Geostatistics in criminology:

A spatial analysis of drug dealing in Mexico City

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A bit of context

Drug dealing in Mexico City [3]:

- Increase of 127.6% from 2017 to 2018.

- Became the eighth federal entity with the highest rate per 100,000 inhabitants in 2019, and the ninth in 2020.

There is a need to identify:

- Geographical areas in which this problem is most prominent

- Geographical areas in which drug dealing might be associated to other crimes so that local authorities, law enforcement and other relevant stakeholders are able to make informed decisions.

Mexico has seen a concerning increase of drug consumption in recent years, characterized by early use among youths and the lack of addiction treatment programs, especially for populations at risk, such as youths in prison [2] .

Organized crime

Crimes committed by groups of people that conspire together to carry out an illicit business [4].

Crimes associated to organized crimes mostly fall into one of two notions[5]:

- As criminal activities conducted by organizations with profit as the main goal

- As systematic criminal activities run by stable organizations.

According to the definition of the Federal Law Against Organized Crime, these crimes include among others:

Crimes against health in the form of drug dealing	Collection and arms trafficking
Robbery or theft of vehicles	Kidnapping

The following have also been associated to an increase in organized criminal activity

Intentional homicide	Extortion

Drug trafficking and drug dealing

- Understand the dynamics taking place within the supply chain of drug markets, which includes the production, distribution, commercialization and consumption of drugs [1].

- Understanding drug trafficking at the global level remains a complex task due to the variability found in illegal markets, which depends on region, drug type, commercial activity undertaken, among others. [1]

- Drug dealing: one of the last links in the supply chain of drug trafficking in Mexico. Differentiated from high-scale trafficking in the sense that the buyers are the consumers of the product [7].

Challenges

Lack of historical, disaggregated, and actualized official data on criminal groups and their modus operandi, drug users, drug types and prices, drug seizures, etc.

Reliance on data obtained through journalistic works, field work and published statistics on crime reports (not the actual number of crimes committed, see dark figure).

Research approaches to drug dealing

Main criminological theories and approaches covered by researchers [12-14]:

Rational choice theory

Routine activity theory

Social disorganization theory

The commission of drug dealing results from the conjunction of **high-reward, low-risk choices** from both buyer and seller, plus the characteristics of the environment that favor this illegal trade.

In Mexico City:

- Any place is potentially viable to sell and buy drugs such as marihuana, cocaine and crack, such as grocery stores, houses, apartments, or housing units [13].

- A network of commercial relations brings together the seller and buyer [18].

- Three modalities describe the selling points at which they meet: fixed (grocery stores or 'tienditas', other small business premises), semi-fixed (public spaces and events), and ambulatory (on the street) [18].

Data-driven approach to analyzing drug dealing

Spatial study of crime

- •Identify the characteristics and interrelations of the places and behaviors of the actors involved, such as drug buyers and sellers.

- •The geographical variability of criminal behavior can be subsequently quantified and predicted [18].

- •Spatial statistical methods have been used in this context to analyze the distribution of crime incidents and their relationship with other environmental factors found in the study area.

Previous studies

- • In the Cuauhtemoc borough of Mexico City, drug dealing presented clustering in places where commercial activity, local socioeconomic issues, and political negligence are present [24].

- • Evidence suggests that drug dealing is geographically static or strongly congregated in certain neighborhoods [24].

Study approach to drug dealing

- Study the spatial distribution of drug dealing (for the purpose of sale) at the neighborhood level from 2019 to 2020 and as part of Mexico City's market for illegal drugs.

- Identify the clusters in neighborhoods with reported drug dealing crimes, and to visually compare these before and after the start of the COVID-19 pandemic to know how this event affected the patterns of drug dealing in the city.

- Analyze the spatial relationship between drug dealing (for sale purposes) and the following crimes associated to organized crime: illicit carrying of firearms, intentional homicide, extortion, kidnapping, as well as drug dealing (simple possession).

Exploratory questions

In what neighborhoods does the spatial distribution of reported drug dealing show clustering?

What were the changes in the spatial distribution before and after the start of the COVID-19 pandemic, in 2019 and 2020?

Is there a positive spatial correlation between reported drug dealing and other crimes associated to organized crime?

Methodology

Spatial units

- Neighborhoods. Given the endemic and static qualities of drug dealing in Mexico City's neighborhoods [24], these represent suitable units of analysis.

Data collection

- General Attorney's Office of Mexico City: georeferenced crime reports of 2019 and 2020.

- Open data of Mexico City: shapefiles of the administrative divisions of Mexico City.

Data wrangling

- Python 3 (pandas library)

GIS software

- QGIS

- GeoDa

Methodology

Spatial units

Data 2019-2020

- Observational, discrete data

- Not all crimes are reported

- Prone to errors (wrong georreferentiation, etc.)

- 1,808 neighborhoods in 16 boroughs

	2019	2020
Drug dealing (for sale purposes)	1,032	1,179
Drug dealing (simple possession)	5,017	4,187
Intentional homicide	1,344	1,129
Extortion	793	326
Illegal carrying of firearms	420	213
Kidnapping	176	58

Analyze the spatial distribution of drug dealing

- For discrete spatial units (neighborhoods) the inherent aggrupation of the data (the patterns) is of interest.

- Classify drug dealing crime reports using natural breaks (Jenks).
    - Optimization algorithm in which the count of drug dealing reports per neighborhood can be grouped by setting break points that maximize variance between classes and reduces internal class variance.
    - Natural breaks (Jenks) emphasizes the natural groupings of the data, clustering the values that are extreme .

- 5 classes were computed as this is typically a standard to the size of observations, however, tests can be made with less or more classes.

| Choropleth maps were produced to visualize the distribution of the classified values. | Box maps were used to visually represent the same information as a histogram, except with an added spatial component. |

Test for global spatial autocorrelation

1) Global Moran's I statistic, looking to reject the null hypothesis of spatial randomness in favor of the alternative, which implies clustering.

- Representative of the entire spatial pattern, does not provide information about the location of the clusters.

- Positive index: clustering of neighborhoods with similar values.
- Negative index: clustering of neighborhoods with dissimilar values (outlier).
- A value of zero means that there is no spatial autocorrelation.

Test for local spatial autocorrelation (univariate)

2) Local statistics: provide a way of identifying significant spatial variation of crime reports between a neighborhood and its adjacent ones.

- Local indicators of spatial association (LISA) measure the extent of significant spatial clustering around an observation, in this case, a neighborhood.

- The Local Moran I statistic provides a way to identify local clusters and spatial outliers.

- Allows to assess the spatial clustering of neighbors with similar characteristics.

Test for local spatial autocorrelation (bivariate)

3) Bivariate Local Moran's I: measures the spatial correlation between two different variables.

- In this case, between drug dealing (for sale purposes) and each of these: illicit carrying of firearms, intentional homicide, extortion, kidnapping, and drug dealing (simple possession).

Being a relative measure for the univariate and bivariate case, it is only when it is interpreted within the context of its p-value that significance can be assessed about the type of cluster or outlier it represents.

Weights calculation

Contiguity-based spatial weights to constrain the number of neighbors: queen contiguity criterion was chosen to define neighbors that share edges and vertices.

Property	Value
type	queen
symmetry	symmetric
id variable	POLY_ID
order	1
# observations	1808
min neighbors	0
max neighbors	24
mean neighbors	5.56
median neighbors	5.00
% non-zero	0.31%

Analysis and results

Neighborhoods with a high number of drug dealing reports in the **Cuauhtemoc**, **Venustiano Carranza**, Coyoacan, Alvaro Obregon and Iztapalapa boroughs.

