**Exploring Use of GIS Technology in Policing**

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**REPORTS 1-3**

# GIS in Policing: Literature Summary, Environmental Scan, & Comparative Statistics

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**REPORT 1 of 3**

# GIS in Policing: Literature Summary

Regan Mania

Supervised by Dr. Kristy Buccieri

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# 1.0 Introduction

Geographic Information System (GIS) are software programs that are increasingly utilized by policing organizations in Canada. These programs allow for the storage and visualization of geographic data, which can then be analysed to inform decision making processes (Malm & Tita, 2006, p.366). In Canadian policing, this allows for mapping of crime patterns, tracking of criminal activity, and development of crime prevention policies (Malm & Tita, 2006, p.366). GIS can be coupled with criminological theories to better equip departments to respond to issues as they arise, such as hotspots, while also creating predictive patterns, or predictive policing. These tools can be used to evaluate the effectiveness of programs and can be utilized out in the field to better understand the community's needs (Malm & Tita, 2006, p.366). GIS data collected by police can be coupled with other GIS data, such as census data, to improve community relations, ensuring those who may be in lower socio-economic areas receive adequate support.

GIS technology must be applied appropriately, as over-policing through the use of this technology may strain tensions with communities, especially those who have historically been subjected by police. Over-policing of vulnerable communities is a longstanding issue, and one that must be considered when looking to utilize GIS technology, ensuring that those who may have fractured relationships with police do not have their relationships fractured further.

# 2.0 Objectives of Research Project

This project was conducted on behalf of the Peterborough Police Service in Peterborough, Ontario. This study was conducted through a literature review of 25 sources on GIS technology, both in and outside of policing, as well as in Canada and the United States. Through these 25 sources, we aimed to determine the use of GIS by police in Canada, as well as the level of use, and type of use. Furthermore, we aimed to understand the progression of GIS use in Canada, as innovations and practices changed as the technology advanced. The aim is to understand the usage of GIS in Canadian policing, in hopes of informing the usage of GIS policies and practices at the Peterborough Police Service, and successfully implementing the technology.

# 3.0 Findings

## 3.1 Historical Usage of GIS

In Canada, GIS has been used professionally for approximately forty years, beginning in the 1980's. As technology has improved, particularly through the 2000's, the use of GIS has increased. Throughout the literature summary we explored the progression of the technology, with several articles using the technology in the 1990's. In *Formal Scientific Research of Traffic Collision Data Utilizing GIS,* we are first exposed to gaps in the literature on the subject, as the technology was in its relative infancy (Arthur & Waters, 1997). Through this article, we see some of the first studies conducted on the use of GIS and traffic, which is a central issue in policing. This article

provided a foundational understanding of the importance of GIS for policing traffic, as well as the use of multiple technologies such as photo radar, or the deployment of road-checks, such as drunk driving prevention (Arthur & Waters, 1997, p.135). These practices, and the knowledge, are now commonplace, demonstrating the important progress we have made since the 1990's, as well as the important foundational research we examined to understand the practical applications for today.

Continuing through the early 2000's we found the bulk of our literature, as this period was significant for the broader adoption of GIS, as well as expanding research. Technology progressed rapidly between the 1990's and early 2000's, as did access to GIS technology. One of the first articles we can turn to is *Residential Burglaries and Neighborhood Socioeconomic Context in London, Ontario: Global and Local Regression Analysis*, as it combines both police GIS, and census data to predict and understand crime in the university city of London, Ontario (Malczewski & Poetz, 2005). One of the central focuses of this article is the socioeconomic role that the University of Western Ontario plays, in conjunction with crime rates. This article is significant to this research project, as Peterborough is also a university town and may experience similar socioeconomic conditions and crime. Through this article, we begin to see use of combined data sets, mapped through GIS, allowing for a more complete understanding of both data sets.

Through the 2010's the literature continued, however much of it built upon previous studies conducted in the previous decade and began to look at more niche applications and criminological theories. One article of significance is *Exploring Hotspots of Drug Offences in Toronto: A Comparison of Four Local Spatial Cluster*

*Detection Methods,* by Quick and Law (2013) as it recognizes a gap in the previous literature on spatial cluster detection, a type of methodology used with GIS, and works to critique the method, which had not been previously done. This allows for a demonstration of the evolution of the usage of GIS, in an Ontario policing context, which allows Peterborough Police to understand their options for spatial cluster detection methods and select the most appropriate method for their use. Throughout their article, authors Quick and Law (2013) discuss the four types of spatial cluster detection methods, as they relate to drug hotspots. This research is of significant importance to Peterborough Police, as spatial cluster detection methods allow for a data visualization of areas with high-risk, which would allow for better resource allocation and potential crime prevention.

Continuing into the 2020's, we see a continued engagement with other resources to further enhance the use of GIS in Canadian Policing. GIS has now become widely known, as reflected in the number of articles from the first three years of this decade. Out of approximately thirty sources for this literature summary, five were published within the last three years, demonstrating the rising use and case-studies about the use of GIS. One article of significance is the Dunlop et al., (2022) article, *Social Work and Technology: Using Geographic Information Systems to Leverage Community Development Responses to Hate Crimes.* Within the article, the authors expand on the previous research involving the use of community partners in policing, while exploring for the first time, the use of GIS in hate crimes (Dunlop et al., 2022). This phenomenon, while not a crime in itself under the *Criminal Code,* has seen a rise, and police must be capable of responding, and ultimately preventing this from occurring in the first place

(Dunlop et al., 2022, p.216). Hate crimes target those who are usually in a minority or distinct group, so they must be given protections, while also not provoking potential mistrust (Dunlop et al., 2022, p.205). This mistrust, in the case of racialized groups, may come from a complicated historical relationship with the police, and the GIS use must be mindful of that, ensuring groups do not feel overpoliced or over-surveilled through the use of data collection, storage, and analysis. Furthermore, Dunlop et al., (2022) discuss the importance of bias when creating policies, such as community engagement programs, as they could influence the program type and delivery, which could potentially harm the community (p.207). Throughout their article the authors discuss the importance of using community partners, such as social workers to develop community programs to ensure those in the targeted group feel safe and supported (p.206).

These four distinct periods of GIS usage reflect the changing technology, as greater access and understanding contribute to greater usage. The 1990's was characterized by exploratory research, such as the impact of GIS on understanding traffic patterns and resource deployment. The early 2000's saw the continued exploration of GIS, as well as the introduction of multiple data sets, such as census data to understand the socio-economic status of high-crime areas. Moving into the 2010's we saw a greater expansion on multiple data sets, along with a greater adoption of GIS by organizations such as the police, as well as the beginning of critiques for GIS methods. Finally, the early 2020's has seen continued exploration of GIS, with multiple studies conducted in the first three years, and expanding on the use of multiple resources, while also exploring new phenomenon such as hate crimes.

## 3.2 Micro Use of GIS

GIS can be utilized to explore micro phenomenon such as individual crimes, or individuals within the community who may be a suspect. This practice first emerged in the 1990's, as seen in early articles such as Grescoe's (1996) *Murder, He Mapped*, which explores early uses of geographic profiling to determine who a murder suspect may be. Throughout this article, we see an emerging form of GIS, used to analyze potential suspects based on their geography and the geography of their crimes. In this article we see the first critique of early GIS systems as well, as they could only perform simple functions such as pinning a location, which could only visually represent where a crime occurred, limiting the context (Grescoe, 1996, p.1). Early GIS pioneer, Rossmo (2003), advanced the field by creating geographic profiling, creating an equation to calculate a suspect's home- or workplace-based criminological theories about distance and routine activities. This calculation considers previous criminological research about 'buffer zones' or the distance a criminal is willing to go from their home to a commit a crime, which is approximately 250 to 500 meters (Grescoe, 1996, p.2). One issue that arises from this early theory is its limited scope, as it only works with those who are serial criminals, and works best with those who have committed five to six crimes (Gresco, 1996, p.3). Furthermore, many are apprehended before they are able to commit that many crimes, and not all crimes fall into this pattern, with those who are unemployed and unhoused not necessarily having a central location (Grescoe, 1996, p.3). This early theory is important as it may shape the way that Peterborough utilizes GIS to track down serial criminals and engages in crime prevention methods for those in a specific area.

Descriptive mapping is the data visualization feature of GIS, allowing for data points to be visualized based on characteristics. Data visualization may include colour coding or shape coding based on characteristics, location, and frequency (Canter, 2012, p.7). For example, a high-rise building would have a different data visualization than a single-family home, as the number of incidents in the high rise would result in a bigger cluster, potentially with a greater loss value and different property value, as well as a greater variety in data points such as age (Canter, 2012, p.7). In the case of traffic collision data, visualization may take the form of insurance value, speed, or type of accident, all of which could be visualized and create different data points depending on the intersection (Arthurs & Waters, 1997, p.124).

Discrete spatial distributions are a central part of micro-analyses in GIS, as they are defined by locations such as addresses. Analytical mapping can test hypotheses about the spatial distribution of discrete patterns, which would reflect whether a redistribution of resources has been effective (Canter, 2012, p.7). Examples of discrete spatial distributions may include traffic intersections or businesses, as they are defined by locations, and analysis on program effectiveness is easily conducted. Furthermore, these locations may be identified as hotspots, a collection of crimes in one place or at one address.

Hot spots provide a macro or micro perspective on crime, depending on their use in GIS. In the case of micro, hot spots may be utilized to highlight one place where crime is common, which may be limited to a street or intersection, rather than an entire downtown core, for example. This is a shift away from the individual characteristics of crime, as seen in geographic profiling, into the characteristics of the area. There are

several theories about hot spots which would be relevant to the implementation of GIS, as targeting those specific places, such as a traffic intersection, may reduce crime. One theory about hotspots is rooted in routine activity theory, which states that a potential criminal may target a location as they know the area, as they pass by throughout their activity (Eck et al., 2002, p.5). This theory is elaborated on by Eck et al., as they discuss the potential for the perimeters of low crime places to overlap, creating an opportunity for a hotspot (2002, p.5). As the perimeters of these low crime places become further from the center, as they overlap, there is an increased opportunity for crime there (Eck et al., 2002, p.5).

