

MURDER AND DRUG TRAFFICKING SPATIAL DEPENDENCE

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Abstract

This paper analyzes the correlation between drug trafficking and homicides in the city of Belo Horizonte, Minas Gerais - Brazil, to identify the spatial relationship between these phenomena in the urban environment. Based on data from the police reports in the period of 2007 to 2016, the spatial patterns of these criminal typologies and their spatial association were evaluated. The data were grouped on a 500-meter square grid, showing the main hot spots for the two types of crimes, as well as their recurrence. To complement the analysis, an indicator was proposed based on the assumptions of Ousey and Lee (2002), who describe the pre-existing social conditions for the relationship between drug trafficking and homicides to be established. From the methodology adopted, it was possible to verify the spatial association between the two criminal classifications, as well as the tendency for clusters of cells with a high incidence of crimes to be formed. There was also an association between the empirical data and those regions of the city where the pre-existing social conditions that encourage the association between drug trafficking and homicides are present, reinforcing the idea that the illegal drug market is a contingent cause of lethal violence.

Keywords: Violence. Homicide, Drug Trafficking, Spatial Analysis, Spatial correlation.

Resumo / Résumé

DEPENDÊNCIA ESPACIAL ENTRE HOMÍCIDIOS E TRÁFICO DE DROGAS

O presente trabalho tem como objetivo analisar a correlação entre os eventos de tráfico de drogas e homicídios no município de Belo Horizonte – Brasil, de forma a identificar a relação espacial entre os fenômenos no ambiente urbano. Tomando por base dados das ocorrências no período de 2007 a 2016, foram avaliados os padrões espaciais destas tipologias criminais, bem como sua associação espacial. Os dados foram agrupados em uma grade quadrada com dimensão de 500 metros, sendo identificados os principais hot spots dos tipos de crimes avaliados, bem como a recorrência destes. De forma a complementar a análise, foi proposto um indicador com base nos pressupostos de Ousey e Lee (2002) que descrevem as condições sociais pré-existentes ao estabelecimento da relação entre tráfico de drogas e homicídios. A partir da metodologia proposta, foi possível verificar a associação espacial entre as duas tipologias criminais, bem como a tendência à formação de clusters de células de alta incidência de crimes. Verificou-se também a associação entre os dados empíricos e as regiões da cidade nas quais as condições sociais pré-existentes à associação entre tráfico de drogas e homicídios estão presentes, reforçando a ideia de que o mercado ilegal de drogas é uma causa contingente de violência letal.

Palavras-chave: Violência, Homicídio, Tráfico de drogas, Análise espacial, Correlação Espacial.

DÉPENDANCE SPATIALE ENTRE HOMICIDES ET TRAFIC DE DROGUES

Cet article analyse la corrélation entre le trafic de drogue et les homicides dans la ville de Belo Horizonte - Brésil, afin d'identifier la relation spatiale entre les phénomènes en milieu urbain. Sur la base des données des rapports de police de 2007 à 2016, les schémas spatiaux de ces typologies criminelles ont été évalués, ainsi que leur association spatiale. Les données ont été regroupées dans une grille carrée de 500 mètres de dimension, identifiant les principaux points chauds des types de délits évalués, ainsi que leur fréquence. Afin de compléter l'analyse, un indicateur a été proposé sur la base des hypothèses d'Ousey et Lee (2002) qui décrivent les conditions sociales préexistantes pour l'établissement de la relation entre le trafic de drogue et les homicides. À partir de la méthodologie proposée, il a été possible de vérifier l'association spatiale entre les deux typologies criminelles, ainsi que la tendance au regroupement des cellules avec une incidence élevée de délits. Il y avait également une association entre les données empiriques et les régions de la ville dans lesquelles les conditions sociales préexistantes à l'association entre le trafic de drogue et les homicides sont présentes.

Mots-clés: Violence, Homicides, Trafic de drogue, Analyse spatiale, Corrélation spatiale.

INTRODUCTION

Different studies have consistently found strong connections between drugs and violence (GOLDSTEIN, 1985). The veracity of the nexus between drug markets and homicide has been widely accepted and adopted by many scholars, policymakers, and the mass media (OUSEY; LEE, 2002).

Although there appears to be a close association between drugs and violence, and drug use and trafficking seem to be important etiological factors in the incidence of violence, little effort has been made to place this relationship in a conceptual framework to guide further empirical research (GOLDSTEIN, 1985).

Theoretical criminology models include various important suggestions about how crime rates vary as a result of changes in the scope of illicit drug markets. Goldstein (1985), argues that, in general, the introduction and expansion of illicit markets lead to increased violence. This is mainly because participants in illegal markets have no legal recourse when business transactions go wrong.

This argument has become mainstream knowledge in the United States, however, there are relatively few studies of homicide in the illicit drug market.

Furthermore, Zimring and Hawkins (1997) suggested that the generality of the association between these variables may be exaggerated. The authors propose that the illegal drug market is a contingent cause of lethal violence, that is, the expansion of illicit drug markets only produces a rise in homicides under certain conditions.

In Brazil, in their work *Conglomerados de homicídios e o tráfico de drogas em Belo Horizonte, Minas Gerais, Brasil, de 1995 a 1999*, Beato et. al (2001) found that although there were no geographic data related to drug trafficking in Belo Horizonte in the study period, all the clusters identified were linked to neighborhoods and slums where drug trafficking, notably crack, seemed to predominate.

With the advance of Geographic Information Systems and the modernization of official police records of occurrences, it is currently possible to analyze the spatial correlation between phenomena.

As of 2007, the Minas Gerais Military Police implemented the Social Defense Events Register (REDS), which georeferences all occurrences. Consequently, it is possible to analyze the spatial correlation between drug trafficking crimes and drug trafficking.

Thus, this work aims to use spatial analysis to examine the relationship between drug trafficking events and drug trafficking locations in the city of Belo Horizonte, to identify whether a correlation exists between these phenomena in the urban environment and if any possible clusters correspond with the original investigations predicting their location in the favelas.

This study is pertinent because, despite the recognition of the relationship between homicides and drug trafficking, few investigations have proven this spatial relationship or sought to identify whether this behavior occurs in subnormal agglomerates and outside them.

The results can contribute to the evaluation and improvement of public security policies, as well as support operational planning to prevent outbreaks of violent crimes.

THE RELATIONSHIP BETWEEN ILLICIT DRUGS MARKETS AND HOMICIDE: A BIBLIOGRAPHIC REVIEW

The idea that drugs and crimes are related goes back at least 100 years (INCIARDI, 1981), and there has been scientific research on the connection between drugs and violence since the 1970s (MONTEFORTE; SPITZ, 1975; ZAHN; BENCIVENGO, 1974).

However, until the mid-1980s, most of the research on drug-related violence was framed in terms of individual perspectives, attributing violent acts to the physical or psychological effects of drug ingestion or drug addicts' attempts to acquire the economic resources needed to sustain their addictions. However, with the proliferation of crack markets in the United States during the 1980s, these individual explanations have been largely replaced by Goldstein's (1985) model of systemic violence.

