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Spatial analysis of reporting rates of intimate partner sexual violence against women and associated geospatial indicators

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Objective - was to map and analyze spatially the rates of IPSV notification against women aged 15-49 years in the state of Paraná, Brazil, during the period from 2009 to 2014 and to identify the associated socioeconomic and demographic indicators. Design - A retrospective, ecological study. Settings - Data retrieved from the Database of the Information System of Notification Diseases of the Ministry of Health of Brazil. Participants - All cases of intimate partner sexual violence (n = 516) against women aged 15-49 reported in the Notification of Injury Information System between 2009-2014. Outcome measures - The data were evaluated through exploratory analysis of spatial data. Results - Rates of reporting of sexual violence indicated positive overall spatial autocorrelation (Global Moran I Index = 0.7105, $p \leq 0.001$). In the univariate analysis, all the demographic and socioeconomic indicators analyzed presented positive spatial autocorrelation ($p<0.001$), but, after the adjustments in spatial logistic regression, the associated indicators were: judicial separations and moral/psychological violence rate. Five large groups of the high-high type were identified, predominantly in the South region and only one in the Northern region of the state of Paraná. Conclusions - All the indicators analyzed can influence intimate partner sexual violence, but, after spatial regression, only the indicators 'judicial separation' and 'moral/psychological violence rate' were significant. Municipalities with high rates and concentrations of intimate partner sexual violence groups prevailed in the southern region of the state. Greater attention should be directed to the southern region of the state where municipalities with high rates of IPSV predominate and are involved in high-clusters, as well as separated women with suspicion or evidence of moral/psychological violence.

What is already known on this subject

- National and international studies have shown individual and social factors associated with intimate partner sexual violence.
- As far as we know, a study that presented the spatial distribution of intimate partner sexual violence against women and identified the municipal socioeconomic and demographic indicators involved has not been developed.

What this study adds

- The spatial analysis of the data allows geographically knowing the distribution of intimate partner sexual violence against women in the state of Paraná, identifying the vulnerable mesoregions and the municipal indicators that influence the phenomenon.
- The logistic regression model evidenced the association between the municipal indicators, judicial separations and the rate of moral/psychological violence on intimate partner sexual violence, which are still little explored in the scientific literature.
- Knowing the panorama of intimate partner sexual violence in the mesoregions and the municipal indicators associated with this type of aggravation becomes the first step in order to plan or even strengthen strategies of control and prevention.

Introduction

Sexual violence and intimate partner violence are common forms of violence practiced all over the world. It is a violation of human rights that damages the physical, sexual, reproductive, emotional, mental and social health of the victim and his/her family.[1]

According to data from the "Map of Violence 2015", regarding the murder of women in Brazil, there was a tendency for the country to increase the homicide rate from 2006 to 2013 (4.2 - 4.8/100,000 women). In the state of Paraná, this trend also occurred, but it presented a rate above the national level in both periods (4.7 and 5.2/100,000 women). In the year 2013, Paraná was one of the three states in the country that had the highest rates of homicides among white women, with rates higher than 5/100,000 white women,[2] which results from the colonization of the state, predominantly formed by European descendants.[3]

In Brazil, intimate partner violence has been associated with increased use of health services by women.[4] Several national and international studies have shown social and individual risk factors associated with intimate partner violence against women, including schooling,[5-7] race,[7] age and socioeconomic status.[8]

The notification of violence against women is still a recent process in the country, and is carried out at health units. However, the woman is responsible for deciding whether to report to the accountability bodies, to submit to medical-expert examinations, or even to carry out abortion of concepts resulting from sexual violence.[9] Scholars in the country have aroused interest specifically in the problem of sexual violence experienced by women and developed descriptive studies specifically on the subject.[10-11] As far as we known, a study that specifically analyzed the spatial distribution of the reporting rates of intimate partner sexual violence (IPSV) against women and the associated municipal socio-economic demographic indicators has not been carried out yet at the national and international levels.

Knowing the spatial distribution of IPSV against women and the socioeconomic and demographic indicators involved in this type of aggravation is the first step to identify geographically vulnerable areas and priorities in the establishment of public

policy investment, and to construct protocols and instruments that aim at the prevention, identification and containment of this type of violence.

The objective of this study was to map and analyze spatially the rates of IPSV notification against women aged 15-49 years in the state of Paraná, Brazil, during the period from 2009 to 2014 and to identify the associated socioeconomic and demographic indicators.

Methods

Study design and location

This is an ecological, retrospective study, based on secondary data on IPSV notification rates, using geospatial analysis techniques.

Paraná is located in the South of Brazil, it is bordered by Paraguay and the states of São Paulo, Mato Grosso do Sul and Santa Catarina. It consists of 399 cities administratively grouped into 22 regional health care responsible for health care management (Figure 1).

It covers an area of 199,880 km^2 with a population density of 56.25 inhab./km^2. It represents the fifth state in the ranking of Human Development Index (HDI=0.749) and the fourth in the state economy of the country.[3]

Data source

Data on IPSV notifications by place of residence were obtained through the Notification of Injury Information System (SINAN)[12] of the Ministry of Health, the number of population adjusted by age group of municipalities through the Brazilian Institute of Geography and Statistics (IBGE),[13] and the demographic and socioeconomic indicators were obtained through IBGE[13] and Parana Institute of Economic and Social Development (IPARDES).[2] The number of notifications of IPSV (spouse, ex-spouse, boyfriend, and ex-boyfriend) per residence against women aged 15-49 years in the 399 municipalities of the state were obtained, among the years available at SINAN (2009-2014). According to data from the World Health Organization, young women are at greater risk of intimate partner violence and sexual violence.[1]

In order to minimize the variation in IPSV notification rates by city and the possible random fluctuations derived from the analysis of small populations, the empirical Bayesian Estimator was used.[14] This estimator calculates a weighted notification rate, taking into account regional variances and, therefore, allows the comparison between different populations. Thus, specific IPSV notification rates per 100,000 inhabitants were obtained for each of the 399 municipalities in the state of Paraná.

Initially, 13 municipal socioeconomic and demographic indicators based on the last demographic census (2010) were formulated from the data bases indicated: percentage of civil registry of judicial separations, percentage of women aged ≥10 years separated/divorced and population density (inhab/km²) were obtained from IPARDES,[3] the percentage of non-economically active women ≥10 years, percentage of women ≥10 years old, *pardas* and black, percentage of women without spouses with children, percentage of men ≥10 years without income, percentage of women ≥10 years without income, women aged 15-49 years who are not taxpayers in domestic service, proportion of the population with a complete and incomplete elementary school level, and proportion of women with a complete and incomplete elementary level were obtained from IBGE;[13] and the number of reports of intimate partner physical violence among women aged between 15 and 49 years old and the number of reports of intimate partner moral/psychological violence among women aged 15-49 years were obtained in SINAN.[12]

Spatial Data Exploratory Analysis

Spatial analysis was used to specify geographically the distribution of IPSV notification rates through map visualization. The cartographic base of the state of Paraná, entitled Political-Administrative Division, was made available free on the Internet in shapefile (SHP) and online through the Institute of Lands Cartography and Geoscience (ITCG).[15]

In order to determine measures of global and local spatial autocorrelation, the exploratory data analysis (ESDA) by area (polygons) was performed.[16]

Using the Global Moran (I) index, the spatial autocorrelation was calculated by

evaluating the IPSV notification rate for each municipality. This index identifies whether the geographical areas of a map tend to be grouped (positive and negative spatial dependence) or scattered (spatial independence).[17] In order to plot spatial autocorrelation, the local indicators of spatial association (LISA) was applied. Choropleth maps showed significant spatial clusters, with high or low association values determining regions that may contribute to spatial autocorrelation.[17] The global and local spatial autocorrelation coefficients were considered significant when $p<0.05$.

Spatial clusters were categorized according to the pattern and characteristics of adjacent districts. High/high (HH) clusters are a set of districts that had high IPSV reporting rates surrounded by other districts with high IPSV reporting rates in the univariate analysis. On the other hand, clusters identified as low/low (L/L) are groups of districts with low rates surrounded by low-income districts. When the opposite occurs, that is, clustering of districts with low IPSV reporting rates are surrounded by high rate districts, LISA maps categorize them as low/high (L/H) or when the inverse occurs, as high/low (H/L).

The geospatial data were analyzed by areas (polygons) to evaluate the spatial distribution of IPSV notifications and areas with higher density of events using choropleth maps. The exploratory spatial data analysis (ESDA) was applied through QGIS software version 2.14 and GeoDaTM version 0.9.5-i.[16]

Spatial regression

In order to identify the geospatial impact of socioeconomic indicators in agglomeration areas of IPSV reporting rates, multivariate spatial regression analysis was applied.[18] All indicators that presented p-value ≤ 0.20 in the spatial autocorrelation result (Global de Moran I Index) were considered for entry into the spatial regression model. Using an autoregressive spatial error model (SAR), the failure rate regressed, controlling socioeconomic factors (Percentage of civil registry of legal separations; Percentage of women ≥10 years without income; Percentage of women with more than 10 years with complete elementary education and incomplete high school; Physical intimate partner reporting rate among 15- to 49-year-old women; Reporting of intimate partner moral/psychological violence among 15- to 49-year-old women). SAR modeling is a strong approach to understand spatial data when error terms are autocorrelated.

Statistical analysis was performed using the R language for statistical computation.[18]

The study did not need ethical approval and consent by each individual since the data used were secondary, available on government databases of online data.

Results

In the IPSV notifications, most of the victims were white women (67.8%), aged between 30 and 39 years (34.3%), incomplete elementary school (37.6%), the main aggressor was the spouse (52.0%), with suspected alcohol use (52.1%), occurred at home (83.5%), were cases of repetitive violence (69.4%), and women were referred to the outpatient clinic (51.2%) and the outcome was discharge (80.6%).

Figure 2 shows the spatial distribution of the weighted rate of IPSV notification classified according to intensity grades. Of the 399 cities in the state of Paraná, rates above 2.82-75.3 were identified in 20.1% of the municipalities, distributed mainly in the Metropolitan, West, South Center, North Center and Southeastern mesoregions.

The IPSV notification rates indicated positive spatial autocorrelation (Moran Global I Index = 0.710519), showing that IPSV notification rates in municipalities influenced this same rate in neighboring municipalities.

