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Determinants of homicides in the state of Bahia, Brazil, in 2009

Determinantes dos homicídios no Estado da Bahia, Brasil, em 2009

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ABSTRACT: *Purpose:* To carry out a study of association between socioeconomic and demographic factors and homicides in general population, in the state of Bahia, in 2009. *Methods:* This is an ecological study. The data were collected from the database of the Information System about Mortality of the Ministry of Health, from the Brazilian Institute of Geography and Statistics and the Institute of Applied Economic Research. The Global Moran index was calculated for the detection of spatial autocorrelation, and the Local Moran index was calculated for the detection of spatial Clusters. The transformation in the variable answer (homicides rates) was performed and it was shaped using the Conditional Autoregressive Model. *Results:* The data showed spatial autocorrelation. Two clusters of municipalities with high rates of homicides were identified, one located predominantly in the Greater Metropolitan Region of Salvador and the other in the South Region of Bahia, especially Eunápolis and Lauro de Freitas, which had the highest rates. The Average Residents Variables, local GDP and the Percentage of Illiteracy presented an inverse association with homicide rates, and the variables Firjan's municipal development index of work and income. Enrolment in high school and the Average of Bolsa Família were directly associated. *Conclusions:* The urbanization process, in most cases, not controlled by the State, in most cases, made the cities bigger and with better socioeconomic conditions, attraction centers for people with different socioeconomic levels, increasing the social inequality among the residents of these regions, with parallel increase in homicide rates.

Keywords: Violence. Epidemiologic factors. Residence characteristics. Statistical analysis. Spatial analysis. Socioeconomic factors.

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RESUMO: *Objetivo:* Realizar estudo de associação entre fatores socioeconômicos e demográficos e homicídios na população geral, no estado da Bahia, em 2009. *Métodos:* Trata-se de um estudo ecológico. Os dados foram coletados da base de dados do Sistema de Informações sobre Mortalidade do Ministério da Saúde, do Instituto Brasileiro de Geografia e Estatística, e do Instituto de Pesquisas Econômicas Aplicadas. Foi calculado o índice de Moran Global e foi calculado o índice de Moran Local para a detecção de clusters espaciais. Realizou-se a transformação na variável resposta taxa de homicídios, e a mesma foi modelada utilizando o modelo autorregressivo condicional. *Resultados:* Os dados apresentaram autocorrelação espacial. Foram identificados dois conglomerados de municípios com altas taxas de homicídio, um localizado predominantemente na Região Metropolitana de Salvador e o outro na região do Sul Baiano, com destaque para Eunápolis e Lauro de Freitas, que apresentaram as maiores taxas. As variáveis Média de Moradores, Produto Interno Bruto municipal e Percentual de Analfabetismo apresentaram associação inversa às taxas de homicídio, e as variáveis Índice Firjan de Desenvolvimento Municipal – trabalho e renda, Matrícula no Ensino Médio e Média do Bolsa Família apresentaram associação direta. *Conclusões:* O processo de urbanização, na maior parte das vezes, não controlado pelo poder público, tornou as cidades maiores e com melhores condições socioeconômicas, pólos de atração de pessoas de diferentes níveis socioeconômicos, aumentando a desigualdade social entre os habitantes dessas regiões, havendo paralelamente, aumento das taxas de homicídio.

Palavras-chave: Violência. Fatores epidemiológicos. Distribuição espacial da população. Análise estatística. Análise especial. Fatores socioeconômicos.

INTRODUCTION

External causes ranked third in overall mortality in Brazil in 2007, and homicide accounted for 36.4% of these deaths[1]. Moreover, this group of causes is also significant in hospitalizations, representing 8.6% of hospital admissions for all causes in the country in 2011, and with about 5.0% higher cost than other causes[2].

Compared to other World Health Organization (WHO) member countries, Brazil was ranked sixth in the ranking of homicide mortality rates in 2005, with 25.8 deaths per 100,000 inhabitants. Compared to other Latin American countries, only El Salvador and Colombia had higher rates, with 50.1 and 45.4 deaths per 100,000 inhabitants, respectively. In general, European countries like France, Germany and Spain presented much smaller rates, bellow 1.0 deaths per 100,000 inhabitants, which also occurs in countries like Japan and Australia[3].

