Spatial Point Pattern Analysis of Drug Related Crimes in October 2017 in Manila City

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According to a lot of studies and statistical reports presented by several anti-drug related agencies, drug substance abuse in the Philippines has always been increasing at an alarming rate. This study aims to analyze this phenomenon through the analysis of spatial point patterns of the locations of drug-related incidents in Manila City in October 2017. The point pattern for drug related crimes was then tested for spatial dependence with specific establishments in Manila city such as schools, churches, and police stations. Notable results presented in this paper are (i) the imposition for PDEA to lead Oplan Tokhang has significantly decreased the amount of reported drug related crimes (ii) drug related crimes are clustered on residential areas (iii) there is a possibility that drug personalities tend to lay-low after a drug related crime has been reported to the police in their vicinity and will eventually return to commit these crime after some time (iv) drug related crimes tend to happen far from colleges and universities (v) and drug related crimes happen more frequently near public high schools.
Keywords: drugs, drug-related incidents, drugs and youth, Manila, spatial point patterns

1. Introduction

1.1. Motivation

According to a report of the Department of Health (DOH) in 2012, there were only about 20,000 drug users across the country when the Republic Act No. 6425, otherwise known as “Dangerous Drugs Act,” was implemented in 1972. This number has then continuously increased that by 2001, Social Weather Station Survey had estimated that at least 2.2 million Filipinos are drug users (DOH, 2012). The “Comprehensive Dangerous Drugs Act” or Republic Act No. 9165 was then signed in 2002 to cater the ongoing boom of drug use (Congress of the Philippines, 2002). Fast forward to 2017, the Philippine Drug Enforcement Agency (PDEA), the main organization tasked to handle the ongoing drug problem in the country, now estimates for there to be 4.7 million illegal drug users in the Philippines (Cabrera, 2017). With the continuous efforts by the current administration against drug abuse, the Philippine National Police stated on May 2017 that drug-related crimes diminished by 11.74% since July 2016 (Reyes, 2017).

An alarming report by the Dangerous Drugs Board (DDB) in 2015 stated that almost forty-nine percent (48.85%) of the reported cases for rehabilitation to the said agency indicated that they first tried to use drugs at 15-19 years old. Meanwhile, according to 2015 Nationwide Survey on the Nature and Extent of Drug Abuse in the Philippines, 7% of the current drug users are composed of students (DDB, 2016). Among the top causes of drug abuse among students are peer influence, serious family problems, and suffering frustrations (Caday, 2017). In response to the disturbing cases of drug abuse by minors, according to a news report by CNN Philippines (2017), the Commission on Higher Education has given its permission for higher education institutions to include mandatory drug tests as part of the admission and retention process come AY 2018-2019. That is, if the student tested positive, he/she will be required to undergo rehabilitation before continuing his/her education (CNN Philippines, 2017).

The continuous increase in the number of drug users and the alarming cases of teenagers’ exposure to drug use have motivated the researchers to do a research on the

extent of drug abuse in one of the communities in the Philippines, specifically the capitol Manila City. This is done through spatial point data analysis on drug related crimes in October 2017, and examination of the said drug related incidents with other point patterns in the city. The results of this paper will be significant for policy making bodies in the government for them to create informed decisions to mitigate the severing drug problem in the country.

1.2. Objectives of the Study

This study aims to see how drug-related incidents are mapped throughout Manila and their behavior with each other: whether they cluster or repulse. Furthermore, the researchers aim to find statistical evidence to prove whether there is relationship between locations of drug-relation incidents and several types of establishments: police stations, churches, public high schools, and colleges and universities. The specific objectives of this paper are:

a. To determine where do drug-related incidents proliferate in Manila.
b. To distinguish the behavior of the locations of drug-related incidents through space, and if possible, through time.
c. To test whether drug-related incidents tend to cluster or repulse from locations of police stations, churches, public high schools, and colleges and universities.

1.3. Scope and Limitation

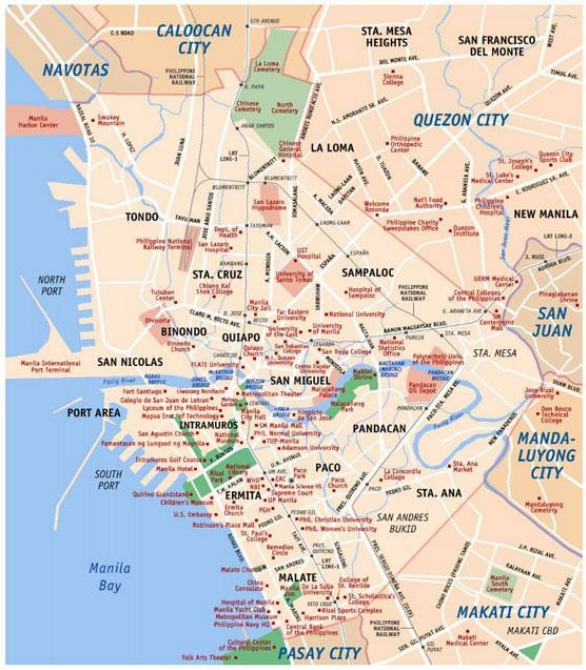
This paper studies only the drug related crimes in Manila City in October 2017. It does not scope the event of interest outside the specified study area and timeline. Additionally, the researchers only aim to examine the locations of incidences of this type of crime to solve the drug problem in the Philippines. The researchers do not study further the outcomes of the police operations in dealing with these crimes, for the dataset is only limited in the location of the crimes, the timestamp of the report, and the police station it was reported to. The problem of cases of alleged human rights violations during police operations are outside the scope of this study.