Figure 3 shows the spatial autocorrelation, by means of the formation of the types of clusters presented in the state of Paraná according to the IPSV rates. Five high-clusters were identified, four of which were located in the southern region of the state, involving the Metropolitan, West, Southeast, South Center and Southwest mesoregions. Only one was identified in the North region and covered the mesoregions North Center and Pioneer North. The high-clusters involved 17.3% of the state's municipalities, the largest of which was found in the Metropolitan mesoregion, encompassing municipalities located predominantly in RSs: 2nd (20 municipalities) and 1st (2 municipalities). The second largest cluster of the high-high type consisted of municipalities located in the western mesoregion, encompassing RSs: 20th (12 municipalities) and 9th (6 municipalities). The third and fourth high-clusters consisted of 10 cities each: one located in the South-eastern mesoregion and part of the South Center macro-region, including municipalities belonging to the RSs: 6th (5 municipalities) and

4th (5 municipalities). The other identified in the Southwest and South Center mesoregions involved cities belonging to RSs: 7th (7 municipalities) and 5th (3 municipalities). The fifth cluster of the high-high type involved nine municipalities located in the mesoregions North Center and Pioneer North that included RSs: 17th (7 municipalities), 16th (1 municipality) and 18th (1 municipality).

Results of the correlation analysis between the dependent variable and the geoespatial socioeconomic indicators evaluated by the bivariate Global Moran I Index, showed that all indicators presented positive autocorrelation and were significantly associated with the IPSV notification rate ($p<0.001$).

After spatial regression modeling, the SAR model indicated the occurrence of highly significant and positive spatial autocorrelation (Rho=0.8194). The mean effect of the dependent variable (VAB) relative to the spatial neighborhood in the region in question was 81.94%, which reveals the presence of high spatial dependence in the analyzed data set.[19]

The result of the model shows that the variations in the VAB between municipalities are explained in approximately 77% by means of the proposed model, exerting a positive influence on all the geospatial socioeconomic indicators analyzed, confirming that they impact positively on the spatial distribution of IPSV notifications. However, only the indicators 'Percentage of civil registry of legal separations' and 'Reporting rate of intimate partner moral/psychological violence among women aged 15 to 49' were statistically significant (Table 1).

Table 1 - Multivariate spatial regression model. Parana, Brazil, 2009-2014.

Variables	Coefficient	Standard-Error	Z-value	Probability
Percentage of civil registry of judicial separation	0.005	0.002	2.559	0.010
Percentage of women ≥10 years without income	0.004	0.014	0.318	0.75
Percentage of women >10 years old with complete elementary education and incomplete high school	0.052	0.034	1.542	0.123

Reporting rate of intimate partner physical violence among women aged 15-49	9.28	0.0006	0.148	0.882
Reporting rate of intimate partner moral/psychological violence among women aged 15-49	0.010	0.016	6.22	<0.001

Discussion

As in this study, a previous geospatial study evidenced the vulnerability to situations of violence in the southern region of Paraná, which presented a higher concentration of homicides (high-high cluster).[20] In 2013, a report of the cities with the highest rates of municipal socioeconomic development was published, based on indicators: employment and income, education and health. The five cities with the highest index in the state of Paraná were Maringá, Apucarana, Cianorte, Campo Mourão and Paranavaí, located mainly in the northern region of the state, involved in this study in lower concentrations of IPSV notifications (low-low clusters).[21]

Socioeconomic factors, such as lower level of schooling[6-8, 22-23] and income[8, 23-24] have been associated with intimate partner violence. Likewise, in this study, the indicators 'percentage of women without income' and 'with complete elementary education and incomplete high school' presented positive spatial autocorrelation with the rates of IPSV notifications against women. Financial dependence has been pointed out by Brazilian women victims of violence as a reason for non-denunciation of the partner.[25] International studies corroborate this result, showing that the low financial autonomy of women presented as a risk factor for physical and sexual violence[26] and financial independence as a protection factor for intimate partner violence.[27] A Brazilian study on intimate partner violence conducted in different contexts of the country, one in an advanced urban center, located in the Southeast (São Paulo municipality), and the other in a poorly developed rural pole located in the Northeast (15 municipalities belonging to Zona da Mata of the state of Pernambuco) showed that the financial autonomy factor remained significant only in the regression model referring to the Zona da Mata area of Pernambuco.[6] In 2000, the United Nations (UN) integrated amidst the objectives for the development of the millennium, the promotion

of the equality between the genders and the autonomy of the woman. Recently, UN has published a report showing progress in this area.[28]

Women who suffered intimate partner psychological/moral violence were more likely to develop symptoms of posttraumatic stress.[29] In Brazil, sexual violence against women has been associated with psychological disorders.[30-31] Overlapping of various types of intimate partners violence (physical, sexual and psychological) against women has also been described, with psychological/moral violence being followed in 90% of cases by physical and sexual violence.[32] Among forms of psychological violence, noncompliance with a judicial order has been presented in the country as a new form of moral violence against women. This results from a patriarchal culture that leads men to believe that they have rights, including to break the law that protects women.[33]

A national study has also demonstrated the association between sexual violence and separated/divorced women.[10] The partner often feels separation as the loss of control of the relationship and partner, plus fear of losing the relationship with his/her child.[34] Violence and threats to the lives of women and children become more intense in the period of separation,[35] where custody often takes place, endangering the safety of mother and child.[34] Problems related to the division of assets have also stood out as the trigger for intimate partner violence.[36] This phase translates to a very critical moment where violence can reach the extreme where many women are murdered.[37]

This is the first study in the scientific literature to analyze the spatial distribution of IPSV reporting rates and associated municipal indicators. Geospatial studies are essential for understanding social problems. This study allowed identifying the vulnerable mesoregions in the maps, as well as the influence of the municipal indicators involved.

IPSV rates were calculated based on secondary data recorded in SINAN. The reporting of violence against women is still a recent process in this country and underreporting is still a present problem, either because of lack of training and/or misunderstanding of its importance by health professionals[38] or even by omission. However, knowing the panorama of the IPSV in the mesoregions and the municipal indicators involved in this type of injury becomes the first step in order to plan or even strengthen strategies of control and prevention.

Conclusion

The conclusion is that the IPSV could be influenced by all the municipal indicators analyzed, but, after exploring the predictors of spatial regression, only the indicators 'judicial separation' and 'moral/psychological violence' indicators were statistically significant. Greater attention should be directed to the southern region of the state where municipalities with high rates of IPSV predominate and are involved in high-clusters, as well as separated women with suspicion or evidence of moral/psychological violence.

a) Author Contributions:

Kátia Biagio Fontes; Ana Carolina Jacinto Alarcão; Luciano Andrade; Maria Dalva de Barros Carvalho were involved in conceptualization; Kátia Biagio Fontes; Luciano Andrade were involved in formal analysis; Kátia Biagio Fontes; Ana Carolina Jacinto Alarcão; Oscar kenji Nihei; Sandra Marisa Pelloso; Maria Dalva de Barros Carvalho were involved in Investigation; Kátia Biagio Fontes; Luciano Andrade; Maria Dalva de Barros Carvalho were involved in Methodology; Kátia Biagio Fontes; Maria Dalva de Barros Carvalho were involved in Project administration; Kátia Biagio Fontes; Ana Carolina Jacinto Alarcão; Oscar kenji Nihei; Sandra Marisa Pelloso; Luciano Andrade; Maria Dalva de Barros Carvalho were involved in Resources; Luciano Andrade was involved in statistical analysis; Maria Dalva de Barros Carvalho was involved Supervision; Kátia Biagio Fontes; Ana Carolina Jacinto Alarcão; Oscar kenji Nihei; Sandra Marisa Pelloso; Luciano Andrade; Maria Dalva de Barros Carvalho were involved in Writing (original draft, review & editing);

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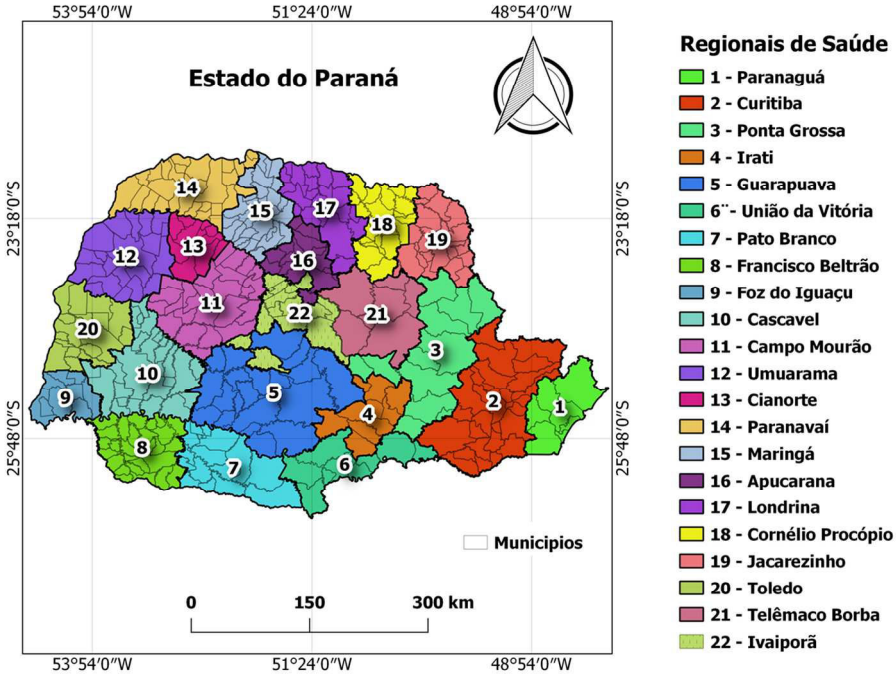

Figure 1 - Regional Health Units of the state of Paraná. Source: Department of Health of the state of Paraná (BR), 2012.