THE SYSTEMIC MODEL

In 1986, Goldstein published *Homicide related to drug traffic*, arguing that as well as being a criminal issue, violence is also an important public health problem.

At the time, Goldstein pointed to drug trafficking as an important etiological factor in homicide. This focus has intensified due to a wide range of studies conducted in the past two decades.

Preble² (1980 apud GOLDSTEIN, 1986) conducted an ethnographic study of heroin addicts in the Spanish Harlem district of New York between 1965 and 1967. About 15 years later, in 1979 and 1980, he followed up on the 78 participants and obtained detailed information about what had happened to them. Preble (1980) found that 28 of the drug addicts had died, of whom eleven, 40% of the deaths, were victims of homicide. The 1983 New York City Police Department's homicide analysis, based on 1981 data, reported that 24% of known homicides in New York City were drug-related and ranked as the second most common form of homicide, after the general category of "disputes".

Goldstein's (1985) study *The drugs/violence nexus: A tripartite conceptual framework* theoretically structures the relationship between drugs and violence in a tripartite model, in which these phenomena are related in three possible ways: the psychopharmacological, the economically compulsive, and the systemic (GOLDSTEIN, 1985).

The psychopharmacological model suggests that as a result of the short or long-term ingestion of specific substances, some individuals may become excitable, irrational, and exhibit violent behavior.

In other words, drug use can contribute to a person's violent behavior, or it can change a person's conduct in a way that causes them to become victims of violent behavior (GOLDSTEIN, 1985, 1986).

According to the economically compulsive model, some drug users engage in economically driven violent crimes, such as robbery, to pay for their drug use. Heroin and cocaine fit well in this model, as they are expensive drugs characterized by patterns of compulsive use. These users usually obtain money or drugs by working in the drug business, and participating in petty theft or prostitution, for example (GOLDSTEIN, 1985).

In the systemic model, violence is intrinsic to involvement in any illegal activity. Systemic violence refers to traditionally aggressive patterns of interaction within the system of drug distribution and use.

There are no definitive data on the proportions of violence by drug users that can be attributed to each of the three models. However, knowledgeable observers of the drug scene suggest that systemic violence is responsible for most of the violence perpetrated by or directed at drug users. The systemic violence model differs from drug violence models at the individual level because it does not attribute violence to drug use or dependence. Instead, it claims that drug-related violence is a product of the structure of the market in illicit goods.

Based on the concept of systemic violence, Blumstein (1995) speculated that the rising homicide rates in the United States in the late 1980s and early 1990s mainly resulted from the increased demand for crack. The body of research on the systemic violence models postulated by Goldstein (1985) and Blumstein (1995) is relatively small but growing. The first studies on this theme, for example, Goldstein et al. (1989), were chiefly descriptive analyzes that attempted to classify homicides by motivation, based on known circumstances.

Subsequent studies³ complemented Goldstein's descriptive work by examining the multivariate relationship between drug activity and homicide in more than one city. Although the results of these studies are not completely uniform, they generally support the hypothesis of a positive association between the drug market and lethal violence. However, there has been little research on the relationship between drug market activities and murder within the city during the increase in homicide rates in the 1980s and the subsequent fall in the 1990s.

CONTINGENT MODEL

Despite the popularity of Goldstein's model explaining the relationship between homicides and the drug market in the United States, data from industrialized European countries indicate that there is little association between illicit drug markets and homicide rates in these societies, which effectively put

a check on the well-known American explanation proposed by Goldstein.

In light of this contradictory evidence, Zimring and Hawkins (1997) proposed the hypothesis that illicit drug markets are a “contingent cause” of homicide, not a universal one.

In other words, the association between the drug market and homicide occurs in some social contexts, but not in others.

Zimring and Hawkins (1997) suggested that drug markets are a “contingent cause” of rising homicide rates, rather than being a systemic issue. The “systemic” question of drug-related violence is completely absent from academic writings on the question of illicit drugs in European countries such as Italy and the Netherlands. (ZIMRING; HAWKINS, 1997, p. 148-149).

Therefore, Zimring and Hawkins (1997) propose an alternative hypothesis about the link between the illicit drug market and homicide. Specifically, they modify the prominent models of systemic violence by arguing that “the creation and expansion of illegal markets will produce extra homicides when there are already social circumstances conducive to lethal violence” (ZIMRING; HAWKINS, 1997, p. 153).

According to Ousey and Lee (2002), as the relationship between the drug market and homicide is variable, the challenge for researchers is to determine which social circumstances facilitate or inhibit this association.

As an initial step in specifying important contingencies, Ousey and Lee (2002) used the existing criminological literature to identify the structural characteristics of those urban areas that can reasonably be considered “social conditions conducive to violence”.

In particular, the authors selected five leading homicide covariates: resource deprivation, population structure, percentage of divorces, the percentage of the 15 to 29 age group; and the Southern region indicator variable⁴ and then elaborated the following hypotheses:

a)hypothesis 1: the variation in the activity of distribution of illicit drugs within the city is positively associated with the variation in homicide rates within the city during the period 1984-1997.

b)hypothesis 2: the association of homicides in the illicit drug market is greater in cities with high levels of resource deprivation.

c)hypothesis 3: the association of homicides in the illicit drug market is greater in cities with a large percentage of a divorced population.

d)hypothesis 4: the association of homicides in the illicit drug market is greater in cities with a large and densely crowded population.

e)hypothesis 5: the association with the illicit drugs and homicide market is greater in cities with a large percentage of the population aged 15 to 29 years.

f)hypothesis 6: the association of homicides in the illicit drug market is greater in the southern region than in other regions of the USA.

Ousey and Lee’s (2002) conclusions indicate that the results partially support the models of systemic violence and contingent causation of the nexus between the drug market and homicides.

As predicted by the systemic violence model, the authors found that, on average, during the period 1984-1997, the variation of the illegal drug market within the city has a significant positive relationship with the variation of homicide rates in the city.

Thus, it appears that as these markets expand, there is a corresponding increase in the rates of lethal violence.

However, this positive relationship does not apply to all social contexts. Following the contingent causation thesis outlined by Zimring and Hawkins (1997), Ousey and Lee (2002) found that the effect of an expansion of activity in the illicit drug trade on homicide rates depends on the level of resource deprivation (and, in one case, the percentage of divorces) in a given city.

In cities where the pre-existing level of resource deprivation is average or above average, illegal activity in the drug market tends to have a significant positive impact on homicide rates.

Overall, the findings of the association between the drug market and homicide and the interaction between resource deprivation and the unlawful drug trade are robust in different operationalizations of

the illegal drug market activity.