By analyzing the deaths by homicide in Brazil, one can notice an increase in rates until 2003, and a subsequent fall, which was not consistent[2]. In the following years, the observed decline has been due to the decrease in homicides, especially in the state of São Paulo, between 1999 and 2007, which represents a decrease of 65.0% in this rate[4]. In contrast, the rates in the North and Northeast regions showed an increase in this period. The latter region had greater proportional growth (10.5%) compared to the whole country, from

8,739 deaths by homicide (20.0% of the total deaths) in 1997 to 15,432 deaths (31% of total homicides in Brazil) in 2007[2].

The State of Bahia exemplifies this trend by presenting a sharp rise in homicide rates, which increased from 15.6 per 100,000 inhabitants in 1997 to 25.8 per 100,000 inhabitants in 2007, showing the state's importance in the context of social violence in the region and, consequently, in Brazil. During this period, the percentage of deaths by homicide in the state of Bahia, in relation to all deaths by homicide in the Northeast region, increased from 22.64% in 1997 to 23.51% in 2007, and the state's percentage of deaths by homicide in relation to Brazil increased from 0.47 to 1.09% during the same period.

Given the importance of this phenomenon in the country and in the Northeast region, this study aimed to examine possible associations between socioeconomic and demographic variables and homicide rates in the state of Bahia, in 2009. The study is relevant, as the literature indicates discrepancies between the findings of studies that seek to associate variables or socioeconomic and demographic factors to deaths by homicide[5,6]. This not only indicates the existence of gaps in knowledge regarding the importance of these variables in determining homicides, but especially in the way they act and interact[7].

Another issue that arises is the unit of analysis in these studies, for most of them[8,9] refers to municipalities, with few focusing on the federative unit and comparing similarities and differences between their municipalities. In addition, only a few of them perform spatial data modeling, being restricted most of the times to describing and spatially identifying regions with high and low risk of death by homicide.

METHODS

STUDY DESIGN AND VARIABLES

This is an ecological study, which aimed to evaluate the associations between socioeconomic and demographic variables and homicide rates in 2009 in the State of Bahia. The outcome variable is the rate of deaths by homicide per 100,000 inhabitants for each municipality, which was calculated by dividing the total number of homicides of Bahia residents, recorded in each municipality in the state, for the total estimated for each of the 417 municipalities.

The number of homicides and the population per municipality were extracted from the Brazilian Ministry of Health's Mortality Information System (SIM/DATASUS). Homicides, according to Chapter XX of the International Statistical Classification of Diseases and Related Health Problems, 10th Revision of November, 2006 (ICD-10), classified as "External Causes of Morbidity and Mortality", grouping X85-Y09, are given the generic title of Aggressions, and the population used was the one estimated for the year of 2009.

In the state, with variations between municipalities, it was observed that, in recent years, after the growth of deaths by homicide, the growth of the death classification group categorized as "external causes of undetermined intent" also occurred. It is noteworthy

that the increase in this group, whose intentionality is unknown, affects the strength of the associations. In the present study, it is considered that its growth may have reduced the magnitude of the observed associations, given that several studies[6,10] have shown that a portion of the "undetermined intent" death classification group is composed of homicides.

Exposure variables, according to the theoretical model proposed in the literature[5,11,12], are of the socioeconomic and demographic type. Data were collected from the Brazilian Institute of Geography and Statistics (IBGE)[13] and the Institute of Applied Economic Research (IPEA)[14]. The variables collected by IBGE are reported below:

- Demographic Density – The ratio between the total resident population and area of the municipality, in 2010 (inhabitants/km²);
- Percentage of the population aged 15 to 24 years – People between 15 and 24 years compared to the total population, in 2010;
- Average of residents per household – Sum of the number of residents per private, permanent households, divided by the number of private, permanent households;
- Proportion of poor – is the ratio between the number of individuals with per capita family income below 50% of the minimum wage relative to the total sum of all individuals with per capita family income in all income brackets, in 2010;
- Percentage of illiteracy – Percentage of people aged 15 years and older, who cannot read and write a simple note, in the language they know, in the total resident population of the same age group in a given geographical area, in 2010.