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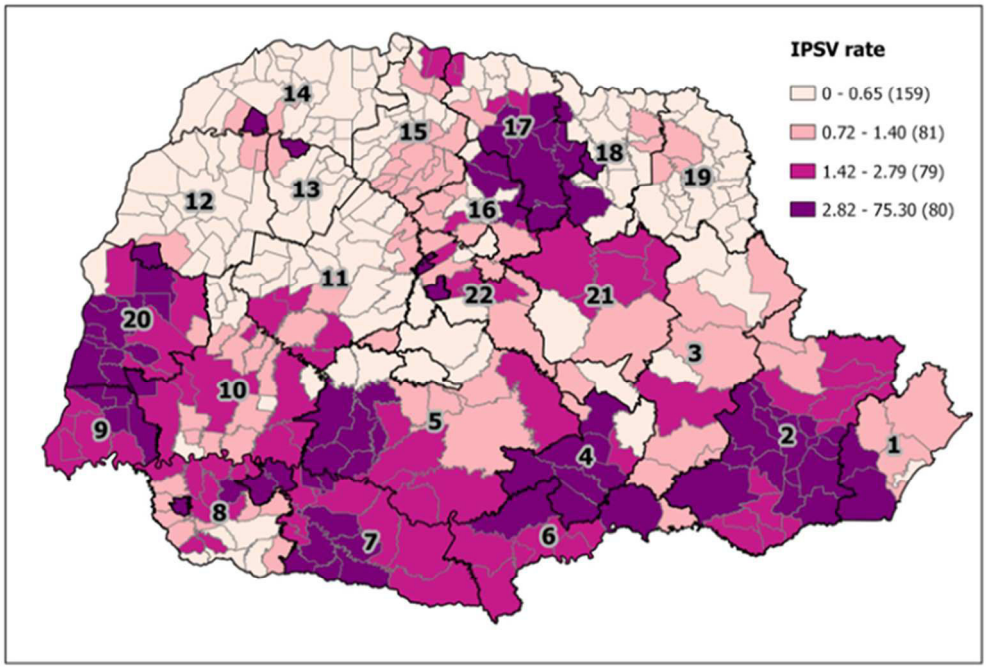

Figure 2 - Spatial distribution of IPSV weighted notification rate. Paraná, Brazil, 2009-2014.

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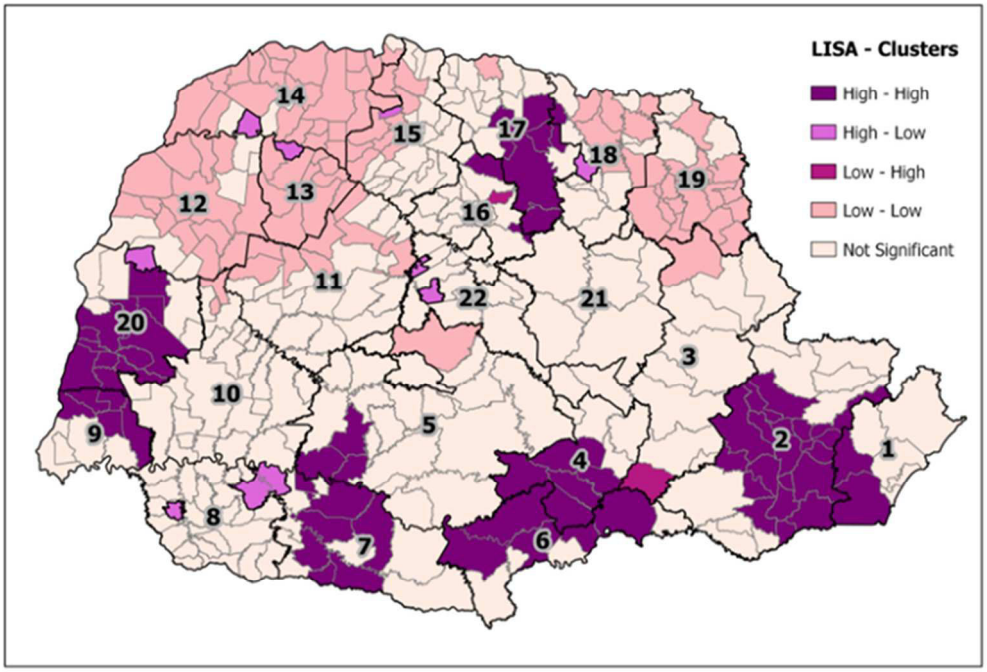

Figure 3 - LISA univariate analysis: formation of clusters types according to the IPSV notification rate. Paraná, Brazil, 2009-2014.

131x90mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6
Participants	6	*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5,6
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-8
		(*b*) Describe any methods used to examine subgroups and interactions	6-8
		(*c*) Explain how missing data were addressed	not applicable
		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	6-8
		(*e*) Describe any sensitivity analyses	7

Continued on next page

Results			**page**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	not applicable
		(c) Consider use of a flow diagram	not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*		
		Cross-sectional study—Report numbers of outcome events or summary measures	*8-9*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-9
		(*b*) Report category boundaries when continuous variables were categorized	8-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8-9
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Regional disparities in the intimate partner sexual violence rate against women in Parana State, Brazil, 2009-2014: An ecological study.

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Regional disparities in the intimate partner sexual violence rate against women in Parana State, Brazil, 2009-2014: An ecological study.

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Descriptors: spatial analysis; epidemiology; sexual violence; violence against women; intimate partner violence.

Objective - The aim of this study was to evaluate disparities in a Brazilian state by conducting an analysis to determine whether socioeconomic status is associated with the reported rates of intimate partner sexual violence against women as measured. Design - A retrospective, ecological study. Settings - Data retrieved from the Database of the Notifiable Diseases Information System of the Ministry of Health of Brazil. Participants - All cases of intimate partner sexual violence (n = 516) against women aged 15-49 years old reported in the Notifiable Diseases Information System between 2009 and 2014. Outcome measures - The data were evaluated through an exploratory analysis of spatial data. Results - We identified a positive spatial self-correlation regarding the Intimate Partner Sexual Violence (IPSV) rate (0.7105, $p<0.0001$). Five high-high type clusters were identified, predominantly in the Metropolitan, West, South Central, Southwest, Southeast, and North Central mesoregions and only one in the North Pioneer mesoregion of the state of Parana. Our findings also indicate associations between the IPSV rate and socioeconomic predictors (women with higher education, civil registry of legal separations, economically active women, demographic density and average female income) were significantly spatially non-stationary, indicating that in certain regions of the state, regression coefficients verify that certain variables in the model are associated with the VPSI rate. In addition, compared to the OLS model, the GWR model improved the understanding of the associations between socioeconomic indicators and the IPSV notification rate, showing a better adjustment (OLS vs. GWR model: R^2: 0.95 vs 0.99; AICc: 4117.90 vs 3550.61; Moran's I: 0.0905 vs -0.0273). Conclusions: IPSV against women was heterogeneous in every state. The GWR model showed a better fit, enabling an analysis of the distribution of each indicator in the state.

Strengths and limitations of this study

- The ecological design of the study allowed for the identification of the Parana State's geographical areas and clusters with higher notification rates of intimate partner sexual violence against women.
- At a population level, the study design also enabled the identification of the social and economic factors associated with higher notification rates of intimate partner sexual violence against women.
- As a limitation, the study findings are based on data from sexual violence notifications, which may reflect only part of the cases of intimate partner sexual violence in Parana State, since it is frequently under-notified.
- We cannot infer causality in this study; we can only determine associations of the significant variables.

Introduction

Intimate partner violence is the most common type of violence against women and is perpetrated by a partner or former partner. Sexual violence and intimate partner violence are major public health problems that occur throughout the world, and they can damage the physical, sexual, reproductive, emotional, mental and social health of the victim and his/her family. [1]

According to global estimates by the World Health Organization (WHO), one in three women have already suffered sexual violence,[1] the majority of which occurs in the domestic environment, corresponding to 12 million people annually.[2] In Brazil, sexual violence against women has been positively associated with low family income, experience of sexual violence in childhood,[3] development of post-traumatic stress symptoms[4] and contracting sexually transmitted diseases.[5]

Although frequent, estimating the magnitude and consequences of sexual violence becomes a challenge because many women are silenced by shame, discrimination, and fear of partner reprisals.[5] A 2005 study conducted by WHO in 10 countries showed that the rate of Intimate Partner Sexual Violence (IPSV) amongst women aged 15-49 ranged from 6.2% in Japan to 58.6% in Ethiopia.[1]

Recent studies performed in Brazil on public health services have shown a IPSV rate of 20.3% in women aged 15-49 in the southeast of the country[6] and 5.7% in women aged 20 to 59 in the state of Espirito Santo. [4] Another study conducted in the city of São Paulo and 15 municipalities in the state of Pernambuco showed rates of 10.1% and 14.3%, respectively. [7]

The notification of violence against women remains a new process in Brazil and is conducted at health units. However, the woman is responsible for the decision to report it, to submit herself to medical examinations and even to perform abortion of concepts resulting from sexual violence.[8]

Data from the Ministry of Health of Brazil on notification rates of IPSV involving women show that between 2009 and 2014, the southern region presented the

second highest rate of this type of violence. Amongst the states in the southern region, Parana ranked first in this category (17.6/100,000 women) with a figure higher than the national rate (10.4/100,000 women). [9]

Geospatial studies conducted in Brazil have identified areas that are vulnerable to domestic violence against women in municipalities in the states of Paraiba[10] and Rondonia, [11] where networks of social and economic relations may favour or curb its occurrence.[11] Studies about IPSV against women are scarce in the scientific literature, and to our knowledge, until now, a study has not been developed that analysed the spatial distribution of IPSV against women and associated geospatial indicators.

Determining the spatial distribution of IPSV against women and the socioeconomic indicators involved in this type of violence is the first step to identify geographically vulnerable areas and priorities in the establishment of public policy investment and to construct instruments aiming to prevent, identify and contain this type of violence.

This study evaluates regional disparities in Paraná state and performs analyses to determine whether socioeconomic status is associated with the rates of Sexual Violence by Intimate Partner notification against women aged 15-49 years in the state of Paraná, Brazil during the period from 2009 to 2014.

Methods

Study design and location

This was an ecological, retrospective study, based on secondary data on IPSV notification rates, using geospatial analysis techniques.

Parana state is located in southern Brazil (latitude coordinates 22°30′58″ and 26°43′00″ and longitude coordinates 48°05′37″ and 54°37′08″), covering an area of 199,880 km^2; it is bordered by Paraguay and Argentina countries and the states of São Paulo, Mato Grosso do Sul and Santa Catarina. Parana contains ten geographic mesoregions, subdivided into 399 municipalities (Figure 1).

According to the 2010 Brazilian Census, Parana state includes 10 444 526 inhabitants who live predominantly in urban areas (85.3%).[12] The state of Parana is ranked fifth in the ranking of the Human Development Index (HDI=0.749) and fifth according to economy Brazil.[13] Figure 1 shows the distribution of the HDI in the state of Paraná[14] and its administrative regions. As shown, the state is unevenly economically developed. The northern and western areas of the state are more developed (with more cities with higher HDIs), as is the metropolitan area of the state capital (Curitiba). The centre and southern areas are less developed compared to the rest of the state. This disparity is important to understand the distribution of health outcomes such as IPSV.