THE ASSOCIATION BETWEEN DRUG TRAFFICKING AND HOMICIDE IN BRAZIL

Given that the use of theoretical models from developed countries is worthy of consideration, we examine the international literature's approach to research applied to the Brazilian reality. Marcelo Lopes de Souza's work addresses the issue of drug trafficking and its influence on socio-spatial dynamics in Brazilian cities, especially Rio de Janeiro. Among his findings, the objective increase in violent crime and the increase in the population's feeling of insecurity are direct and indirect problems resulting from the increase in drug trafficking (SOUZA, 1993, 2008).

The market in unlawful drugs is a multi-scale phenomenon involving networks, activities, and types of social actors. The structure of drug trafficking in Brazil is divided into two specific "subsystems", according to Souza's (2008) classification. The first is the import/export/wholesale subsystem and the second, the retail subsystem, is supplied by the former with a supply of drugs and weapons.

Souza (2008) also emphasizes that the retail subsystem, composed of gangs, receives logistic support from favelas and other segregated spaces in the city.

Regarding the empirical evidence of the rudimentary organization of favela-based drug trafficking, Souza (2008) presents two striking characteristics: pulverization and violence. There are constant wars over the territorial control of drug-dealing spots and savage settlements of scores, which is reinforced by Zaluar (1994), who states that brute force and intimidation are the only ways to avoid betrayals.

Souza (2008) argues that territorial pulverization and the networks' spatial instability establishes an unconventional territoriality, as the controlled areas are not contiguous and there is no "territorial pact", unlike other criminal modalities. "This territorial dispersion, alongside chronic violence, is also evidence of the autonomy of agents operating in the retail subsystem". (SOUZA, 2008, p. 436).

Writing on the violence inside the favelas, Souza reports that the only safe place is the interior of the "community" due to the rules imposed by the traffickers, who are often born and raised in the neighborhood. These actors are often "legislators, judges and executors" of their "informal laws", whose aim is to ensure peace for the business and make it clear who is in charge of the area. (SOUZA, 1994; 1995a; 1995b; 1996a).

The above corroborates the systemic perspective of the relationship between drug trafficking and homicide proposed by Goldstein (1986) because the drug lords' rule of the favelas uses violence as a resource for social control. Thus, the ordering mechanism that maintains security in territories controlled by the illicit drug trade is also the source of violence.

Another factor considered by Souza (2008), in addition to the high population density and massive poverty, refers to the actual location of the favelas (the spatial structure, in the case of the hillside favelas), which have a unique value as hiding places, with their narrow alleys, observation points, and labyrinthine road structure. These factors confer advantages for the defender and disadvantages for invaders.

Thus, the fruits of Souza's long and in-depth work adhere to Goldstein's (1986) systemic theory. Nevertheless, Souza emphasizes the lack of reliable quantitative data to support studies in this line. Therefore, the present work aims to contribute to the analysis of retail drug trafficking activities from a quantitative perspective in another social reality, which is correlated to the Rio de Janeiro model presented by Souza.

MATERIALS AND METHODS

To analyze the phenomena of drug trafficking and homicide, data were obtained from official sources (police reports) collected in the Databank of the Social Defense Events Records (REDS) within the spatial limits of the city of Belo Horizonte from 01/01/2007 to 12/31/2016. The period was selected

due to the implementation of the electronic recording system with the precise georeferencing of occurrences, which enabled an analysis of the spatial correlation between the two phenomena.

The data were initially tabulated and information that did not have a georeference of the locations of occurrences was excluded. In total, there were 14,202 points of homicide events (6,007 successful and 8,195 attempted) and 34,538 locations of drug trafficking incidents.

The research began by analyzing if the events are locational, that is, whether they are related to the places where they occur; the nearest neighbor analytical technique was used for both crimes studied.

Then, in an exploratory way, the probability density of the occurrence of the events was investigated using the Kernel density estimation and the existence of Hot Spots to map the areas with the highest criminal incidence.

Along with histograms, the Kernel estimator is probably the most frequently used and mathematically studied method for calculating densities (SILVERMAN, 1986, p.22). The Kernel Density Estimator calculates the density of points at a given distance, also called the search radius. Its calculation assigns a value of 1 to each analyzed point, generating a decay curve of the phenomenon with the distance to the limit of the search radius, where this value is zero. Once the radii have been overlapped, the values of the incident cells are summed, resulting in a surface density estimate for the phenomena under analysis. In the present work, the technique is used to assess the density of drug trafficking and homicide incidents in Belo Horizonte.

After analyzing the densities of the occurrences, their spatial distribution was evaluated. To identify possible accentuated areas of higher incidence of the two criminal typologies, the Hot Spot Analysis technique was used from the Getis-Ord-Gi*_s statistics. Similar to the linear correlation analysis, this analysis was based on a 500 x 500-meter mesh. This technique starts with the analysis of the frequency of occurrences in each cell compared to the surrounding cells. The statistical significance of the values is evaluated by comparing the sum of the values of a cell and its neighbors in proportion to the sum of the values of all the cells. Therefore, a cell becomes statistically relevant if it has a high incidence of a phenomenon and is surrounded by cells that also have a high incidence. The usefulness of the Hot Spot analysis becomes evident, as those parts of the study area with clusters of cells with a high number of occurrences can be identified. As its design is based on the concept of proximity, this methodology allows the evaluation of contexts with great variability of data, since a Hot Spot is only determined by the existence of a set of adjacent cells with a high number of occurrences.

The spatial correlation between crimes was examined by superimposing the data on a 500 x 500-meter framework and applying Pearson's linear correlation coefficient for the dot count per grid. Linear correlation is a measure of the linear association between variables, which can be defined by Pearson's correlation coefficient (r) that describes how well a straight line adjusts through a point cloud. In the case of Pearson's correlation (r), the two variables are associated by sharing the variance, that is, it is a measure of the shared variance between two variables.

Thus, a linear relationship means that the best way to illustrate the relationship pattern between any two variables is through a straight line. So, Pearson's correlation (r) requires shared variance and that this variation is distributed linearly (FIGUEIREDO FILHO; SILVA JUNIOR, 2010). The coefficient is used for data that are linearly related and to apply this coefficient, the sample should be random, and the variables distributed normally.

The Pearson correlation coefficient (r) varies from -1 to 1. The sign indicates the positive or negative direction of the relationship and the value suggests the strength of the relationship between the variables. A perfect correlation (-1 or 1) indicates that the score of one variable can be determined exactly by knowing the score of the other. On the other hand, a zero value correlation indicates that there is no linear relationship between the variables (FIGUEIREDO FILHO; SILVA JUNIOR, 2010). In this work, the interpretation was based on the classification proposed by Bisquerra; Sarriera, and Martínez (2004), according to the intervals shown in Table 1 below:

Interval	Interpretation
- 1.00	perfect negative correlation
[-1.00; - 0.80 [	very high negative correlation
[- 0.80; - 0.60 [	high negative correlation
[- 0.60; - 0.40 [	moderate negative correlation
[- 0.40; - 0.20 [	low negative correlation
[- 0.20; 0.00 [	very low negative correlation
0.00	null correlation
] 0.00; 0.20]	very low positive correlation
] 0.20; 0.40]	low positive correlation
0.40 - 0.60	moderate positive correlation
0.60 - 0.80	high positive correlation
0.80 - 1.00	very high positive correlation
1.00	perfect positive correlation

Table 1 - Interpretation of Pearson's correlation coefficient r . Source: Bisquerra; Sarriera; Martínez (2004, p. 147).

