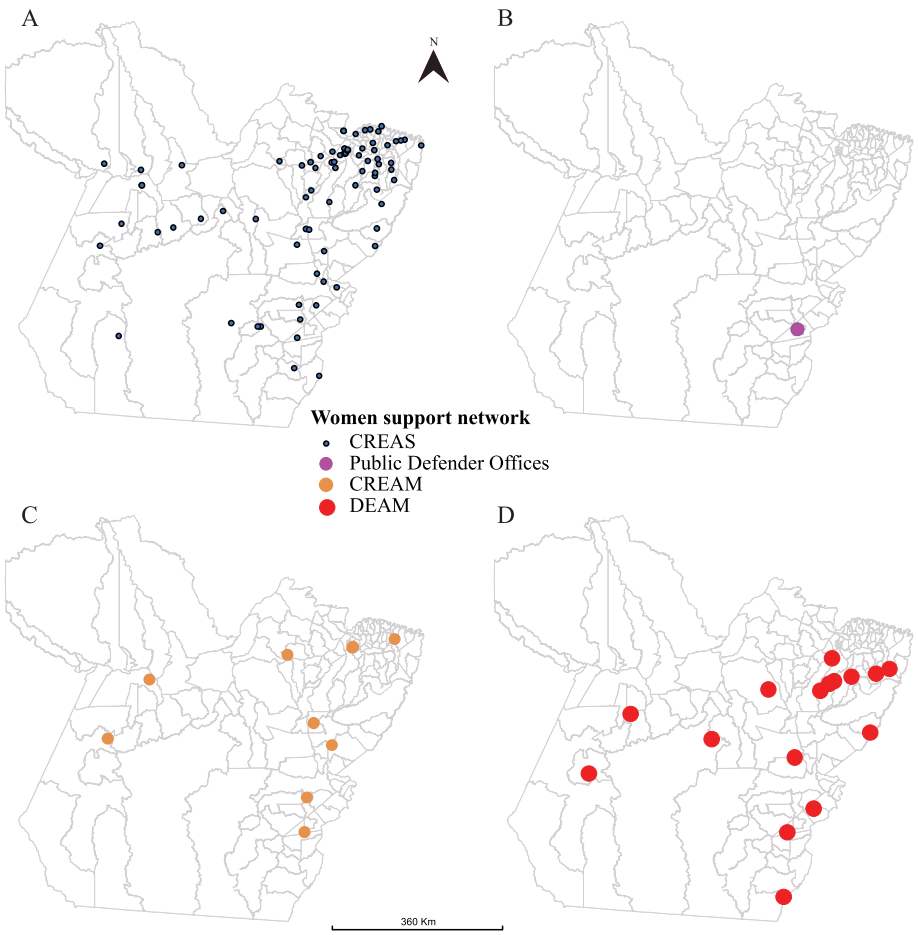

Fig. 2 Locations of social support services for women experiencing domestic violence in Pará: **A** CREAS, **B** Public Defender Offices, **C** CREAM, **D** DEAM

results were multiplied by 100,000. The crude rates were then analyzed using spatial distribution and spatial autocorrelation analyses.

To identify spatial patterns in feminicide rates, spatial distribution and autocorrelation analyses were performed. The spatial autocorrelation analysis assumes that neighboring municipalities share the same characteristics where municipalities with high (hotspots) or low feminicide rates (coldspots) would be clustered. The Shapiro–Wilk test indicated that the feminicide rates were not normally distributed (2016–2018: $W = 0.7185$; $p < 0.001$; 2019–2021: W 0.64485; $p < 0.001$). For that reason, we employed the Gi statistic. This technique analyzes the possibility of clusters within a group of spatial data attributes, whether in points or polygons. This analysis includes the global and local Getis-Ord G (G and Gi*, respectively). While G indicates whether there is an autocorrelation, Gi* gives the location of the clusters that are classified as hotspots (municipalities clusters with high-high incidence rates) or cold spots (municipalities clusters with low-low incidence rates) with 99%, 95%, and 90% confidence intervals [23].

