AN ANALYSIS OF VULNERABLE AREAS TO HOMICIDE IN A NEIGHBORHOOD
ANÁLISE DE VULNERABILIDADE A HOMICÍDIOS EM UM BAIRRO

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RESUMO

No Brasil, desde 2000, aproximadamente 50.000 pessoas são mortas todos os anos. Em 2012, a taxa de homicídios foi de 29 ocorrências por 100.000 habitantes. Em anos recentes, todos os estados brasileiros excederam o limiar de epidemia estabelecido pela Organização Mundial de Saúde. Neste sentido, este estudo propõe um modelo de decisão multicritério para identificar as áreas mais vulneráveis em relação a homicídios. Usou-se o método PROMETHEE II para agregar as variáveis e o índice de Moran para identificar as áreas mais críticas. Os resultados são mapas destacando dois tipos de clusters e dois outliers. Uma vez que se sabe onde as ações devem ser alocadas, a próxima tarefa é definir o que precisa ser feito, em um contexto preventivo. Fica claro que as estratégias integradas são a melhor opção para lidar com a vulnerabilidade - o esforço da polícia, o empoderamento da comunidade e a transformação do espaço urbano.

ABSTRACT

In Brazil, since 2000, approximately 50,000 people are murdered every year. In 2012, the homicide rate in Brazil was 29 homicides per 100,000 inhabitants. In recent years, all Brazilian states exceed the threshold of epidemic established by World Health Organization. In this sense, the present study proposes a multiple criteria decision model to identify the most vulnerable areas regarding homicides. We employed PROMETHEE II multicriteria method in order to aggregate the variables and we used local Moran's I to identify the most critical areas. The results are maps highlighting two types of clusters and two outliers. Since we know where the actions must be allocated, the next task is to define what need to be done, in a preventive context. It is clear that integrated strategies are the best option to deal with vulnerability – police effort, community empowerment, and transformation of urban space.

Palavras-chave: Public Security, Multiple Criteria Decision Aid, Geographic Information

Área: D&SP - PO em Defesa e Segurança Pública

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1. Introduction

Violent deaths in developing countries is a known and old problem. According to United Nations Office on Drugs and Crime (UNODC) (UNODC, 2013), the regions with higher homicide rates are Southern Africa, Central America, South America, Middle Africa, and the Caribbean – all of them with homicide rates above than 16 homicides per 100,000 inhabitants. Brazil has higher homicide rate than the most populous countries in the world such as China, India, United States, Indonesia, Pakistan, Nigeria, Bangladesh, Russia, Japan, and Mexico (Waiselfisz, 2013). Brazil is more similar to countries like South Africa according to its levels of violence (Breetzke, 2010).

The Brazilian scenario regarding homicides is alarming. Something needs to be done in order to change the present trend of homicide and try to decrease the homicide rate to an acceptable level. Of course, it is unreasonable to attempt to prevent all homicides, but something needs to be done to save the majority of the 50,000 lives that are being lost every year. We believe that the first step in order to combat homicides is a better understanding about the problem.

In this context, a multiple criteria analysis can be useful to identify the most vulnerable areas regarding homicides. The results may reveal significant insights about homicides and they should be taken into account in the development of new researches and in the elaboration of public policy. Since public resources are limited, some kind of prioritization is need to allocate them. In this paper, we propose a preliminary methodology to identify the most vulnerable areas in a neighborhood. Through this methodology, the neediest areas of public attention were highlighted. We used PROMETHEE II multicriteria method, considering six variables representing homicide vulnerability and a spatial analysis.

This paper is divided in five sections. The second section brings the literature review and the third section shows the methodology of this study. The following section presents the application of the methodology and the last section concludes this paper with the discussion and final remarks.

2. Literature review

Violence is a problem in all world, mainly in developing nations. Countries like Brazil have been trying to reduce their crime rates for many decades, with or without success. Brazil is far from be an example in public security, even though many programs have been applied all over the country. Therefore, there is a need of actions that are more efficient to combat and prevent crimes. However, it is not only a question of which are the best actions, we also need to define where the actions should be allocated.