Following the evaluation of the linear correlation between the phenomena, the degree of recurrence of Hot Spots of criminal typologies was calculated. The identification of homicide and drug trafficking Hot Spots was carried out for both the data set and each year separately. This stratified analysis stage enabled the identification of the recurrence of criminal typologies in these parts of Belo Horizonte's territory. Given the 10-year analysis period, the cells were classified according to their recurrence as Very Low (up to 2 years of recurrence as a hot spot); Low (3 to 4 years); Medium (5 to 6 years); High (7 to 8 years); and Very High (9 to 10 years). In this way, as well as the spatial distribution and formation of occurrence Hot Spots, the degree of consolidation of these situations could also be analyzed.

To encompass the dimensions proposed by Ousey and Lee (2002), four variables were selected, which were obtained and translated on the scale of the census sectors, based on data from the 2010 Census. Resource deprivation was based on the variable average income of those responsible for permanent private households (excluding census sectors in which the average income was equal to 0 in 2010). The population structure was assessed based on the demographic density (inhabitants per km²) in each of the census sectors. The family structure (approached by the authors through the percentage of divorcees) was measured from the variable of the percentage of female heads of households without primary education and at least one child under 15 years old, as used in the calculation of the Index of Social Vulnerability (IVS) (IPEA, 2015). This variable is made available at the territorial level of the Human Development Units (HDU), having been made compatible with the census sectors. The fourth variable employed was the percentage of the population aged between 15 and 19 years old in each census sector.

To create the Vulnerability Index, the scales of all the variables were standardized from 0 to 1. In a subsequent step, the average income variable was inverted, giving the resource deprivation in each sector. The four variables were combined with equal weights of 25%.

RESULTS AND DISCUSSIONS

This section presents the results and analyzes the spatial correlation between homicides and drug trafficking in the data collection period from 01/01/2007 to 12/31/2016. The data comes from Table 2.

During the study period, there were a total of 34,538 drug trafficking cases and 14,202 homicides, both attempted and successful. Figure 1 identifies the variation trend between the phenomena in this

period.

Per Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Homicide	1696	1707	1521	1341	1420	1488	1513	1277	1131	1108
Drug Trafficking	1539	3221	3691	4433	4025	3807	3344	3828	3504	3146

Table 2 - Homicides and Drug Trafficking - Belo Horizonte - 2007 to 2016. Source: Minas Gerais Military Police Database, 2020

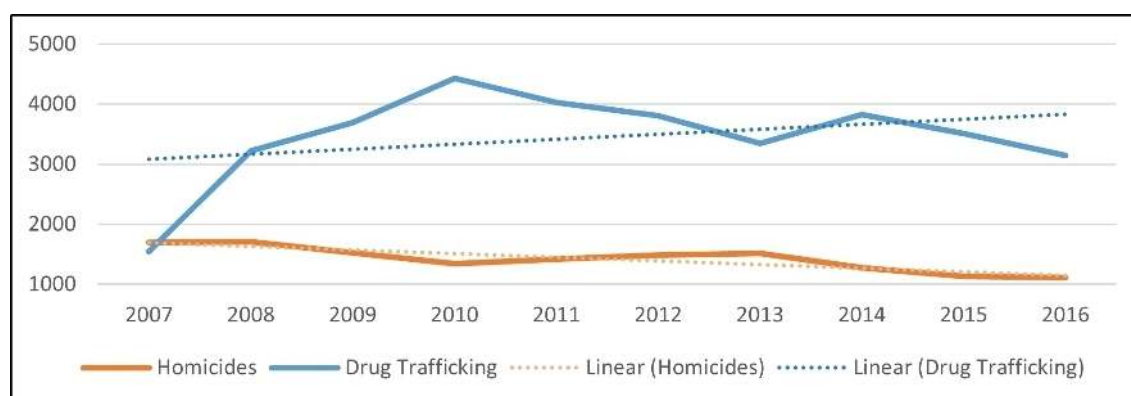


Figure 1 - Variation of Homicide and Drug Trafficking in Belo Horizonte - 2007-2016. Source: Minas Gerais Military Police Database, 2020

It is observed that the curves cross precisely in the year the analysis period began, and after this, the trend was for the number of drug trafficking events to increase whilst the number of homicides fell.

It is worth noting that 2000 marks the beginning of the Homicide Control Program (Fica Vivo) in Belo Horizonte, which was institutionalized by the state government in 2003. From 2007 to 2016 there was a negative association between the variation of illicit drug distribution activities and homicide rates within the city, which contradicts Ousey and Lee's (2002) hypothesis.

Although there is a negative association in the overall behavior in the study period, an analysis was carried out to ascertain whether the phenomena occur in the same territorial space, that is, in micro-space, where interactions and social processes occur.

Figure 2 and the analysis of the nearest neighbor show that both homicides and drug trafficking have a distribution pattern of aggregate points, therefore, these are locational phenomena related to the environment in which they occur. According to Beato et al. 2001), homicide conglomerates formed in the favelas and slums in Belo Horizonte in the study period. A map was created to show the location of favelas and slums (Figure 3) to identify whether there is a similar trend for clusters in these areas.