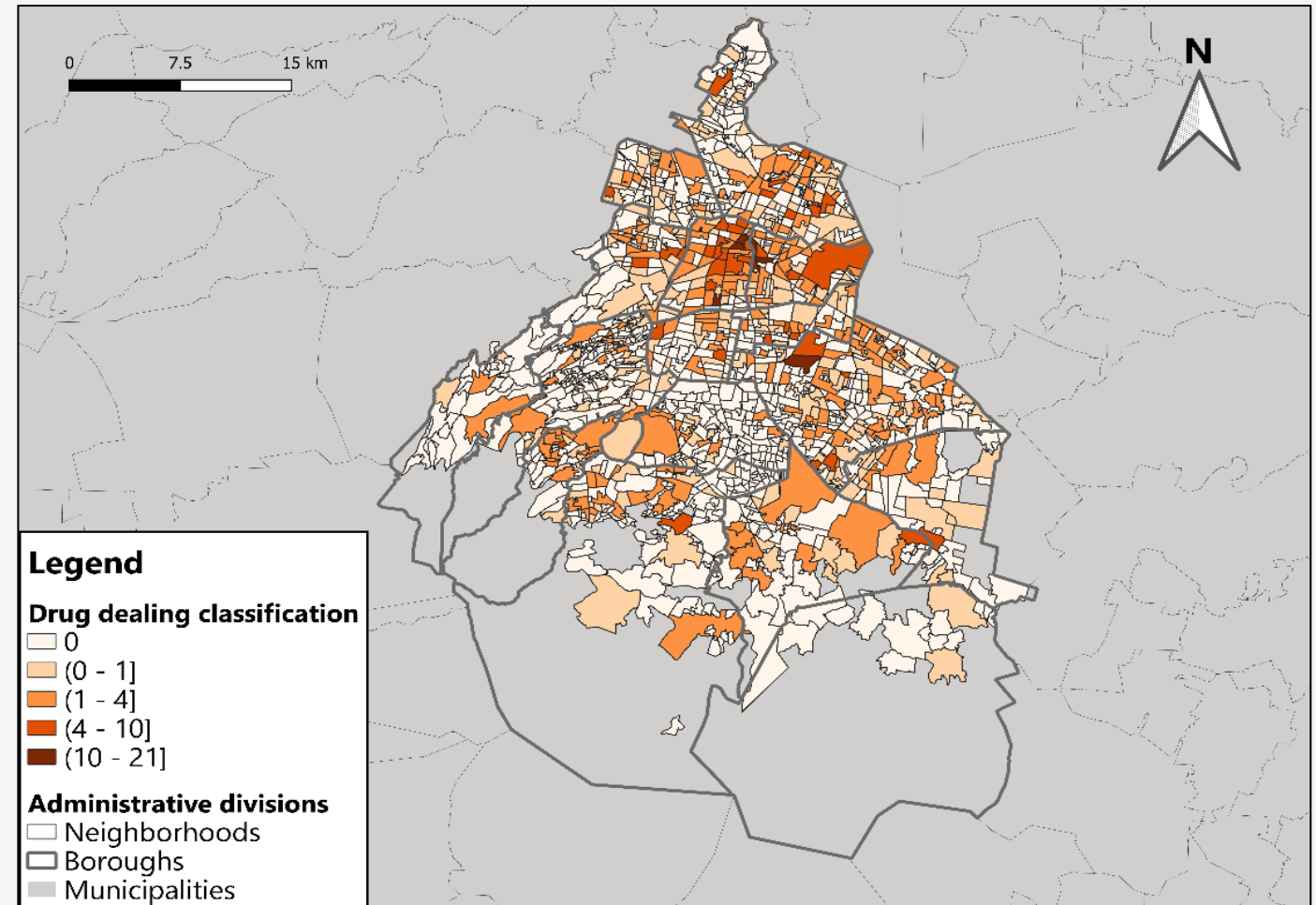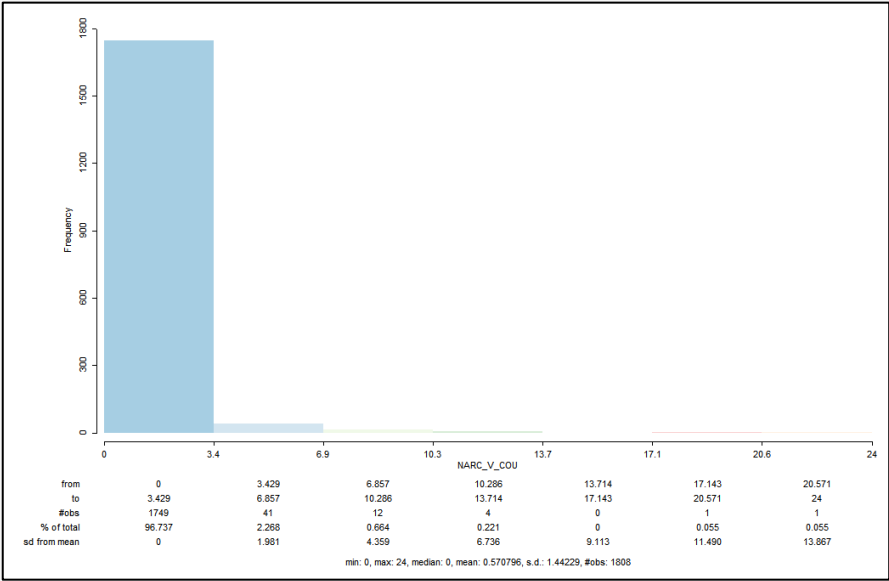| Borough	Neighborhood
Cuauhtémoc	Morelos III
	Morelos I

Map 1. Distribution of reported drug dealing in Mexico City, 2019.
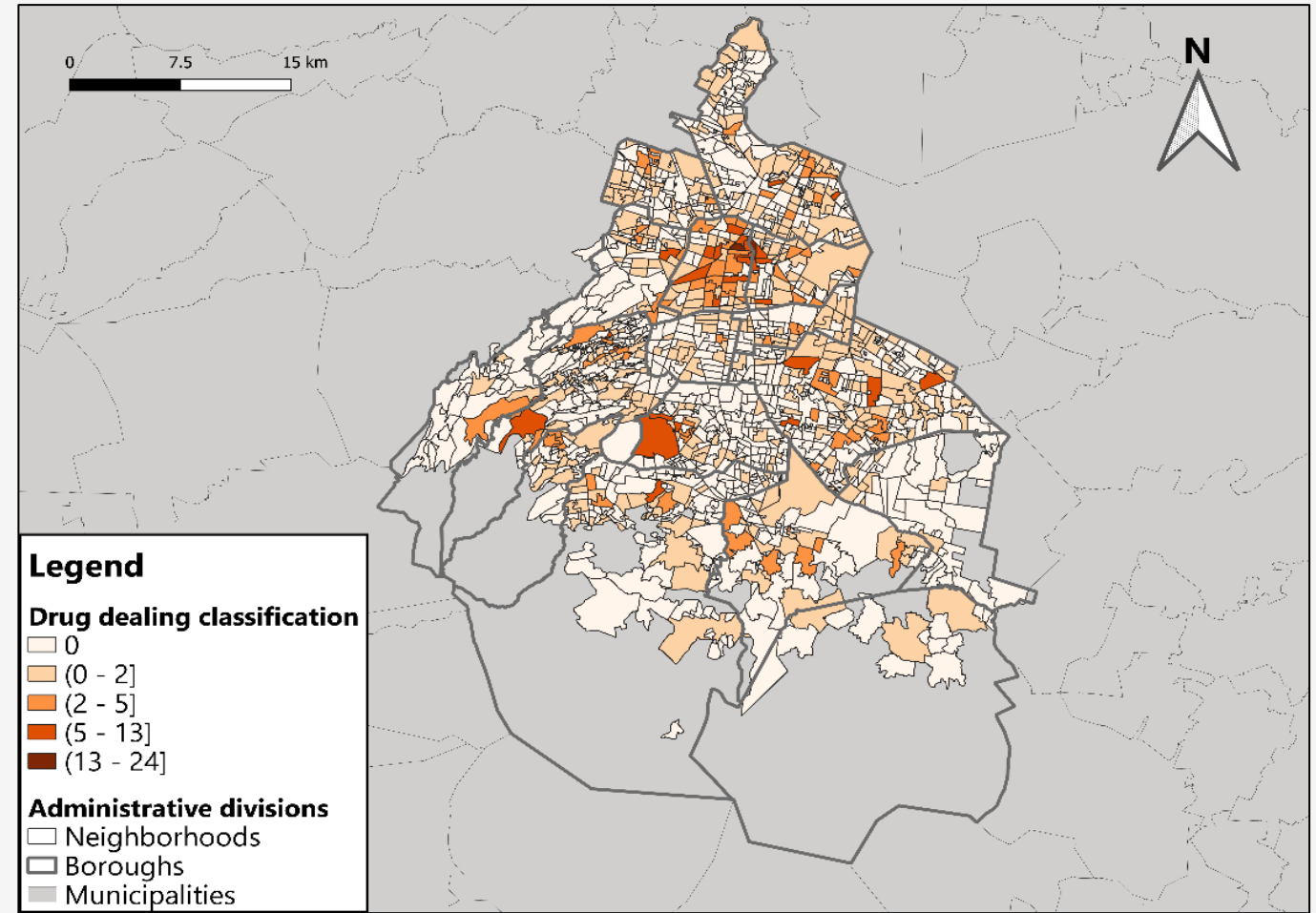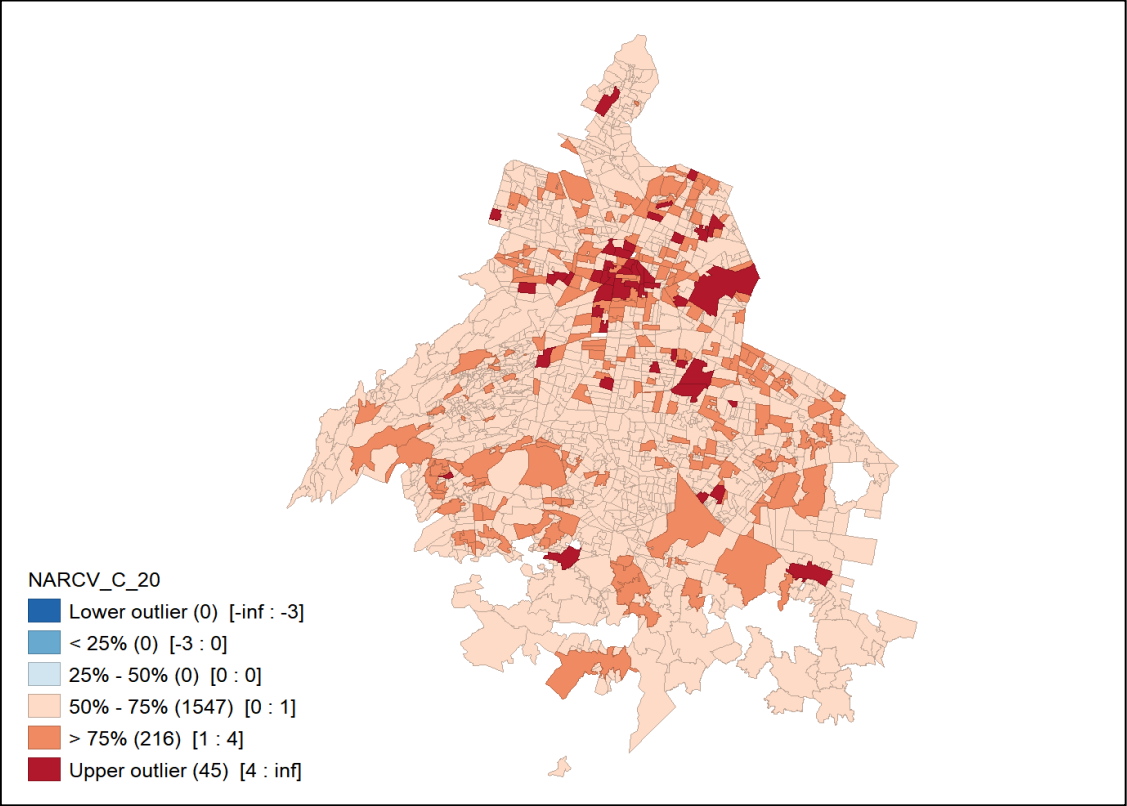