Araújo Júnior & Fajzylber (2001) affirm that criminality is a social, economic, and political problem that needs to be faced. It is social because it affects directly quality of life and life expectancy. It is economic because it limits the economic development of a place. Finally, it is political because the actions to deal with criminality involve a large participation of governments and allocation of public resource.

It is impossible for a government improving police coverage, social conditions, or economic factors in an entire city or state, for example. The resources to managing a place are limited, so some kind of allocation have to be made, to direct the funds. For instance, Curtin et al. (2005) assert that a good allocation of limited resources (considering police) may help in reducing response time and saving money, without affect the level of attendance.

Therefore, the allocation of public resources is a relevant task. Due to this importance, we need to guarantee the transparency and efficiency of the process. The opinion of a decision maker (mayor or manager, for instance) is crucial on this problem, but the decision process also needs a formal methodology. The decision maker will contribute with his knowledge and preferences, because he knows about the dynamics of the problematic. On the other hand, the formal approach can help the expert to consider massive data or many viewpoints, for example. Therefore, the junction of decision makers and structured models seems a good option to allocate public resources.

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Many works were written in this context, employing different techniques. Hirschfield & Bowers (1997) developed a tool to analyze area profiles, showing applications in Merseyside (England). These authors confirm that spatial variations of crime may be explained by several factors as demographic, social, cultural, lifestyle, and land use characteristics. Due to this fact, an approach involving more information can be more advantageous than hotspots considering only past crimes. Therefore, they developed the software "profiler", that is a demographic, land use, and crime risk profiling system. Through this system, it is possible to address singular insights, as the identification of disadvantaged areas and the effects of surroundings.

The paper of Caplan and colleagues (2011) shows the use of Risk Terrain Model to forecast crimes of shooting. They assert that, usually, police agencies do crime analysis by simple density maps, indicating a reactive attitude. However, an alternative would be to consider factors that increase or decrease the propensity to crimes. Through Risk Terrain Modeling, one is able to consider many factors to assess risk and the result is a map showing the places with highest risk. They made an application in the community of Irvington (New Jersey), considering dwellings of known gang members, locations of retail business infrastructure, and locations of drug arrests. One of the conclusions of Caplan et al. (2011) is that "the identification of risky areas permits public safety practitioners to intervene and allocate resources to reduce risk".

Gurgel & Mota (2013) also suggest a substitute approach to the police occurrences model: a multicriteria method, SMARTS. Their procedure is aimed to suggest a structured methodology to identify zones that are in greater need of public actions. They considered population density, population growth, percentage of population living in bad conditions, human development index, income concentration, and degree of police occurrences to order the zones. An application was made in a Brazilian context and they concluded that their model can be useful to public planning: "it may help to improve the management of public safety and to reduce violence.".

A study was conducted by Camacho-Collados et al. (2015) with the objective of design patrol sectors. They tried partitioning the territory in Madrid in the best possible way, considering a multicriteria approach. The model includes the following attributes: area, support received, demand, diameter, area ratio, isolation ratio, demand ratio, and diameter ratio. The primary necessity of the model was to create districts as efficient and homogeneous as possible. Camacho-Collados et al. (2015) affirm that their algorithm generates patrolling configurations that are more efficient than the current one.

Recently, Bogomolov and colleagues (2015) published a study employing hotspot classification, but considering additional information. They considered demographic factors and people dynamics features, in order to identify places more or less likely to become crime hotspots. The 124,119 small cells of London Metropolitan Area were classified as high or low crime level in the next month (a dichotomic classification). The authors affirm that their model has an accuracy of almost 70 percent, so the junction of aggregated and anonymized data collected by the mobile infrastructure and demographic information seems to be useful to evaluate crime levels. Bogomolov et al. (2015) affirms that their "proposed approach could have clear practical implications by informing police departments and city governments on how and where to invest their efforts and on how to react to criminal events with quicker response times.".

Figueiredo & Mota (2016) developed a Geographic Information System - Multicriteria Decision Making model to evaluate security level in a Brazilian context. They applied Dominance-Based Rough Set Approach to classify areas into five security levels, considering income, Gini index, infrastructure, education, and demographic density. Figueiredo & Mota (2016) affirms that this method does not require a high cognitive effort from the decision maker, making the process easier.