Data source

For this study, data on the number of notifications of intimate partner sexual violence (IPSV) (both sex partners: spouse, ex-spouse, boyfriend, ex-boyfriend, girlfriend, ex-girlfriend) for both genders, against women aged 15-49 years old, per residence, in the 399 municipalities of the state, from 2009 to 2014, were obtained from the Notifiable Diseases Information System (SINAN)[9] of the Ministry of Health. Since 2003, notification of violence against women has been compulsory in health services in Brazil.[15]

The population of each municipality, according to age group, was obtained from the Brazilian Institute of Geography and Statistics (IBGE).[12] Five municipal socioeconomic and demographic indicators based on the last demographic census (2010) were formulated: 'population density (inhabit/km²)' was obtained from the Parana Institute of Economic and Social Development (IPARDES),[9] whereas data on the 'civil registry of judicial separations (%)', 'women with higher education (%)', 'economically active women (%)', and 'female average income' were obtained from the IBGE.[12]

Spatial Analysis

Spatial autocorrelation

We used the exploratory analysis of spatial data (ESDA) for the determination of the spatial self-correlation measures of IPSV rates. Firstly, to minimize the variation in IPSV notification rates by city and the possible random fluctuations derived from the analysis of small populations, the empirical Bayesian Estimator was used in the Queen weights matrix in GeoDa, which considers all neighbourhoods that have a common frontier. [16-17]

This estimator calculates a weighted notification rate, taking into account regional variances and therefore allowing a comparison between different populations. In the state of Paraná, 364 (91.2%) municipalities have less than 20 thousand inhabitants; thus, most cities are small, and the distribution of phenomenon is heterogeneous. Furthermore, the underreporting of IPSV is an important problem, particularly in small cities.[18]

Using the Global Moran's I statistic, the spatial self-correlation was calculated considering the IPSV notification rate per 100,000 women for each municipality. Moran's I varies between -1 and +1. Values greater or less than the expected Moran's I value [E (I) = -1 / (n - 1)] indicate a positive or negative self-correlation, respectively. Positive spatial self-correlation indicates that neighbouring areas present values similar to those of the analysed area, and negative spatial self-correlation indicates that neighbouring areas present values different from those of the analysed area. A Moran's I value of 0 (zero) represents the hypothesis of spatial independence.[19]

The Global Moran's I can hide local patterns of spatial association since a negative value of Global Moran's I does not necessarily indicate the absence of a spatial correlation on a local level. To avoid this limitation, local indicators of spatial association (LISA) were applied to identify significant cluster formation, visualized in choropleth maps. Spatial clusters were categorized according to the pattern and characteristics of adjacent districts. High-high (HH) clusters are a set of districts that had high rates surrounded by other districts with high reporting rates. Low-low (L/L)

are groups of districts with low rates surrounded by low rate districts. The global and local spatial autocorrelation coefficients were considered significant when $p<0.05$.

Spatial regression

Although Global and Local Moran's I are well-known statistical techniques, they are univariate and do not take into account the multivariate effect. Thus, we chose to use regression models with and without control for spatial dependence.

Therefore, the Ordinary Least Square regression (OLS) and Geographically Weighted Regression (GWR) regression models were used to explore the relationship between IPSV notification rates and independent variables.

Ordinary Least Squares (OLS)

In the OLS regression, we included all predictors within our secondary database that have been previously shown to be associated with IPSV. Thus, to improve multicollinearity and to improve the model's performance, we iteratively conducted a sensitivity analysis and chose the model with the best Akaike information criterion/Bayesian Information Criterion (AIC/BIC) values and less multicollinearity. The variables entered in the model were: 'women with higher education (%)', civil registry of legal separations (%)', 'economically active-busy women (%)', 'population density (inhabitants/km ²)', and 'women's average income'.

In sequence, residuals from the global OLS model were analysed for spatial self-correlation using Moran's I to evaluate the extent of the outcome that, after modelling for predictors, could be explained by the spatial component. Comparing the models OLS and Spatial Lag, the increase was not very large. Thus, we chose to keep the classical regression.

Geographically Weighted Regression (GWR)

Additionally, since the dependent variable presented strong (univariate) positive spatial self-correlation, we chose to use GWR to identify possible local associations and demonstrate the effect of the multivariate model regarding space. Thus, the coefficients

of each predictor that were significant in the overall model were plotted to determine the impact of space on the outcome.

Compared to the OLS model, which presents constant regression coefficients in relation to the geographic space (stationarity), in the GWR model, the coefficients are estimated locally from the analysis of the spatial variability of the results in each area, making it possible to verify the presence of spatial non-stationarity, in other words, whether the relationships between regression variables vary in relation to geographic space.[20] Consequently, the GWR model generates a set of local linear regression models rather than a global model, with estimates for each sample in space.[21] The performance of the GWR model was evaluated based on the adjusted R^2 indicators, Akaike's information criterion parameters (AICc) and Moran's I of the residues of both models.

The spatial self-correlation and the OLS model were processed using GeoDa software version 1.10.0.8 (Spatial Analysis Laboratory, University of Illinois at Urbana-Champaign, Urbana, USA), [17] whereas the GWR model was implemented by GWR 4.0.[22] Choropleth maps were generated using the software QGIS 2.14.[23]

Ethical notes

This study did not require ethical approval and consent from each individual since the data used were secondary and available on government databases of online data; moreover, this study followed the national guidelines for research with humans.[24]

Results

A total of 516 IPSV reports against women aged 15-49 were recorded in the period 2009-2014. Mean annual rates of 2.93/100.000 women with IPSV against women occurred in the period, with municipal rates ranging from 0 to 23.3/100,000 women. According to the race/colour/ethnicity of the victims, the predominantly affected women were white (67.8%) and brown (20.0%). The predominant age groups were 30- to 39-year-olds (34.3%) and 20- to 29-year-olds (28.5%).

According to education, incomplete primary education (37.6%), complete secondary school (16.3%) and incomplete secondary school (12.2%) predominated. Only 6.4% of subjects reported having a higher education. The main aggressor was the spouse (56.4%), followed by a former spouse (22.7%), former boyfriend (10.7%) and boyfriend/girlfriend (10.3%). The likely aggressor suspected alcohol use in 52.1% of the cases. According to location, the violence occurred predominantly in the home (83.5%) or in a public pathway (8.1%). The majority of cases were referred to as repetitive violence (69.4%). The women assessed were predominantly referred to the outpatient clinic (51.2%) or hospital admission (7.9%). Occurrences evolved to evasion/escape or death in 1% and 0.6% of cases, respectively. It was not possible to identify the gender of the aggressor due to the nonexistence of this variable in the database.

Figure 2A shows the spatial distribution of the weighted rate of IPSV notification classified according to intensity grades. Of the 399 cities in the state of Paraná, rates above 1,79-6,55 were identified in 33,3% of the municipalities and were mainly distributed in the Metropolitan, West, South Central, Southwest, Southeast, North Central and North Pioneer mesoregions.

The IPSV notification rates presented positive spatial autocorrelation (Global Moran's I=0.710519, $p<0.0001$), showing that IPSV notification rates in municipalities influenced this same rate in neighbouring municipalities.

Figure 2B shows the spatial autocorrelation, by means of the formation of the types of clusters presented in the state of Paraná according to the IPSV rates. Five high-high clusters were identified, involving 19.5% of the state's municipalities. Four clusters were located in the southern region of the state, involving the Metropolitan, West, Southeast, South Centre and Southwest mesoregions. Only one cluster was identified in the North mesoregion. The largest high-high cluster encompassed municipalities located predominantly in the Metropolitan mesoregion.

As indicated in Figure 1, a further analysis of the data presented in Figure 2B

shows that although some municipalities involved in high-high cluster formation presented a high HDI (0.73-0.82), the clusters predominantly presented municipalities with a lower HDI. Conversely, particularly in the north mesoregion, municipalities with a high HDI predominately displayed a low-low pattern cluster.

Classical and OLS regression models (GWR) were used to identify the socioeconomic indicators most associated with sites with the highest IPSV reporting rates.

According to these models, the indicators 'civil registry of judicial separations', 'economically active women', 'demographic density' and 'average female income' were significant. The indicator 'women with higher education' was significant only in the GWR model. The correlation with the IPSV notification rate was negative in both models for 'women with higher education' and 'civil registration of judicial separation' and positive for 'economically active women'. However, the indicators 'demographic density' and ‘average female income' presented different results (negative or positive correlation) according to the model used.

Compared to the OLS model results, the GWR model improved the understanding of the associations between socioeconomic indicators and the IPSV reporting rate. The adjusted R^2 coefficient increased from 0.95 to 0.99, the AICc decreased from 4117.90 to 3550.61 and the Moran's I of the residues increased from 0.0905 to -0.0273, showing a better fit in the GWR model (Table 1).

Table 1 - Comparison of the OLS and GWR Multivariate spatial regression models. Parana, Brazil, 2009-2014.

	OLS		GWR
Variables*	Est. (SE)	t(Est/SE)	Est. Mean (Est. SD)
Pred 1	-0,000112 (0,000126)	-0,888274	0,000068 (0,001093)
Pred 2	0,008735	28,1311681	0,002573

	(0,000310)		(0,004972)
Pred 3	-0,014992	-8,564911	-0,000450
	(0,001750)		(0,009987)
Pred 4	-0,096828	-4,832063	-0,001957
	(0,020039)		(0,061672)
Pred 5	-0,000261	-1,163508	0,000066
	(0,000224)		(0,000298)
AIC		4117,90	3550,61
Moran's I		0.0905	-0.0273
Adj. R2		0,95	0,99

*Pred 1: Demographic density (inhabitants/km²); Pred 2: Economically active women (%); Pred 3: Civil registry of judicial separations (%); Pred 4: Women with higher education (%); Pred 5: Women's mean income.