Source: Own elaboration with data from the General Attorney's Office of Mexico City.

Neighborhoods with a high number of drug dealing reports in the **Cuauhtemoc**, **Venustiano Carranza**, Miguel Hidalgo, Gustavo A. Madero and **Iztapalapa** boroughs.

Borough	Neighborhood
Cuauhtemoc	Morelos III
	Morelos I
	Doctores V
Venustiano Carranza	Morelos I
	Ampliación Penitenciaría
	Centro I
Iztapalapa	Barrio San José

Map 2. Distribution of reported drug dealing in Mexico City, 2020.

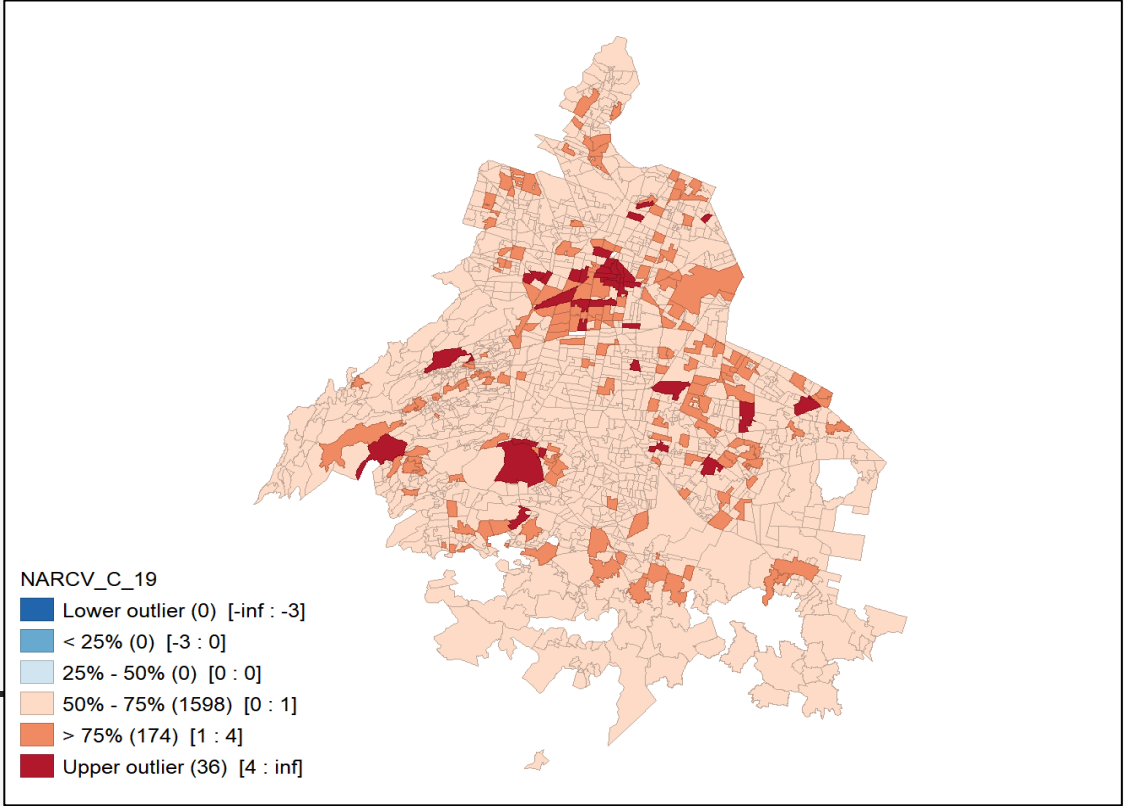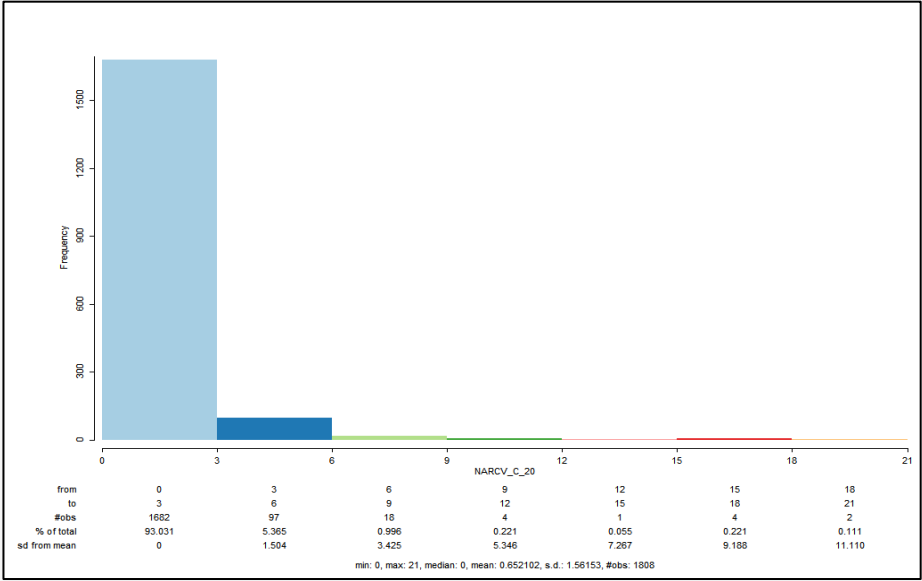Source: Own elaboration with data from the General Attorney's Office of Mexico City.