Variables collected from IPEA and their definitions are as follows:
- Average receipt of *Bolsa Família* – Sum of the total value of the benefit received, divided by the number of benefits received in 2010;
- Municipal Gross Domestic Product (Municipal GDP) – Sum of all goods and services produced by the municipality in 2008;
- Number of students enrolled in high school – Total enrollment in high school in the municipality in 2010;
- FIRJAN Municipal Development Index (IFDM) on education - Varies from 0 to 1. The closer to 1, the greater is the development. It considers the following information: tuition in early childhood education, dropout rate, age-grade distortion rate, percentage of teachers with higher education, average of daily hours in class and the result of IDEB (Basic Education Development Index). Its source is the Brazilian Ministry of Education, and refers to each municipality in 2007;
- IFDM on employment and income – Varies from 0 to 1 The closer to 1, the greater is developing. It considers the following information: formal employment generation, formal employment stock and average wages in formal employment. Its source is the Brazilian Ministry of Labor and Employment, and data were collected for each municipality in 2007.

DATA ANALYSIS

Because the data are spatially localized, i.e., from the municipalities of the state studied, the possible importance of their spatial arrangement in the analysis was considered[15].

Exploratory and descriptive data analyses, as well as exploratory spatial data analyses, were performed in order to observe the behavior of homicide rates in the space. To this end, shaded maps were used to detect possible municipalities with an excess of the issue under study. Digital meshes containing scanned maps of the municipalities of Bahia were downloaded from the IBGE site, and the software used to analyze the damage was R[16], version 2.14.0, as well as Spdep, xlsx, maptools, spatstat, foreign and RcolorBrewer libraries.

Another way to view the spatially located data is through smoothed maps that re-estimate the rates of the issue according to the behavior of their neighbors. This study used the Global Empirical Bayes estimator, which re-estimates homicide rates in each municipality by making use of a global average[15].

This re-estimation process considers the population size of each municipality, making the largest corrections in municipalities with smaller populations. The criteria used to establish the neighborhood between the municipalities was the connectivity between the borders, i.e., given two towns, I and J, they are neighbors if they share at least one side in common.

To test the hypothesis that there is a spatial correlation between the data, we used the Moran Index[17], which checks for spatial independence. The Local Moran Index[17] was used to detect spatial patterns of the issue, seeking, locally, the existence of municipalities clusters with similar behavior regarding homicide rates.

For the data modeling, the Conditional Autoregressive Model (CAR) was used for the transformed outcome variable. The Global Empirical Bayes estimator was applied to the rates and, sequentially, the log was applied to the re-estimated rates, in order to obtain data normality[15].

The CAR model is expressed by $Z = X\beta + \varepsilon$, with $\varepsilon = \lambda W_\varepsilon + \xi$, where W_ε is the error component with spatial effects, λ s the autoregressive coefficient and ξ is the error component with constant and uncorrelated variance[15].

The variables were tested individually, in order to assess which of them would be initially incorporated into the model, and they were later tested jointly, to assess the effects when they were in the presence of each other, as a way of control. Thus, they were removed from the model one by one, first the least significant (at a significance level of 10%) and so on, until only the significant variables were left in the model. The use of a significance level of 10% in the initial stage of the study sought not to delete variables that could prove significant in the joint analysis, aiming to expand the analysis possibilities.

To assess the quality of the adjusted model, the graphical analysis of the residuals was made, searching for signs of violation of the independence assumptions. For a quantitative test, the Moran's I index was used on the residuals[18].

RESULTS

In 2009, of the 5,210 homicides recorded in the state of Bahia, in 4,876 of them, the victim was male, representing 93.6% of deaths; and 334 cases involved females (6.4%). The most affected age group was 15 – 24 years old, which totaled 2,374 deaths (45.5%), followed by the 25 – 34 years old group, with 1,592 cases (30.5%). These data show a profile known from other studies[19,20], in which young males are the main victims of homicides.

It is noteworthy that of the 417 municipalities in the study, 112 (26.8%) presented number, and consequently a homicide rate, equal to zero.

Figure 1 shows the distribution of homicide rates in the space, in which the colored bar represents the value of homicide rates. Therefore, the municipalities represented by the lighter color present lower rates, while those with a darker color are the ones where rates are the highest.