Figure 3 shows the contribution of different indicators in the variation of the IPSV notification rate: 1) the population density rate increased mainly in the western mesoregion (Figure 3A); 2) the rate of 'economically occupied women' increased in the Southeast Metropolitan, Eastern Centre and North Pioneer mesoregions (Figure 3B); 3) the rate of 'women with higher education' decreased in the Western, North West, North Central, South West, South Central and South East mesoregions (Figure 3C); 4) the rate of 'Mean female income' increased in the western, Northern Pioneer, North Central and Eastern Central regions (Figure 3D); and 5) the rate of 'civil registry of legal separations' decreased in the IPSV notification rate (Figure 3E). The residuals of the model presented a random distribution throughout the state (Figure 3F).

Discussion

This is the first study in the scientific literature to analyse the spatial distribution of IPSV reporting rates and associated municipal indicators. The use of spatial analysis successfully identified clusters of IPSV rates against women and demonstrated that the phenomenon was heterogeneous in the state, with high-high clusters distributed mainly in the Metropolitan, West, Centre South, Southwest, Southeast and North central mesoregions. It was possible to identify important socioeconomic indicators associated with the reporting rates of IPSV against women, which could contribute to understanding the phenomenon; these rates will serve as a subsidy for the identification of vulnerable populations and the elaboration and implementation of policies for the prevention and control of this type of grievance.

Demographic density has been shown to increase the likelihood of IPSV reporting rates. The positive association between demographic density and homicide has been previously demonstrated in this country; [25-26] however, other studies did not report this association.[27-29] In our study, mesoregions with high HDI values, such as the Metropolitan, North Central and West, were involved in high-high clusters.

Our findings showed that the proportion of women with higher education and who were judicially separated contributed to the decrease in IPSV. Previous studies have shown that women with higher schooling and income are more likely to leave violent marriages.[30]

The average female income and the proportion of economically active women influenced the increase in the reports of IPSV, contrary to the results of previous studies. Low financial autonomy has been presented as a risk factor for sexual violence by intimate partners. [31-32] Conversely, financial independence is a protective factor for physical and emotional violence.[31] In recent years, there has been a decrease in the wage gap between men and women in the United States that has led to a reduction in violence against women.[33] In 2000, the United Nations (UN) integrated the objectives for the development of the millennium, the promotion of the equality between the genders and the autonomy of women. The UN has published a report showing progress

in this area. [34]

In the twentieth century, after the entry of women into the labour market, the family system in Brazil has experienced a transition process in which male control based on its role as provider is in check, consistent with the occurrence of violence, including sexual violence.[35]

Acceptance of beatings by the wife has been presented as a risk factor for sexual violence.[31] Daughters with parents involved in marital violence are more likely to suffer intimate partner violence,[31, 36-37] as are the offspring of offending abuse,[32] suggesting that violence can spread for generations. This context may prevent women from verbalizing complaints of violence to health professionals.[38]

The reporting of violence against women is a new process in Brazil, and underreporting remains a problem, either because of lack of training and/or misunderstanding of its importance by health professionals[18] or even due to the omission of victims.[38] However, identifying the panorama of IPSV in the regions and the municipal indicators involved in this type of injury becomes the first step to plan or even strengthen strategies of control and prevention.

In 2003, the Brazilian government formulated a National Plan of Policies for Women[39], which amongst other actions had the purpose of implementing a National Policy to Combat Violence against Women, guaranteeing specialized services and a humanized care network. [40]

In 2015, the state of Parana launched a protocol that unifies care for people who have suffered some type of sexual violence outside the home environment.[41] Most health programs and services do not yet have protocols for domestic violence cases and sexual violence against women as an intimate partner.[35]

Since most municipalities in the state do not yet have all the reference services of the network to combat violence against women (specialized police stations, shelter houses), the expansion of human resources and structure becomes essential. Moreover, since violence against women is a paradigm that can propagate for generations, the

clarification and guidance of women and children and adolescents should be a priority.

Conclusions

IPSV against women was heterogeneous in every state and was distributed throughout the Metropolitan, West, Central, Southwest, Southeast and Central North mesoregions. The maps generated by the GWR model analysed the distribution of each indicator in the state, demonstrating the utility of this model in the study of the dynamics of IPSV and in the identification of local determinants in IPSV notification rates. The identification of the areas vulnerable to IPSV and their respective determinants will serve as a subsidy in the elaboration of prevention strategies and in the strengthening of public policies of attention to women in the prevention and control of this aggravation.

a) **Authors' Contributions:**

Kátia Biagio Fontes, Ana Carolina Jacinto Alarcão, Luciano Andrade, and Maria Dalva de Barros Carvalho were involved in conceptualization; Kátia Biagio Fontes and Luciano Andrade were involved in formal analysis; Kátia Biagio Fontes, Ana Carolina Jacinto Alarcão, Oscar kenji Nihei, Sandra Marisa Pelloso, and Maria Dalva de Barros Carvalho were involved in investigation; Kátia Biagio Fontes, Luciano Andrade, and Maria Dalva de Barros Carvalho were involved in methodology; Kátia Biagio Fontes and Maria Dalva de Barros Carvalho were involved in project administration; Kátia Biagio Fontes, Ana Carolina Jacinto Alarcão, Oscar kenji Nihei, Sandra Marisa Pelloso, Luciano Andrade, and Maria Dalva de Barros Carvalho were involved in resources; Luciano Andrade was involved in statistical analysis; Maria Dalva de Barros Carvalho was involved in supervision; and Kátia Biagio Fontes, Ana Carolina Jacinto Alarcã, Oscar kenji Nihei, Sandra Marisa Pelloso, Luciano Andrade, and Maria Dalva de Barros Carvalho were involved in writing (original draft, review and editing).

b) Competing interests - None declared.

c) Funding - There was no support.

d) Data sharing statement - No additional data are available.

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Figure 1 - State of Paraná and municipality Human Development Index levels.[14]

Figure 2 - A) Spatial distribution of weighted IPSV notification rate/100.000 women. Paraná, Brazil, 2009-2014. B) LISA univariate analysis: formation of cluster types according to the IPSV notification rate/100.000 women. Parana, Brazil, 2009-2014.

Figure 3 - Map of waste/significant variables within the GWR model, separating the tracks in quantile. A) Spatial distribution of the demographic density (inhabitants/km²); B) Spatial distribution of the economically active women (%); C) Spatial distribution of

the women with higher education (%); D) Spatial distribution of the average female income; E) Spatial distribution of the civil registry of legal separations (%); F) Spatial distribution of the standardized residuals.

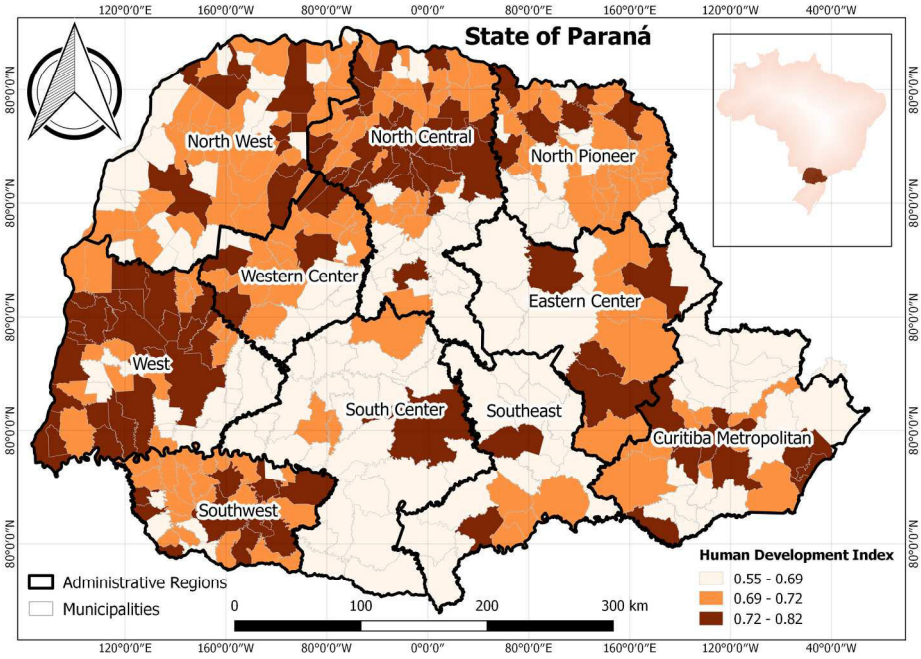

Figure 1 - State of Paraná and municipality Human Development Index levels.

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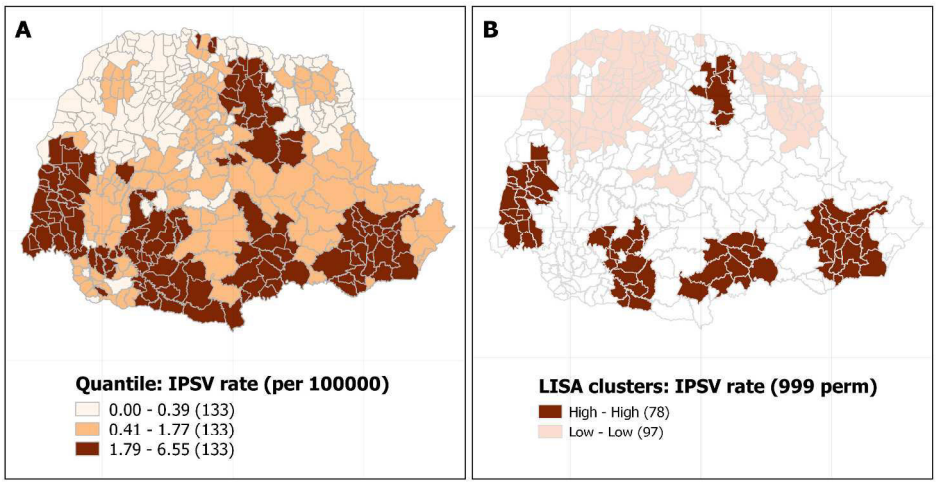

Figure 2 - A) Spatial distribution of weighted IPSV notification rate/100.000 women. Paraná, Brazil, 2009-2014. B) LISA univariate analysis: formation of cluster types according to the IPSV notification rate/100.000 women. Parana, Brazil, 2009-2014.