For the spatio-temporal risk analysis, we used SaTScan™ version 9.7. This analysis allows us to identify the spatial zones in a specific time period in which feminicide rates increased allowing to associate it with the influence of policies or other social phenomena. The following criteria were applied: the clusters should not be overlapped, have a maximum size equal to 50% of the exposed population and of the time period, with 999 replications. To be considered at risk, the area had to have a relative risk (RR) greater than one and a p-value < 0.05 [24].

To determine the association of SDH with feminicide, we used the geographically weighted regression (GWR) analysis technique [25]. The feminicide rates and SDH were considered the dependent and independent variables, respectively. First, we employed Pearson's correlation analysis to verify the correlation between the dependent and independent variables in Rstudio software V.1.4 (RStudio, Boston, MA, USA).

Next, we analyzed the statistically significant correlations through ordinary least squares (OLS) regression to measure the dependence of the variable, employing the stepwise method in IBM SPSS Statistics version 23 (Armonk, NY, USA). Only models composed by selected variables with variation inflation factors (VIF) lower than ten were considered. The best explanatory model for this phenomenon was defined by the lower Akaike information criterion (AIC), VIF, and value ($p < 0.05$). After discarding the spatial dependence of the residuals of the chosen model, we applied GWR through the MGWR software (Arizona State University, Tempe, USA). We opted to use the adaptive-bandwidth kernel since its AIC is smaller than the fixed-bandwidth (Adaptive: AICc = 371.098; Fixed: AICc = 368.656). We also analyzed the GWR residuals for spatial dependence. The OLS and GWR models were compared through the adjusted R^2, AIC, and corrected AIC (AICc).

SDH were obtained in the Health Ministry website (https://datasus.saude.gov.br/informacoes-de-saude-tabnet/), in Fundação de Amparo a Pesquisa do Pará (https://www.fapespa.pa.gov.br/anuario-estatistico-do-para), and in the Forum Brasileiro de Segurança Pública (https://forumseguranca.org.br). Supplementary (Suppl.) Box 1 shows all variables categorized in their respective domains.

We generated all maps in ArcGIS version 10.5 using Universal Mercator Projection (UTM), Zone 22 S, Datum SIRGAS 2000. We obtained the shapefile of Pará from the Brazilian Institute of Statistics and Geography (IBGE) website. All results are given in color scales.

Results

During the study period, 339 feminicides were reported in Pará. The number of municipalities reporting feminicide increased over time (2016–2018 = 63 municipalities, 2019–2021 = 100 municipalities), with those in the Belem metropolitan, the northeast, southeast, and southwest mesoregions being the most affected (Fig. 3).

The Gi global autocorrelation was statistically significant for the first three-year period (2016–2018: G = 0.054; $p = 0.001$) and non-significant for the second three-year period (2019–2021: G = 0.42; $p = 0.36$). However, the local Gi* showed hotspots in both periods. Between 2016 and 2018, there was a large hotspot comprising municipalities of the southeast and southwest mesoregions (Fig. 4A). In the second period, 2019–2021, the hotspot contracted and comprised only the municipalities of the southeast, and a new hotspot appeared in the northeast mesoregion (Fig. 4B).

Figure 5 shows the spatio-temporal risk analysis for feminicide in Pará. There was only one risk zone (RR = 2.11; $p < 0.001$) composed of municipalities in the northeast, Marajó, southeast, and southwest of Pará from 2018 to 2020.

Analysing all the statical significant variables in Pearson's correlation (Suppl. Box 1) through OLS only one explanatory model was indicated (Suppl. Table 1) composed by "primary care coverage rate," "youth homicide rate per 100,000 inhabitants," and the "total high school pass rate," with the residues of the model without spatial dependence (I = 0.07, $p = 0.12$). We then analyzed the model using the GWR method that revealed a higher explainable power than OLS (GWR: AICc = 368.656, $R^2 = 0.373$, adjusted $R^2 = 0.319$; OLS: AICc = 380.069, $R^2 = 0.237$, adjusted $R^2 = 0.221$) (Suppl. Table 2). The