2019
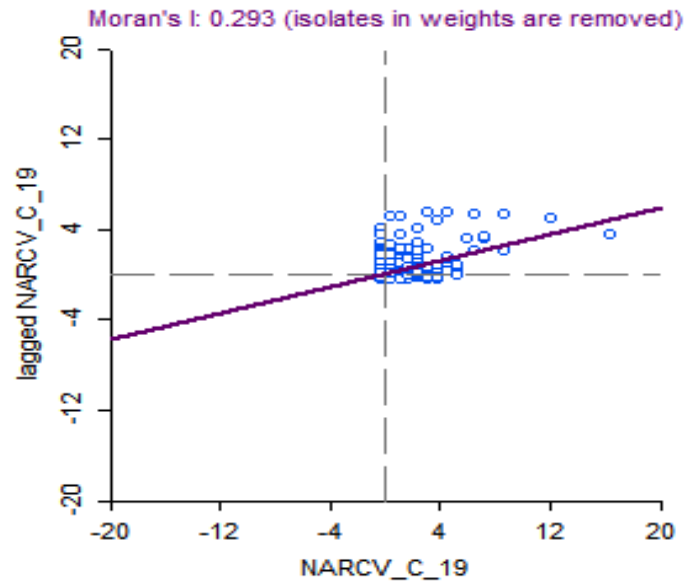

from	0	3.429	6.857	10.286	13.714	17.143	20.571
to	3.429	6.857	10.286	13.714	17.143	20.571	24
#obs	1749	41	12	4	0	1	1
% of total	96.737	2.268	0.664	0.221	0	0.055	0.055
sd from mean	0	1.981	4.359	6.736	9.113	11.490	13.867

min: 0, max: 24, median: 0, mean: 0.570796, s.d.: 1.44229, #obs: 1808

2020

from	0	3	6	9	12	15	18
to	3	6	9	12	15	18	21
#obs	1682	97	18	4	1	4	2
% of total	93.031	5.365	0.996	0.221	0.055	0.221	0.111
sd from mean	0	1.504	3.425	5.346	7.267	9.188	11.110

min: 0, max: 21, median: 0, mean: 0.652102, s.d.: 1.56153, #obs: 1808

NARCV_C_19

- Lower outlier (0) [-inf : -3]
- < 25% (0) [-3 : 0]
- 25% - 50% (0) [0 : 0]
- 50% - 75% (1598) [0 : 1]
- > 75% (174) [1 : 4]
- Upper outlier (36) [4 : inf]

NARCV_C_20

- Lower outlier (0) [-inf : -3]
- < 25% (0) [-3 : 0]
- 25% - 50% (0) [0 : 0]
- 50% - 75% (1547) [0 : 1]
- > 75% (216) [1 : 4]
- Upper outlier (45) [4 : inf]

Global Moran's I 2019 and 2020

2019

Moran's I: 0.293 (isolates in weights are removed)

- Moran's I index = 0.293
- Weak clustering pattern of neighborhoods with similar values.

2020

Moran's I: 0.280 (isolates in weights are removed)
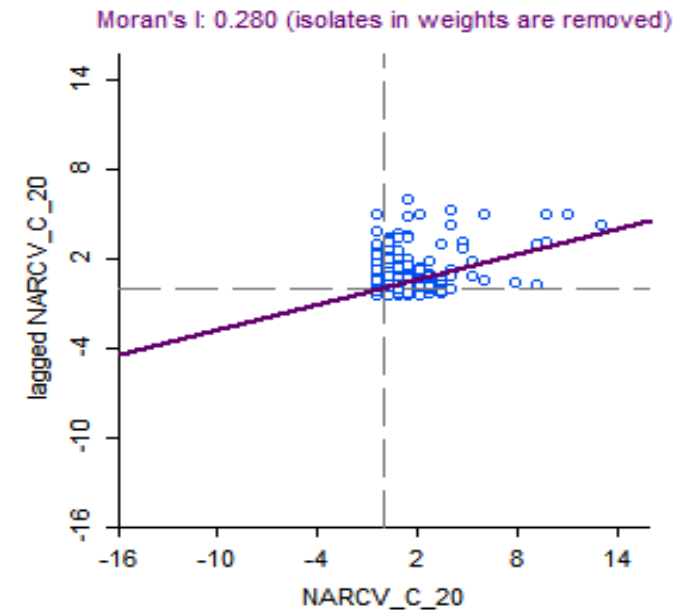
- Moran's I index = 0.28
- Weak clustering pattern of neighborhoods with similar values.

Local Moran's I (univariate) 2019

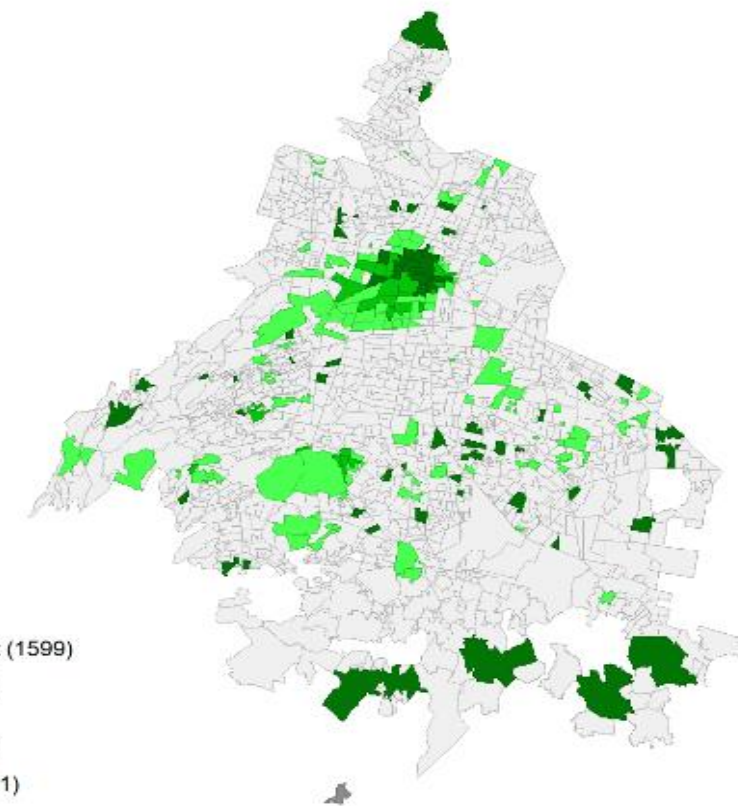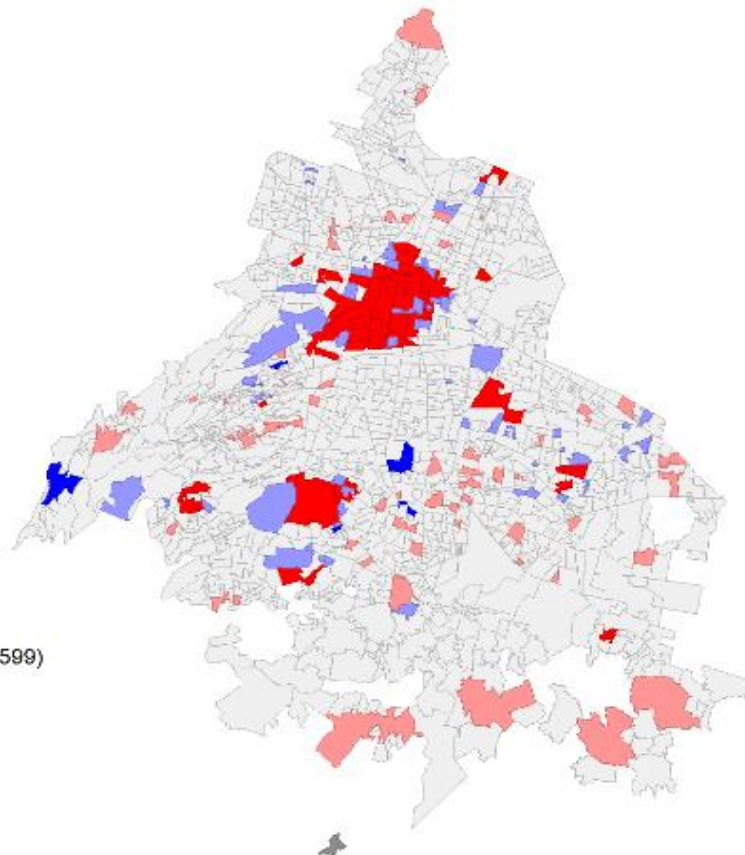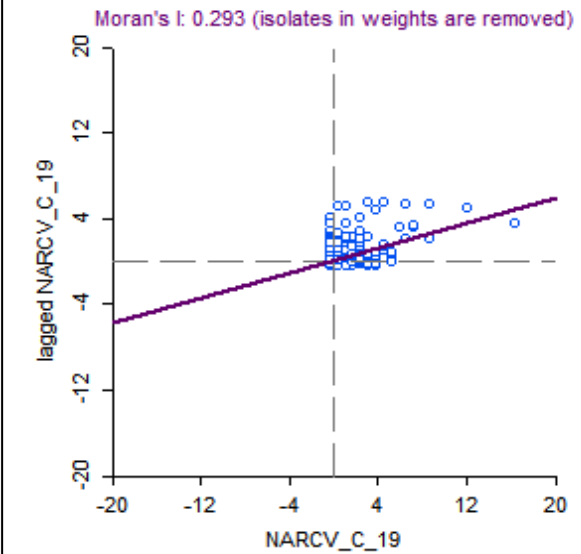- Moran's I: 0.293. Weak clustering pattern of neighborhoods with similar values.