Area characteristics would fall under the theoretical umbrella of environmental criminology. These characteristics, which could be mapped, would include high traffic intersections, side streets, or pedestrian areas (Swartz, 2000, p.3). For example, a high traffic area may see more calls in service, due to a potentially dangerous intersection. Resources could be deployed to direct traffic, or in the case of cross-party collaboration, a potential redevelopment of the intersection. In the case of side streets, crime may take place due to poor lighting and less traffic, which could be addressed through greater patrols and redeployment of officers, with fewer concentrated on main streets and more patrolling side streets. Finally, pedestrian areas may also see a rise in calls for service, as lighting may be poor, and police vehicles cannot patrol pedestrian walkways. In the case of pedestrian areas, such as the Rotary Trail in Peterborough, the use of other resources such as bicycles or officers on foot may work as the presence of officers works to combat the perceived environmental benefits of a low-lit area. Hot spots, as

part of a micro focus of GIS, are critical to understand and address, as individual places contribute to the overall trends of a city.

Individual crimes, when mapped in GIS, are given the same weight, which may create cluttered maps. This issue can be combatted, on the micro level, by determining what crimes are the most important in a map, or ways to layer them. Furthermore, hot spots can be determined by selecting the number of crimes in an area, rather than looking at a map littered with dots (Eck et al., 2000, p.9). As discussed by Eck et al., one can determine a hot spot through the use of repeat crime addresses (2000, p.8). When selecting types of crimes to test, Eck et al., first selected property crimes such as burglaries, as they have a greater spatial significance, allowing for a precise address (200, p.5). As Peterborough expands their use of GIS, they may want to select crimes of spatial significance such as property crimes, as those will be the easiest to correlate to a specific address.

Once the authors demonstrated the significance of property crimes, Eck et al. then selected to focus on addresses with multiple crimes beyond property crimes. Through their expanded search, they were able to determine the total amount of crime, such as places with four crimes accounted for more than one forth of crime, whereas places with more than three crimes accounted for more than one third of all crime (Eck et al., 2002, p.9). This type of selection is known as minimum plotting density (mpd), allowing for data filtering based on the minimum number of events at one address (Eck et al., 2002, p.9). Minimum plotting density allows for more targeted responses, which in turn prioritizes resources and makes for more proactive policing.

GIS data may be subject to manipulation, which may lead to the targeting of individuals, an inherent flaw of the micro-level capabilities. As discussed in *Profiling Minorities: Police Stop and Search Practices in Toronto, Canada*, author Yunliang Meng highlights the issues of youth subjected to stop and search in Toronto. Meng (2017) focuses on the racial bias towards Black youth who were subject to an increase in stop and search, from 42.7% to 44.9% between 2003 and 2012, whereas white youth experienced a decrease (p.5). This increase was also experienced when the overall crime rate itself dropped by 42% in the same time period (Meng, 2017, p.5). The number of Black men stopped accounted for 22% of the total population of Black men, and youth specifically found themselves targeted due to the attributes of their age group being perceived as antisocial (Meng, 2017, p.6). The attributes of these men may be preconceived, as hot spots targeted by police are often socio-economically disadvantaged areas, therefore people, including police, may replace racial characteristics of neighbourhoods for racial backgrounds of individuals, creating the flawed perception that one may be suspicious (Meng, 2017, p.9). Racial bias in stop and search is not simply hypothesized, in 2003, Black youth were arrested for every 3.21 stopped, whereas white youth were arrested for every 5.13 stopped (Meng, 2017, p.13). While I recognize the stop and search has decreased in use since this statistic was created, however racial bias still occurs, and mapping of characteristics, including race may lead to the increase of over policing of this population, as maps may also include socio-economic characteristics. Hot spot policing results in increased surveillance, traffic enforcement and disorder enforcement (Meng, 2017, p.7), which may be good when trying to target an increase in crime, however socio-economic

characteristics must be taken into consideration when addressing a hotspot, as an effort that builds community relations may be more appropriate. Finally, racial bias, and history of racial bias must be taken into account, as Meng discusses in her article, the harm experienced by the community may cause irreparable harm to the relationship between police and racialized members of the community (Meng, 2017, p.20).

Socio-economic characteristics can be mapped using other data sources, such as the census. The mapping of this data can make policing practices more effective, rather than punitive and tailor needs to the community. In the case of Black youth, engaging with after-school programs and introducing police in that venue may be more productive long term as relationships are built and maintained (Harries, 2000, p.6). Sex workers and those who use drugs, are two groups who have faced similar over-policing as Black youth. Their relationship to police is demonstrated in *Mapping Violence and Policing as an Environmental-Structural Barrier to Health Service and Syringe Availability Among Substance-Using Women in Street Level Sex Work,* an article by Shannon et al., (2008) utilizing GIS as a method to visualize police violence against sex-workers. Fractured relationships and fear of police led those in the article to avoid accessing resources including syringe harm reduction programs, which may lead to an increase in calls for service. By fracturing their relationship with the community, police resources are being used inefficiently as those who may experience an overdose in an unsafe place have to call for service, rather than feeling safe to access resources such as safe injection sites. This is visualized using GIS, and those who used drugs reported avoiding areas with healthcare such as safe injection sites, due to over policing and police harassment (Shannon et al., 2008, p.144). In a city like Peterborough, this data

would be critical to combat issues such as overdoses, as avoiding over policing would allow for access to resources such as safe injection sites. Fear of police cause those using drugs to retreat into unsafe situations, also increasing the risk of potential arrest as well for possession of illegal drugs. It should be noted that this article was written in 2008 and since then we have seen the rise in fentanyl, so the use of safe injection sites is of even greater importance and police harassment or over policing should not stand in the way of that.

## 3.3 Macro Use of GIS

GIS can be used to examine both individual areas, as well as widespread areas, such as cities. Trends can be evaluated for entire cities, comparisons can be made against certain areas in cities, and pilot projects can be launched. As discussed in the micro use of GIS section, individual points can be mapped to visualize data, however once again, we must be selective in our data as we do not want to create one uniform mark that cannot be distinguished. Timelines, locations, and characteristics can all be mapped and selected to visualize the trends in a city, providing a broader view than a single intersection or building (Harries, 2000, p.5). The macro use of GIS, I believe, is of greater importance to Peterborough as it expands this initiative, as a broad view of the city and the potential for pilot projects would be of greater benefit.

As discussed previously, hot spots can be used for both macro or micro analysis, and this is supported in the use of cluster detection. In *Exploring Hotspots of Drug Offences in Toronto: A Comparison of Four Local Spatial Cluster Detection Methods*, we see authors Quick and Law (2013) deploying a new method of spatial analysis known as spatial cluster detection, which identifies high risk areas (p.215). The use of cluster

analysis allows for both micro and macro analysis, as small clusters can indicate an individual problem that needs a specific resource, whereas a large cluster can indicate a widespread issue that needs general policing (Quick & Law, 2013, p.217). Furthermore, the context of the cluster can inform why that type of crime is occurring such as socio-economic status or social programming (Quick & Law, 2013, p.217). Finally, the authors found that one key characteristic played a role in the formation of clusters, and that was proximity to major arteries such as the 401 in Toronto (Quick & Law, 2013, p.228). This article focused on drug offences, and their research found that major intersections caused clusters as they worked as easy connection points for the transportation and sale of drugs (Quick & Law, 2013, p.228). The use of clusters is important in the development of GIS in Peterborough, as it provides a unique opportunity for both micro and macro analysis.

As a university town, Peterborough has a young population that routinely moves in and out of town, and has two distinct locations, which may be reflected in the crime stats when they are mapped. Beginning with an older article from 2005, we can see how the University of Western Ontario impacts the town of London, Ontario. We will then explore a 2015 article about two different universities in Ottawa, Ontario, and the impact their different locations have on crimes committed around their campuses. The transition between the two articles will highlight, first the impact the university has on the community, and secondly the different communities created by university campuses, as their locations have their own characteristics.

London, Ontario is home to the University of Western Ontario, and the crime trends of the city are detailed in the article *Residential Burglaries and Neighborhood*

*Socioeconomic Context in London, Ontario: Global and Local Regression Analysis* by (Malczewski & Poetz, 2005). The authors sought to understand the impact the University of Western Ontario had on the crime trends in the neighbouring areas. The authors took several data sources, including data from Statistics Canada, which provided information on the employment status of areas, the percentage of multi-dwelling homes, rentals, and percentage of movers within the last five years (Malczewski & Poetz, 2005, p.519). Using criminological theory, the authors hypothesized that the areas around the University of Western Ontario would experience greater residential burglary ratios, as the community experiences lower cohesion and greater opportunities to commit crimes (Malczewski & Poetz, 2005, p.518). To test their hypothesis the authors used geographically weighted regression, which can be used to find the spatial relationship between independent and dependent variables, in this case the location versus the characteristics of the neighbourhoods in London, Ontario (Malczewski & Poetz, 2005, p.5220). The authors selected a location with a range of 1 and 5 kilometers to test the spatial relationship of each characteristic (Malczewski & Poetz, 2005, p.522). Upon conclusion, the authors found that the areas around the University of Western Ontario had higher than average residential burglary ratios, based on the data provided by Statistics Canada (Malczewski & Poetz, 2005, p.525). Without collecting data, the authors were able to calculate and test the likelihood of residential burglary ratios using pre-existing data from Statistics Canada and could be an important starting point for understanding the potential residential burglary ratios in Peterborough. These trends would be able to be mapped in GIS, and a similar study could be

undertaken in Peterborough to understand the impact of Trent University on crime in neighbouring areas.

Building upon the previous research conducted in London, Ontario, authors LaRue & Andresen, sought to understand the relationship between crime and universities (2015, p.190). They contributed two new points, the concept of crime generators and crime attractors, both of which may be useful to Peterborough's use of GIS and provide a greater analysis of hot spots. Crime generators are non-criminal places that bring together motivated offenders and suitable targets, which allow for the creation and recognition of opportunities for crime (LaRue & Andresen, 2015, p.190). Crime attractors draw in motivated offenders because of their opportunities to potentially commit crimes (LaRue & Andresen, 2015, p.190). The authors seek to understand universities as potential crime generators and crime attractors, and the spatial patterns of crime they produce (LaRue & Andresen, 2015, p.190). This study was conducted in Ottawa and allowed for a comparison of two universities, Carleton which is located in the suburbs, and the University of Ottawa which is located downtown (LaRue & Andresen, 2015, p.197). Using crime data from Ottawa Police, the authors were able to determine the variations in types of crime on the two university campuses. Both universities had positive relationships with burglary, however Carleton had a positive relationship with motor vehicle theft that was not applicable to the University of Ottawa (LaRue & Andresen, 2015, p.205). Based on the location of the campus, the authors theorize that there is an increase in car theft due to more students having to commute to campus (LaRue & Andresen, 2015, p.206). These findings are significant to Peterborough, as they highlight the importance of spatial analysis, specifically in a

university town such as Peterborough. Furthermore, this study can also be applied to Trent University's two campuses in Peterborough, as there is one on the outskirts of the city, as well as one downtown.