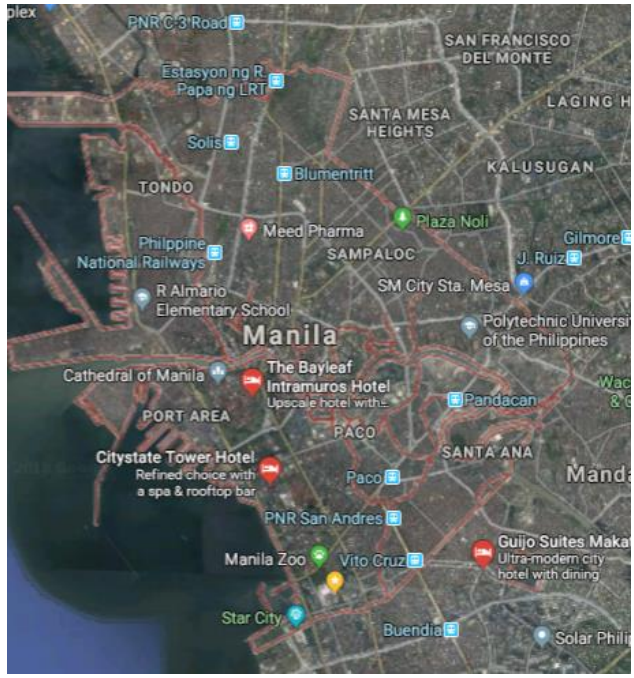
2. Review of Related Literature

Background on Manila City

Manila is the capital city of the Philippines, located at the western part of the National Capital Region. Based on the 2015 census, it had a population of 1,780,148 and was held to be the most densely populated city in the world with 71,263 persons per square kilometer (PSA, 2016). According on the classifications of the Philippine Statistics Authority in their 2015 census, it is composed of 897 barangays and 14 main subdivisions namely Tondo, Binondo, Quiapo, San Nicolas, Santa Cruz, Sampaloc, San Miguel, Ermita, Intramuros, Malate, Paco, Pandacan, Port Area, and Santa Ana. Among these areas, Tondo is the most populated with 631,363 inhabitants, followed by Sampaloc (375,119) and Santa Ana (PSA, 2015). Due to high volume of squatter areas, Tondo is the most densely populated area in Manila with an estimated 69,000 inhabitants per square kilometer (Celdran, 2014). The figure below shows the political map (from Orange Smile) and satellite map (from Google Maps) of Manila City.

Figure 1: Political (Left) and Satellite (Right) Maps of Manila City





In 2016, Manila has the second highest index crimes in the country with 54,689 reported cases next to Quezon City (ABS-CBN News, 2016). In 2017, it was reported by the Manila Police District that the crime rate in Manila decreased by 38.7 percent (Aberia, 2017). Manila, in history, has been a seat of Roman Catholicism due to Spanish influence and continued to do so currently, which is why it is estimated that more than 90% of its population are Catholics (About Manila, 2010). A lot of Catholic churches are situated in Intramuros wherein several old Christian tertiary institutions were also built (About Manila, 2010). There is also a large concentration of colleges and universities in the area aptly named as "University Belt" located in San Miguel, Quiapo, and Santa Cruz ("University Belt," 2012). There are currently 31 public high schools in Manila City that is under the Division of City Schools Manila (Department of Education Manila, n.d.)

Definition of Drug Related Crimes

United Nations Office on Drugs and Crime (UNODC) defines drug-related crimes or incidents as "intentional acts that involve the cultivation; production; manufacture; extraction; preparation; offering for sale; distribution; purchase; sale; delivery on any terms whatsoever; brokerage; dispatch; dispatch in transit; transport; importation; exportation; possession or trafficking of internationally controlled drugs" (UNODC, 2016). In the Philippines, it is defined in RA. 9165 (The Comprehensive Dangerous Drugs Act of 2002) as the importation, sale, administration, delivery, distribution, transportation, possession, use, cultivation, unlawful and unnecessary prescription of prohibited and regulated drugs and paraphernalia used, maintenance of a den, dive, or resort for prohibited drug users, and as an employee and visitor of prohibited drug dens (Congress of the Philippines, 2002).

Drug use among the youth

According to the World Health Organization (2011), substance use is the hazardous use of psychoactive substances, such as drugs, that can lead to dependence syndrome – a phenomenon wherein the user has a strong and uncontrollable desire to take a substance, after repeated use. The dependence on drugs led to a global problem which affected many lives, including the youth. A study by Califano (2007) showed that around 3.8 million American college students abuse prescription drugs and/or illicit drugs. In another study by the United Nations Office on Drugs and Crime (UNODC, 2011), it was revealed that *cannabis* usage rate of Grade 10 pupils in America was at 33.4% in 2010.

According to several reports, the primary reasons of substance misuse among adolescents were curiosity, social pressure and peer pressure (Wright et al., 1995; Yeung, 1997). In another study, students drug themselves in order to relieve stress, relax, have fun,

forget their problems, and be “one of the gang” (Califano, 2007). Another reason for substance use is for reduction of stress and anxiety caused by schooling. Windle and Tutzauer (1991), found that young adults who are joint abusers of cocaine and alcohol have the lowest high-school dropout rates and the highest scores on a standardized measure of verbal intelligence. Yamada et al. (1996) showed that alcohol and marijuana use among high-school students had significant and adverse effects on the probability of high-school graduation. However, it should be noted that these reports are contrary to several studies reporting negative correlation between drug abuse and schooling (Hawkins et al., 1992; Brook et. al., 1999; Alcabes et al., Blakemore and Low, 1983). Stress have been known to increase a person’s vulnerability to addiction (Sinha, 2008). Several studies showed that adolescents facing many recent negative life events have increased levels of drug use and abuse (Newcomb and Harlow, 1986; Brown, 1987; Chassin et al., 1998; Cooper et al., 1990).

All of these literatures about drug abuse among the youth have obligated the researchers to examine the point pattern of drug related incidents with the point patterns of public high schools, colleges, and universities in Manila City.

Crimes and Religion

Ellis and Peterson (1996) found out that among individuals, persons who were most religious commit crimes at lower rates than those who were least religious. They also discovered that at a societal level, more religious countries have lower crime rates than less religious countries. However, among youth, religious commitment was not associated to any measure of delinquency (Hirschi and Stark, 1969). Irvin-Erickson (2015) studied the relationship of different places to criminal activities in New Jersey. One of the findings in the study was that churches tend to have criminogenic spatial influences on street robberies.

Crimes and Police Presence

A study by Tengbeh (2006) analyzed four categories of crime in Manzini, Swaziland in 2004. These were crimes against property, crimes against people, drug related crimes, and crimes against public order. Part of the results found that incidents of crime were dominant between 250 and 500 meters from police stations. The study also noted that accessible police stations would complement efforts in combating crime in the area (Tengbeh, 2006). Furthermore, hot spots policing could be another approach in diminishing crime in an area. Hot spots policing is a strategy wherein police will identify "hot spots" or areas with high amounts of crime and deploy responses in those areas. (Santos, 2017) Results of a study by Braga, Papachristos, and Hureau (2012) showed that "20 of 25 tests of hot spots policing interventions reported noteworthy crime and disorder reductions." It also showed evidence that hot spots policing is an effective strategy to prevent crimes.