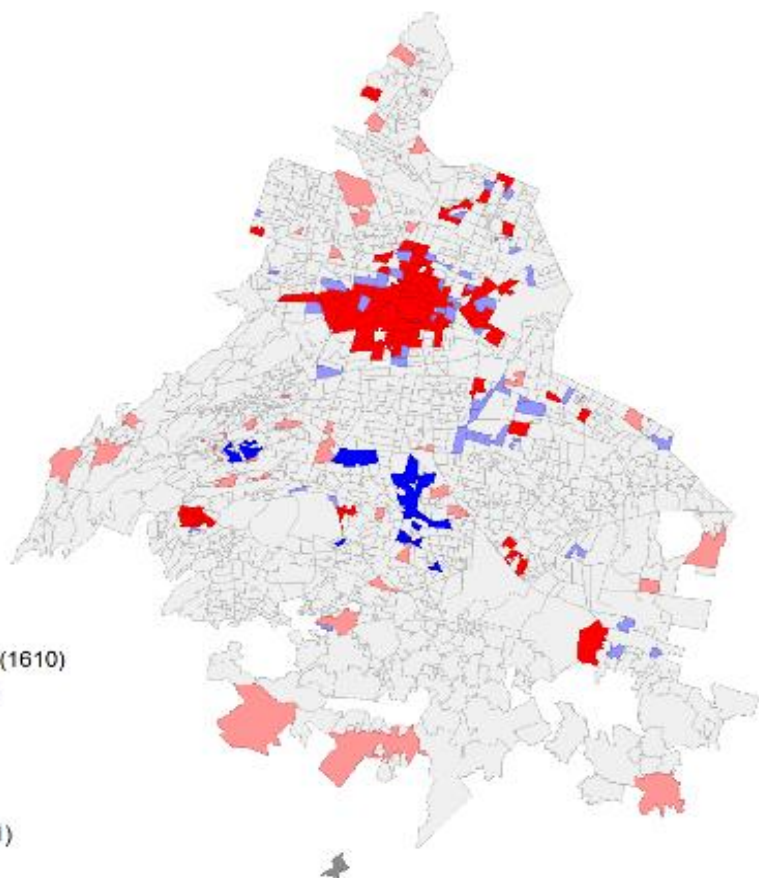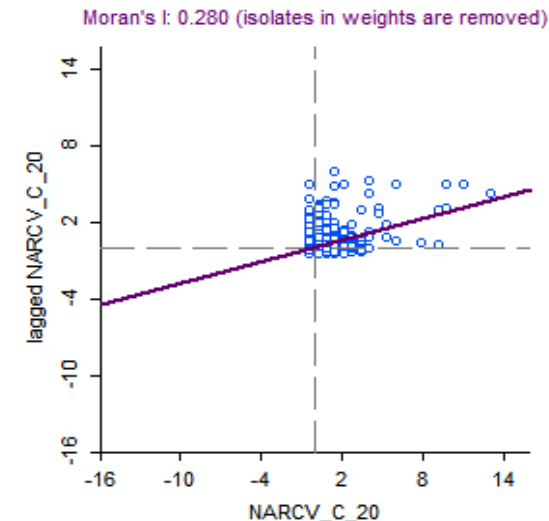| Borough |
| --- |
| Cuauhtémoc (Centro Histórico) |
| Coyoacán (Ciudad Universitaria, Copilco) |
| Álvaro Obregón (Lomas de los Cedros) |

Local Moran's I (univariate) 2020

- Moran's I: 0.28. Weak clustering pattern of neighborhoods with similar values.