Specialized policing is an important tool that can be utilized through the use of GIS, as it allows for a visualization of data prior to implementation, as well as the effectiveness during programs. While marijuana is now legal, one study to note is *A Spatial Analysis of Green Teams: A Tactical Response to Marijuana Production in British Columbia*, as it highlights the use of tactical teams and their potential effectiveness. Using GIS, the authors visualized the effectiveness of green teams, or specialized marijuana taskforces, as they hypothesized that their effectiveness was short-lived and costly (Malm & Tita, 2006, p.362). Based on their research, the authors found that green teams were effective in slowing the growth of production of marijuana, and their work was worthwhile despite being expensive and taking resources from broader policing projects (Malm & Tita, 2006, p.362). This paper offers a clear demonstration of the effectiveness of GIS in policing, as there was a visual representation of the effectiveness of a police project, such as a specialized drug taskforce.

Predictive crime mapping is another crucial part of GIS and can be used on a macro scale to ensure resources are deployed in key areas. This is demonstrated by Fitterer et al., (2015) as they discuss the use of GIS and predictive crime mapping to decrease break and enters in Vancouver, Canada. To conduct their study, they characterized the space- and time of break and enters, and then used 200m wide grid squares to visualize the number of break and enters, before and after their study (Fitterer et al., 2015, p.126). Using the data of previous break and enters, along with

criminological theory about routine activities, the authors were able to compute the likelihood of an offender breaking into a similar home in the area of the previous crime (Fitterer et al., 2015, p.130). Through the use of a spatial model, the authors saw a significant decrease in the number of break and enters, demonstrating the importance of spatial analysis through GIS, as it provides useful information for predictive policing (Fitterer et al., 2015, p.128).

Finally, for a practical application of a macro use GIS for first responders, we can examine the report, *Innovation in GIS Emergency Response Planning*, from Public Safety and Emergency Preparedness Canada. This document was published in 2003, however the guiding principles are valuable and can shape the way Peterborough implements GIS into their police force. GIS can be used for a variety of functions, however the authors found that most agencies used it for tactical, locations of interest, and buffer zones (Spearin, 2003, p.11). On a macro level, this would allow for strategic police deployment, ensuring that officers are patrolling hot spots, as well as potential areas for crime identified previously such as the areas around Trent University. This study also found that overall, the use of GIS for organizations resulted in improved planning, preparedness, responsiveness, and communication (Spearin, 2003, p.12). All of these would be of great benefit to Peterborough Police, as they work towards more proactive policing. The use of macro-GIS is critical as we move forward in policing, with data being readily available, including crime trends and predictions, allowing for more precise and proactive policing.

# 4.0 Recommendations

Based on the literature reviewed, I would recommend beginning with a macro view use of GIS for the Peterborough Police. This would allow for an overview of crime trends, with the opportunity to station officers according to the real time data. Furthermore, a macro view would also allow for testing of projects, such as new policing methods and see the overall impact they had on the community or area they were implemented in. The testing of projects can be visually represented, as specific officers, for example, are colour coded if they are part of a new community initiative. This recommendation is based on the work from British Columbia and the use of green teams, as they had a role in the disruption of illegal marijuana production. A macro view would also allow for the filtering of crimes by type, severity, and frequency. I would also recommend a macro view based on the predictive policing work from British Columbia, where researchers were able to establish a boundary in which break and enters were likely to occur, as well as the likelihood. Furthermore, they compared these occurrence and proximity patterns to random patterns to determine the significance of said observed patterns. Based on annual trends researchers were able to establish a trend of progressive decrease in break and enters. Using the proximity patterns, researchers were able to target hot spots, leading to a substantial reduction in offences. The development of Peterborough's macro view GIS system is critical in visually understanding the city's crime data and can work to better serve the community through predictive policing.

Once established, Peterborough can begin to advance, looking at individual cases and use a micro-analysis. This would include focusing on individual areas or

streets, such as high accident intersections. When discussing a street or concentrated area, I caution that discretion should be used, as over policing may fracture relationships with groups, such as people who use drugs, or racialized individuals.

## 5.0 Summary

GIS is an important policing tool that has become increasingly common over the last thirty years. This technology is critical in the development and practice of modern policing, as it allows for visual representation of data and informed policy decision making. Furthermore, this technology has the ability to aid predictive policing as criminological theory and data visualization come together to show where a crime might occur. In order to better serve the community, Peterborough Police should implement GIS first on a macro-level, then on a micro-level to address not only the overarching issues but also the individual issues that the city faces.

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**REPORT 2 of 3**

# GIS in Policing: Environmental Scan

Regan Mania

Supervised by Dr. Kristy Buccieri

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# 1.0 Introduction

Geographic Information System (GIS) is a software program that is commonly used by police services across Ontario. These programs have been in use across the province for approximately thirty years, with use expanding to smaller police services since they were first introduced. As the technology has progressed, usability and access have improved, allowing many small police services across Ontario the opportunity to adopt the technology. The services in Ontario that have adopted the technology, use it as a way to visualize both individual crimes, as well as hot spots, allowing for more targeted responses. Furthermore, by targeting responses these smaller services are able to visually track data on a macro level to see the efficacy of their response. Major police services, such as the Toronto Police Service, provide more comprehensive data and GIS maps, allowing for richer analysis, including colour coding areas on macro levels, as well as providing neighbourhood specific data. GIS maps may allow for services, both small and large, the ability to better predict where and when crimes may occur, while also visualizing resource efficacy. However, more research is needed to understand the strengths and limitations to this approach.

While many services use GIS for their own planning and tracking, several have also made their GIS available to the public. This public information allows civilians the opportunity to see the potential risk of their neighbourhood, as well as the efficacy of police programming and responses. Publicly available data is a critical tool in community relations as it allows residents the opportunity to see their safety and for police to provide visual evidence of their work, including the impact they may have on crime trends through the utilization of data. It should also be noted, however, that these

crime maps may also stigmatize certain geographic areas by promoting a sense that they are unsafe. The benefits and risks need to be weighed in assessing the usage of GIS in policing.

## 2.0 Objectives of Environmental Scan

This project was conducted on behalf of the Peterborough Police Service in Peterborough, Ontario. This environmental scan was conducted through an online search of police agency websites in Ontario, as well as any publicly available GIS maps. Through searching online, we aimed to determine the use of GIS by police in Ontario, as well as the level of use, and type of use. Furthermore, we aimed to determine how many services across Ontario were using the technology, as well as the population size of the community they served and the geographical location. The aim is to understand the usage of GIS in Ontario policing, in hopes of informing the usage of GIS policies and practices at the Peterborough Police Service, and implementing the technology using a critical lens.

## 3.0 Populations Definitions

For this environmental scan, the size of a police service will be distinguished by the size of the community they serve, with large services covering a Census Metropolitan Area, as well as select Census Divisions. A Census Metropolitan Area is defined by Statistics Canada (2016) as an area with a total population of 100,000 or more of which 50,000 or more live in the core. These areas include the following

communities: Barrie, Bellville, Brantford, Greater Sudbury, Guelph, Hamilton, Kingston, Kitchener—Cambridge—Waterloo, London, Oshawa, Ottawa, St. Catharines—Niagara, Thunder Bay, Toronto, and Windsor (Statistics Canada, 2016). Statistics Canada (2016) includes Peterborough as an official Census Metropolitan Area. In Ontario, there are three other police services which serve census divisions, these are York Region, Peel Region, and Halton Region (Statistics Canada, 2016). Census Divisions are provincially legislated areas, which include regional districts (Statistics Canada, 2016). Due to the population of these regions, as well as the GIS data they provide, their police services have been included in this environmental scan. All of the remaining police services in this environmental scan which have not been named above, will be referred to as small police services.

# 4.0 Findings

## 4.1 Small Police Services

Across Ontario there are thirteen small police services using GIS mapping. The communities served by these police departments range in population from approximately 5000 in Gananoque, to approximately 80,000 in Kawartha Lakes (Statistics Canada, 2023). Of the fourteen small police services using GIS, eleven of them are hosted on a common website, CrimePlot. The police services using CrimePlot.com include Aylmer, Brockville, Cobourg, Cornwall, Gananoque, Kawartha Lakes, Saugeen Shores, St. Thomas, Strathroy-Caradoc, Timmins, and Woodstock. At

the bottom of the CrimePlot website is a note that says it is a Midland Police Service Initiative (2024). The remaining two police services who are not hosted on CrimePlot use another common platform, Police Reporting. South Simcoe and Stratford police services are hosted on Police Reporting; however, the website is not as commonly used by smaller police services. Should Peterborough explore a common platform, CrimePlot may be the best host at the moment, due to its commonality amongst Ontario police services and the opportunity for cross service collaboration with those using the platform. However, CrimePlot is elementary in its design and use, with no opportunity to use filters, only allowing individual crimes and hot spots to be viewed. The simplicity may be of value to the Peterborough Police Service, allowing for a simpler start up process, with the potential to look at other platforms in the future.

Ontario's remaining fifteen small services who do not use GIS can be split up into three groups, those who do not use GIS and do not publicly state any intention of doing so, those whose cities use GIS but not the department, and those who have stated that they would like to implement GIS. Of the fifteen police services who do not use GIS, nine have not stated publicly whether they would implement the technology, nor do they have any public plans to. The second group are those whose city's use GIS, but their police service does not, at five out of fifteen. These communities include LaSalle, North Bay, Port Hope, Rama, and Sault Ste. Marie. Lastly, the community looking to implement GIS is Akwesasne Mohawk Police Service, as outlined in their 2020 five-year plan (Francis, 2020, p.7).