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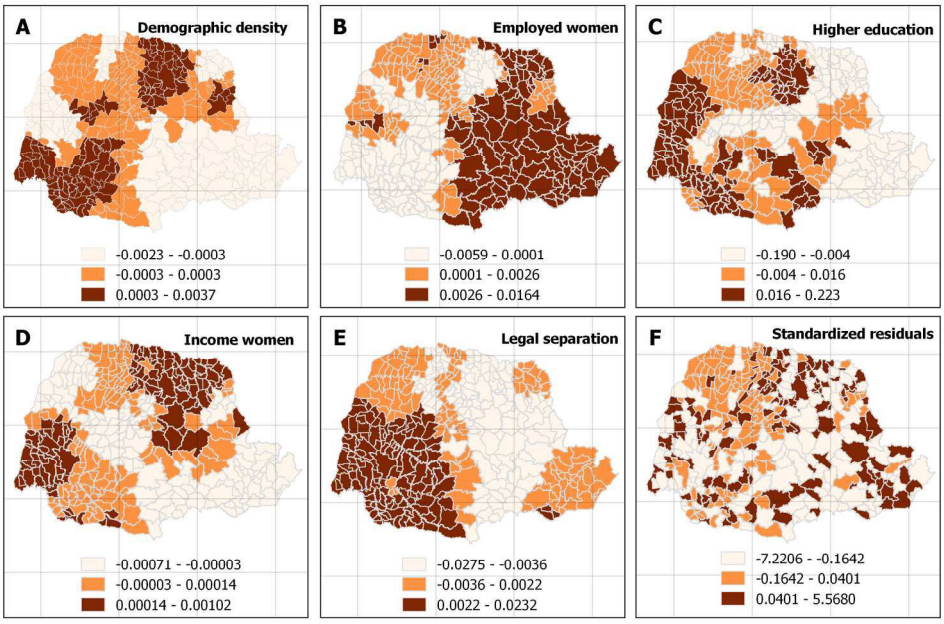

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	not applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	not applicable
Bias	9	Describe any efforts to address potential sources of bias	*not applicable*
Study size	10	Explain how the study size was arrived at	not applicable
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	not applicable
		(b) Give reasons for non-participation at each stage	not applicable
		(c) Consider use of a flow diagram	not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	9-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9-11
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Regional disparities in the intimate partner sexual violence rate against women in Parana State, Brazil, 2009-2014: An ecological study.

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Regional disparities in the intimate partner sexual violence rate against women in Paraná State, Brazil, 2009-2014: An ecological study.

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Descriptors: spatial analysis; epidemiology; sexual violence; violence against women; intimate partner violence.

Objective - Evaluate disparities in a Brazilian state by conducting an analysis to determine whether socioeconomic status was associated with the reported intimate partner sexual violence rates against women. Design - A retrospective, ecological study. Settings - Data retrieved from the Notifiable Diseases Information System database of the Ministry of Health of Brazil. Participants - All cases of intimate partner sexual violence (n = 516) against women aged 15-49 years reported in the Notifiable Diseases Information System between 2009 and 2014. Outcome measures - The data were evaluated through an exploratory analysis of spatial data. Results - We identified a positive spatial self-correlation in the intimate partner sexual violence (IPSV) rate (0.7105, $p \leq 0.001$). Five high-high-type clusters were identified, predominantly in the Metropolitan, West, South Central, Southwest, Southeast, and North Central mesoregions, with only one cluster identified in the North Pioneer mesoregion. Our findings also indicated that the associations between the VPSI rate and socioeconomic predictors (women with higher education, civil registry of legal separations, economically active women, demographic density and average female income) were significantly spatially non-stationary; thus, the regression coefficients verified that certain variables in the model were associated with the IPSV rate in some regions of the state. In addition, the GWR model improved the understanding of the associations between socioeconomic indicators and the IPSV notification rate, showing a better adjustment than the OLS model (OLS vs. GWR model: R^2: 0.95 vs 0.99; AICc: 4117,90 vs 3550,61; Moran's I: 0.0905 vs -0.0273, respectively). Conclusions: IPSV against women was heterogenous in the state of Parana. The GWR model showed a better fit and enabled the analysis of the distribution of each indicator in the state, which demonstrated the utility of this model for the study of IPSV dynamics and the indication of local determinants of IPSV notification rates.

Strengths and limitations of this study

- The ecological design of the study allowed the identification of geographical areas and clusters in Paraná State with higher intimate partner sexual violence against women notification rates.
- At the population level, the study design also enabled identification of the social and economic factors associated with higher intimate partner sexual violence against women notification rates.
- As a limitation, the study findings are based on data from sexual violence notifications, which may reflect only a portion of the cases involving intimate partner sexual violence in Paraná State, since this crime is frequently under-notified.
- We could not infer causality in this study and could only determine associations of the significant variables.

Introduction

Intimate partner violence is the most common type of violence against women and is perpetrated by a partner or former partner. Sexual violence and intimate partner violence are major public health problems that occur worldwide and can damage the physical, sexual, reproductive, emotional, mental and social health of the victim and his/her family.[1]

According to global estimates by the World Health Organization (WHO), one in three women has suffered sexual violence,[1] the majority of which occurs in the domestic environment, corresponding to 12 million people annually.[2] In Brazil, sexual violence against women has been positively associated with a low family income, experience of sexual violence in childhood,[3] development of post-traumatic stress symptoms[4] and contraction of sexually transmitted diseases.[5]

Although frequent, estimating the magnitude and consequences of sexual violence is challenging because many women are silenced by shame, discrimination, and fear of partner reprisals.[5] A 2005 study conducted by the WHO in 10 countries showed that the rate of intimate partner sexual violence (VSPI) amongst women aged 15-49 years ranged from 6.2% in Japan to 58.6% in Ethiopia.[1]

Recent studies performed in public health services in Brazil have reported VSPI rates of 20.3% in women aged 15-49 years in the southeast of the country[6] and 5.7% in women aged 20 to 59 years in the state of Espirito Santo. [4] Another study conducted in the city of São Paulo and 15 municipalities in the state of Pernambuco showed rates of 10.1% and 14.3%, respectively. [7]

Notification of violence against women remains a new process in Brazil and is conducted at health units. However, the woman is responsible for the decision to report the violence, to submit herself to medical examinations and even to perform an abortion if conception results from sexual violence.[8]

Data from the Ministry of Health of Brazil on VSPI notification rates involving women showed that the southern region presented the second highest rate of this type of violence between 2009 and 2014. Among the states in the southern region, Paraná ranked first in this category (17.6/100,000 women) with a figure higher than the national rate (10.4/100,000 women). [9]

Geospatial studies conducted in Brazil have identified areas that are vulnerable to domestic violence against women in municipalities in the states of Paraiba[10] and Rondonia, [11] where networks of social and economic relationships may favour or curb its occurrence.[11] Studies investigating VSPI against women are scarce in the scientific literature, and to the best of our knowledge, no study has analysed the spatial distribution of VSPI against women and the associated geospatial indicators.

Determining the spatial distribution of IPSV against women and the socioeconomic indicators involved in this type of violence is the first step in identifying geographically vulnerable areas and priorities for the establishment of public policy investment and constructing instruments to prevent, identify and contain this type of violence.

This study evaluates regional disparities in Paraná State and performs analyses to determine whether socioeconomic status is associated with the sexual violence by intimate partner notification rates for women aged 15-49 years in the state of Paraná, Brazil, from 2009 to 2014.

Methods

Study design and location

This study was an ecological, retrospective study based on secondary data for the IPSV notification rates that used geospatial analysis techniques.

Paraná State is located in southern Brazil (latitude coordinates 22°30′58″ and 26°43′00″ and longitude coordinates 48°05′37″ and 54°37′08″) and covers an area of 199,880 km^2. This state is bordered by Paraguay and Argentina and the states of São Paulo, Mato Grosso do Sul and Santa Catarina. Paraná contains ten geographic mesoregions subdivided into 399 municipalities (Figure 1).

According to the 2010 Brazilian Census, Paraná State includes 10.444.526 inhabitants who live predominantly in urban areas (85.3%).[12] The state of Paraná is ranked fifth in the Human Development Index (HDI=0.749) and is the fifth state ranked according to the economy in Brazil.[13] Figure 1 shows the distribution of the HDI in the state of Paraná and its administrative regions.[14] Notably, the economic development of the state is uneven. The northern and western areas of the state are more developed (with more cities with higher HDIs), as is the metropolitan area of the state capital (Curitiba). The centre and southern areas are less developed than the rest of the state. This disparity is important for understanding the distribution of health outcomes, such as IPSV.

Data source

For this study, data for the number of notifications of intimate partner sexual violence (IPSV) (sex partners, including a spouse, ex-spouse, boyfriend, ex-boyfriend, girlfriend, and ex-girlfriend) for both genders against women aged 15-49 years old per residence in the 399 municipalities of the state from 2009 to 2014 were obtained from the Notifiable Diseases Information System (SINAN)[9] of the Ministry of Health. Since 2003, notification of violence against women has been compulsory in health services in Brazil.[15]

The population of each municipality according to age group was obtained from

the Brazilian Institute of Geography and Statistics (IBGE).[12] Five municipal socioeconomic and demographic indicators based on the last demographic census (2010) were formulated as follows: 'population density (inhabit/km²)' was obtained from the Paraná Institute of Economic and Social Development (IPARDES),[9] whereas data on the 'civil registry of legal separations (%)', 'women with higher education (%)', 'economically active women (%)', and 'average female income' were obtained from the IBGE.[12]

Spatial Analysis

Spatial autocorrelation

We performed an exploratory analysis of spatial data (ESDA) to determine the spatial self-correlation measures of the IPSV rates. First, to minimize variation in the IPSV notification rates by city and the possible random fluctuations derived from the analysis of small populations, the empirical Bayesian Estimator was used in the queen weights matrix in GeoDa, which considers all neighbourhoods that have a common frontier. [16-17]

This estimator calculates a weighted notification rate by considering regional variances and therefore allowing comparisons between different populations. In the state of Paraná, 364 (91.2%) municipalities have less than 20 thousand inhabitants; thus, most cities are small, and the distribution of the phenomenon is heterogeneous. Furthermore, underreporting of IPSV is an important problem, particularly in small cities.[18]

Using the Global Moran's I statistic, spatial self-correlation was calculated based on the IPSV notification rate per 100.000 women for each municipality. Moran's I varies between -1 and +1. Values greater or less than the expected Moran's I value [E (I) = -1 / (n - 1)] indicate a positive or negative self-correlation, respectively. A positive spatial self-correlation indicates that neighbouring areas present values similar to those of the analysed area, and a negative spatial self-correlation indicates that neighbouring areas present values different from those of the analysed area. A Moran's I value of 0

(zero) represents the hypothesis of spatial independence.[19]

The Global Moran's I can hide local patterns of spatial association, since a negative Global Moran's I values does not necessarily indicate the absence of a spatial correlation on a local level. To avoid this limitation, local indicators of spatial association (LISA) were applied to identify significant cluster formation, which was visualized in choropleth maps. Spatial clusters were categorized according to the patterns and characteristics of the adjacent districts. High-high (HH) clusters are a set of districts with high rates that are surrounded by other districts with high reporting rates. Low-low (L/L) clusters are groups of districts with low rates surrounded by low rate districts. The global and local spatial autocorrelation coefficients were considered significant when $p<0.05$.