3. Methodology

3.1. Methodological Sketch

All coordinates of events are extracted through the use of Google Maps. The information on drug related incidents in Manila City in October 2017 are gathered from BantayKrimen.com, a website that maps crimes that was reported and is managed by the Philippine National Police. The point patterns in BantayKrimen has no coordinates, so the researchers also manually extracted them from Google Maps. The list of all Catholic churches was provided by Google Maps search engine. The names of colleges and universities in Manila are gathered from FindUniversity.ph, and the list of public high schools are gathered from the Department of Education Manila website (depedmanila.blogspot.com). The list of police stations included in the study are from the dataset itself since BantayKrimen also gives the police station the specific drug related crime was reported to.

The software R-Studio version 1.1.383 (with base R version 3.4.3) was used for the statistical analyses. The packages *spatstat* and *lattice* were used to generate the statistical results.

3.2. Statistical Analyses Used

The statistical concepts discussed in this section are from Cressie (1993), Baddeley (n.d.), and Bivand et.al (2013).

The first part of the results and discussions deals with the descriptive statistics on the drug related crime in October 2017 in Manila City. The event of interest is described with their timestamp, the police station in which the crime was reported, and the area wherein the crime happened. Then the event of interest was subjected to the Clark-Evans' Test for Complete Spatial Randomness (CSR). CSR is a state of a univariate spatial pattern to have constant intensity and no spatial interaction between points. This means that the points tend to appear randomly in the area of interest. A point pattern that is said to be a CSR is a homogenous Poisson process i.e., it follows the probability mass function:

$$f_{y(A)}(y) = \frac{e^{-\lambda A}(\lambda A)^{y}}{y!}$$

Where λ is the intensity paramater and A is the area of the study region. The event of interest was then tested for Complete Spatio-Temporal Randomness (CSRT), which tests whether there is space-time interaction on the point pattern based on space and time distances. The test used for CSTR in this paper is the Mantel test. Unlike other tests for CSRT, Mantel test doesn't need specifications on critical space and time distances. The test statistic is the sum across all pairs of the time distance multiplied by the spatial distance formally defined below:

$$Z = \sum_{i=1}^{N}\sum_{j=1}^{N} s_{ij}t_{ij}$$

Where s_{ij} is the spatial distance and t_{ij} is the temporal distance from ith event with the jth event. The said test statistic is then compared with the estimates from simulated point patterns. A pseudo p-value can be computed by the formula given below:

$$pseudo - p - value = \frac{\#\ of\ times\ |Z|\ is\ greater\ than\ |simulated\ values| + 1}{\#\ of\ simulations + 1}$$

The second part of the results discusses the first order property of the event of interest or the distribution of the event on the study area. This includes the discussion of the intensity of the event of interest and the density of the event across the area. In this paper, Kernel estimation is used for plotting intensity across the area of interest. The intensity λ(s) per pixel is estimated by:

$$\hat{\lambda}_{\tau}(s) = \frac{1}{\delta_{\tau}(s)}\sum_{i=1}^{n}\frac{1}{\tau^2}k\left(\frac{(s - s_i)}{\tau}\right)$$

Where $\frac{1}{\delta_{\tau}(s)}$ is the edge correction, k is the kernel, and τ is the bandwidth. The kernel used in this paper is the Gaussian kernel.

The next part of the results and discussion will deal with the second order property of a spatial point process, which pertains to the behavior of the points to cluster or repulse. The nearest neighbor distance (NND) is defined to be the distance from one event to another event, or one event to a random point. A formal test for clustering can be done by creating simulations of random points on the study area and computing for the average nearest neighbor distance in each simulated spatial point pattern. The computed average NND for the real dataset was then compared with the computed NND from the simulations. A pseudo p-value is computed using the formula presented earlier in the Mantel test for CSTR.

Two functions, which uses the nearest neighbor distances, will be graphed to examine the tendency for the events to cluster or repulse: the G function and the F function. G function maps the proportion of the number of pairs of events that are within the specified event-to-event NND, while the F function maps the proportion of pairs of event and random point within the specified point-to-event NND. These functions are formally defined as:

$$G(w) = \frac{\#\,(w_i \leq w)}{n} \text{ and } F(x) = \frac{\#(x_i \leq x)}{m}$$

Where *w* is the event to event nearest neighbor distance, *x* is the random point to event distance, *n* is the number of events, and *m* is the number of points in the study region. An early rising in the G function, and an indication that the G function is generally greater than the F function will both imply that the events are clustered in the region.

The K and L functions are both functions that was also used to explain the second order property of events. These functions calculate measure based on how many pairs of observations have distances that are less than or equal the specified *h* distance. The K function and L function are defined as:

$$K(h) = \frac{1}{\lambda^2 A}\sum\sum_{i \neq j} I_h(d_{ij}) \text{ and } L(h) = \sqrt{\frac{K(h)}{\pi}} - h$$

Where A is the area of the study region, λ is the intensity, d_{ij} is the distance between i^{th} and j^{th} event in the study region, $I_h(d_{ij})$ is an indicator function with a value of 1 if $d_{ij} \leq h$ and 0 otherwise, and π is the constant pi. Simulation envelopes are then created on the K function and L function of the theoretical CSR point pattern by plotting, along with the simulated estimates, critical intervals for the Monte Carlo test. Peaks in positive values of the K function and L function suggests attraction or clustering of points, while troughs in the negative values suggest repulsion of points. The level of significance tested by the test using simulation envelope is:

$$\alpha = \frac{1}{1 + no.of\ simulations}$$

The final part of the results and discussion deals with the examination of the spatial dependence of the point pattern of drug related crimes with respect to the point patterns of other structures in Manila City such as Catholic churches, colleges and universities, public high schools, and police stations. To test these, the researchers used the bivariate K and L function. These are the same as the univariate K and L functions defined earlier, but instead of using pairs of the same events, it uses the number of pairs of events that are not alike. These are formally defined as:

$$K_{12}(h) = \frac{A}{n_1 n_2}\sum_{i=1}^{n_1}\sum_{j=1}^{n_2} I_h(d_{ij}) \text{ and } L_{12}(h) = \sqrt{\frac{K_{12}(h)}{\pi}} - h$$