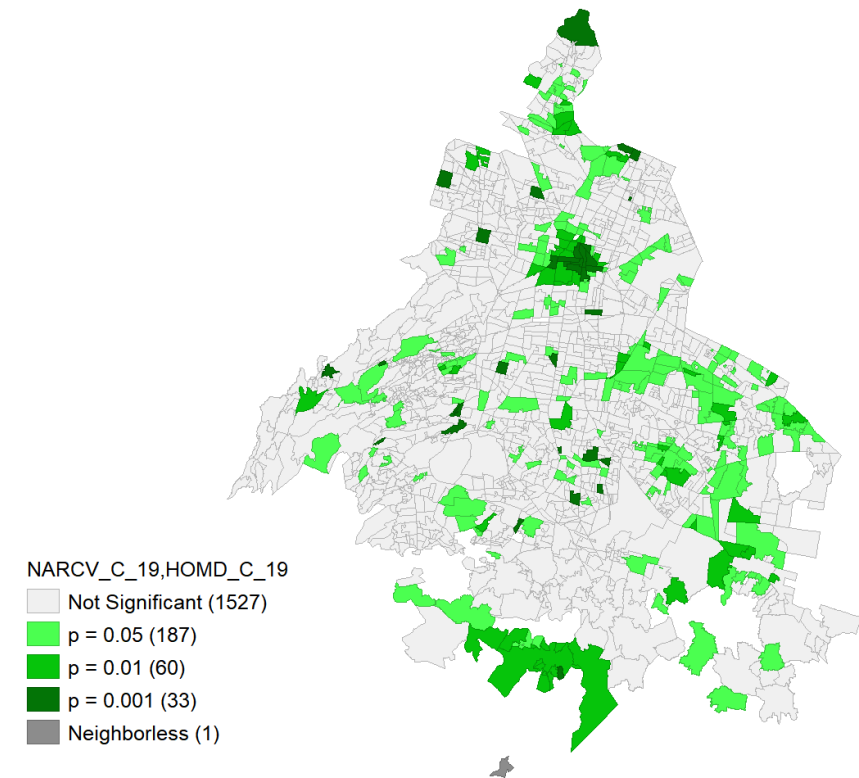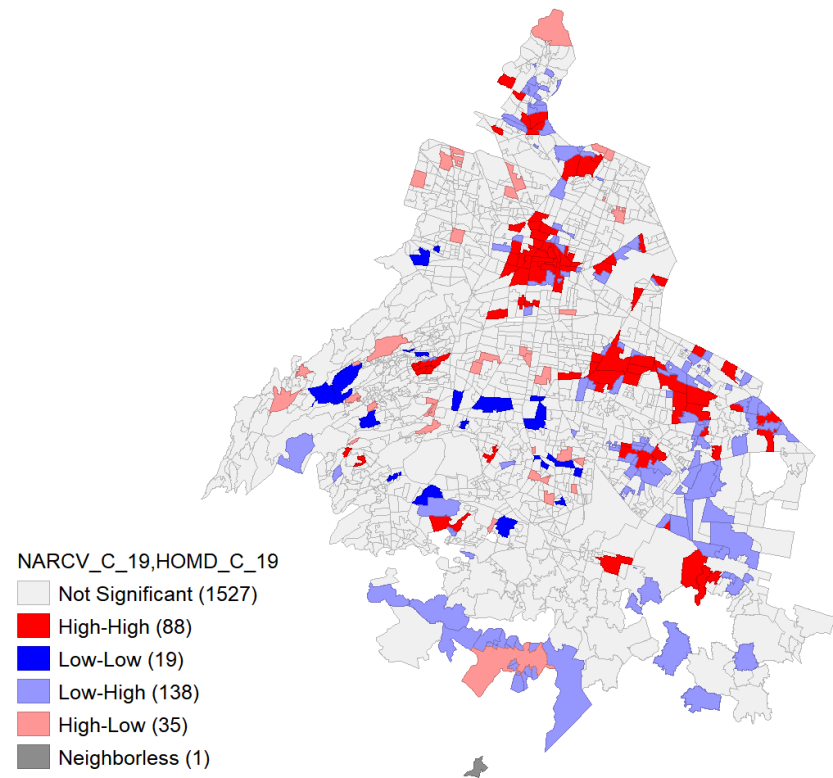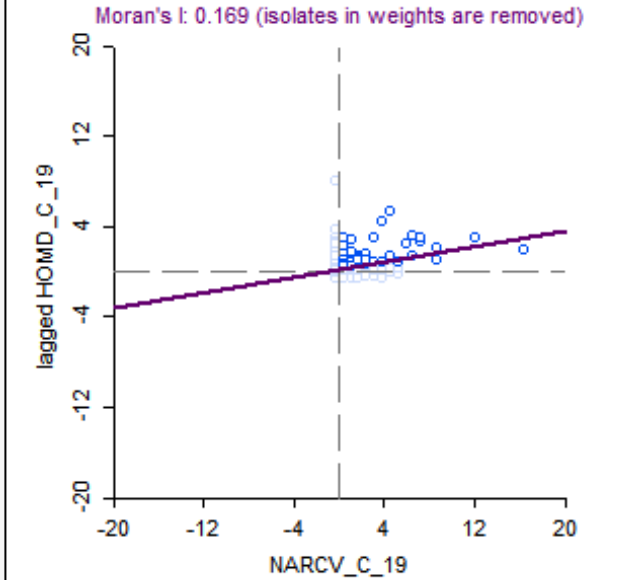| Borough |
| --- |
| Cuauhtémoc (Centro Histórico) |
| Miguel Hidalgo (Anzures) |
| Iztapalapa (Central de Abasto) |
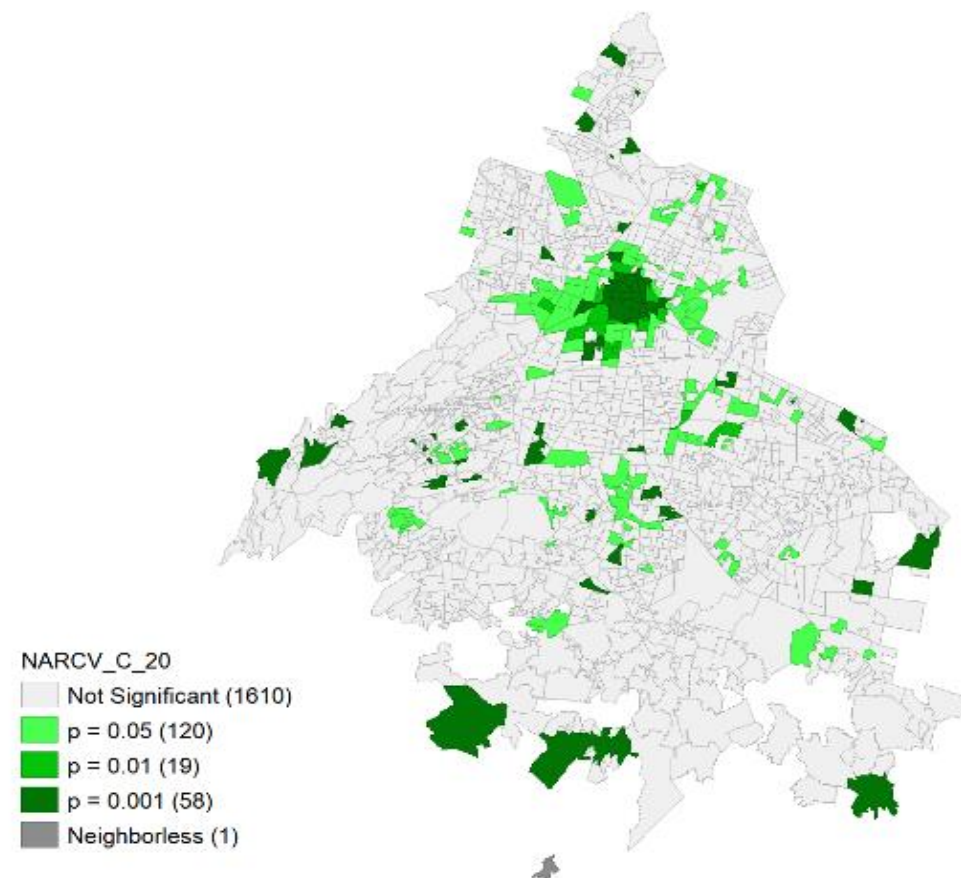
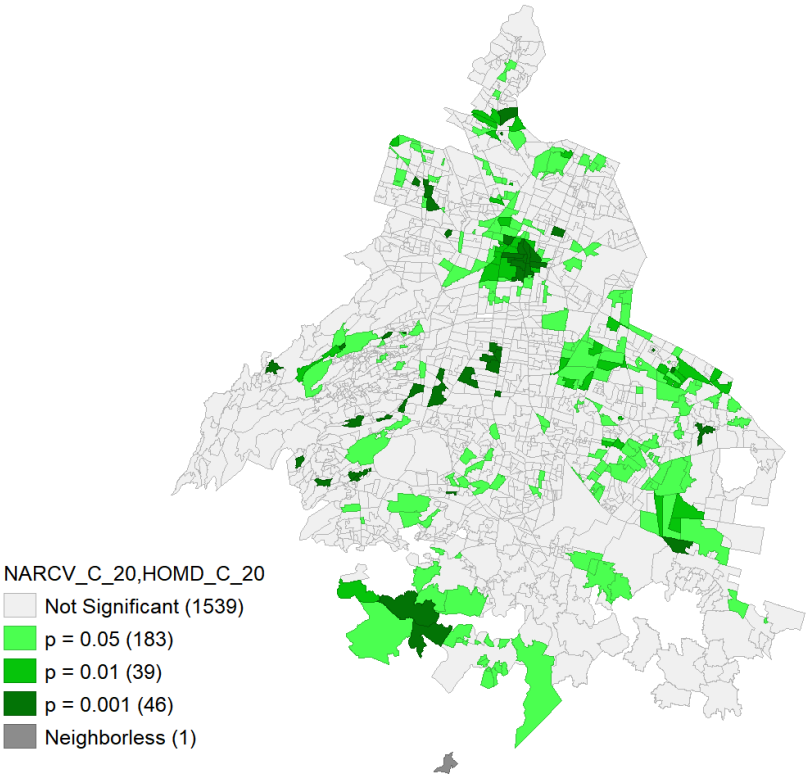# Local Moran's I (bivariate) for drug dealing and intentional homicide, 2019

- Moran's I: 0.169. No clustering pattern of neighborhoods with similar values.

Borough
Cuauhtémoc (Centro Histórico)
Gustavo A. Madero (near Reclusorio Norte)
Iztapalapa (Santa María Aztahuacán)
Álvaro Obregon (Metro Observatorio)
Tlalpan (housing space)
Tláhuac, Xochimilco (near Teuhtli volcano, perifery)

Moran's I: 0.169 (isolates in weights are removed)

NARCV_C_19,HOMD_C_19
- Not Significant (1527)
- High-High (88)
- Low-Low (19)
- Low-High (138)
- High-Low (35)
- Neighborless (1)

NARCV_C_19,HOMD_C_19
- Not Significant (1527)
- p = 0.05 (187)
- p = 0.01 (60)
- p = 0.001 (33)
- Neighborless (1)