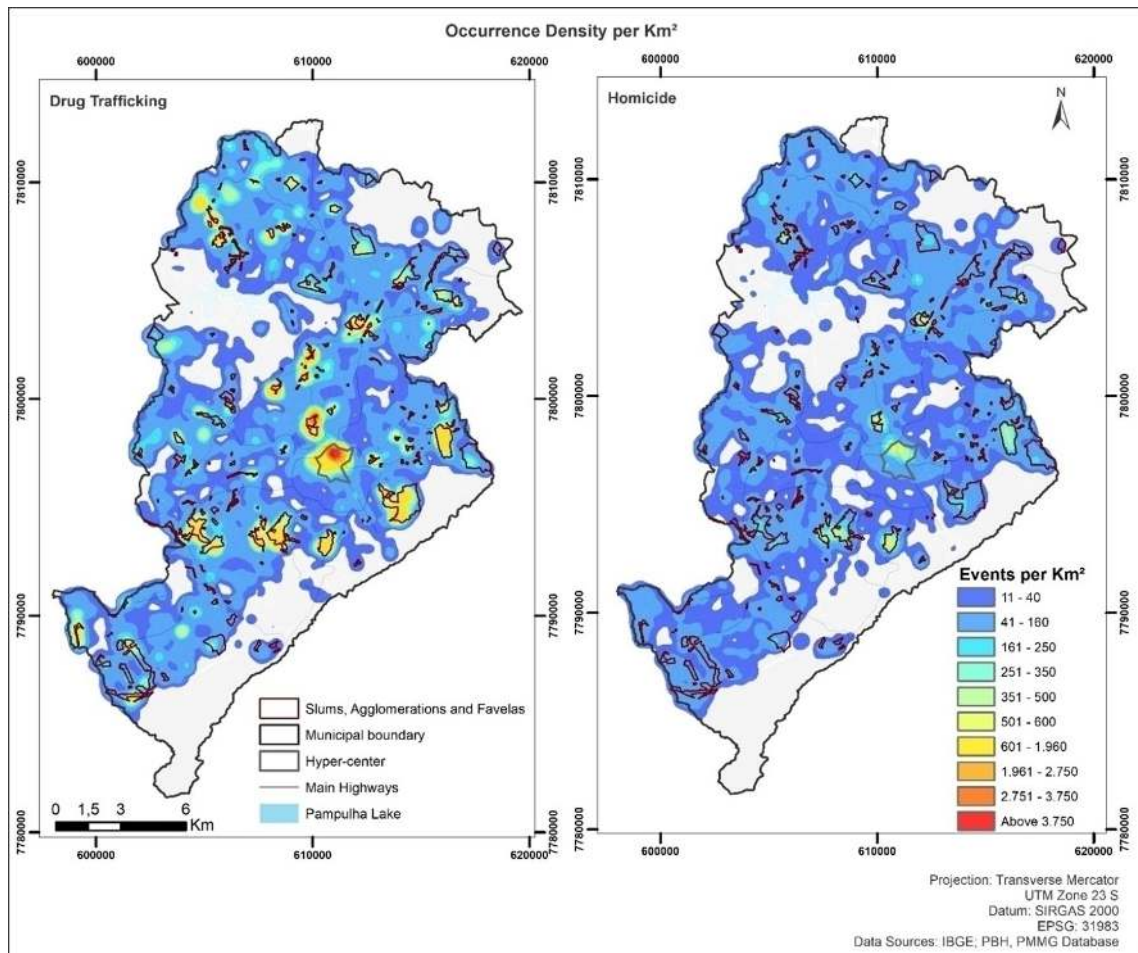


Figure 2 - Map of occurrence density per km² - Drug Trafficking x Homicide - Belo Horizonte - 2007-2016. Source: Minas Gerais Military Police Database, 2020

Figure 2 shows the map of towns and slums in Belo Horizonte, as defined by the Zones of Special Social Interest (ZEIS), according to Law 7166/96 and its amendments (BELO HORIZONTE, 1996). Belo Horizonte has 209⁶ favelas, slums, and popular housing developments, occupying an area of 16.74 km², which corresponds to 5.05% of the municipality's total area. There are 366,239 inhabitants, approximately 15% of the total population (PBH, online⁷).

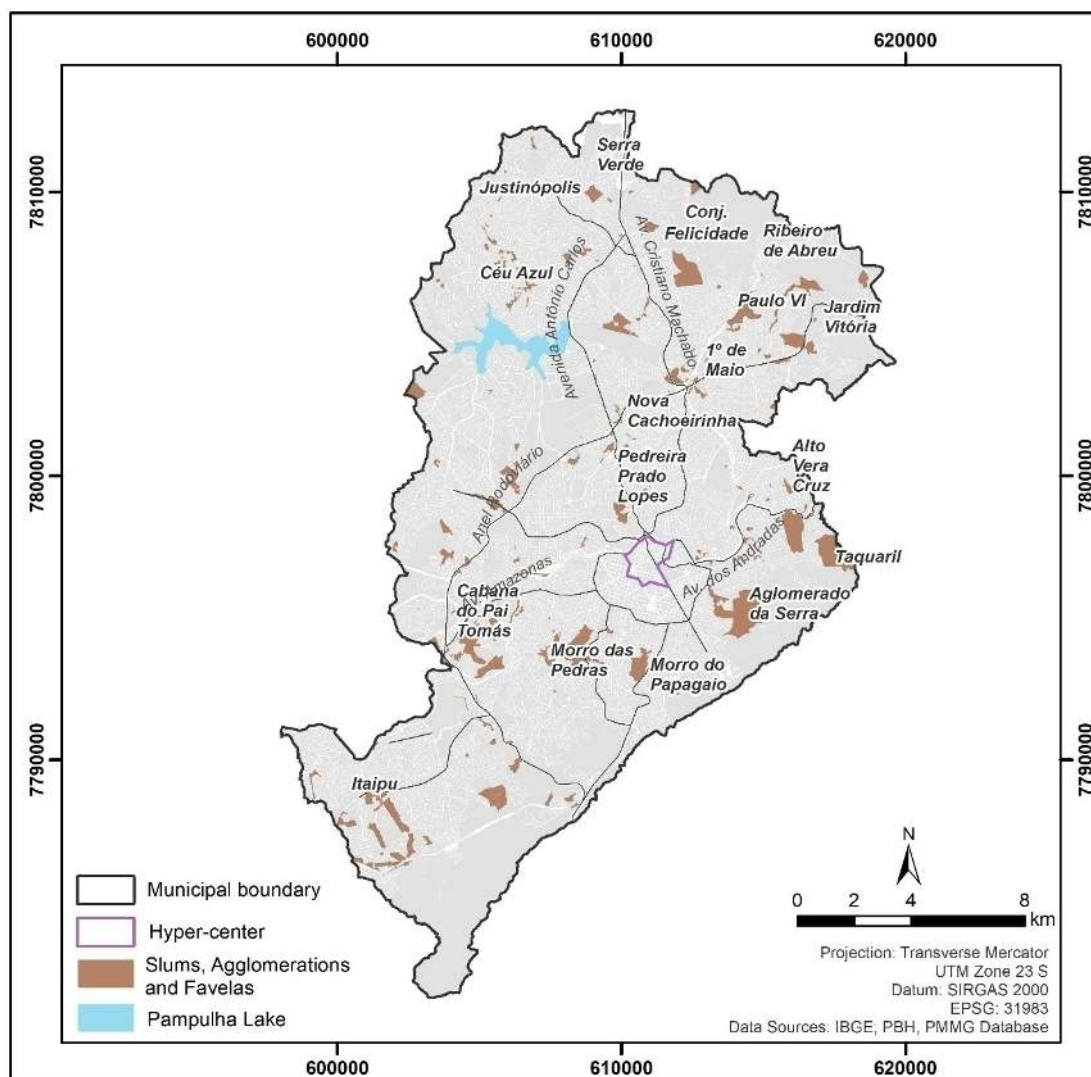


Figure 3 - Location map of Slums and Favelas - Belo Horizonte. Source: PRODABEL.

The number of events and their respective density are shown in the table below.