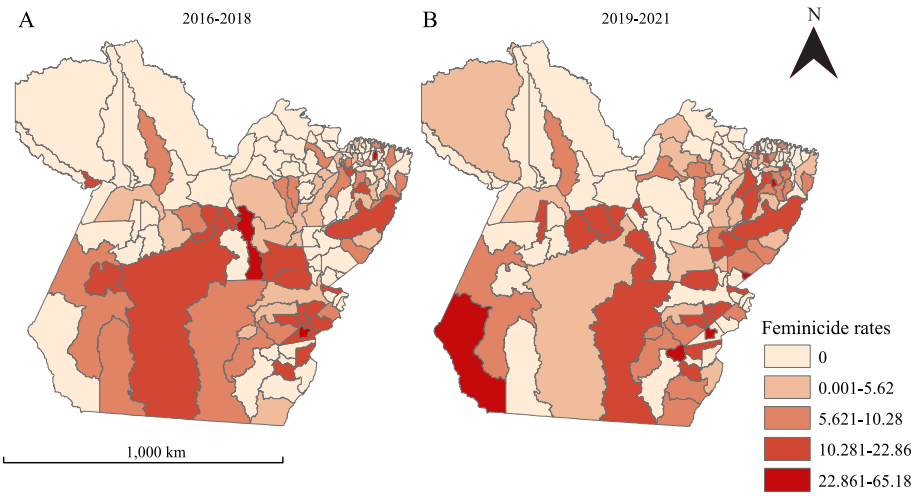

Fig. 3 Spatial distribution of feminicide for three-years periods: **A** 2016–2018 and (**B**) 2019–2021

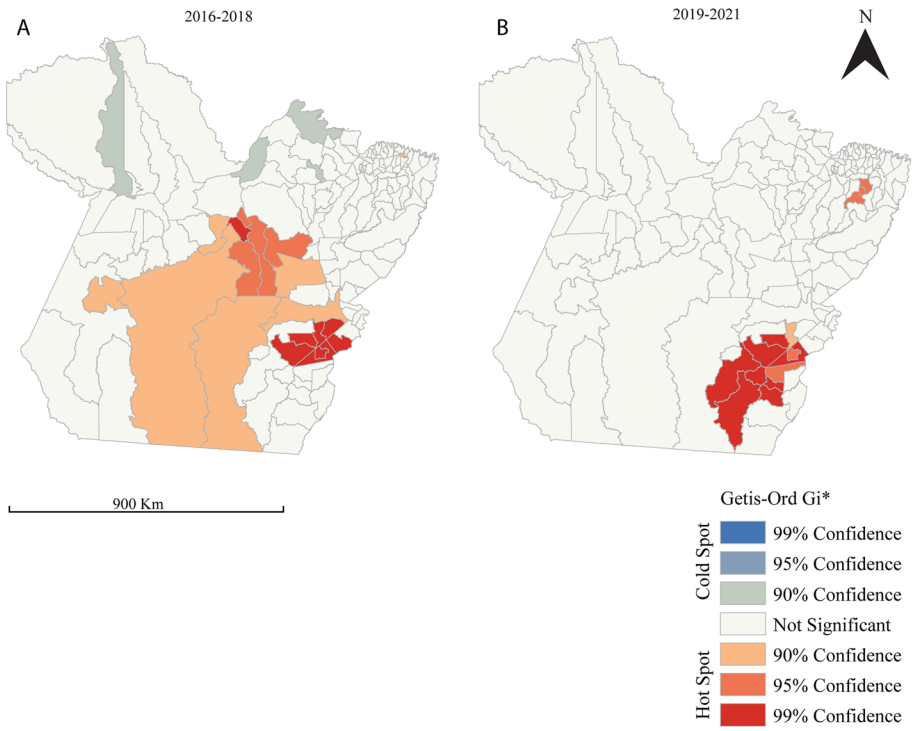

Fig. 4 Local indicator of spatial autocorrelation for the three years periods: **A** 2016–2018 and (**B**) 2019–2021

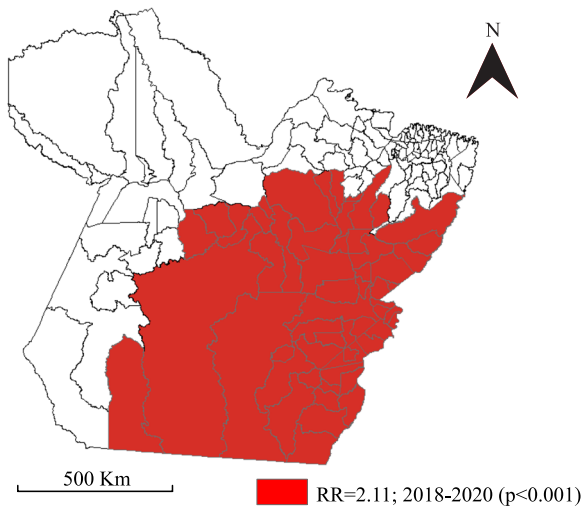

Fig. 5 Spatio-temporal risk zone for feminicide in Pará

GWR model residuals did not show spatial dependence (I = −0.08; $p = 0.13$).