Where A is the area of the study region, n_1 is the number of the 1^{st} type of event, n_2 is the number of the 2^{nd} type of event, d_{ij} is the distance between i^{th} 1^{st} type of event with the i^{th} 2^{nd} type of event in the study region, $I_h(d_{ij})$ is an indicator function with a value of 1 if $d_{ij} \leq h$ and 0 otherwise, and π is the constant pi. Simulation envelopes are also created from the Bivariate K and L functions. As with the univariate case, the envelopes can be used to test for significance on the dependence of the two point patterns: peaks from the simulation envelopes imply that the two types of events tend to cluster or attract, while troughs from the simulation envelopes imply that the two types of events tend to repulse. The level of significance of the test is computed using the formula presented earlier in the univariate K and L functions.

4. Results and Discussion

4.1. Descriptive Statistics

Given below is the Spatial Point Pattern involving the sets of events that will be studied in this paper: drug related crimes in October 2017, Catholic churches, colleges and universities, public high schools, and police stations in Manila City. The specified window is the boundary of Manila City from a shapefile downloaded from *philgis.org.*

Figure 1: Spatial Point Pattern of Catholic Churches, Colleges and Universities, Public High Schools, Police Stations, and Drug Related Crimes in October 2017 in Manila City

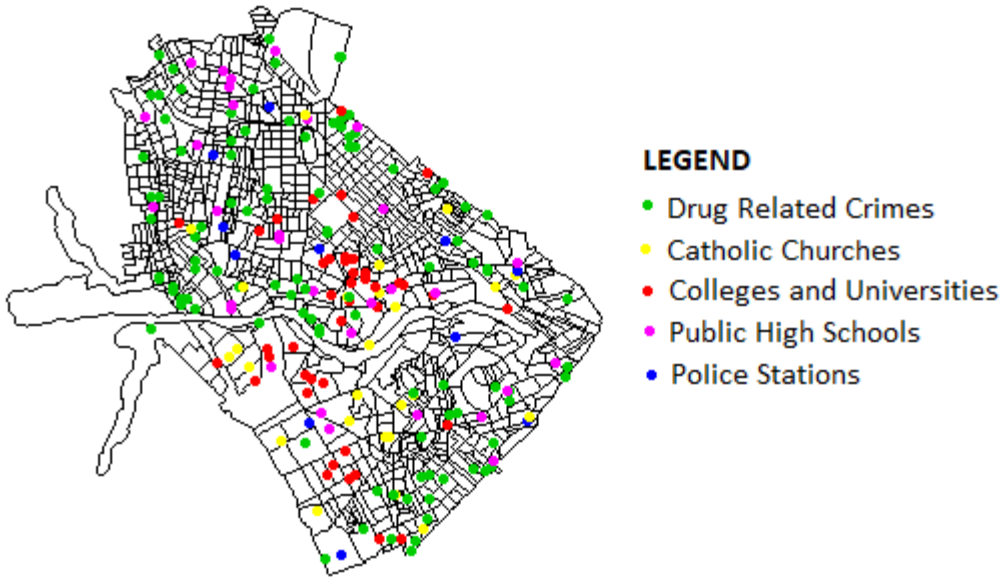


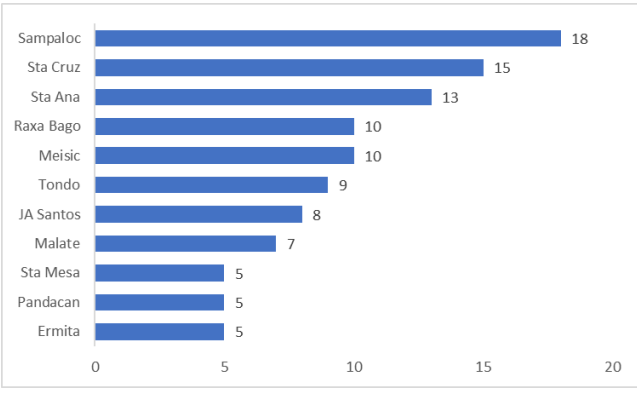
Table 1: Summary of the Spatial Point Pattern in Figure 1

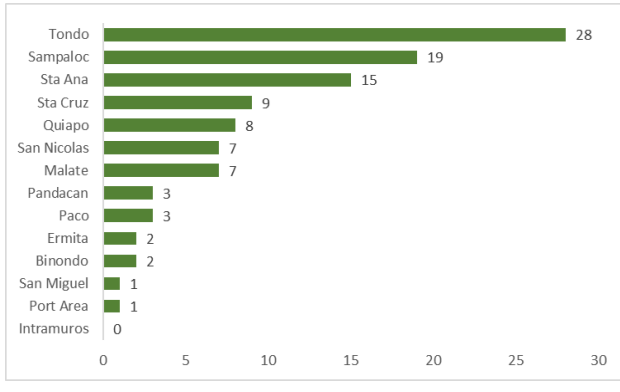
Event	Frequency	Proportion	Intensity
Drug Related Incidents	105	0.4861	35261.81
Catholic Churches	26	0.1204	8731.50
Colleges and Universities	43	0.1991	1440.55
Public High Schools	31	0.1435	10410.63
Police Stations	11	0.0509	3694.10

Enclosing Rectangle: [120.94222, 121,0237] x [14.560531, 14.6385] units
Window Area = 0.00297773 square units
Fraction of frame area: 0.469

Among the set of events, the event of drug related crimes in Manila in October 2017 is the one with the highest calculated intensity. This is simply because there are more drug related crime incidents that were recorded in the specified period of time than the number of occurrence of any other type of events. Overall, there are 105 recorded drug related incidents in October 2017, 26 Catholic churches, 43 universities and colleges, 31 public high schools, and 11 police stations in Manila City. It can be seen from the point map that the drug related incidents are scattered in the edge parts of the city that are mostly residential. Catholic churches and colleges and universities in Manila are mostly situated in the center of the city. This might be an indication that drug related crimes are repelled by tertiary educational institutions and religious structures. Meanwhile, police stations are scattered all throughout the city, and there are some drug related crimes that are near public high schools.