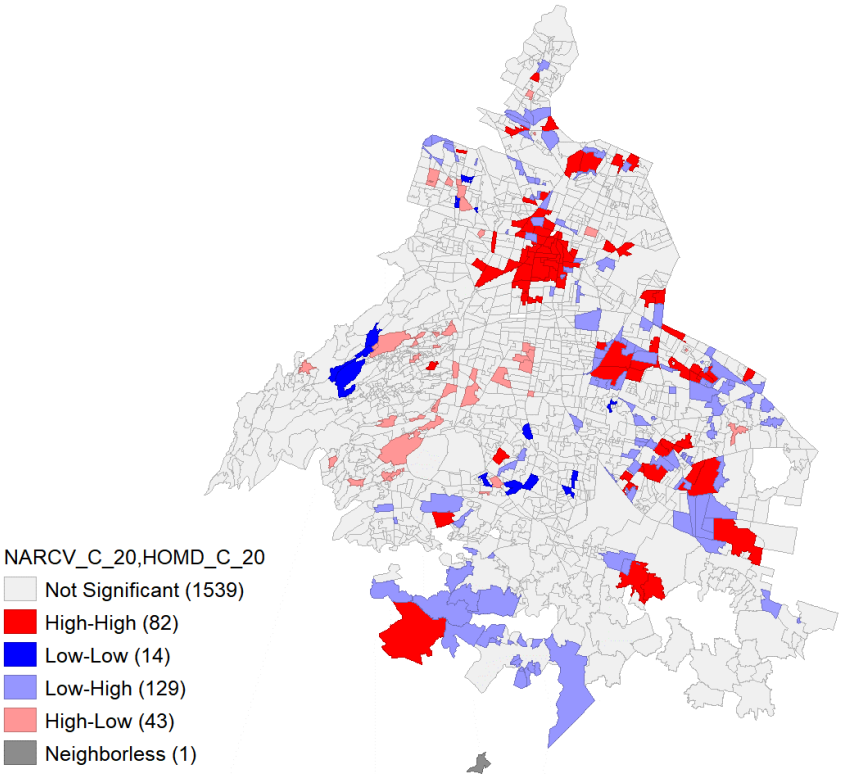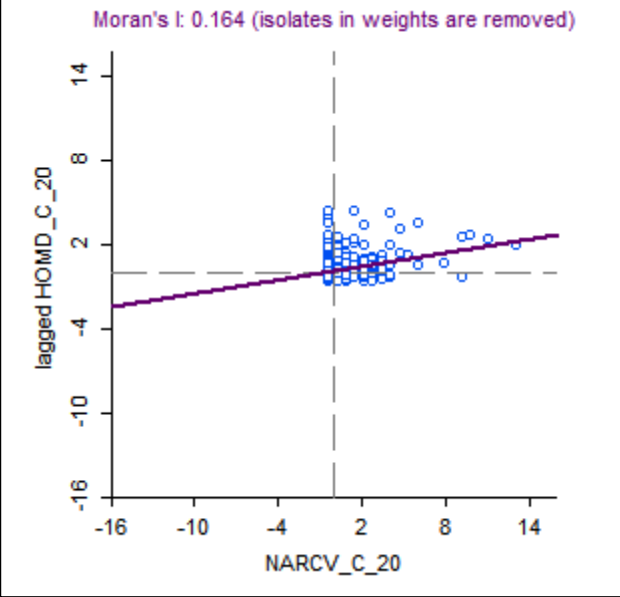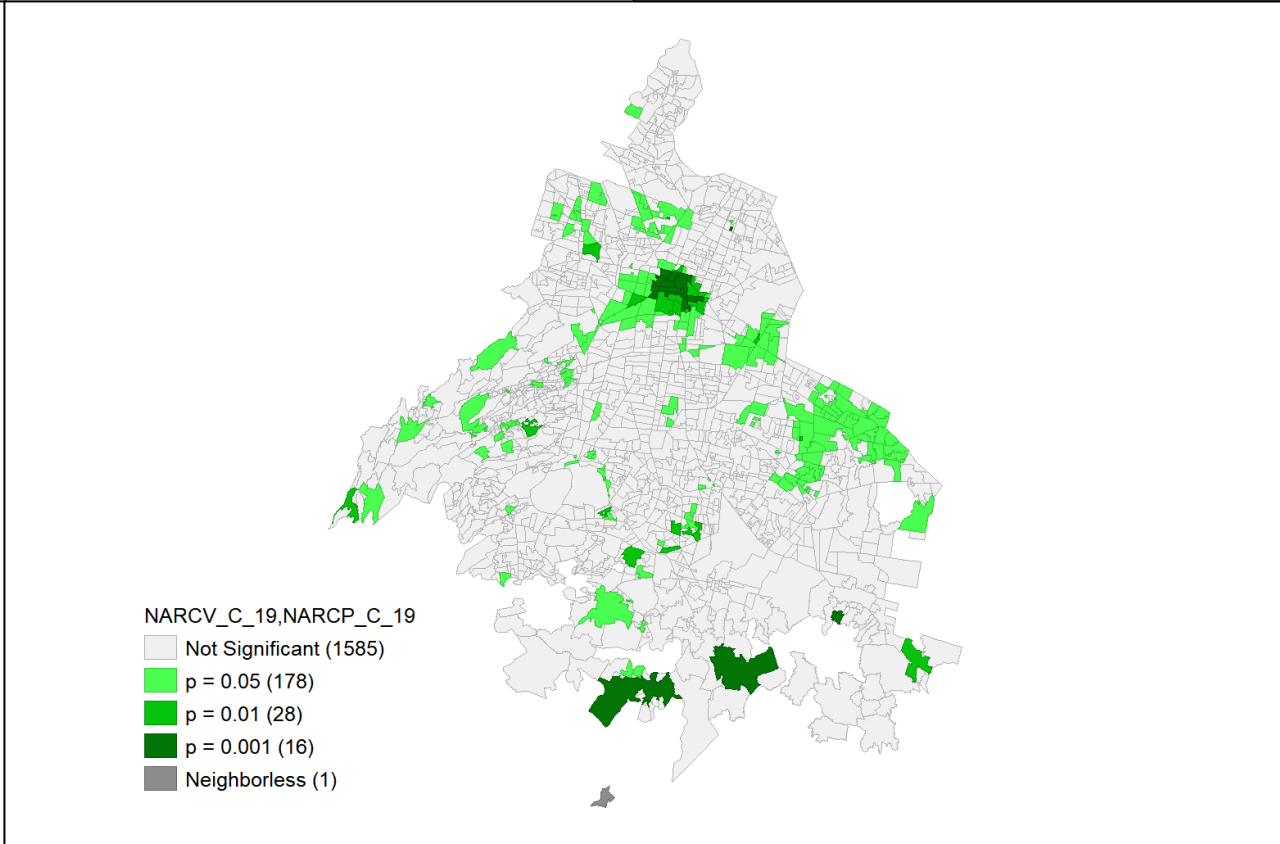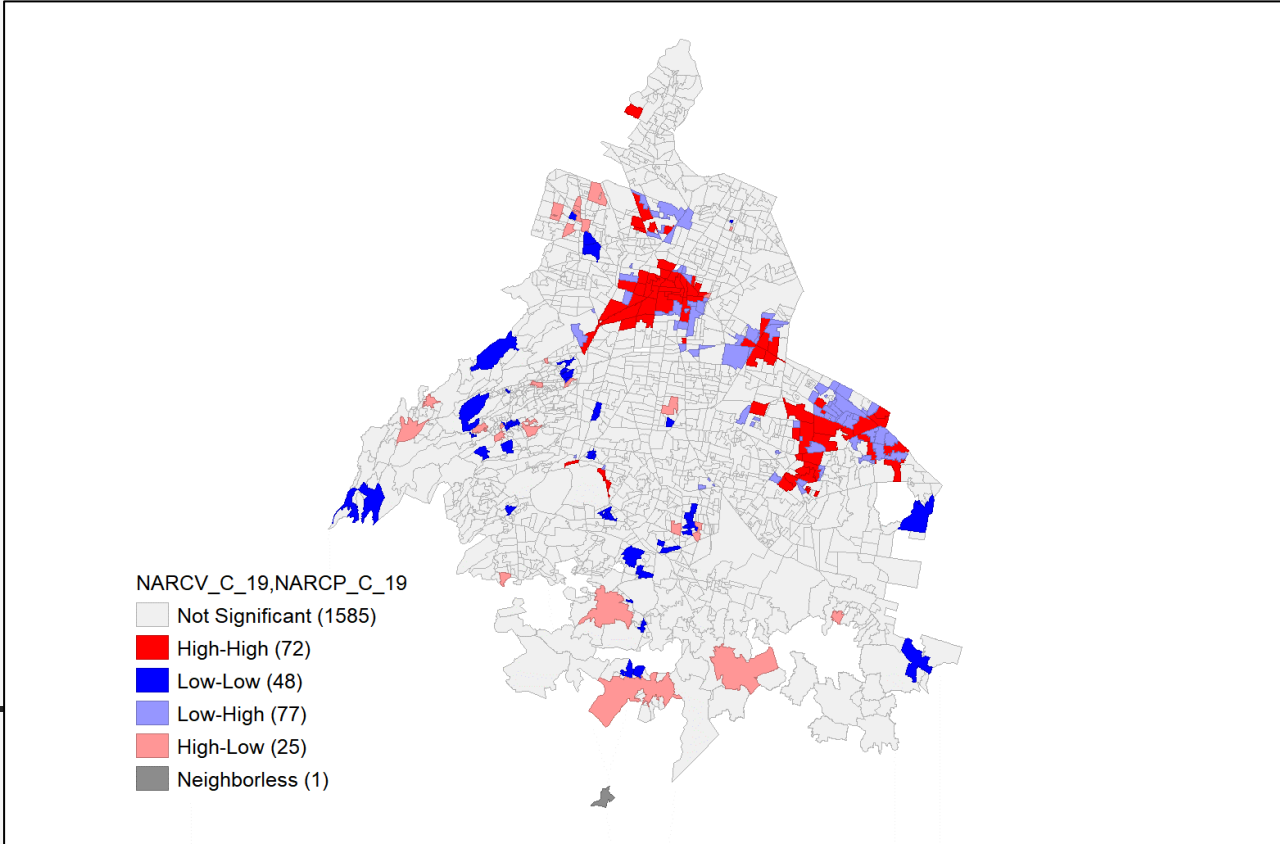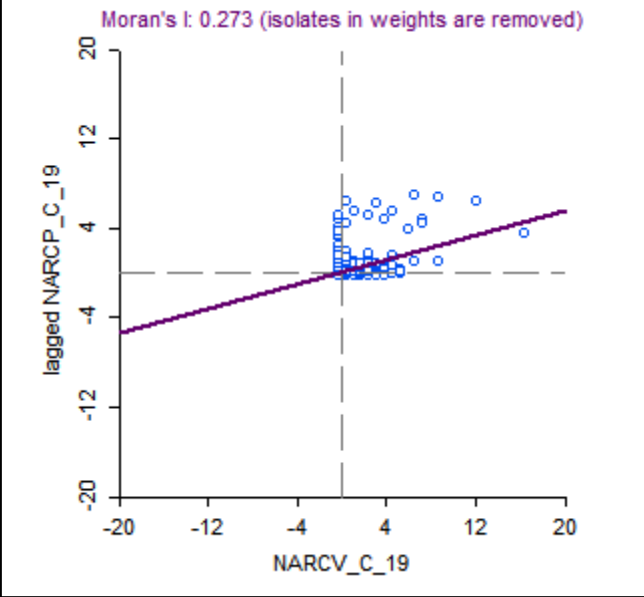# Local Moran's I (bivariate) for drug dealing and intentional homicide, 2020