Crime	Location	Total events	Density (events / Km ²)
Trafficking	Outside Favelas and Slums	23,437	70.76661
	Inside Favelas and Slums	(11,101)	663.1422
Homicide	Outside Favelas and Slums	11,141	33.63958
	Inside Favelas and Slums	3,061	182.8554

Table 3 - Density of Homicide and Drug Trafficking inside and outside Slums and Favelas - Belo Horizonte - 2007-2016. Source: Minas Gerais Military Police Database, 2020.

It is evident that crime density is significantly higher inside than outside slums for both types of crime (9.37 times higher for drug trafficking and 5.44 times higher for homicide), which corroborates the findings of Beato et al. (2001).

The correlation analysis was carried out by grouping the occurrences in a 500 x 500-meter grid. In absolute terms, the number of events of the two offenses is quite different so maps of hot spots were created for each of the phenomena using the confidence level.

The Getis Ord Gi* method^{8,9} was used to analyze the hot spots and the data was added to the grid, which verified whether there is a spatial concentration of low and high values of a given phenomenon in the spatial units in question. The squares representing the hot spots for the confidence levels of 90, 95, and 99% confidence were used to create the map and are shown in orange, light red, and dark red, respectively.

The use of the Getis-Ord Gi* statistic indicates whether the spatial units of analysis with greater or lesser incidences of the phenomena tend to be spatially concentrated. Therefore, their intensity is analyzed from each of the boxes compared to its neighbors. Thus, a hot spot is identified not only by the presence of a unit with a high incidence of crime but by the grouping of squares with high values.

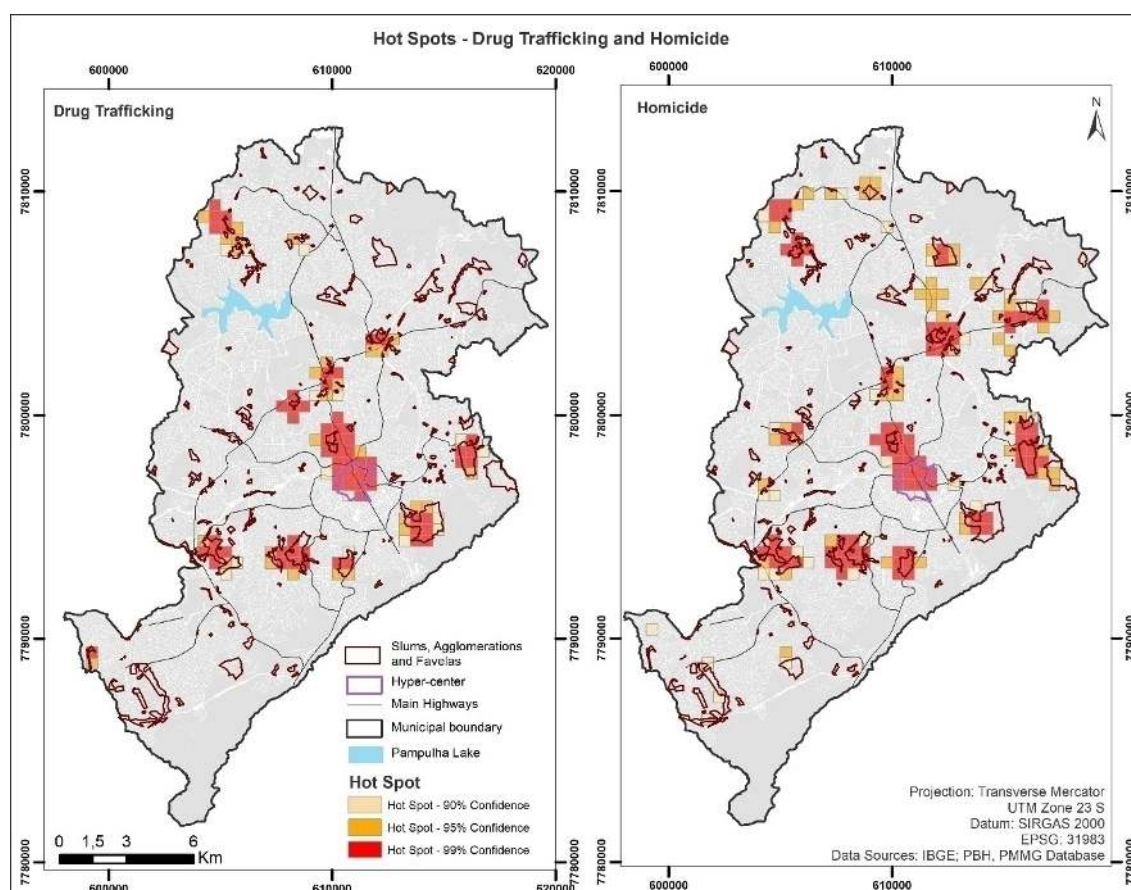


Figure 4 - Hot Spots by confidence level - Drug Trafficking vs. Homicide - Belo Horizonte - 2007-2016.
Source: Minas Gerais Military Police Database, 2020.

As shown in Figure 4, not all favelas and slums are areas with a concentration of trafficking and homicides, however, all the hot spots are located in these areas. There is also the hyper-center, characterized by the high flow of people and crime attractors, defined by land use and occupation.

Next, the correlation between the phenomena was verified and Pearson's correlation index was calculated as $r = 0.75$. According to an interpretation based on Bisquerra, Sarriera, and Martínez (2004), described in Table 3, there is a high positive correlation between drug trafficking and homicides.

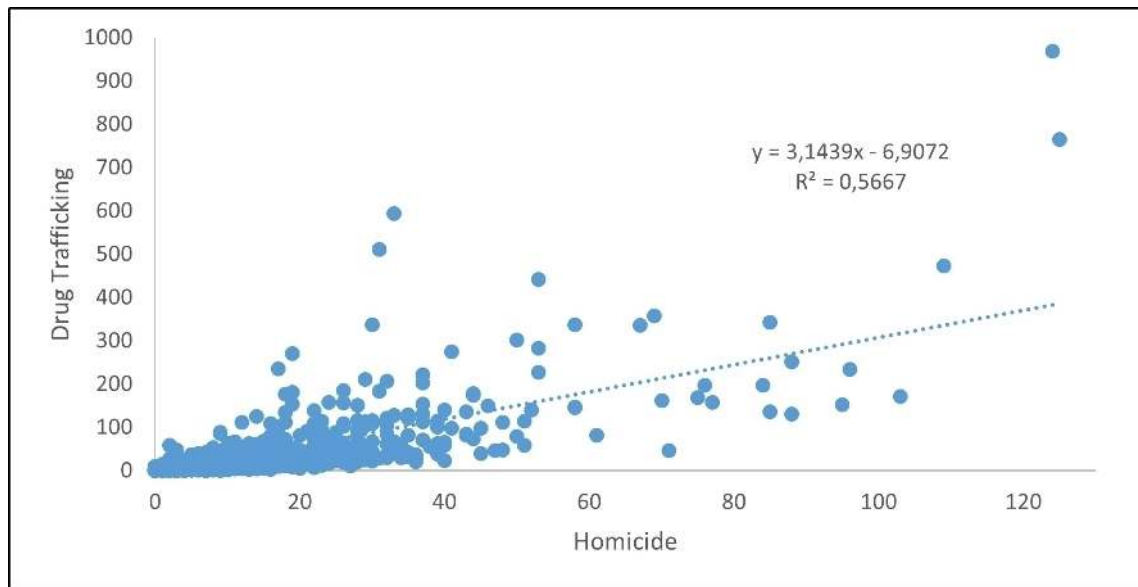


Figure 5 - The Relationship between Drug Trafficking and Homicide - Belo Horizonte - 2007-2016. Source: Minas Gerais Military Police Database, 2020.