Figure 2: Number of Reported Drug Related Crime in Manila for October 2017 per Police Station (Left) and per Manila Main Area (Right)



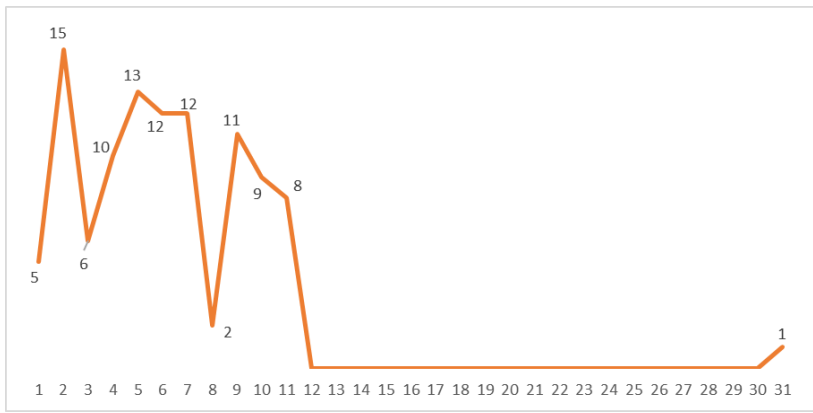


Among the police stations in Manila City, the Sampaloc Police Station (Police Station #4) has the highest reported drug related crime in the month of October 2017 with 18 reported cases. Meanwhile, Ermita, Pandacan, and Sta. Mesa Police Stations recorded the lowest number of drug related crimes. Most of the reported drug related incidents are in the Tondo Area with 28 cases in the month of October, even though the number of the reported cases in the Tondo Police Station (PS #2) is only at 9. This is because most of the cases in the Tondo area are reported in other stations such as Raxa Bago and JA Santos Police Stations (PS #1 and PS #9, respectively). No recorded drug related incident has been found in the Intramuros Area, where a handful of churches and colleges and universities are situated. Among the barangays, Barangay 273 of San Nicolas Area and Barangay 384 of Quiapo Area has the highest recorded number of drug related incidents at 3 cases in October 2017.

Based on the information on the time of the drug related crimes, the median time for the event of interest to happen in Manila City is 6:00 PM and the modal time is 7:30 PM. This means that most of the drug related crimes in Manila has been reported during the early nights.

Most of the reported drug related crimes occurred during the first week of October: from October 1 (Sunday) to October 7 (Saturday) with 73 cases, almost 70% of the reported cases in the month of October. This can be highly attributed to the fact that President Duterte lift the leadership of the Philippine National Police from the Oplan Tokhang and was given back to the Philippine Drug Enforcement Agency (PDEA) starting from October 10 (Corrales, 2017). From the line graph below, the sudden decrease in the number of reported drug related crimes is evident from October 10. From October 10 with 9 cases, it dropped to 8 cases on October 11, and then dropped further to 0 case on October 12. The daily reported number of drug related crime stayed at 0, until October 31 when there was a reported new case.

Figure 3: Timeline of the Number of Drug Related Crimes in October 2017 in Manila



4.2. Testing for Complete Spatial Randomness

Testing for Complete Spatial Randomness is the gateway for further spatial point pattern analysis. In this paper, the test used for checking for CSR on the drug related crimes in October 2017 in Manila is the Clark-Evans Test for Complete Spatial Randomness.

Table 2. Test for Complete Spatial Randomness

Clark-Evans Test for CSR		
Event	**R**	**p-value**
Drug Related Incidents	0.8764	0.0154

At 0.05 level of significance, we can reject the null hypothesis that the drug related incident point pattern in Manila City exhibits CSR. This implies that the drug related crimes are scattered heterogeneously across the area of interest i.e. there is a possibility of clustering or repulsion of the event of interest in Manila City.

4.3. Testing for Complete Spatio-Temporal Randomness

A proper test for Complete Spatio-Temporal Randomness (CSTR) of the point pattern is the Mantel test. The test not only incorporates the distances of the points but also take into

consideration the time for the event to happen in that location. The result for the Mantel test with 100 simulations is given in Figure 4 and Table 3.

Figure 4: Histogram of Simulated Spatio-Temporal Correlations

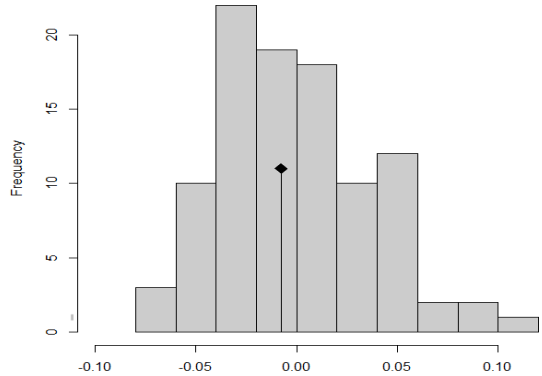


Table 3: Mantel Test for Spatio-Temporal Correlation (100 simulations)

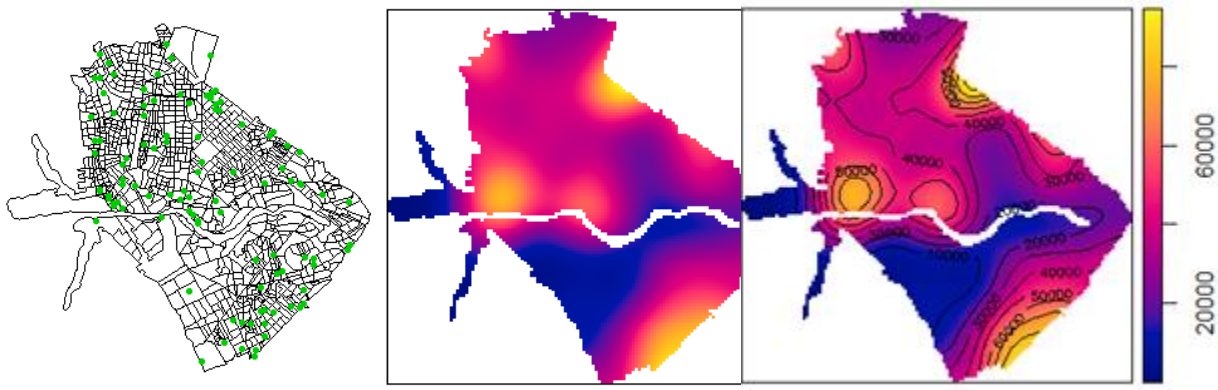
Mantel Test for Spatio-Temporal Correlation		
Event	**Observation**	**Pseudo p-value**
Drug Related Incidents	-0.0073	0.5000