## 4.2 Large Police Services

Across Ontario all police services of Census Metropolitan Areas use GIS, except for Peterborough. Per Statistics Canada, Peterborough is a Census Metropolitan Area, yet throughout my research I discovered that we are the only police service not publicly using GIS. All of the previously mentioned services in Census Metropolitan Areas use GIS, as do the services of the three census subdivisions. The use of GIS amongst Census Metropolitan Area services can be broken down into three categories, beginning with most commonly used platform to least. ArcGIS is the most commonly used platform amongst these police services, at six out of eighteen. The research shows that this platform is most commonly used by police services with the largest populations, as Ottawa, Toronto, York Region, Halton Region, Peel Region, and Windsor Police Services all use the platform. While the level of detail offered by ArcGIS is useful, it may not be necessary at the moment for Peterborough. City Protect and Police Reporting were tied at the second most common platforms, with three services using each of them. City Protect is more intuitive and offers greater detail initially, whereas Police Reporting did not always load the data or would leave a blank map. Thunder Bay, Kingston, and Niagara Police Services all use City Protect, whereas Brantford, Guelph, and Waterloo Regional Police Services used Police Reporting. Finally, there was a three-way tie for least commonly used platforms, with Microsoft, Community Crime Map, and Crime Plot each having two users. Crime Plot is commonly used by small Ontario police services, with eleven small services using their platform. Microsoft hosts a service called Power Bi, which is used by Durham Region and Barrie. It should be noted that Power Bi is limited in its capabilities for Durham Region, as the dates a user can

select are limited, and the app fails to load for Barrie. The final platform is Community Crime Map, which is used by Hamilton and London Police Services. Community Crime Map is hosted by LexisNexis and overall is an easy to navigate system, allowing users the ability to select individual crimes and set filters, as well as identify sex offenders. Each of these services have at least one other user, however some are easier to access and understand as a member of the public.

## 4.3 Ontario Provincial Police

The Ontario Provincial Police do utilize GIS technology at their General Headquarters in Orillia, Ontario. I could not find publicly available maps; however, I can confirm they do have at least one GIS analyst working at general headquarters based on two old job postings. The first post is from 2008 for a geomatics specialist and discusses the use of GIS in the job description, while the other post is from 2022 and is for a senior GIS analyst role. Both of these postings discuss the role as managing the OPP GIS database, and the subsequent utilization of the database. While no publicly available maps could be found, there was confirmation of an OPP database.

# 5.0 Summary

Based on the environmental scan I conducted, I would recommend going with a platform like Crime Plot or Community Crime Map. Each of these services have more than one user, with Crime Plot hosting nineteen services, while Community Crime Map hosts two sizeable police services, London, and Hamilton. CrimePlot is elementary in its

design, with limited filters and each crime displayed on the map, forming hotspots as you move around the map. Many services do not appear to have updated their maps in several years, so CrimePlot may be of less value to Peterborough Police Service. The Community Crime Maps many filter options could be of value to the Peterborough Police Service, and has the capability to display zones, which would fit into the zone model deployed by Peterborough Police. ArcGIS may be useful to Peterborough as well, however based on its use by larger police services it may be unnecessary for Peterborough at this time. I would recommend potentially looking at a smaller GIS platform like Community Crime Maps at this time, evaluating its effectiveness, and then exploring further into a platform like ArcGIS. One central takeaway from this environmental scan is that Peterborough is the only Census Metropolitan Area without a robust GIS system and may want to evaluate the benefits and risks of implementing one with public access.

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**REPORT 3 of 3**

# GIS in Policing: Comparative Statistics

Regan Mania

Supervised by Dr. Kristy Buccieri

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# 1.0 Introduction

Geographic Information System (GIS) is a software program that is commonly used by police services across Ontario. These programs have been in use across the province for approximately thirty years, with use expanding to smaller police services since. As the technology has progressed, usability and access have improved, allowing many small police services across Ontario the opportunity to adopt the technology. The services in Ontario that have adopted the technology, use it as a way to visualize both individual crimes, as well as hot spots, allowing for more targeted responses. Furthermore, by targeting responses these smaller services are able to visually track data on a macro level to see the efficacy of their response. Major police services, such as the Toronto Police Service, provide more comprehensive data and GIS maps, allowing for richer analysis, including colour coding areas on macro levels, as well as providing neighbourhood specific data. GIS maps allow for services, both small and large, the ability to better predict where and when crimes may occur, while also visualizing resource efficacy.

While many services use GIS for their own planning and tracking, several have also made their GIS available to the public. This public information allows civilians the opportunity to see the potential risks within their neighbourhood, as well as the efficacy of police programming and responses. Publicly available data is a critical tool in community relations as it allows residents the opportunity to see public safety and for police to provide visual evidence of their work, including the impact they may have on crime trends through the utilization of data.

# 2.0 Objective of Comparative Statistics

This project was conducted on behalf of the Peterborough Police Service in Peterborough, Ontario. Using the communities from the environmental scan, a comparative analysis of the crime data reported in each location was conducted. The analysis compared crime rates in cities with and without GIS use and hypothesized on any additional variables that might be needed to interpret the data, such as population, location, or race. This statistical comparison will provide an overview of the statistics in each city, how or whether GIS impacts crime rates, and what additional variables should be considered in interpreting the results. It is noted that this is a preliminary analysis, intended to identify future areas of in-depth study.

# 3.0 Methods

The comparative statistics were conducted using publicly available statistics from Statistics Canada's *Incident-based crime statistics, by detailed violations, police services in Ontario*. This data set has sixteen categories, with unique statistics for each one and unique statistics for each municipality included. The categories in the *Incident-based crime statistics, by detailed violations, police services in Ontario* are: actual incidents; rate per 100,000 population; percentage change in rate; number of unfounded incidents; percent unfounded; number of total cleared; number cleared by charge; number cleared otherwise; total number, persons charged; rate, total persons charged per 100,000 population aged 12 years and over; number of total, adult charged; rate, adult charged per 100,000 population aged 18 years and over; number of total, youth

charged; rate, youth charged per 100,000 population aged 12 to 17 years; total, youth not charged; rate, youth not charged per 100,000 population aged 12 to 17 years.

The municipalities selected for this were previously identified municipalities in the environmental scan, with communities which do and do not use GIS in their police services. This data set spanned ten years, from 2013 to 2022, and included data from 2020 when the COVID-19 pandemic began. Data was exported to an excel sheet where it was grouped by community and then separated into sheets by category. A filter for communities with and without GIS was created based on the communities identified in the environmental scan and was used to filter when running t-tests and averaging data. Once data was separated into sheets by categories, it was then filtered by GIS usage and then the ten-year data was averaged for each community. Average data for each community with GIS was then compared to communities without GIS using t-tests. From these t-tests we could see whether there was a significant result ($p > 0.05$) between communities with and without GIS for each category. While the Ontario Provincial Police headquarters in Orillia were identified as using GIS and had data in *Incident-based crime statistics, by detailed violations, police services in Ontario,* their data was often redacted and would be inconclusive for the comparative statistics, so it was excluded from the data set. These comparative statistics do not account for variables such as population size or demographics and are a first inquiry. The community of Rama was also excluded due to inconsistent data and redactions.

# 4.0 Results

The results will be broken down by 'not significant' and 'significant' results per category. Comparative charts for communities with and without GIS were created for categories with significant results from the t-tests. These charts are labelled as '*GIS'* for communities with GIS, and '*Without GIS'* for communities without GIS, along with their respective categories.

## 4.1 Not Significant Results

The first category with a not significant result is *percentage change in rate*. The category is the annual percentage change in the crime rate for each community and was calculated for the total percentage change in rate over ten years. This had a *p-value* of .134907, which does not reach the threshold of $p < .05$. For communities with and without GIS there was not a significant difference in their percentage change in rate.

The second category with a not significant result is *number cleared by charge*. Number cleared is defined by Statistics Canada (2023) as being the number of crimes cleared by the laying of information, either leading to a charge or otherwise. This had a *p-value* of .713578, which does not reach the threshold of $p < .05$. For communities with and without GIS there was not a significant difference in their number cleared by charge. The other category which was related was *number cleared otherwise*, and also did not have a significant result. This had a *p-value* of .55655, which does not reach the threshold of $p < .05$.

Another related category is *total number, persons charged*. This category had a *p-value* of .153349, which does not reach the threshold of $p < .05$. This category was broken down further in *Incident-based crime statistics, by detailed violations, police services in Ontario,* into the category of number of totals, adult charged. While the previous category grouped everyone, including youth, this category allows for an analysis of adult specific charges. As a subcategory it would expect that the analysis would follow the total charged, which it did. This category had a *p-value* of .293151, which does not reach the threshold of $p < .05$. This trend, however, was not followed by the youth statistics, as they did have significant results, leading to questions of who may be policed using GIS or who may be policed more overall.

## 4.2 Significant Results

The first category with significant results is *actual incidents*. This category is defined by Statistics Canada (2023) as being the number of incidents reported to police minus those that are unfounded, resulting in the number of actual incidents. Between communities that do and do not use GIS, there were significant results from the t-tests. This category had a *p-value* of .000024, which does reach the threshold of $p < .05$. When looking at Figure 1, we can see that Toronto's actual incidents are far greater than any other jurisdiction and could perhaps skew the results. For comparison, when examining Figure 2, we can see that communities without GIS do not have actual incidents exceeding 6000, whereas Toronto has nearly 120,000. This may be due to Toronto's large population in comparison to all other regions, even amalgamations such as York.