Borough
Cuauhtémoc (Centro Histórico)
Gustavo A. Madero (near Reclusorio Norte)
Iztapalapa

Moran's I: 0.164 (isolates in weights are removed)

NARCV_C_20,HOMD_C_20
- Not Significant (1539)
- High-High (82)
- Low-Low (14)
- Low-High (129)
- High-Low (43)
- Neighborless (1)

NARCV_C_20,HOMD_C_20
- Not Significant (1539)
- p = 0.05 (183)
- p = 0.01 (39)
- p = 0.001 (46)
- Neighborless (1)

Local Moran's I (bivariate) for drug dealing (for sale purposes) and drug dealing (simple possession), 2019
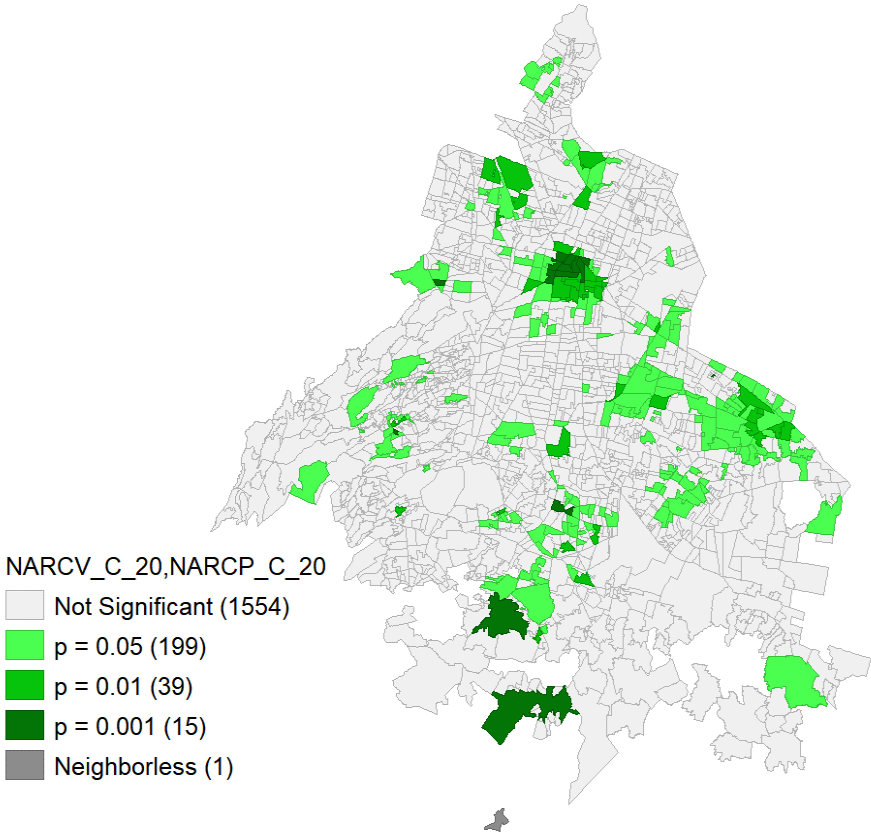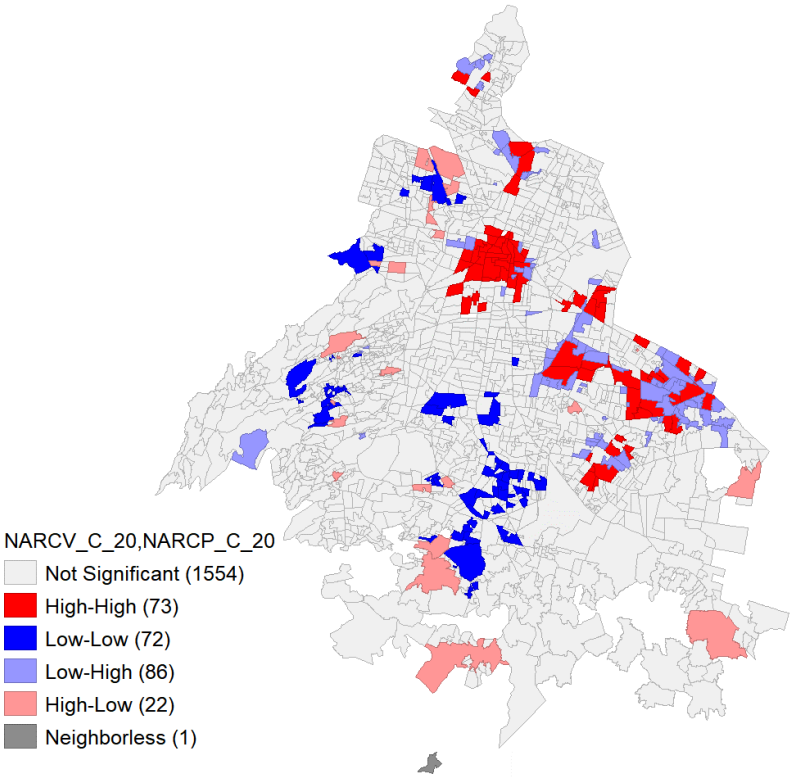
Borough
Cuauhtémoc
Iztapalapa

Local Moran's I (bivariate) for drug dealing (for sale purposes) and drug dealing (simple possession), 2020

Borough
Cuauhtémoc
Gustavo A. Madero
Iztapalapa

Moran's I: 0.247 (isolates in weights are removed)

NARCV_C_20,NARCP_C_20
- Not Significant (1554)
- High-High (73)
- Low-Low (72)
- Low-High (86)
- High-Low (22)
- Neighborless (1)

NARCV_C_20,NARCP_C_20
- Not Significant (1554)
- p = 0.05 (199)
- p = 0.01 (39)
- p = 0.001 (15)
- Neighborless (1)
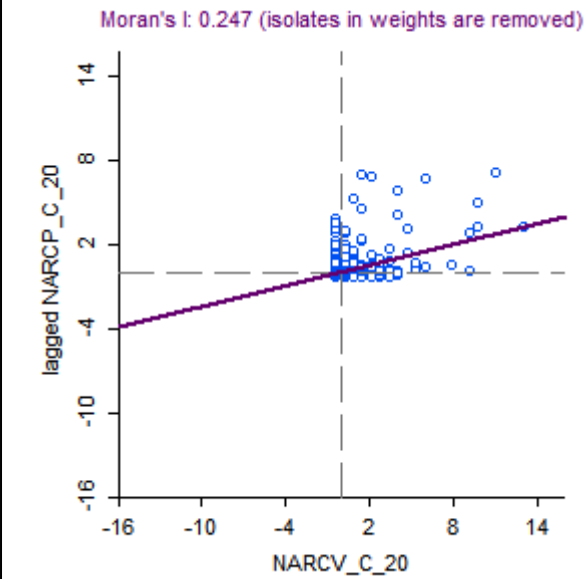
Conclusions

➢ In all cases, the distribution of drug dealing by itself and compared with other crimes is not random.

➢ Drug dealing's distribution is spatially structured.

➢ The autocorrelation when assessing drug dealing and other crimes is weaker (intentional homicide and drug dealing simple possession).

➢ A change in the special pattern of drug dealing is identified before and after the onset of the COVID-19 pandemic, however, the neighborhoods that appear to be static are those located in the Cuauhtémoc borough.

Future research

- Test other clustering methods to classify observations of drug dealing reports.

- Try other methods to test for spatial autocorrelation, such as Geary's.

- Go beyond spatial correlation and consider regression methods to predict areas of concentration.

- Consider other crimes that might be associated with the presence of drug sales to detect patterns in either the commission of this crime or why certain areas have a higher number of reports.

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