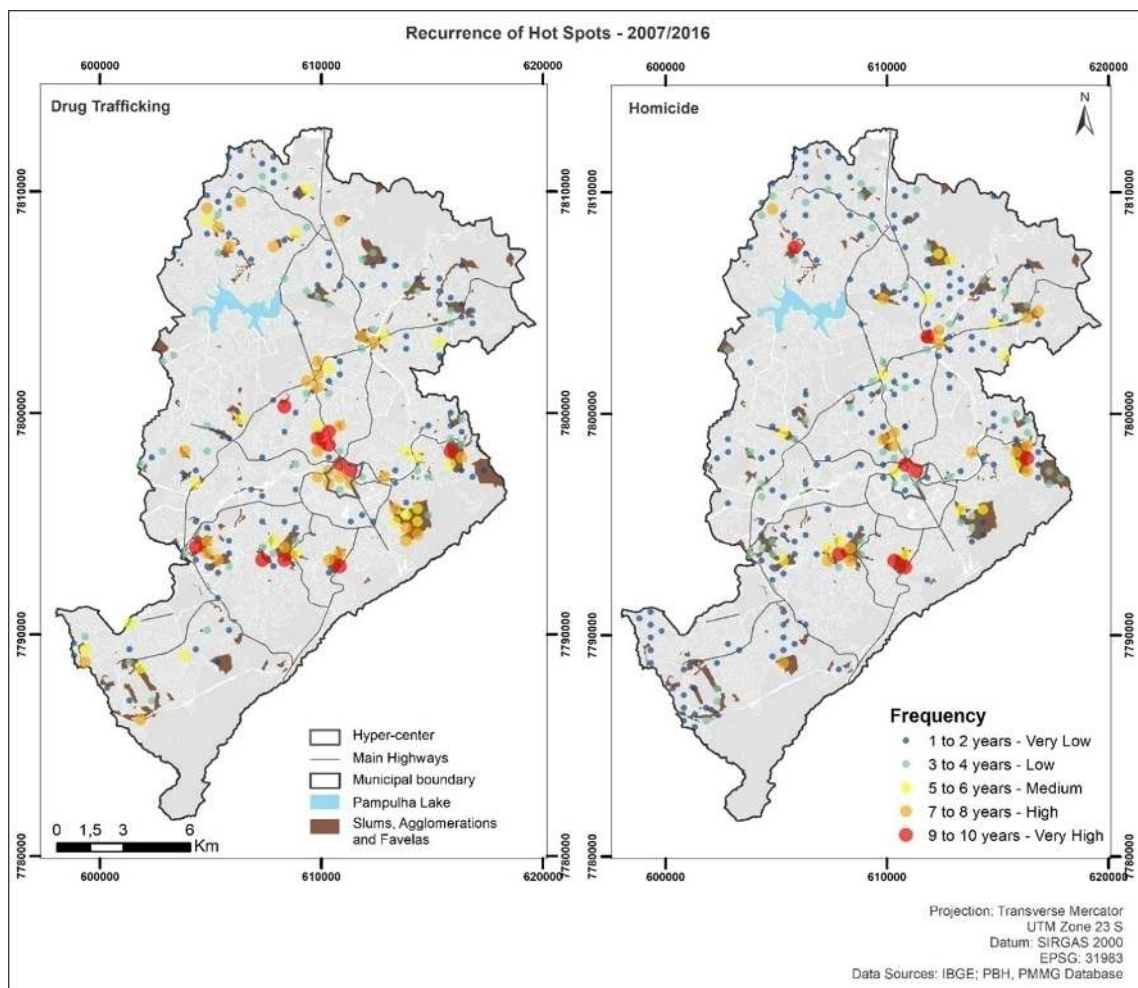


Figure 6 – The Recurrence of Hot Spots - Belo Horizonte - 2007-2016. Source: Minas Gerais Military Police Database, 2020.

According to Figure 5, the determination coefficient r^2 equal to 56% allows us to infer that most of the homicides are linearly related to drug trafficking. To identify the persistence of criminal incidence over time, from a longitudinal perspective, the next step was to analyze the recurrence of hot spots of criminal events (Figure 6).

To accomplish this the data were separated into years (from 2007 to 2016) and treated separately from the Getis Ord Gi* analysis. Then, the squares classified as hot spots in each of the periods were selected and the frequency with which the phenomena occurred was calculated.

In the 10-year analysis period, the cells were classified as Very Low (up to 2 years of recurrence as a hot spot); Low (3 to 4 years); Medium (5 to 6 years); High (7 to 8 years); and Very High (9 to 10 years). This classification verified both the areas of concentration of criminal events and those in which the concentration is recurrent, with a frequency greater than 7 years.

Finally, the covariables from Ousey and Lee's (2002) hypotheses were analyzed as pre-existing social conditions for the relationship between drug trafficking and homicides to occur, namely, resource deprivation; population structure; the percentage of divorces; and the percentage of the population aged between 15 and 29 years.

Four variables were selected to incorporate the dimensions proposed by Ousey and Lee (2002), which were obtained and translated on the scale of the census sectors, based on data from the 2010 Census. Resource deprivation was based on the variable average income of those responsible for permanent private households (excluding census sectors in which the average income was equal to 0 in 2010). The population structure was assessed based on the demographic density (inhabitants per km²) in each of the census sectors. The family structure (approached by the authors through the percentage of divorced people) was measured from the percentage variable of female heads of households without primary education and at least one child under 15 years old, which is used as a component to calculate the Index of Social Vulnerability (IVS) (IPEA, 2015). This variable is available at the territorial level of the Human Development Units (HDUs), having been made compatible with the census sectors. The fourth variable used was the percentage of the population aged between 15 and 29 years in each census sector.

To create the Vulnerability Index, the scales of all the variables were standardized from 0 to 1. In a subsequent step, the average income variable was inverted, obtaining the resource deprivation in each sector. The four variables were combined with equal weights of 25%.