The calculated spatio-temporal correlation is slightly negative which implies that the distances of points is negatively correlated with the length of time of occurrence of events. However, the pseudo-p-value (0.5) provides suggestion of non-significance of the calculated spatio-temporal correlation, which is also manifested from the location of the line of the calculated correlation with the simulated ones in Figure 4. Therefore, we have no sufficient evidence to conclude that there is spatio-temporal correlation among the drug related events in Manila City in October 2017. This means that the point patterns are only correlated in space but not in space-time, and it suffices to discuss the spatial properties of events without any temporal information on the point patterns.

4.4. Examining First Order Properties

This section of the paper will discuss the first order property, or the distribution of the drug related incidents point pattern in the study region. The figure below shows the separate spatial point pattern map and the Kernel density map with bandwidth = 0.005 with and without contours of the drug related incidents in Manila.

Figure 5: Point and Kernel Density Maps (with tau=0.005) of Drug Related Crimes in Manila City with and without contours



Since the test for Complete Spatial Randomness rejected the null hypothesis, it is already expected that the intensity parameter λ of the spatial Poisson process will vary across the region. Using Kernel Estimation, the highest intensities of drug related incidents are found to be in the western (San Nicolas and Binondo Area), northeastern (northern part of Sampaloc and Sta Cruz Area), and southeastern (southern part of Malate and Sta. Ana Area) parts of the city. Even though the

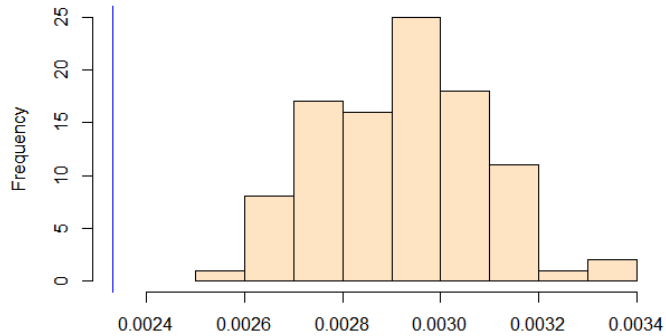
Tondo Area recorded the highest number of drug related crimes, the intensity estimated across the zone is low compared to other zones. This implies that drug related incidents in Tondo are scattered or does not cluster across its area. Meanwhile, the lowest intensity was found out to be in the Intramuros, Ermita, Paco, and San Miguel Area.

4.5. Examining Second Order Properties

The second order property of a spatial point process pertains to the behavior of the points to cluster or repulse. Based on the nearest-neighbor distances (NND), the average NND of the events of interest is 258 meters. This means that on the average, another drug related crime exists 258 meters away from a specific drug related crime in October 2017. Meanwhile, the average second NND is 426 meters, implying that a second drug related crime is expected to be observed 426 meters away from a specific drug related crime in the same month. Since the average second NND is lower than twice the average NND, it can be concluded that there is clustering among the points in the study area.

A test for clustering is made by comparing the computed average NND of the real dataset with computed average NNDs from the simulated point patterns. Figure 3 shows the histogram comparing the computed average NND from the simulated ones.

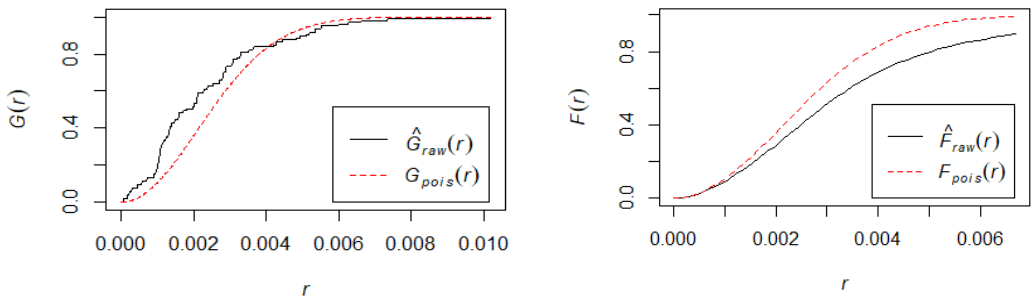
Figure 6: Histogram of Simulated NNDs of Drug Related Crimes (100 simulations)



The blue line indicates the computed NND for the dataset. The computed NND is lower than all the simulated NNDs as presented in figure 3. This means that we can conclude at alpha=0.05 that the drug related crimes in Manila City tend to cluster (with pseudo-p-value=0.0099).

Another way to examine the second order property is assessment of the G function, which is a function of the event-to-event distances, and the F function, which is a function of the random point-to-event distances, are plotted with respect to the theoretical, CSR Poisson spatial point process. The graphs are given below.

Figure 7: Graph of G Function (left) and F Function (right) of Drug Related Incidents in Manila City in October 2017

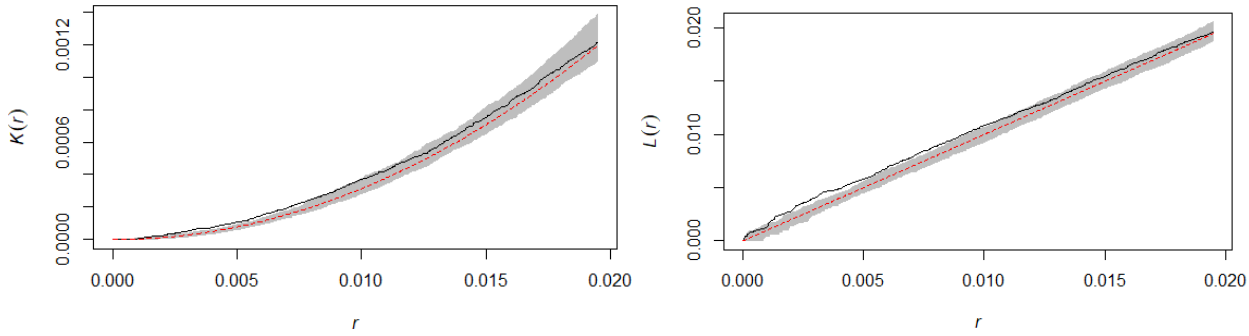


Drug related incidents tend to cluster, since
the G function increased at short distances (small values of r) and the F function line is below the theoretical line and the G-Function. Notice, however, that there is a slight sign of repulsion of points from r=0.004 to r=0.008.