You can clearly see the existence of spatial concentration of homicide rates: coastal municipalities have the highest values, while inland municipalities have the lowest values. The smoothing of the rates further highlights this phenomenon, since municipalities with initially high rates showed lower rates after smoothing, such as some municipalities in the Northern Bahia.

The Moran Index, which assesses the existence of a spatial structure, obtained the value 0,49 (p < 5%), indicating a direct correlation between the observations and corroborating the hypothesis of spatial correlation, observed in the graphical analysis of homicide rates.

Figure 2 shows the Local Indicator of Spatial Association (LISA), which highlighted the existence of spatial clusters, i.e., in the metropolitan region of Salvador, as well as in
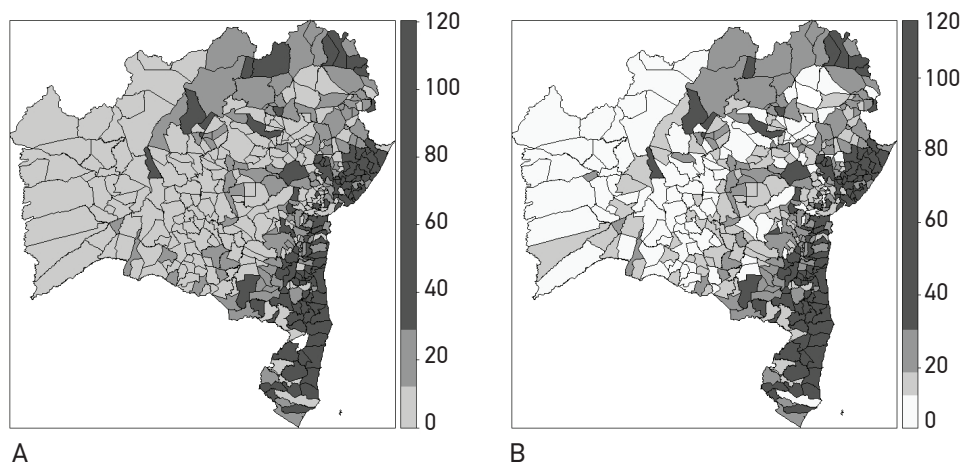

Figure 1. Map of homicide rates (per 100,000 inhabitants) in Population (A) and smoothed homicide rates according to behavior of neighbors (B) in the municipalities of the state of Bahia in 2009.

the southern region of the state, around Itabuna and Porto Seguro, homicide rates follow a pattern of interpersonal violence that spread among neighboring municipalities.

Table 1 shows twenty municipalities belonging to these two clusters, where homicide rates in the general population are higher.

The twenty municipalities presented are responsible for 3,021 deaths by homicide in the state of Bahia, which represents 87% of all deaths by homicide in the 417 municipalities of the state, especially the city of Salvador, with 1,837 deaths by homicide, which represents 53% of cases among the total number of deaths due to homicide.

On the other hand, of the first five municipalities with the highest homicide rates, three of them are located in the middle region of the Southern Bahia, which certainly presents itself as a potentially increased risk of death by homicide when compared to other regions of the state, mainly inland regions. The municipalities located outside the clusters have an average rate of 13.32 deaths per 100,000 inhabitants, well below the average of 54.55 deaths per 100,000 inhabitants of the municipalities that make up the cluster.

The individual data modeling, in which the transformed variable homicide rate was used (normality obtained and verified at 3%) resulted to be significant for all exposure variables. In the multivariate modeling stage, the following variables were not significant: Demographic Density, Percentage of Young Inhabitants, Percentage of Poor Inhabitants and the IFDM on education.