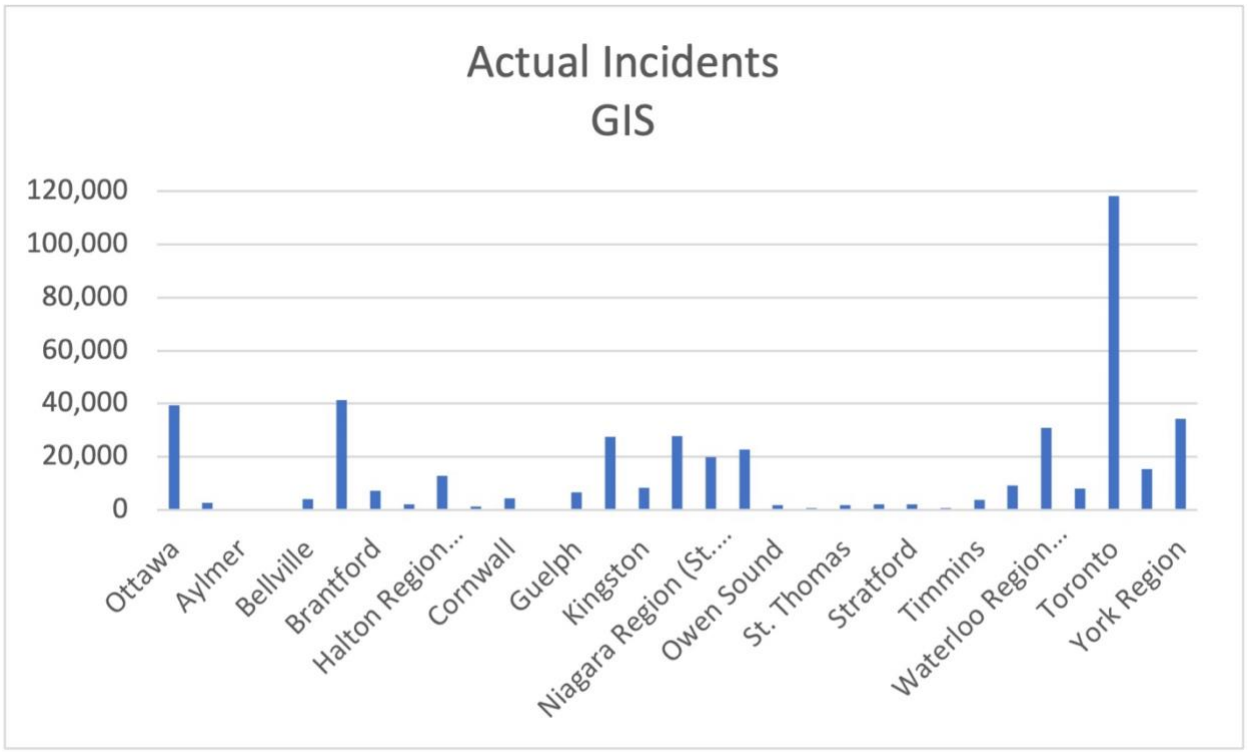


Figure 1.*
*Note all figures represent averages over 10 years

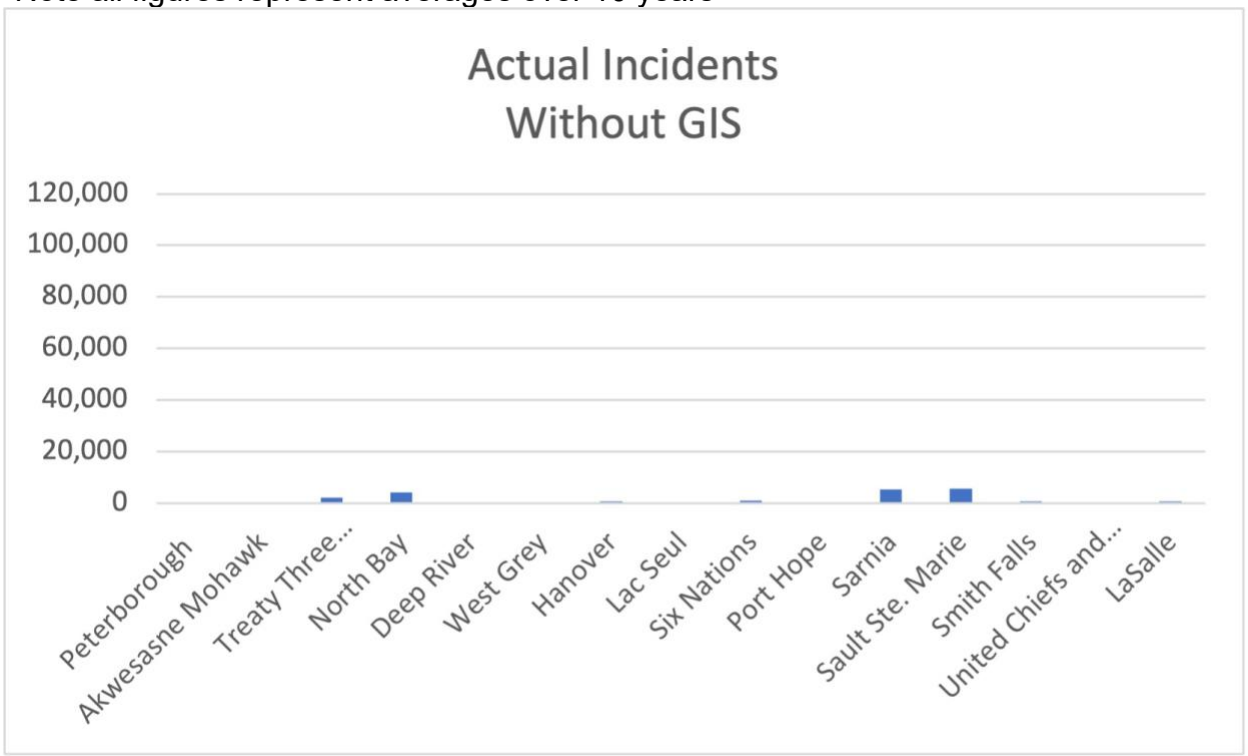


Figure 2.

The next significant category is *rate per 100,000 population*. This category had significant results from t-tests, with a *p-value* of < .00001, which reaches the threshold of $p < .05$. These results, however, were not based on the drastic stats from one community, as there were three key communities without GIS that may have skewed results, as seen in Figure 4. All three communities involved were First Nations policing services and may indicate factors, such as race, population, location, or poverty.

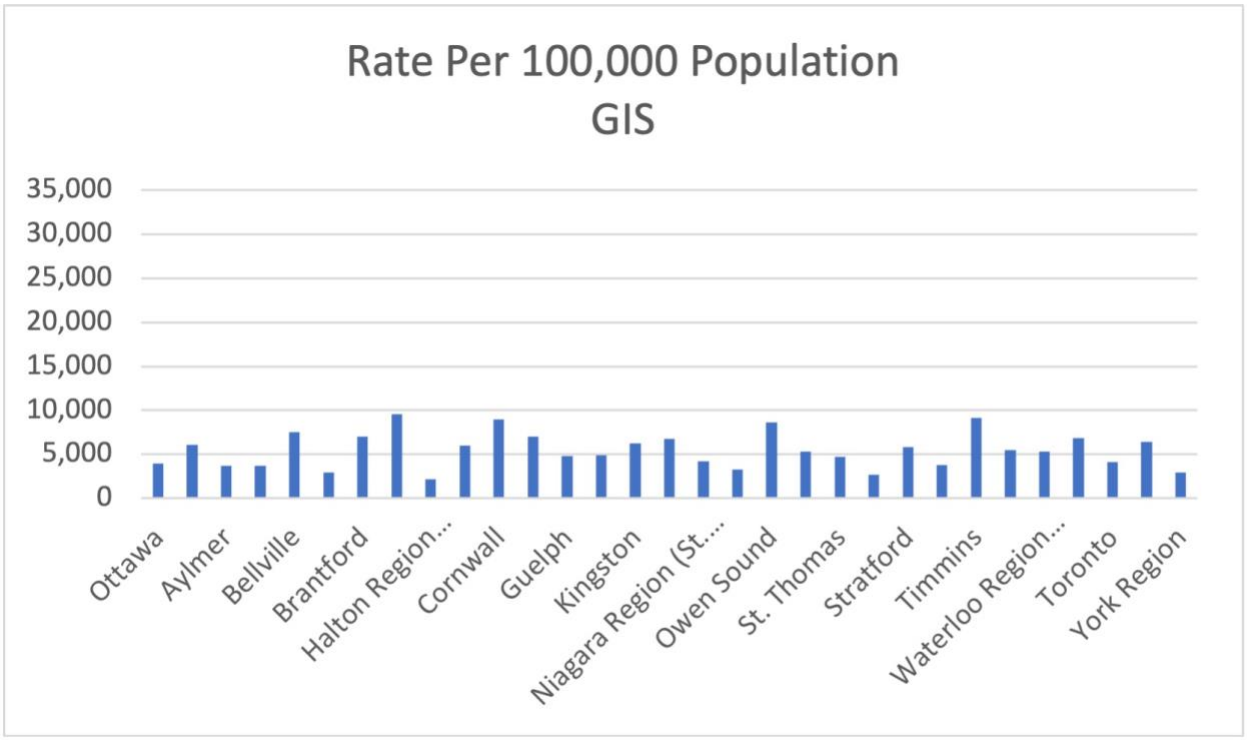


Figure 3.

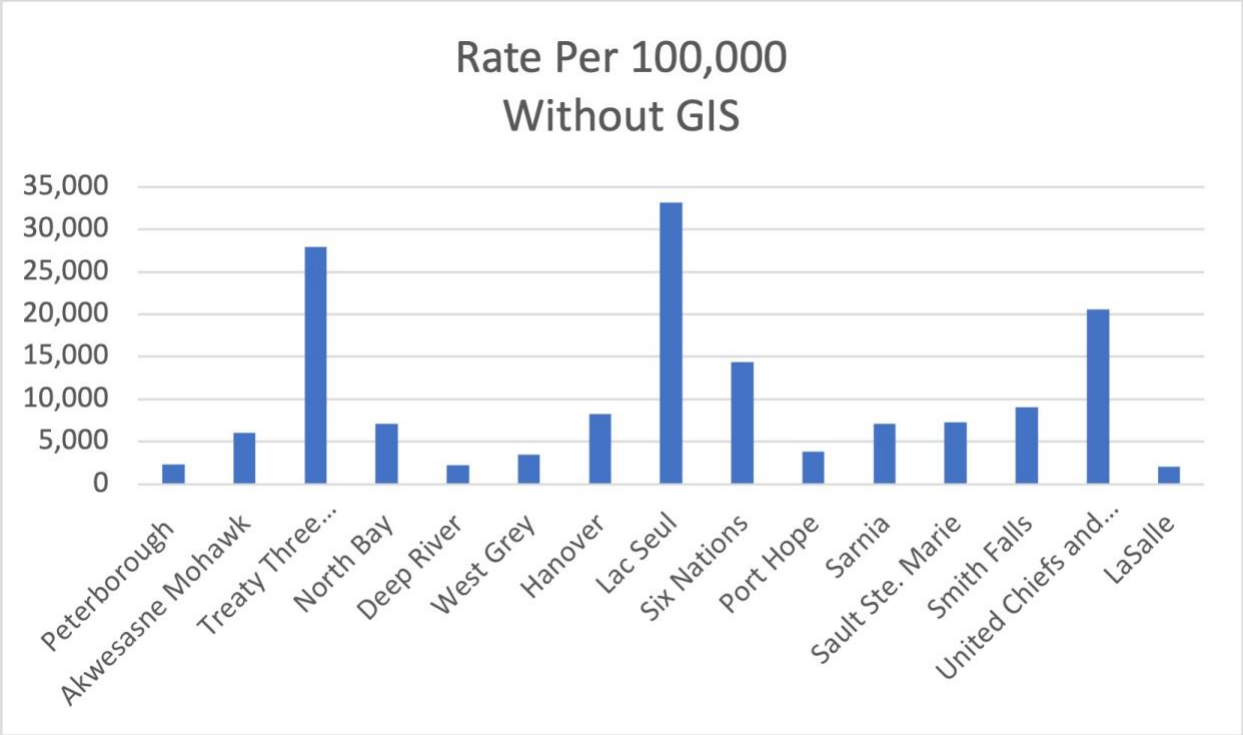


Figure 4.