A test for clustering or repulsion of points can be created from the estimated K function and the L function with their respective simulation envelopes. Since there are hints of the

estimated K function line and L function that are outside above the simulation envelopes from 19 simulations, we can sufficient evidence to say at 0.05 level of significance that the drug related incidents in Manila city tend to cluster.

Figure 7: Graph of K Function (left) and L Function (right) with simulation envelopes (19 simulations) of Drug Related Incidents in Manila City in October 2017



All the three approaches in the description of the second order property of the spatial point pattern presented above (utilization of Nearest Neighbor Distances, G and F functions, and K and L functions with simulation envelopes) indicates evidence of clustering of drug related incidents in Manila City in October 2017.

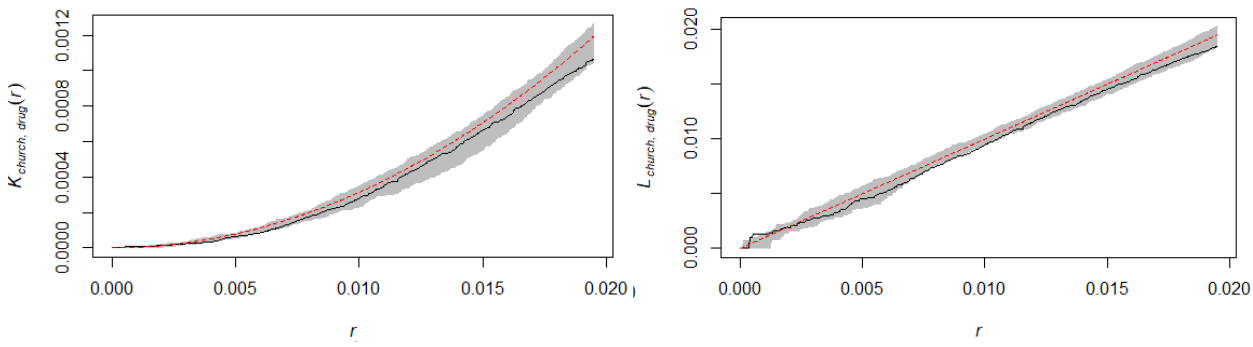
4.6. Examining Spatial Dependence of Drug Related Incidents with Certain Structures

Our final objective is to check whether there is spatial dependence between the location of the event of having a drug related incident and the specific structures in Manila city such as police stations, churches, public high schools, and colleges and universities. That is, we want to test whether drug related incidents will tend to cluster or repulse from these structures. To test this, the researchers created simulation envelopes (with 99 simulations) for the Bivariate K and L functions: two functions that describe spatial dependence between two types of spatial point patterns.

4.6.1. Catholic Churches

The estimated Bivariate K and L functions of the Catholic churches and the drug related incidents in Manila City are below the theoretical Bivariate K and L functions. This implies that drug related incidents tend to happen far from Catholic churches. However, since the estimated lines did not go outside the simulation envelopes, we have no sufficient evidence to conclude at alpha=0.05 that Catholic churches repels drug related incidents.

Figure 8: Bivariate K (left) and L (right) Function Graphs with simulation envelopes (19 simulations) of Catholic Churches and Drug Related Crime in Manila City

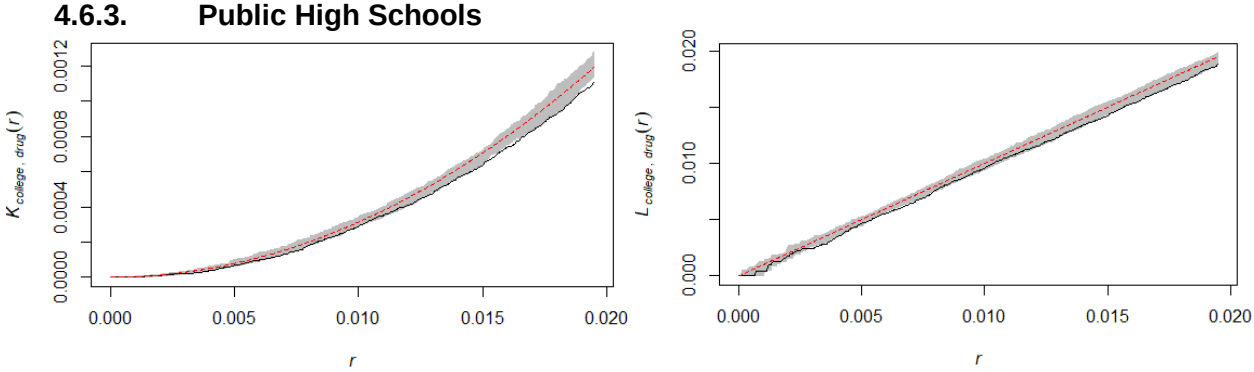


4.6.2. Colleges and Universities

From the figures below, we have sufficient evidence to conclude at alpha=0.05 that drug related crimes tend to repel from colleges and universities in Manila City, since the values of both the estimated Bivariate K and L functions spiked below their respective simulation envelopes.