Table 2 shows the results of the modeling with regard to the other variables, jointly adjusted in the model. The variables are the following: Average of Residents per Household, Municipal GDP and Illiteracy Rate, which showed an inverse association with mortality by homicide. On the other hand, the variables IFDM on Work and Income, Average Receipt of *Bolsa Família* and Enrollment in High School were positively associated with the rate of mortality by homicide.
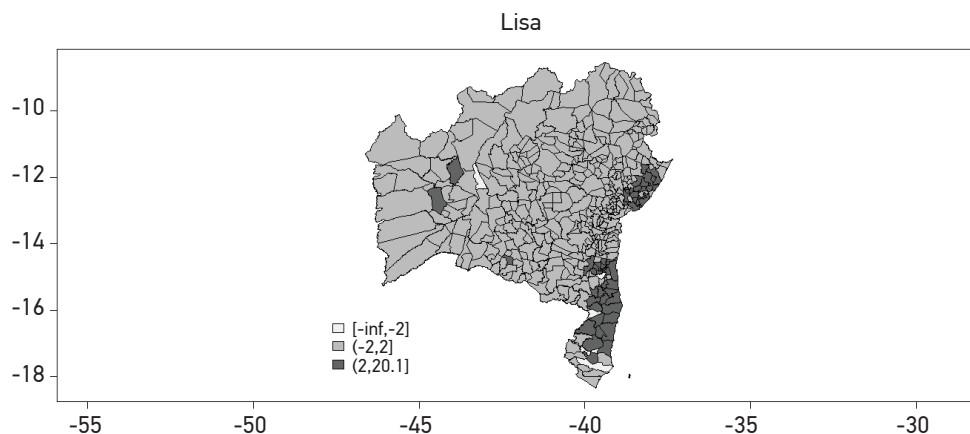

Figure 2. Local Indicator of Spatial Association to detect spatial clusters of homicide rates (per 100,000 inhabitants) in municipalities in the state of Bahia, in 2009.

The diagnosis of the adjustment of the model indicated that the presence of a spatial autocorrelation in homicide rates was contemplated and handled properly by the methodology, for the Moran Index applied on the residuals was approximately zero, with p = 0.741.

Table 1. Homicide rates (per 100.000) of the twenty municipalities with higher rates, which make up the two clusters identified in the study, in the municipalities of Bahia in 2009.

Name of Municipality	Name of Mesoregion	Name of Microregion	Homicide Rate
Lauro de Freitas	Metropolitan Salvador	Salvador	105.1
Simões Filho	Metropolitan Salvador	Salvador	83.1
Amélia Rodrigues	Metropolitan Salvador	Catu	77.8
Dias d'Ávila	Metropolitan Salvador	Salvador	65.8
Salvador	Metropolitan Salvador	Salvador	61.3
Cardeal da Silva	Northeastern Bahia	Entre Rios	104.4
Araças	Northeastern Bahia	Alagoinhas	65.5
Alagoinhas	Northeastern Bahia	Alagoinhas	63.9
Eunápolis	Southern Bahia	Porto Seguro	120.5
Porto Seguro	Southern Bahia	Porto Seguro	93.6
Itabuna	Southern Bahia	Ilhéus-Itabuna	89.9
Canavieiras	Southern Bahia	Ilhéus-Itabuna	86.4
Ibicaraí	Southern Bahia	Ilhéus-Itabuna	77.3
Teixeira de Freitas	Southern Bahia	Porto Seguro	73.3
Itapebi	Southern Bahia	Ilhéus-Itabuna	66.6
Ilhéus	Southern Bahia	Ilhéus-Itabuna	64.3
Itajuípe	Southern Bahia	Ilhéus-Itabuna	63.4
Coaraci	Southern Bahia	Ilhéus-Itabuna	62.9
Almadina	Southern Bahia	Ilhéus-Itabuna	60.4
Mascote	Southern Bahia	Ilhéus-Itabuna	60.3

Table 2. Estimate, Standard Deviation, Statistics z and p-value of the variables used to predict transformed homicide rates.

Variable	Estimate	Standard Deviation	z-value	p-value
Intercept	2.82	0.7668	3.6251	0.0002
Average of Residents	-0.63	0.1443	-4.3782	0.0001
IFDM on Work and Income	1.27	0.2523	5.0263	0.0001
Municipal GDP	-0.01	0.0001	-2.3249	0.0200
Average of *Bolsa Família*	0.02	0.0080	2.5504	0.0107
Enrollment in High School	0.01	0.0002	5.2043	0.0001
Illiteracy Percentage	-0.01	0.0002	-2.9874	0.0028

DISCUSSION

The study enabled the discovery of clusters of homicide rates in the vicinity of the city of Salvador and in municipalities of the southern region of the state of Bahia. These areas are places with higher economic dynamic, and are characterized as tourist areas, which attract a working population, resulting in high population density. However, this variable was not significant in the final model.