Spatial regression

Although Global and Local Moran's I are well-known statistical techniques, they are univariate and do not consider multivariate effects. Thus, we chose to use regression models with and without control for spatial dependence.

Therefore, the ordinary least square regression (OLS) and geographically weighted regression (GWR) models were used to explore the relationships between the IPSV notification rates and independent variables.

Ordinary Least Squares (OLS)

In the OLS regression analysis, we included all predictors within our secondary database that were previously shown to be associated with IPSV. To improve multicollinearity and the model's performance, we iteratively conducted a sensitivity analysis and chose the model with the best Akaike information criterion/Bayesian information criterion (AIC/BIC) values and the lowest multicollinearity. The variables entered in the model were 'women with higher education (%)', civil registry of legal separations (%)', 'economically active-busy women (%)', 'population density (inhabitants/km ²)', and 'average female income'.

In sequence, residuals from the global OLS model were analysed for spatial self-

correlation using Moran's I to evaluate the extent of the outcome that could be explained by the spatial component after modelling for predictors. The increase was not very large when we compared the OLS and spatial lag models. Thus, we chose to keep the classical regression.

Geographically Weighted Regression (GWR)

Additionally, since the dependent variable presented strong (univariate) positive spatial self-correlation, we chose to use GWR to identify possible local associations and to demonstrate the spatial effect of the multivariate model. Thus, the coefficients of each predictor that were significant in the overall model were plotted to determine the impact of space on the outcome.

Compared to the OLS model, which presents constant regression coefficients in relation to the geographic space (stationarity), the coefficients in the GWR model are estimated locally from analysis of the spatial variability of the results in each area, which enables verification of the presence of spatial non-stationarity (i.e., whether the relationships between regression variables vary in relation to the geographic space).[20] Consequently, the GWR model generates a set of local linear regression models rather than a global model with estimates for each sample in space.[21] The performance of the GWR model was evaluated based on the adjusted R^2 indicators, Akaike's information criterion parameters (AICc) and Moran's I of the residues of both models.

The spatial self-correlation and the OLS model were processed using the GeoDa software version 1.10.0.8 (Spatial Analysis Laboratory, University of Illinois at Urbana-Champaign, Urbana, IL, USA), [17] whereas the GWR model was implemented by GWR 4.0.[22] Choropleth maps were generated using the QGIS 2.14 software.[23]

Ethical notes

This study did not require ethical approval and consent from each individual since the data used were secondary and were available from government databases of online data. However, this study followed the national guidelines for research with

human subjects.[24]

Results

A total of 516 VSPI reports against women aged 15-49 years were recorded from 2009 to 2014. A mean annual rate of 2.93/100.000 women with VSPI against women occurred during the period, with municipal rates ranging from 0 to 23.3/100,000 women. According to the race/colour/ethnicity of the victims, the predominantly affected women were white (67.8%) and brown (20.0%). The predominant age groups were 30- to 39-year-olds (34.3%) and 20- to 29-year-olds (28.5%).

Regarding schooling, incomplete primary education (37.6%), complete secondary school (16.3%) and incomplete secondary school (12.2%) predominated. Only 6.4% of the subjects reported having a higher education. The main aggressor was the spouse (56.4%), followed by a former spouse (22.7%), former boyfriend (10.7%) and boyfriend/girlfriend (10.3%). The likely aggressor had suspected alcohol use in 52.1% of the cases. According to location, the violence occurred predominantly in the home (83.5%) or in a public pathway (8.1%). The majority of the cases were referred to as repetitive violence (69.4%). The assessed women were predominantly referred to an outpatient clinic (51.2%) or hospital for admission (7.9%). Occurrences evolved to evasion/escape or death in 1% and 0.6% of cases, respectively. The gender of the aggressor could not be identified due to the nonexistence of this variable in the database.

Figure 2A shows the spatial distribution of the weighted rate of IPSV notifications classified according to the intensity grade. Of the 399 cities in the state of Paraná, rates greater than 1,79-6,55 were identified in 33,3% of the municipalities and were mainly distributed in the Metropolitan, West, South Central, Southwest, Southeast, North Central and North Pioneer mesoregions.

The IPSV notification rates presented positive spatial autocorrelation (Global Moran's I = 0.710519), showing that the IPSV notification rates in municipalities influenced this same rate in the neighbouring municipalities.

Figure 2B shows the spatial autocorrelation using the formation of the types of clusters presented in the state of Paraná according to the IPSV rate. Five high-high clusters were identified, involving 19.5% of the state's municipalities. Four clusters were located in the southern region of the state, involving the Metropolitan, West, Southeast, South Center and Southwest mesoregions. Only one cluster was identified in the North mesoregion. The largest high-high cluster encompassed municipalities located predominantly in the Metropolitan mesoregion.

As indicated in Figure 1, further analysis of the data presented in Figure 2B showed that although some municipalities involved in high-high cluster formation presented high HDIs (0.73-0.82), the clusters predominantly presented municipalities with lower HDIs. Conversely, municipalities with high HDIs predominately displayed a low-low pattern cluster, particularly in the north mesoregion.

Classical and OLS regression models (GWR) were used to identify the socioeconomic indicators most associated with the sites with the highest VSPI reporting rates.

According to these models, the indicators 'civil registry of legal separations', 'economically active women', 'demographic density' and 'average female income' were significant. The indicator 'women with higher education' was significant only in the GWR model. The correlation with the IPSV notification rate was negative in both models for 'women with higher education' and 'civil registration of legal separations' and positive for 'economically active women'. However, the indicators 'demographic density' and ‘average female income' presented different results (negative or positive correlations) according to the model used.

Compared to the OLS model results, the GWR model improved understanding of the associations between socioeconomic indicators and the IPSV reporting rate. The adjusted R^2 coefficient increased from 0.95 to 0.99, the AICc decreased from 4117.90 to 3550.61 and Moran's I of the residues increased from 0.0905 to -0.0273, showing a better fit of the GWR model (Table 1).

Table 1 - Comparison of the OLS and GWR multivariate spatial regression models. Paraná, Brazil, 2009-2014.

	OLS		GWR
Variables*	Est. (SE)	t(Est/SE)	Est. Mean (Est. SD)
Pred 1	-0,000112 (0,000126)	-0,888274	0,000068 (0,001093)
Pred 2	0,008735 (0,000310)	28,1311681	0,002573 (0,004972)
Pred 3	-0,014992 (0,001750)	-8,564911	-0,000450 (0,009987)
Pred 4	-0,096828 (0,020039)	-4,832063	-0,001957 (0,061672)
Pred 5	-0,000261 (0,000224)	-1,163508	0,000066 (0,000298)
AIC	4117,90		3550,61
Moran's I	0.0905		-0.0273
Adj. R2	0,95		0,99

*Pred 1: Demographic density (inhabitants/km²); Pred 2: Economically active women (%); Pred 3: Civil registry of legal separations (%); Pred 4: Women with higher education (%); Pred 5: Average female income.

Figure 3 shows the contribution of different indicators to the variation in the IPSV notification rate. The results were as follows: 1) the population density rate increased mainly in the western mesoregion (Figure 3A); 2) the rate of 'economically active women' increased in the Southeast Metropolitan, Eastern Center and North Pioneer mesoregions (Figure 3B); 3) the rate of 'women with higher education'

decreased in the Western, Northwest, North-central, Southwest, South-central and Southeast mesoregions (Figure 3C); 4) the rate of 'average female income' increased in the Western, Northern Pioneer, Central North and Eastern Central regions (Figure 3D); and 5) the rate of 'civil registry of legal separations' decreased with the VSPI notification rate (Figure 3E). The residuals of the model presented a random distribution throughout the state (Figure 3F).

Discussion

This study is the first to analyse the spatial distribution of the IPSV reporting rates and associated municipal indicators. The use of spatial analysis successfully identified clusters of VSPI rates against women and demonstrated that the phenomenon was heterogeneous in the state, with high-high clusters distributed mainly in the Metropolitan, West, Center South, Southwest, Southeast and North central mesoregions. We identified important socioeconomic indicators associated with the VSPI reporting rates against women, which could contribute to understanding the phenomenon; these rates will serve as a subsidy for the identification of vulnerable populations and the elaboration and implementation of policies for the prevention and control of this type of grievance.

Demographic density has been shown to increase the likelihood of VSPI reporting rates. The positive association between demographic density and homicide has been previously demonstrated in this country; [25-26] however, other studies did not report this association.[27-29] In our study, mesoregions with high HDI values, such as the Metropolitan, North Central and West, were involved in the high-high clusters.

Our findings showed that the proportion of women with a higher education who were judicially separated contributed to the decrease in VSPI. Previous studies have shown that women with higher schooling and incomes are more likely to leave violent marriages.[30]

The average female income and the proportion of economically active women

influenced the increase in the reports of VSPI, which contrasted with the results of previous studies. Low financial autonomy has been presented as a risk factor for sexual violence by intimate partners. [31-32] Conversely, financial independence is a protective factor for physical and emotional violence.[31] Recently, a decrease in the wage gap between men and women in the United States has led to a reduction in violence against women.[33] In 2000, the United Nations (UN) integrated the millennial development objectives for the promotion of equality between the genders and the autonomy of women.[34] The UN has published a report showing progress in this area.

In the twentieth century, after the entry of women into the labour market, the family system in Brazil experienced a transition process in which male control based on the role as provider was held in check consistent with the occurrence of violence, including sexual violence.[35]

Acceptance of beatings by the wife has been presented as a risk factor for sexual violence.[31] Daughters with parents involved in marital violence are more likely to suffer intimate partner violence,[31, 36-37] as are the offspring of offending abuse,[32] suggesting that violence can spread for generations. This context may prevent women from verbalizing complaints of violence to health professionals.[38]

Our regression analysis is based on city indicators and IPSV report rates available on national databases. Reliance on these data could limit the impact of this study. However, we have used the Bayesian estimator to minimize any inconsistencies. The reporting of violence against women is a new process in Brazil, and underreporting remains a problem, either because of a lack of training and/or misunderstanding of its importance by health professionals[18] or because the omission of victims.[38] This fact can account for only some of the cases involving the problem of IPSV in the state of Paraná, resulting in a limitation of this study. However, identifying the panorama of IPSV in the regions and the municipal indicators involved in this type of injury is the first step in planning or even strengthening strategies of control and prevention.