The local R^2 variated from 0.25 to 0.49 indicating a good explanatory model (Suppl. Figure 1). Even in the region in which the model-fit low, the local R^2 is close to 30%. Figure 6 shows the spatial variability of feminicide promoted by the aforementioned SDH. Figures 6A, C and E show the spatial distribution of the youth homicide rates, high school pass rates and primary healthcare coverage, respectively. The youth homicide rate was inversely associated with feminicide risk with a greater risk in northern Pará, where most of the municipalities had low youth homicide rates (Fig. 6B). At the other hand, feminicide risk was directly associated with high school pass rates and primary healthcare coverage with a greater risk in northern and southern Pará where most municipalities had a higher school pass rate (Fig. 6D) and primary healthcare coverage (Fig. 6F), respectively.

Discussion

Our results show that there was a spatial expansion of feminicides throughout the study period, which mainly affected the municipalities in the northeast, southeast, and southwest of Pará. Over time, the size of the hotspot located in southern Pará decreased, and a new hotspot appeared in the northeast between 2019–2021.

Municipalities of northeast of Pará have the greater demographic density which can contribute to increase the feminicide. Previous study that analyzed the epidemiological aspects of feminicide in cities in the state of Sergipe, Brazil, showed a tendency toward a greater occurrence of feminicide cases in large population centers [26].

Concerning the hotspot in southern Pará, this region exhibits rapid economic growth due to investments in