The next significant category is *number of unfounded*, which correlates closely with the initial category of *actual incidents*. This category had significant results, with a *p-value* of .034307, which reaches the threshold of $p < .05$. Similarly to the category of actual incidents, *number of unfounded* also had an outlier, as seen in Figure 5, with York Region having nearly 1000 more unfounded incidents than any other community with GIS. Furthermore, as seen in Figure 6, communities with GIS had approximately ten times as many unfounded incidents when compared to communities without, indicating there may be a difference due to population size. Similarly, the category of *percent unfounded*, also yielded a significant result. The category is separate from *number of unfounded,* and had a different *p-value* of .016783, which reaches the threshold of $p < .05$. The significance, however, came from communities without GIS, specifically

Hanover at 20%, whereas all other communities with high rates stayed around 15%, as seen in Figure 7 and Figure 8.

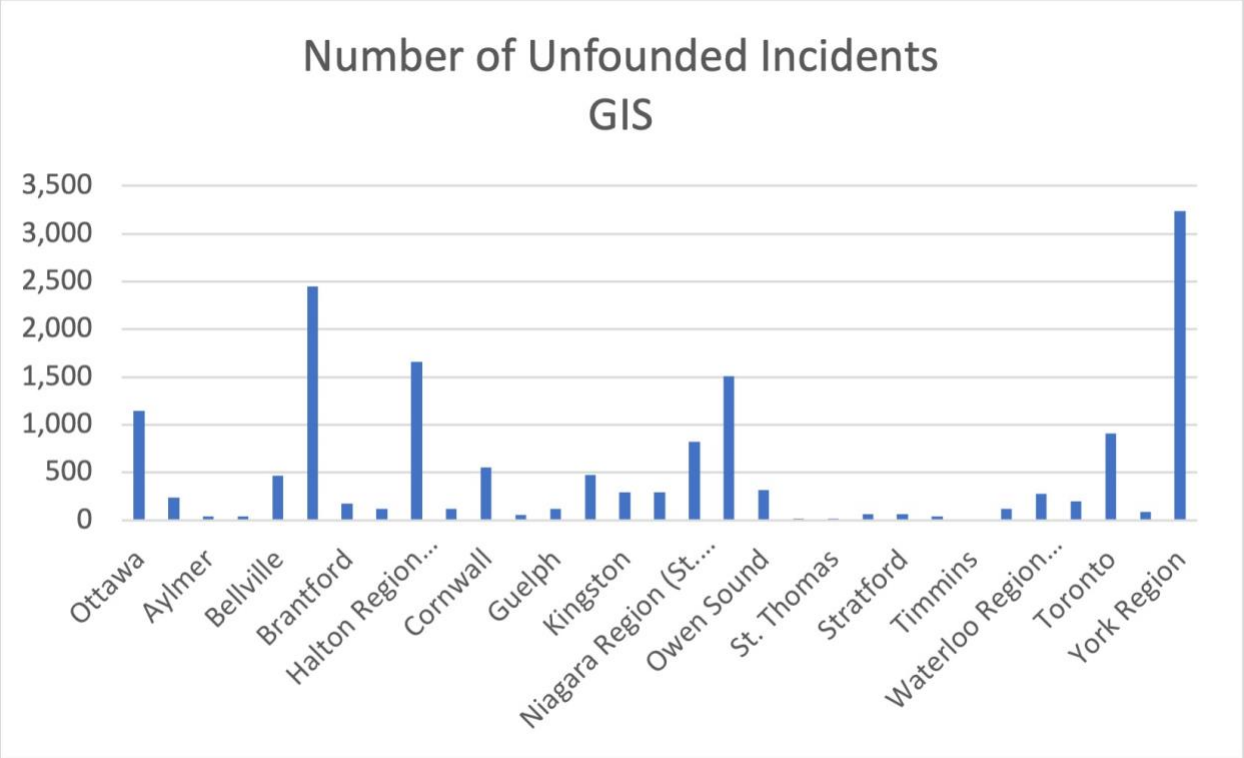


Figure 5.

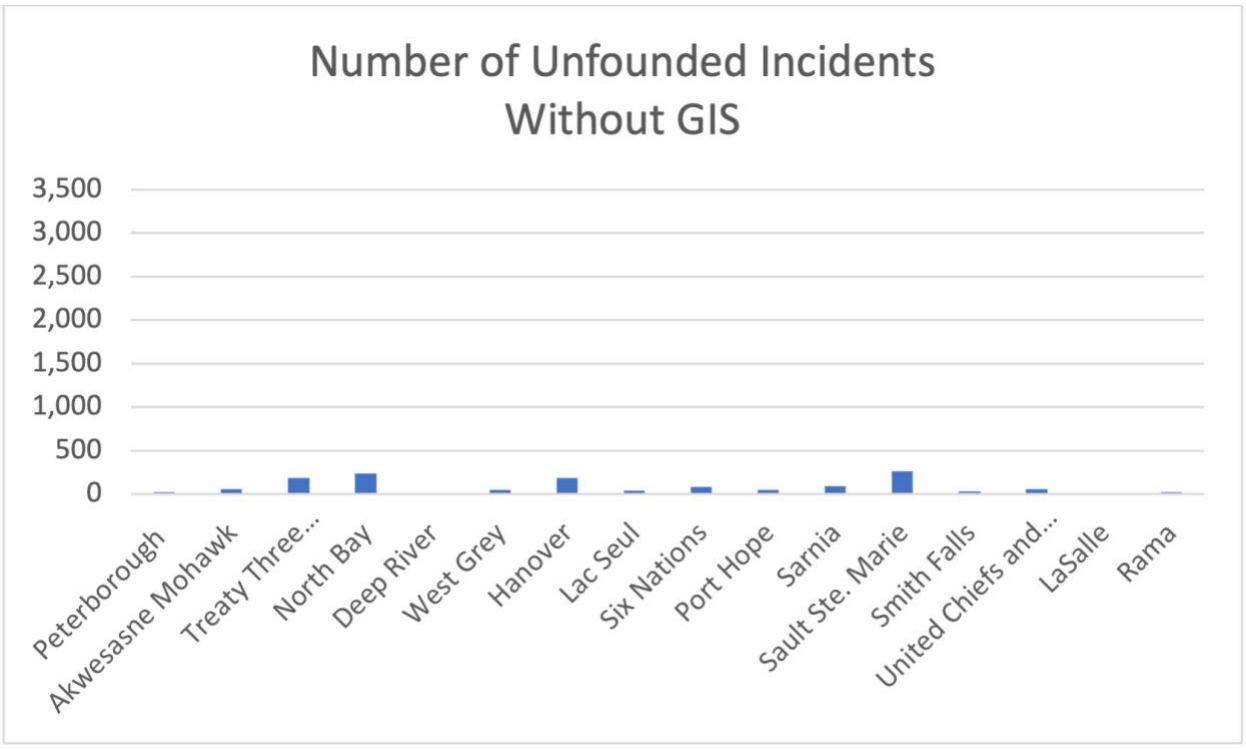


Figure 6.

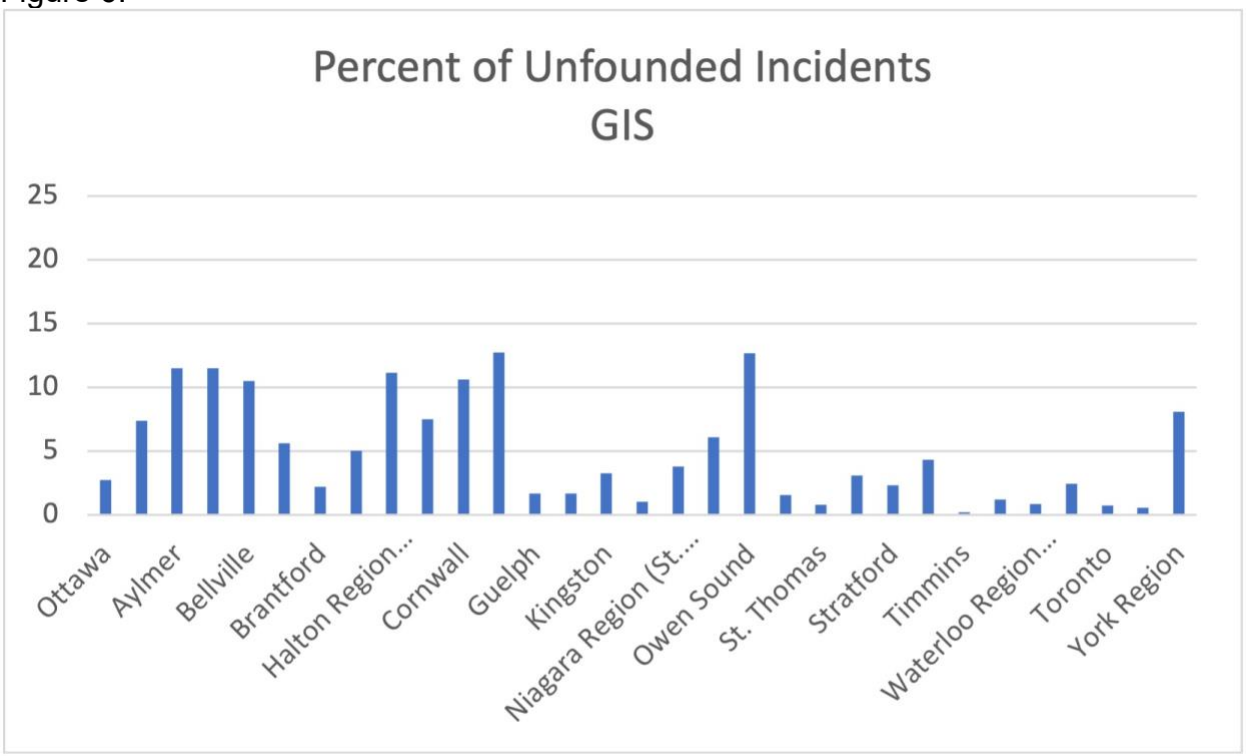


Figure 7.