This vulnerability index permitted a comparison between the empirical data on the concentration and the spatial dependence regimes of the criminal typologies in question with the spatial distribution of the covariates presented in Ousey and Lee's (2002) hypotheses. The data are represented in the map collection in Figure 7.

The independent variables show that the upper strata of each variable coincide with homicide and drug trafficking hot spots. Therefore, the combination of these variables also evidences that the variation in illicit drug distribution is positively associated with the variation in homicide rates within the city, in places where pre-existing social situations are present (resource deprivation, presence of young people between 15 and 29 years old, high population density, families headed by women), corroborating the contingency model for the hypotheses proposed by Ousey and Lee (2002).

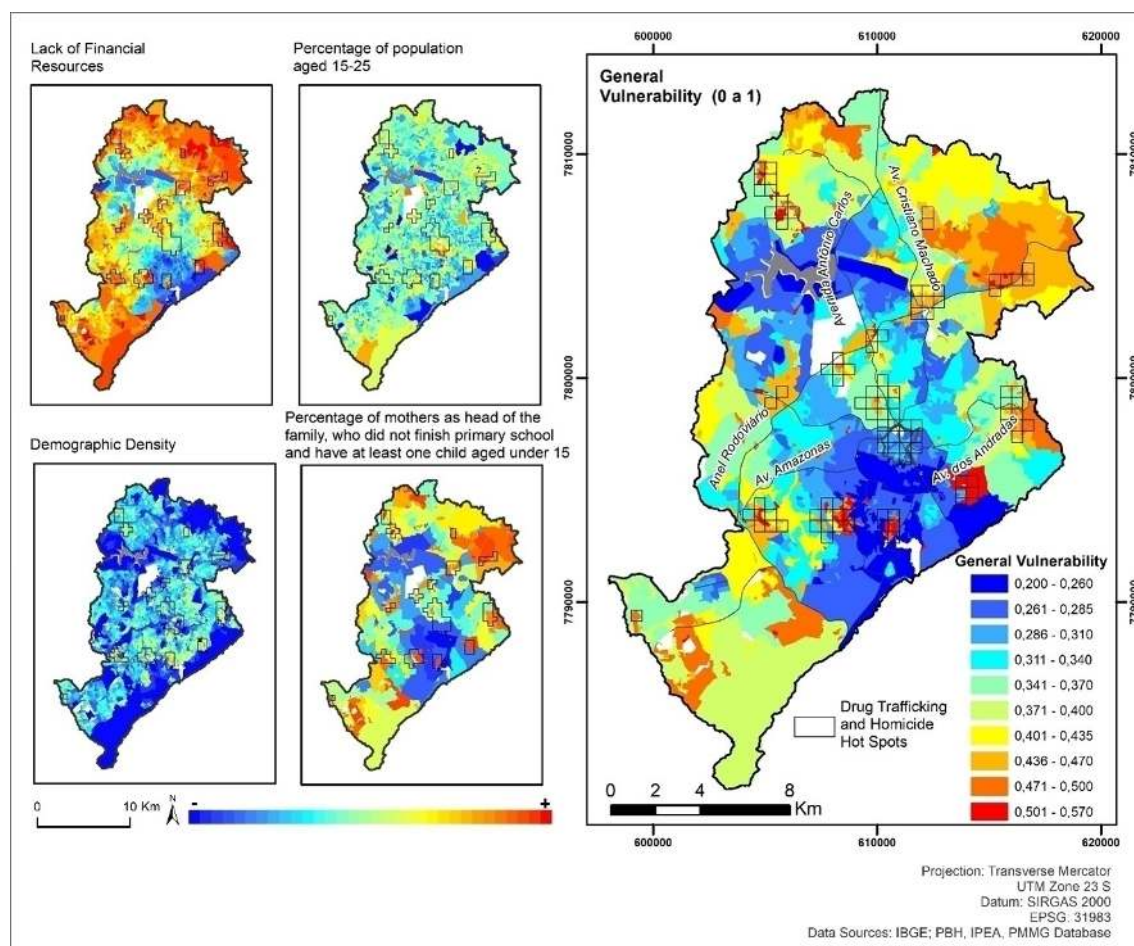


Figure 7 - Variables and vulnerability index to homicides and drug trafficking - Belo Horizonte - 2007-2016. Source: IPEA, Minas Gerais Military Police Database, 2020.

CONCLUSION

The research data evidenced the spatial configuration of the occurrences of drug trafficking and homicides in the city of Belo Horizonte.

The addition of this data to the 500-meter square grid, identified hot spots in the occurrence of the two types of crime, revealing a trend for their occurrence in the same parts of the city's territory.

In addition to analyzing the aggregate of occurrences by square, the analysis of the historical series verified that some regions of the city are repeatedly identified as homicide and drug trafficking hot spots. Based on the 10-year timeframe, it was found that a significant proportion of the areas with a high incidence of these two crimes are characterized by the high frequency of these activities.

It was also found that the covariables suggested by Ousey and Lee (2002) to identify pre-existing social conditions for the relationship between drug trafficking and homicides were strongly correlated with the areas with a higher incidence of these criminal typologies in Belo Horizonte. The overlap between the areas with the highest intensity of these social conditions and the areas with the highest criminal incidence is evident in the study area. Except for the hyper-center (an area with different dynamics from the others), there is a strong connection between the empirical data and the spatialization of data based on the authors' assumptions.

The research results contribute to the international observations on the theme, as well as supporting the development of better security plans for peripheral areas, where conditions come together so that the illicit drug market contributes positively to the incidence of lethality.

NOTE

1 -Conglomerates of homicides and drug trafficking in Belo Horizonte, Minas Gerais, Brazil, from 1995 to 1999

2- PREBLE, E. EI Barrio Revisited. Paper presented at the annual meeting of the Society for Applied Anthropology, 1980.

3 - Baumer (1994); Baumer et al. (1998); Cohen et al. (1998); Cork (1999); Riley (1998)

4- Ousey and Lee (2002) worked with the hypothesis that in the southern region of the United States there was a subculture of violence, which would collaborate as a driving factor in the rates of violence and, consequently, homicides.

5-GETIS, A.; ORD, J.K. Geographical Analysis, v. 24, n 3, 1992. ORD, J.K.; GETIS, A. Local Spatial Autocorrelation Statistics: Distributional Issues and an Application. Geographical Analysis, v.27, n. 4, 1995.

6- 186 favelas and slums and 23 popular housing estates implemented by the government, basically prior to 1993.

7- Available in: <http://portalpbh.pbh.gov.br/pbh/ecp/comunidade.do?evento=portlet&pIdPlc=ecpTaxono> : Accessed on 22 Aug. 2017.

8- GETIS, A.; ORD, JK Geographical Analysis , v. 24, No. 3, 1992 ..

9- ORD, JK; GETIS, A. Local Spatial Autocorrelation Statistics: Distributional Issues and an Application. Geographical Analysis, v.27, n. 4, 1995 ..

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