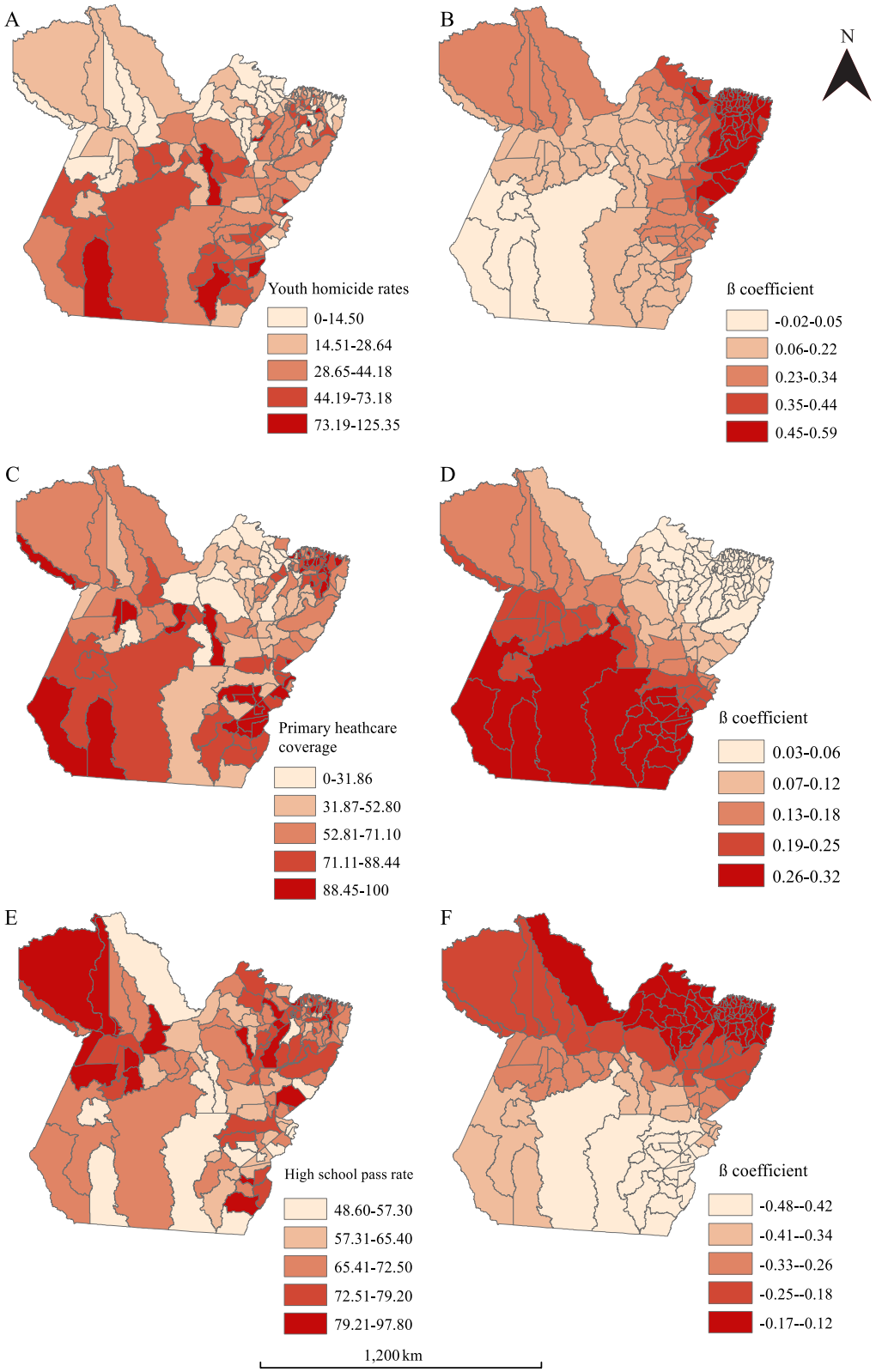

Fig. 6 Spatial mapping of the geographically variability of the Feminicide in Pará promoted by the social determinants of health. Spatial distribution of the (**A**) youth homicide rates, (**C**) high school pass rates, and (**E**) and primary healthcare coverage; Coefficients β of (**B**) youth homicide rates, (**D**) high school pass rate, (**F**) primary healthcare coverage

mining, livestock, agriculture, highway construction, and hydroelectric industries, which promoted a population explosion that was not accompanied by investment in urban infrastructure [27]. For example, the construction of the Belo Monte hydroelectric plant in Altamira, which was completed in 2019, was associated with an increase in homicide in the municipality. In 2017, Altamira was ranked as having the highest homicide rate among all Brazilian municipalities [28].

Although the non-statistical significance in the global Gi between 2019 and 2021 suggest change in the spatial clustering pattern, the local Gi showed emergence of a new hotspot in northeast Pará. This may be associated with the imposed social restriction by COVID-19 that increased the feminicide because women had to live with the criminal for a longer time [29]. Two of the municipalities comprising this cluster, Aurora do Pará and Mãe do Rio, increased their total homicide rates in the pandemic period by 245.29% and 106.06% while in Pará it increased 7.09% (Total homicide rates—2019: Pará = 28.87, Aurora do Pará = 12.76%; 2020: Pará = 31.78, Aurora do Pará = 44.06; Mãe do Rio = 95.92;/100,000 inhabs) [30].

Impact of political and policy changes on feminicide.

To fight feminicide, the government of Pará implemented the program "Pará Peace Woman". Pará Peace Woman is an integrated system comprising women's police stations, judiciary powers, public ministries, and defenders' offices that actively combat intimate-partner-related female violence [31]. This may have contributed to the observed contraction and non-statical significance in the hotspot observed in the period between 2019 and 2021.

However, politics can have negative influence on feminicide. Between 2019 and 2022 Brazil had a strong political conservatism implemented in which the patriarchal system and the subservience feminine were reinforced [32]. During this period there was a decrease of the federal budget allocated to financing public policies fighting feminicide and the dismantling women's secretariats. For example, while in 2016 40% of the resources committed to fighting intimate partner violence were employed, in 2022 it fell to 7% [3, 14, 33]. This Brazilian political scenario may also be associated with the result of the spatio-temporal risk analysis once most municipalities comprising the risk zone supported the Brazilian far-right party in the 2022 represented by Jair Bolsonaro [34].