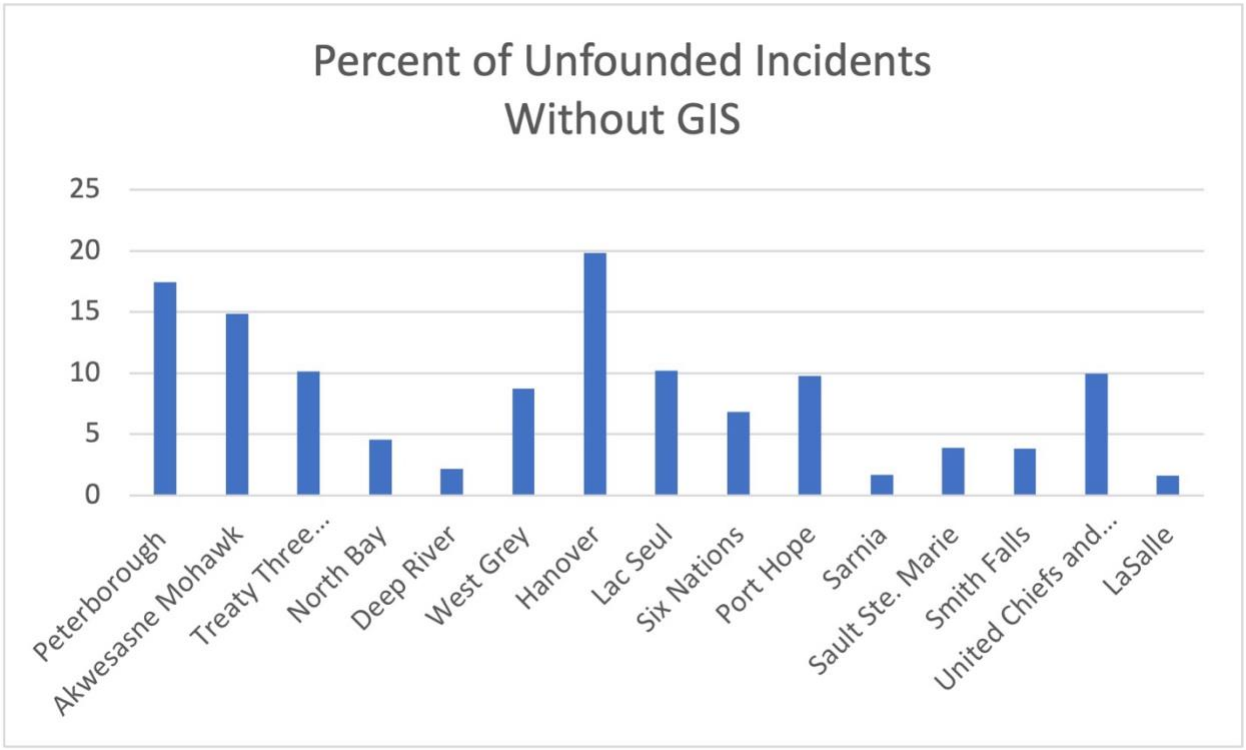


Figure 8.

The next category of significance was *number of total cleared*. As discussed previously, Statistics Canada (2023) defines cleared as being the number of crimes cleared by the laying of information, either leading to a charge or otherwise. While these two categories separately had non-significant results, the total number was significant. This category had significant results, with a *p-value* of .001007, which reaches the threshold of $p < .05$. As with several of the tests, there have been outliers, and in this case it is Toronto with nearly 42,000 total cleared, as seen in Figure 9. In Figure 10, we see that most communities without GIS stay below 2500, once again indicating there may be other factors.

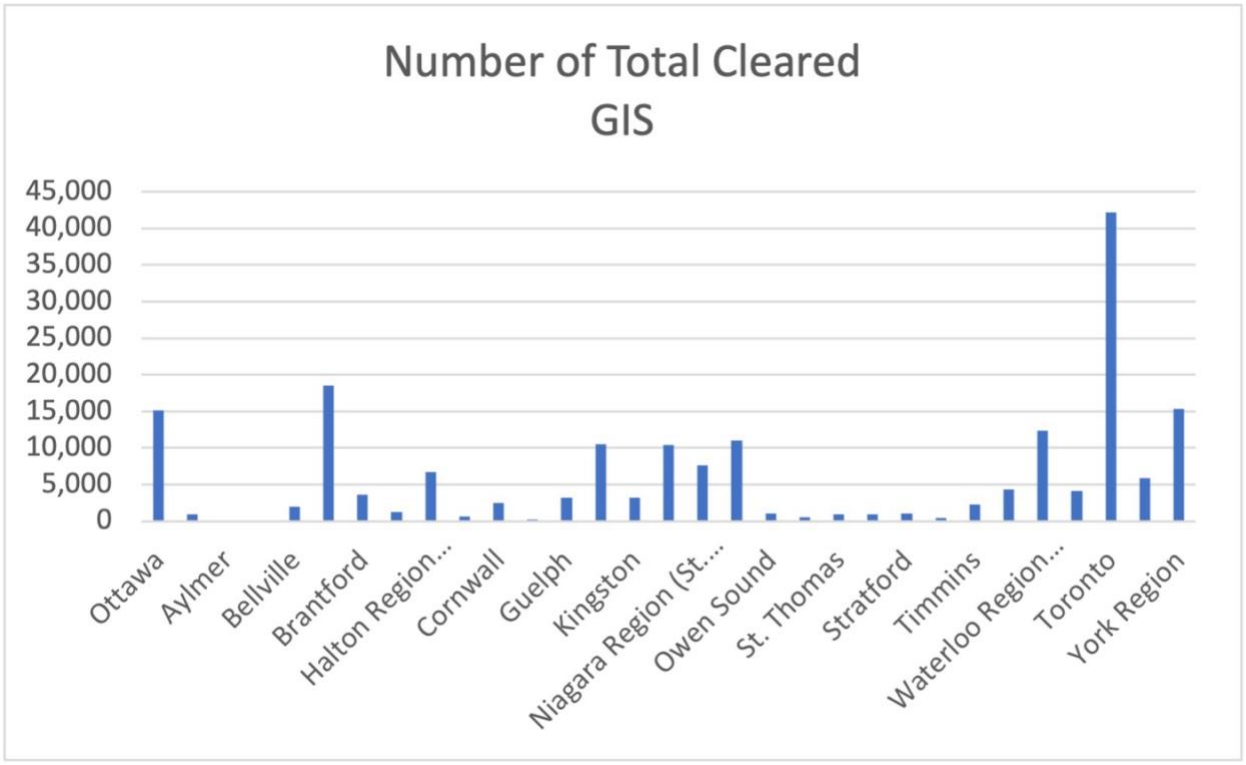


Figure 9.

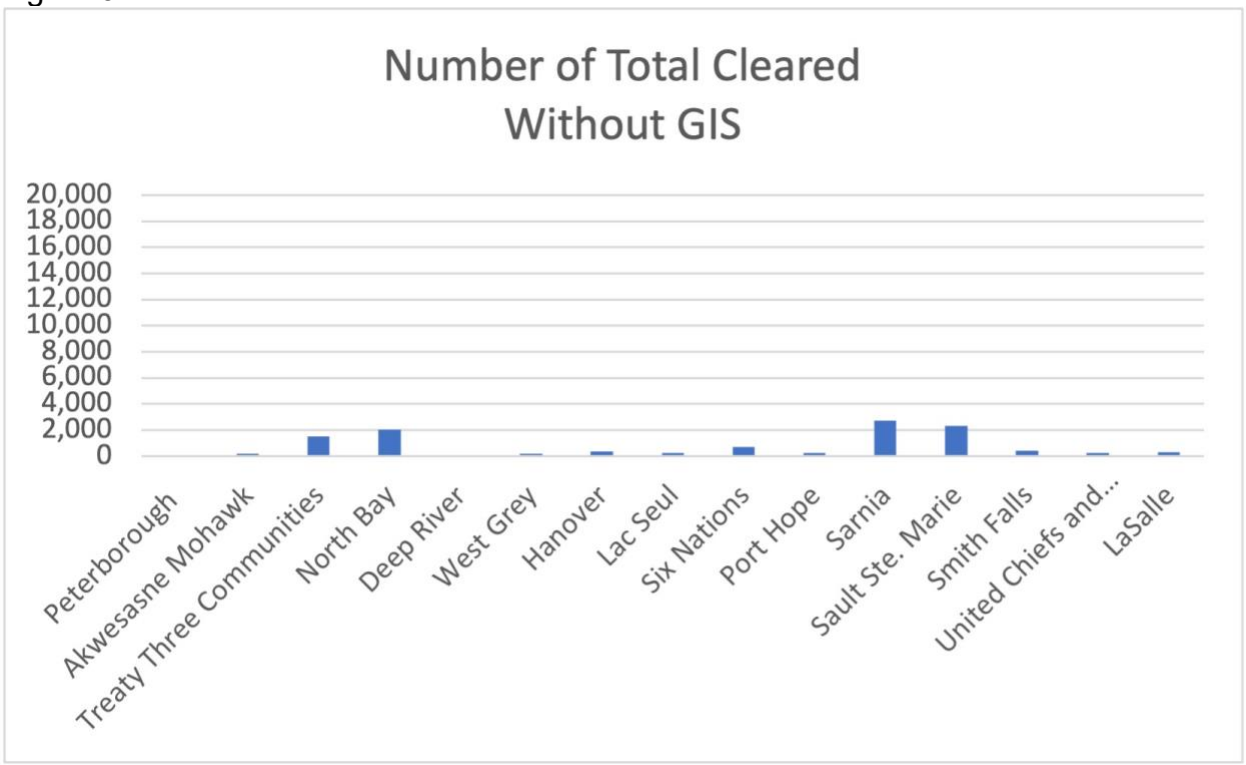


Figure 10.