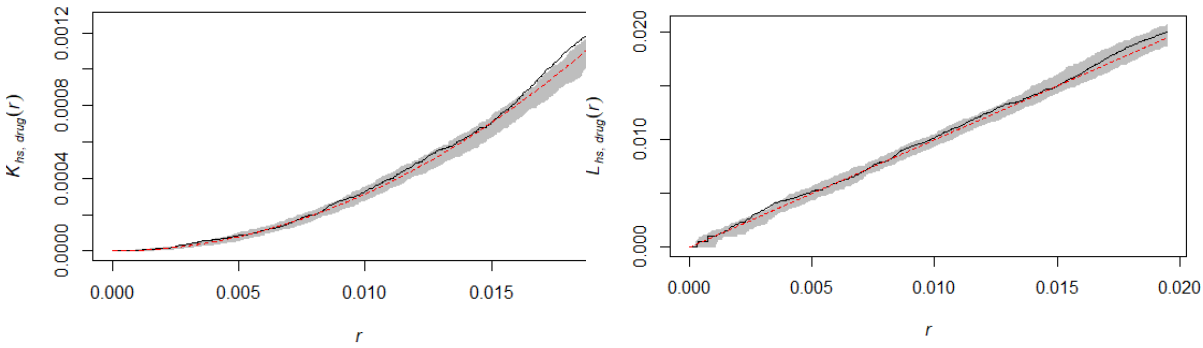
Figures 9: Bivariate K (left) and L (right) Function Graphs with simulation envelopes (19 simulations) of Colleges and Universities and Drug Related Crimes in Manila City

4.6.3. Public High Schools



The estimated Bivariate K and L functions for the public high schools and the drug related incidents are above the simulated Bivariate K and L functions. Also, there are instances wherein the estimated Bivariate K and L functions values are above the simulated envelopes. This means that at alpha=0.05, we have sufficient evidence to conclude that the drug related incidents and public high schools tend to cluster i.e., drug related incidents commonly happen near public high schools.

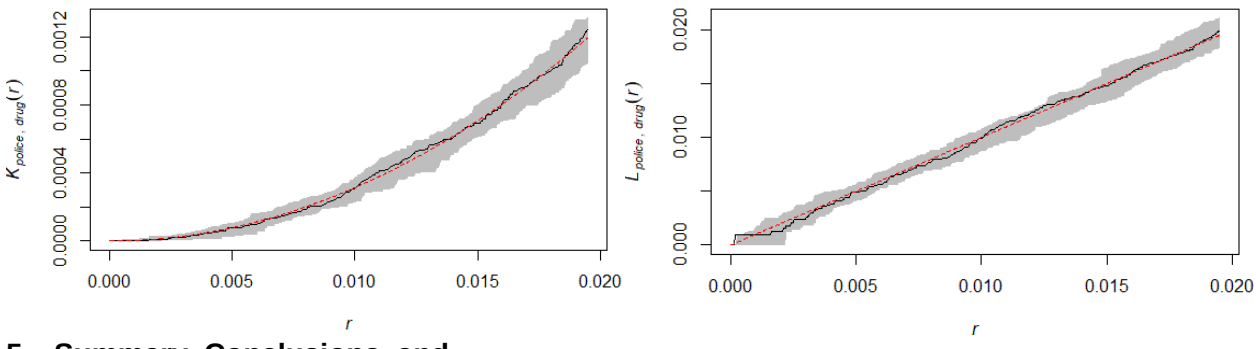
Figures 10: Bivariate K (left) and L (right) Function Graphs with simulation envelopes (19 simulations) of Public High Schools and Drug Related Crimes in Manila City



4.6.4. Police Stations

Since both the estimated Bivariate K and L functions tend to be inside the created simulation envelopes when there is complete spatial randomness, we have no sufficient evidence to conclude at alpha=0.05 that drug related incidents are clustered or repulsed by nearby police stations in Manila City. Notice also that the estimated lines are almost always on par with the simulated Bivariate K and L- functions, further justifying the results of the tests. Figure 11 shows these findings.

Figure 11: Bivariate K (left) and L (right) Function Graphs with simulation envelopes (19 simulations) of Police Stations and Drug Related Crimes in Manila City



5. Summary, Conclusions, and Recommendations

The researchers found out that most drug related crimes in Manila in October 2017 are reported to the Sampaloc Police Station and occur during the early nights. It was also found out that the imposition of the ruling for PDEA to lead Oplan Tokhang from PNP on October 10 has significantly decreased the amount of reported drug related crimes in Manila. This fits with the conjecture that PDEA lacks the capability to fight the problem of drugs in the country due to their lack of funding and human power (Navallo, 2017). The researchers then recommend for the increase of the said agency's funding so that they will be able to have sufficient equipment and hire more people to increase their power against the problem of drugs.

The point pattern of drug related crimes in Manila in October 2017 are found out to not possess Complete Spatial Randomness. This implies that these crimes do not occur randomly in Manila City. However, it failed to reject the test for Complete Spatio-Temporal Randomness. Since the point pattern managed to reject CSR but not for CSTR, it suffices to study the behavior of the points spatially.

The Tondo area has the largest number of drug related crimes in October 2017, but it was found out that the highest intensities of drug related crimes are not in Tondo for they are scattered evenly across its area. The highest intensities are recorded in the San Nicolas, Binondo, Northern Sampaloc, Northern Sta. Cruz, Southern Malate, and Southern Sta. Ana areas. The lowest intensity of the drug related crime is found out to be in the Intramuros, Ermita, Paco, and San Miguel areas.

On the average, another drug related crime is expected to be found 258 meters away from an already reported one in October 2017. Based on the three approaches in describing the second order property of the point pattern of drug related crimes in Manila, it was found out that this type of crime tends to cluster spatially. Since drug related crimes don't cluster in space-time but cluster spatially, this suggests the possibility that most of the people lay-lowed temporarily after a drug related crime was reported to the police in their vicinity, and they eventually returned to commit these crimes again and got reported to the police. this insinuates the prospect that the fear tactic of the police on Oplan Tokhang does not work for some drug criminals. Further research about the factors that push people to go back to drug related crimes should be studied.

It was found out that police stations in Manila city don't repel or attract drug related crimes which again supports the researchers' earlier finding that police's tactic to induce fear in the war on drugs does not work effectively. additionally, it was presented that Catholic churches induces a slight repulsion to drug related incidents. however, we have found no sufficient evidence to conclude this finding.

The researchers found sufficient evidence that drug related crimes in Manila City tend to happen far from colleges and universities. However, an alarming result surfaced from the analyses: that drug related crimes tend to happen near public high schools. This might imply that the problem of drug dependence among minors especially high school students is already getting acute. Actions from public high schools in Manila and the Department of Education are expected in order to save students from drug abuse and the bad effects it will have on the student and the community. Since it is stated in related literature that the most common causes of drug dependence among students are stress in studies and family matters, the role of guidance counselors in high schools have never been more important. For the government body, further solutions on mitigating the drug trades in the Philippines should be done in order to cut its influence on the Filipino youth. More rehabilitation centers should be created to increase students' access to reformation.

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