Demographic and socioeconomic factors influencing feminicide risk

Regarding to SDH and its association with feminicide, it is noteworthy that the greater risk of feminicide in the municipalities of northern Pará is associated with a low youth homicide index and greater schooling level. The school level attained is associated with greater female empowerment and this could trigger the feminicide. A study in Manaus, Amazonas, also showed a higher percentage of feminicide among women having more than eight years of study. The authors argue that highly educated women do not easily accept abuse from their partners, and this would trigger increasingly violent reactions that would culminate in femicide [35]. Although education can play a key role in combatting feminicide as it can encourage students to reflect on the implications of a patriarchal society system with respect to gender inequality and women's quality of life [36, 37], disciplines that discuss the society, such as philosophy and sociology, were only made mandatory in the school curriculum in 2008 through Law No. 11.684/088 [38].

There is concern about the greater feminicide risk in municipalities with greater coverage of primary care network services. As they are in close contact with the community, primary health care (PHC) is an important tool for combating feminicides. In 2002 the Brazilian Ministry of Health launched the "Basic Care Booklet—Intrafamily violence—Guidelines for practice in service" for all healthcare workers in the primary healthcare system [39] to guide the actions of healthcare workers to reduce feminicide in their areas of coverage. However, studies have reported the inability of health professionals to address this issue. In a city in southern Brazil, although PHC workers recognized the expressed signs of violence, they did not intervene because they did not feel capable of taking effective action [40]. Another study among PHC professionals in a municipality in Ceará reported that professionals did not act because of the fear of reprisal from the aggressor [41]. One limitation of this study is the absence of age information for 41 cases (more than 10% of the dataset), which prevented the calculation of age-adjusted feminicide rates. Given the small number of events in several municipalities, we opted to use crude rates to retain all observations. However, it is important to note that variations in age composition across municipalities could bias comparisons, as some areas may have a higher proportion of women in age groups at greater risk for feminicide. This a well-known limitation in demographic and epidemiologic analyses and should be considered when interpreting results. This reinforces the necessity of qualifying professionals to increase the quality of notifications. Additionally, some municipalities in Pará are very large and it could affect parameter estimates and the model performance. Considering it, before analysis we tested the Kernel bandwidth types (adjusted and fixed) to increase the efficiency and accuracy of the model.

Conclusion

Feminicide expanded spatially in Pará, which may be a reflection of the decrease in investment in policies and strategies to fight intimate partner violence. There was a contraction in the hotspot in southern Pará, which may be associated with the implemented strategies to reduce gender-related violence in those municipalities. New hotspots that emerged between 2019 and 2021 in the northeast of Pará may be linked to the social isolation imposed by COVID-19 and the low urban infrastructure of these cities. The spatio-temporal risk zone was mainly composed of municipalities in the southeast/southwest of Pará from 2018 to 2021, which may be influenced by conservative politics in Brazil in this time and by the COVID-19 pandemic.

Spatial variability in the feminicide rate was associated with high school pass rates, low youth homicide rates, and primary health care coverage. Our findings highlight the need for policy interventions, including increased investment in women's shelters, expanded access to legal and psychological support for victims of gender-based violence, and the integration of gender equality education into school.

Abbreviations

SDH	Social determinants of health;
GWR	Geographically weighted regression;
PHC	Primary healthcare;
OLS	Ordinary least squares regression;
VIF	Variation inflation factors;
AIC	Akaike information criterion (AIC)
AICc	Corrected Akaike information criterion

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12905-025-03747-7.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

Acknowledgements

The authors are thankful to the Secretariat of Public Security of the State of Pará for providing all data used in this study. The publication of this article was paid by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) through Edital PROCAD-Amazonia/2018.

Authors' contributions

Concept and design: AKSS, EPB; Collection of data: AKSS, VLAL; Analysis and interpretation of data: AKSS, ILS, EPB; Revision of the paper: AKSS, VLAL, GRONF, MES, ECC, EPB. All authors read and approved the final manuscript.

Funding

This study did not receive any financial support.

Data availability

Restrictions may apply to data availability. All data in this study were used under license, and so are not publicly available.

Declarations

Ethics approval and consent to participate

Since we employed public data without personal identifications, this study did not need to be approved by the Ethical Research Committee, in accordance with Resolution No. 510/2016 of the National Health Council [24].

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 20 August 2024 Accepted: 21 April 2025
Published online: 30 April 2025

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