We know that there are many papers written in this context, but these five examples already show the concern of identifying most critical areas. Moreover, one can observe that this evaluation should be made considering additional information, instead of only past occurrences. This comprehensive approach to identify critical areas is valuable for public planning, because it helps in the task of allocating resources. Therefore, this is the objective of this paper.

3. Methodology

The objective of this study is to answer the following question: which are the most vulnerable areas to homicide in a neighborhood? To answer the research question, we employed a multiple criteria analysis and a spatial analysis. Our expectation is to suggest a useful methodology to identify the most vulnerable areas to homicide.

Our analysis contributes to the identification of vulnerable areas in three distinct ways: (1) it is not only a mathematical approach, because it can consider the preferences of a decision maker; (2) it takes into account many criteria, even allowing conflicting criteria; and (3) it considers the vulnerability of the surroundings.

The application was made in a neighborhood in Recife, Pernambuco, Brazil. This neighborhood is located along the beach and marked by its heterogeneity, related to land use and living standard of population. The area is mixed – there are many households, residential and commercial buildings, leisure areas, touristic points, malls, and stores. In addition, social and economic patterns of the population can be very distinct – it is possible to find luxurious buildings and slums. The neighborhood is 7.53 square kilometers in size, representing only 0,274% of Recife's territory. The neighborhood has 42,272 households and its population was approximately 123 thousand people in 2010 (IBGE, 2015). The average mensal income per household is R$ 7,108 (approximately $2,090).

To perform our analysis, we used as spatial units the census tracts (CT). Census tracts are the basic territorial units of the demographic census, defined by Brazilian Institute of Geography and Statistics. The neighborhood of study has 168 census tracts. The census tracts were chosen because they are the smallest territorial unit available in the demographic census with reliable data.

For our analysis, we used demographic, social, and economic variables representing each census tract. These data were obtained from the demographic census of 2010 (IBGE, 2015). The Brazilian Institute of Geography and Statistics publishes these data every ten years. The dataset can be downloaded at http://censo2010.ibge.gov.br/.

We used Visual PROMETHEE Academic Edition and ArcGIS 10.2 to perform this study.

4. Application

We selected six variables based on the paper of Pereira et al. (2017) to measure vulnerability. Therefore, the variables are: number of residents (density), percentage of literate people (5 years old and older) (education), logarithm of average income (income), logarithm of standard deviation average income (inequality), percentage of households with public illumination (illumination), and percentage of rented households (rented houses). These variables were used as criteria within PROMETHEE II.

Census tracts were considered as alternatives – therefore, this problem has 168 alternatives. A decision maker must define some parameters for the method. Here, we used a fictitious decision maker, in order to show the usability of this approach. In a real application, the decision maker can be a public agency manager or a mayor, for example. The parameters considered are shown in Table1.