The associations were: positive between homicides and IFDM on work and income, and a negative between homicides and municipal GDP. This finding seems to indicate that income or wealth alone is not enough variables to explain the occurrence of homicides. Several authors[21,22], emphasize that such violence would be more related to inequality than poverty. In Brazil, the richest 10% hold 45% of the country's wealth.

Latin American countries are the ones that experience the greatest inequalities in the world, and that may be the reason why they present high homicide rates. In contrast, in countries in Africa, with high percentages of poor people, and in Europe, where inequality is lower, the picture is reversed, and they present low rates of these events.

Increased and unplanned urbanization has also been implicated as a determinant factor for homicides. In this study, an inverse association was observed between Illiteracy Rates and Average of Residents per Household and homicide rates. Unlike the population density, which evaluates how much the municipality is urbanized, the average number of residents per household addresses the family composition. In this sense, family composition seems to act as a protective factor for homicide in inland cities, which has the highest average number of residents per household.

A recent survey, published by IBGE, has shown that fertility rates in inland cities in the states are higher than those in larger municipalities.

Inverse relationship between the rate of illiteracy and homicides was also found. One hypothesis that could be thought of in relation to this finding is: municipalities with the highest percentage of illiteracy are the poorest, which present a lower GDP compared to other municipalities in the state, and in turn, they do not constitute as a place of interest for criminal actions.

There was a direct association between homicides and enrollment in high school. Previous studies[11] indicate that enrollment in high school would be a protective factor for deaths by homicide. However, this association was not assessed jointly in the presence of the other study variables. It is also important to note that this variable does not measure school attendance, nor is compared with the total of young people in each municipality, i.e., it is not possible to observe the percentage of school-age children who are regularly enrolled, and school attendance of these children.

The direct relationship between the Average Value Received by the *Bolsa Família* Program and homicides suggests that the areas that receive the highest average values are those that have more social protection resources, i.e., greater coverage of social protection bodies, as well as those which are socially vulnerable.

Epidemiological studies diverge when it comes to associating socioeconomic variables with homicide rates. Some studies[5,12] found a positive association between homicides and the variables that measure improved living conditions, as in the present analysis. One factor that has also been mentioned[12] is unplanned urbanization, leading to high rates of homicide.

It should be underscored that one limitation to this study is the limited availability of access to free data that enable greater understanding of the violent processes. To this end, it would be important to have Public Safety information on firearms and drugs, as well as the monitoring and dissemination of social actions related to the promotion of peace and prevention of violence that could be provided by the municipalities.

Thus, the issue in question has generated a wide range of hypotheses to be verified. In other studies[4,23], it was found that investments in the areas of Public Security and Education are explanatory factors for the decrease in homicide rates in São Paulo. Therefore, one should evaluate the investment currently applied in these areas as a possible beginning of a process to reverse the increase in homicides in the state of Bahia.

Also shown as good alternatives to the problem are successful examples, such as the cities of New York[4], United States, and Cali[24], Colombia, where the reduction in crime rates was initiated with a comprehensive plan for the prevention and repression of even the simpler criminal attitudes, as well as actions to guide communities on the importance of its relationship with the physical space, preserving plazas, monuments, keeping the streets clean and lessons on civism in schools.

CONCLUSION

By using the spatial analysis model, it was possible to assess the existence of associations between variables studied and homicides, given the assumption of controlling the effect of spatial autocorrelation in these associations. But the findings also indicate that the explanations for this phenomenon are complex and need to be better understood.

This study corroborates the findings obtained in several national[5,12] e and international[25,26] studies, which point to the need for systematically reducing social inequality in cities with high homicide rates.

It is important to highlight some limitations of this study, such as the lack of more detailed information about the municipalities that enable the understanding of violent processes. Another limitation relates to the fact that the information is aggregated in the municipality's unit of analysis, making it impossible to capture existing differences within municipalities.

Moreover, this is an ecological study, and its results cannot be explained at an individual level[27]. It is also necessary to point out that the quality of information available in secondary databases is characterized as another limitation of the studies.

It is worth remembering that violence is a social phenomenon that is part of human history, and it assumes specific features according to time and place[28]. Thus, we are far from any definitive solutions to the problem, with any measure adopted being seen as a challenge to the government and civil society, in order to jointly seek auspicious results.

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