Our study was developed in a Brazilian state with a high HDI, similar to those of developed countries, which allows generalizing the results for similar areas, but mainly

for those areas with economic and social disparities.

The reporting of violence against women is a new process in Brazil, and underreporting remains a problem either due to lack of training and/or misunderstanding of its importance by health professionals[18] or even omission by victims.[38] However, identifying the panorama of IPSV in the regions and the municipal indicators involved in this type of injury are the first steps in planning or even strengthening control and prevention strategies.

In 2003, the Brazilian government formulated a National Plan of Policies for Women[39], which amongst other actions had the purpose of implementing a National Policy to Combat Violence against Women and guaranteeing specialized services and a humanized care network. [40]

In 2015, the state of Paraná launched a protocol that unified care for people who suffered from some type of sexual violence outside the home environment.[41] However, most health programmes and services do not have protocols for domestic violence cases and sexual violence against women by an intimate partner at present.[35]

Since most municipalities in the state do not have all the reference services of the network to combat violence against women (e.g., specialized police stations and shelter houses), expansion of human resources and structures has become essential. Moreover, since violence against women is a paradigm that can propagate for generations, clarification for and guidance of women, children and adolescents should be a priority.

Conclusions

IPSV against women was heterogeneous in every state and was distributed throughout the Metropolitan, West, Central, Southwest, Southeast and Central North mesoregions. The maps generated by the GWR model were used to analyse the distribution of each indicator in the state, demonstrating the utility of this model in the study of IPSV dynamics and the identification of local determinants of the IPSV notification rates. The identification of areas vulnerable to IPSV and their respective

determinants will serve to improve prevention strategies and strengthen public policies aimed to prevent and control IPSV.

a) **Author Contributions:**

Kátia Biagio Fontes, Ana Carolina Jacinto Alarcão, Luciano Andrade, and Maria Dalva de Barros Carvalho were involved in conceptualization; Kátia Biagio Fontes and Luciano Andrade were involved in the formal analysis; Kátia Biagio Fontes, Ana Carolina Jacinto Alarcão, Oscar kenji Nihei, Sandra Marisa Pelloso, and Maria Dalva de Barros Carvalho were involved in the investigation; Kátia Biagio Fontes, Luciano Andrade, and Maria Dalva de Barros Carvalho were involved in the methodology; Kátia Biagio Fontes and Maria Dalva de Barros Carvalho were involved in project administration; Kátia Biagio Fontes, Ana Carolina Jacinto Alarcão, Oscar kenji Nihei, Sandra Marisa Pelloso, Luciano Andrade, and Maria Dalva de Barros Carvalho were involved in resources; Luciano Andrade was involved in the statistical analysis; Maria Dalva de Barros Carvalho was involved in supervision; and Kátia Biagio Fontes, Ana Carolina Jacinto Alarcão, Oscar kenji Nihei, Sandra Marisa Pelloso, Luciano Andrade, and Maria Dalva de Barros Carvalho were involved in writing (original draft, review and editing).

b) Competing interests - None declared.

c) Funding - There was no support.

d) Data sharing statement - No additional data are available.

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Figure 1 - State of Paraná and the municipality Human Development Index levels.

Figure 2 - A) Spatial distribution of weighted IPSV notification rates/100.000 women in Paraná, Brazil, from 2009-2014. B) LISA univariate analysis: formation of cluster types according to the IPSV notification rate/100.000 women in Paraná, Brazil, from 2009-2014.

Figure 3 - Map of waste/significant variables within the GWR model, separated by degree of association. A) Spatial distribution of the demographic density (inhabitants/km²); B) Spatial distribution of economically active women (%); C) Spatial distribution of women with higher education (%); D) Spatial distribution of the average female income; E) Spatial distribution of the civil registry of legal separations (%); F) Spatial distribution of the standardized residuals.

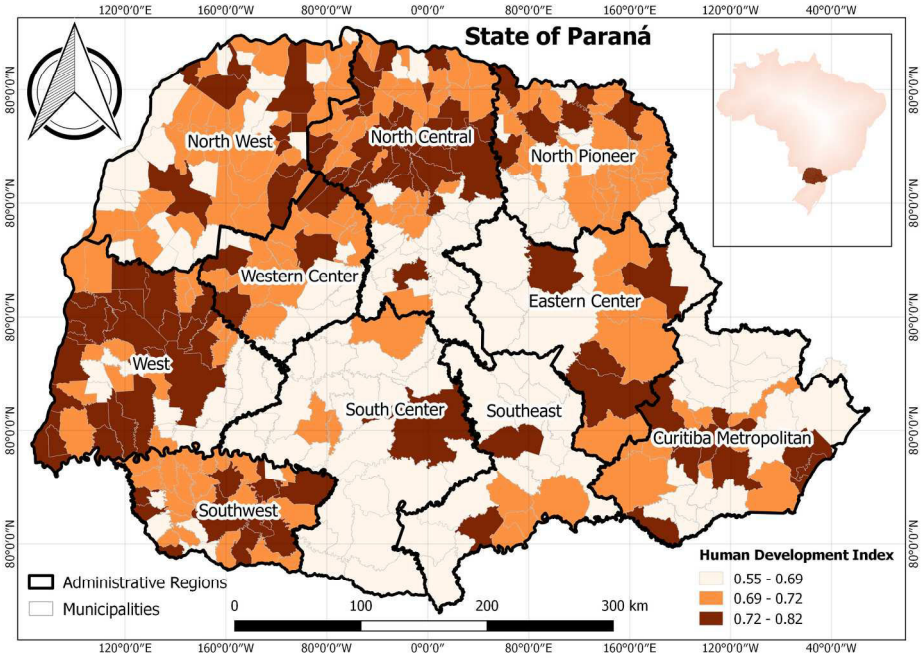

Figure 1 - State of Paraná and municipality Human Development Index levels.

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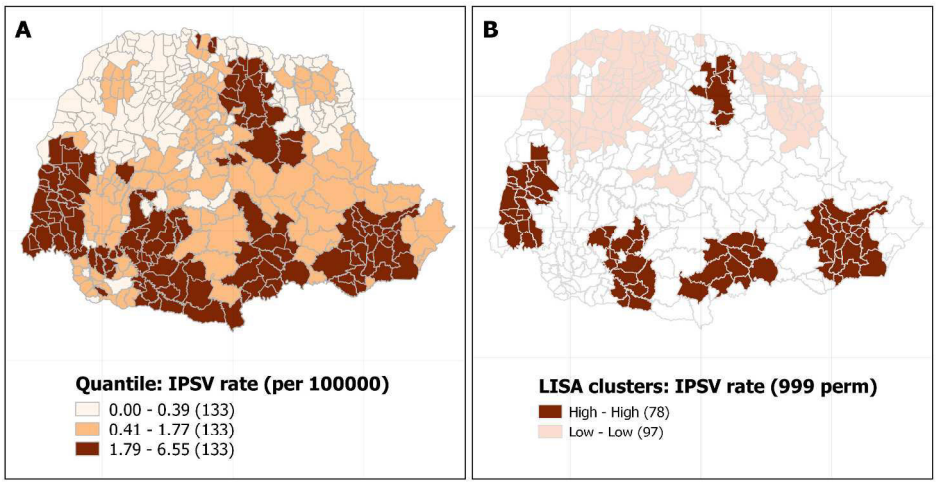

Figure 2 - A) Spatial distribution of weighted IPSV notification rate/100.000 women. Paraná, Brazil, 2009-2014. B) LISA univariate analysis: formation of cluster types according to the IPSV notification rate/100.000 women. Parana, Brazil, 2009-2014.

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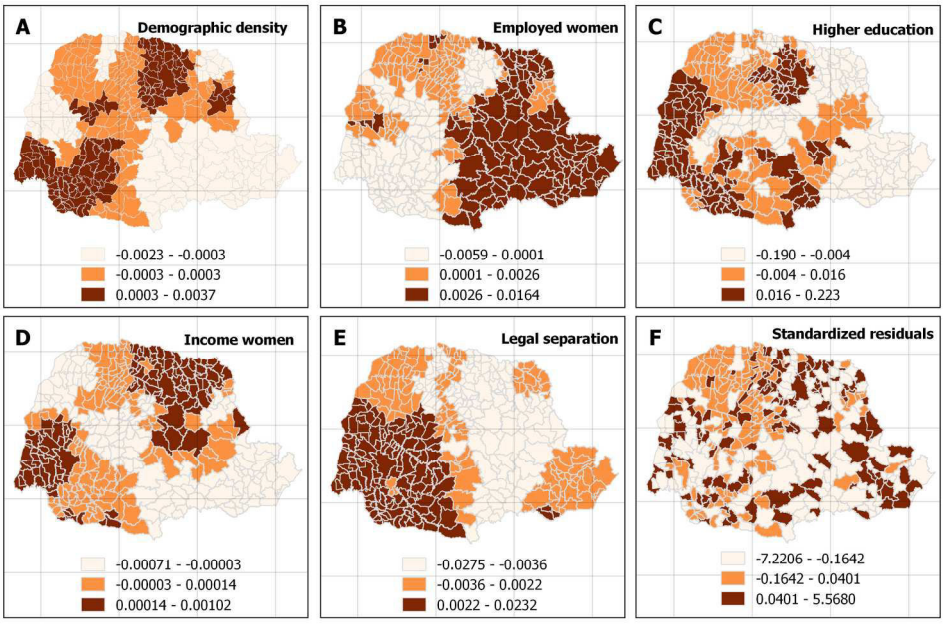

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	not applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	not applicable
Bias	9	Describe any efforts to address potential sources of bias	*not applicable*
Study size	10	Explain how the study size was arrived at	not applicable
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	not applicable
		(b) Give reasons for non-participation at each stage	not applicable
		(c) Consider use of a flow diagram	not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	not applicable
		(b) Indicate number of participants with missing data for each variable of interest	not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	not applicable
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	9-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.