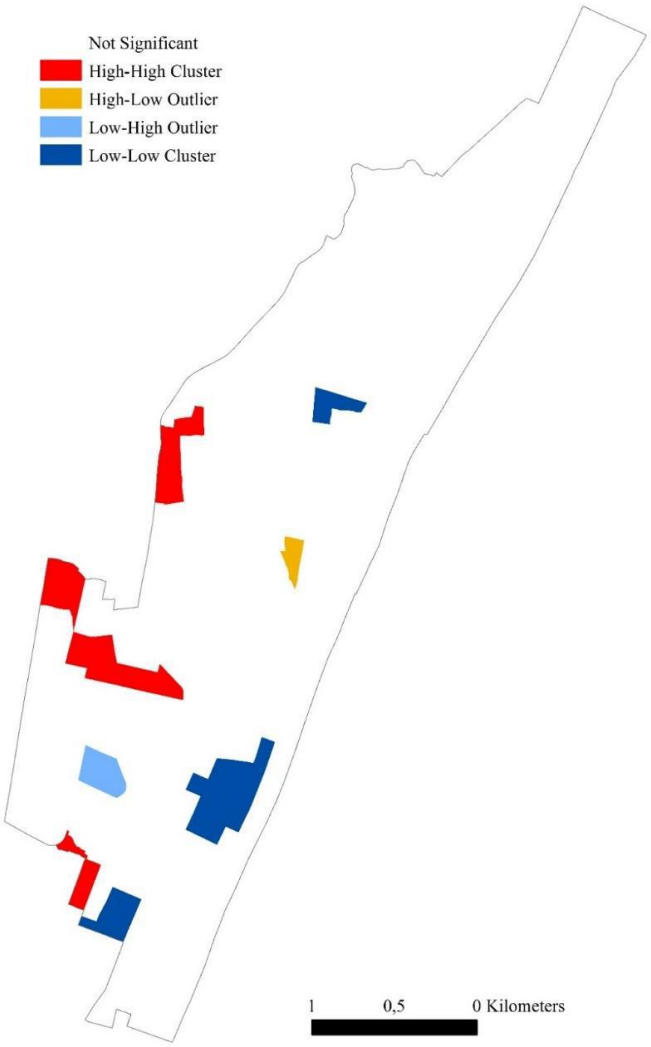
Table 1: Parameters for PROMETHEE II

	Income	Inequality	Education	Density	Illumination	Rented houses
Weight	0.25	0.20	0.18	0.10	0.10	0.17
Preference function	U-shape	U-shape	U-shape	U-shape	U-shape	U-shape
Threshold type	Percentage	Percentage	Percentage	Percentage	Percentage	Percentage
Threshold q	10%	10%	10%	10%	10%	10%

We applied PROMETHEE II in all census tracts. Therefore, the result is a complete order of all 168 census tracts – the first one is the most vulnerable. The highest net flow is 0.4793,

while the lowest is -0.2974. After, we used the net outranking flows of each census tract to measure local Moran's I. We used Cluster and Outlier Analysis tool from ArcGIS to assess Local Moran's I.

This tool is able to show four different types of spatial association: high-high (HH) (area with high value surrounded by areas with high values – hot spots), low-low (LL) (area with low value surrounded by areas with low values – cold spots), high-low (HL) (area with high value surrounded by areas with low values – outlier), and low-high (LH) (area with low value surrounded by areas with high values – outlier). Figure 1 shows the results regarding homicide vulnerability.



The use of local Moran's I is important to considerate the surroundings of each census tract. We cannot consider a census tract in an isolated manner, because the vulnerability of a neighbor may affect an area. Andresen (2015) asserts that this tool can bring significant insights, since it is a more sophisticated technique able to identify four types of clustering. In his work, Andresen (2015) compares kernel density and local Moran's I, considering many crime types.

5. Discussion and conclusion

In this work, we presented a method to identify the most vulnerable areas toward homicides, which is an important task to better allocate the scarce public resource. We opted to use a multiple criteria method to prioritize areas – this approach is interesting

because it permits the consideration of many factors and the preference of a decision maker. Therefore, this approach is able to combine subjective judgments and math. In our case, we employed PROMETHEE II method to rank some areas of a neighborhood, considering vulnerability to homicides. Moreover, we performed a spatial analysis, since the surroundings are relevant because a vulnerable area can affect its neighbors (because of crime displacement, for example).

Since we know where the action must to be allocated, the next task is to define what need to be done. It is clear that integrated strategies are the best option to deal with vulnerability – police effort, community empowerment, and transformation of urban space. Each initiative will contribute in a particular manner and the synergy of them may make the difference.

About the actions against crimes, we can discuss about the fortification of the population, social cohesion, and urban transformations – these initiatives can cause deep changes in communities, conducting to a reduction on criminality. The actions may not present an immediate effect, but the consequences may be efficient and profound. Since the population is experiencing better life conditions, the illicit activities may look less attractive. Violent places around the word transformed their scenarios with good management and commitment of the population; therefore, we can believe that it is also possible in developing countries.

Moreover, this study may help in the definition of policies somehow, since it suggests a structured approach to identify the most vulnerable areas in a city. This kind of analysis may be relevant to public decision makers, since the resources to prevent and combat criminality are scare. Our study proposes a methodology to prioritize areas, considering many factors and decision maker preferences. In this way, the allocation of public resources may be more rational, comprehensive, transparent, and efficient. Therefore, the multiple criteria analysis can bring implications to policies, since it offers a way to identify disadvantaged areas.

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