The following category is where we begin to see potential over-policing or targeted policing of certain groups, in this case youth. In the category of *rate, total persons charged per 100,000 population aged 12 years and over*, we see significant results. This category had significant results, with a *p-value* of < .00001, which reaches the threshold of $p < .05$. Similarly to *rate per 100,000*, this category, *rate, total persons charged per 100,000 population aged 12 years and over*, sees outliers with the First Nations communities, specifically Lac Seul, as seen in Figure 12. Without Lac Seul, the two charts have similar statistics, as seen in Figure 11 and Figure 12.

This trend of significance for *rate, charged per 100,000* is not exclusive to youth however, as the category of *rate, adult charged per 100,000 population aged 18 years and over*, also has significant results. This category had significant results, with a *p-value* of .015442, which reaches the threshold of $p < .05$. Similarly to *rate, total persons charged per 100,000 population aged 12 years and over,* this category of *rate, adult charged per 100,000 population aged 18 years and over,* also had the outlier of Lac Seul, and as seen in Figure 13 and Figure 14, the two charts have similar statistics otherwise. Based on this, we could potentially explore situations unique to Lac Seul, which could indicate their significant spike in rate charged when compared to other communities.

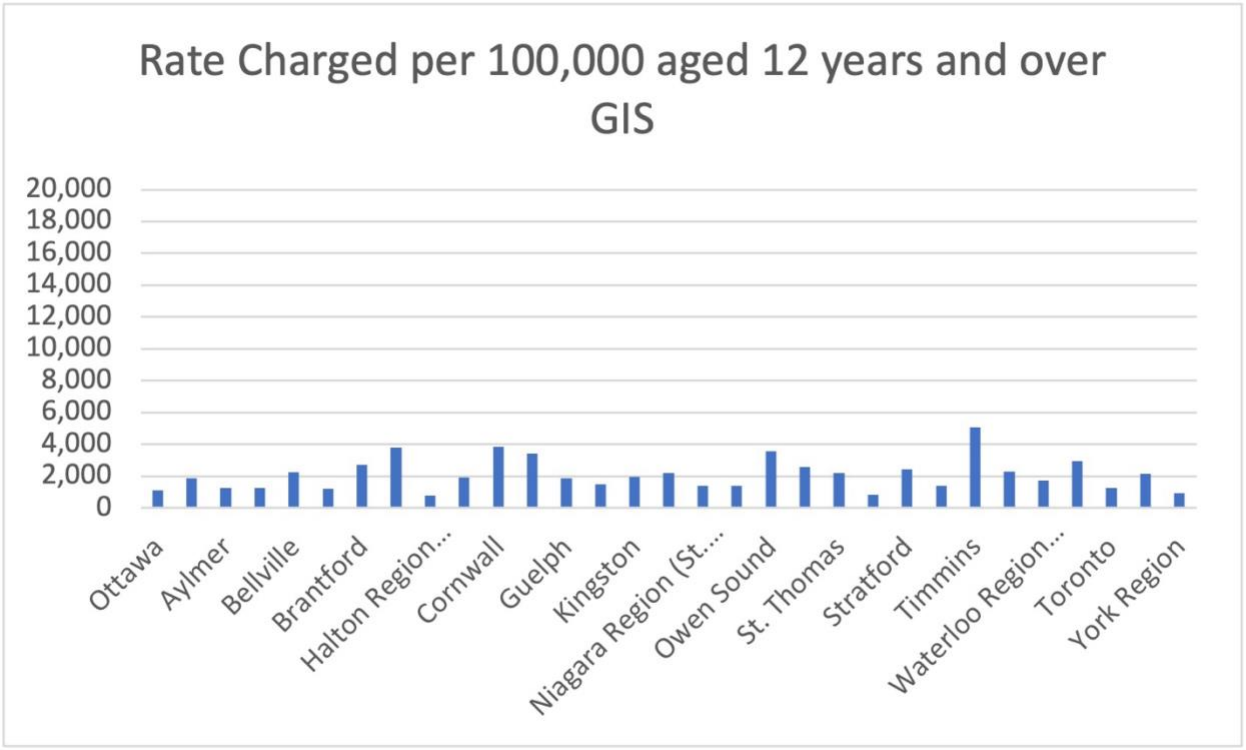


Figure 11.

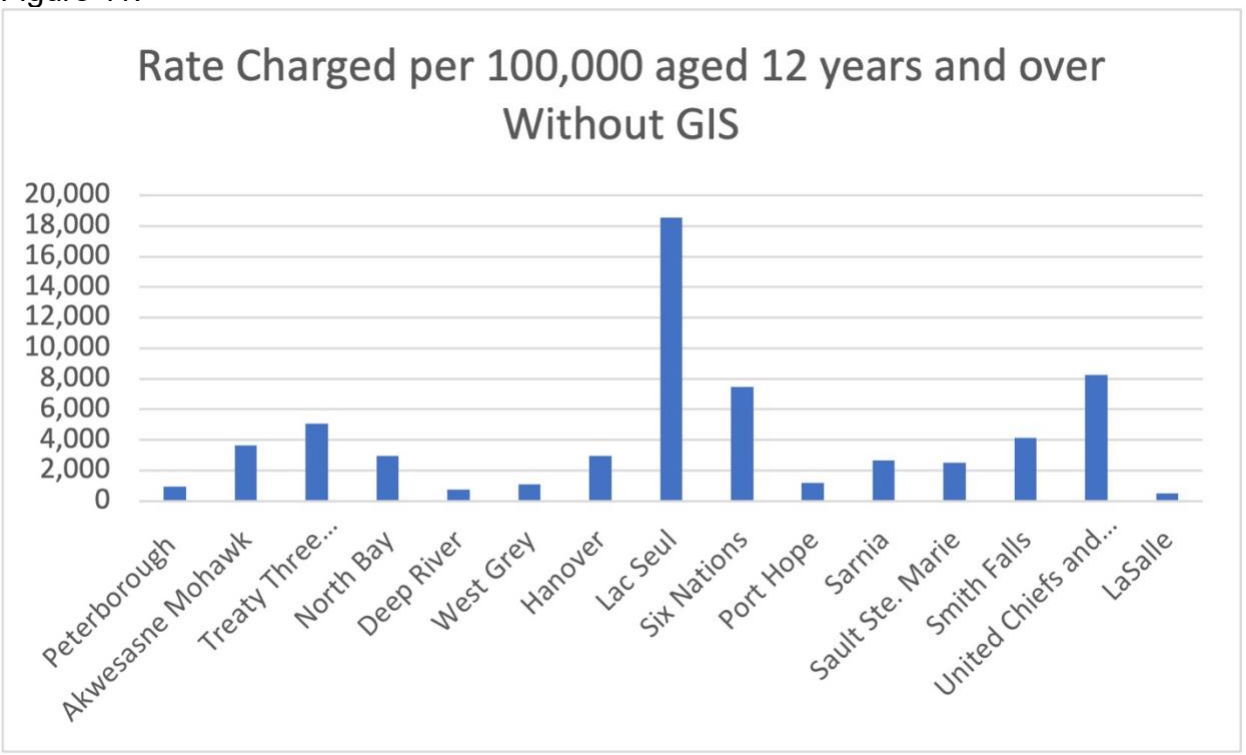


Figure 12.

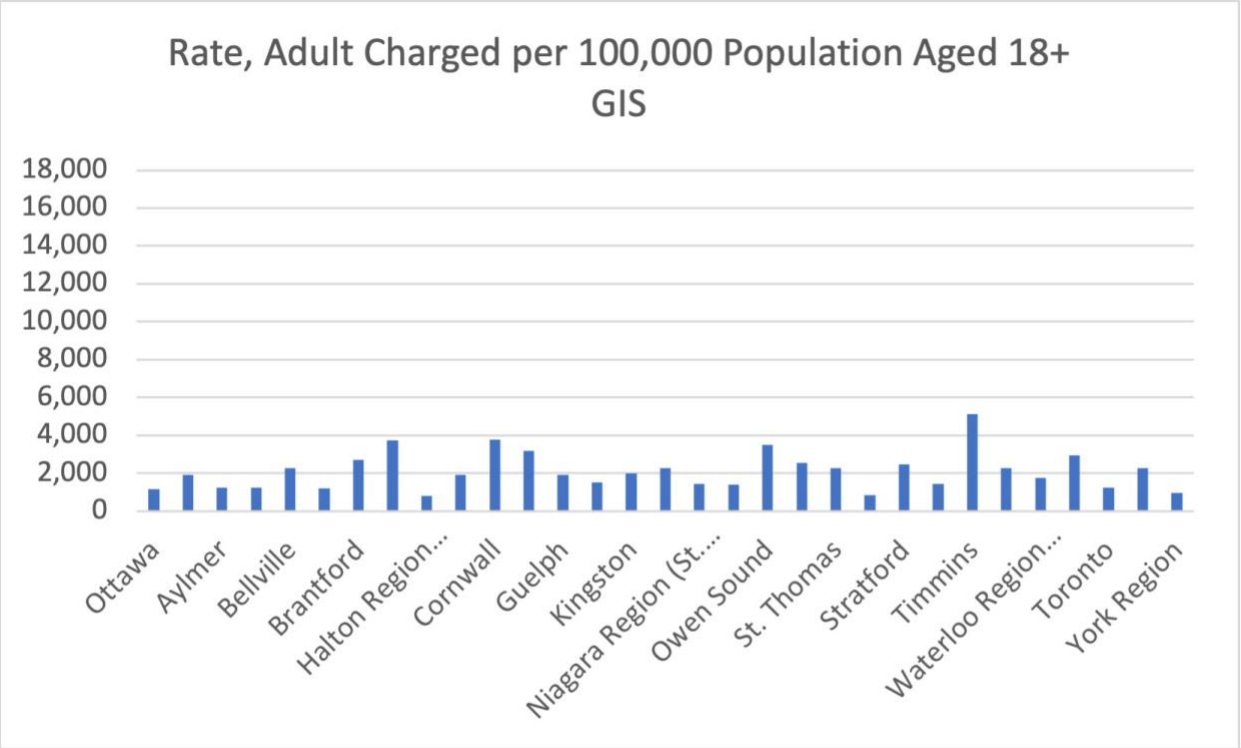


Figure 13.

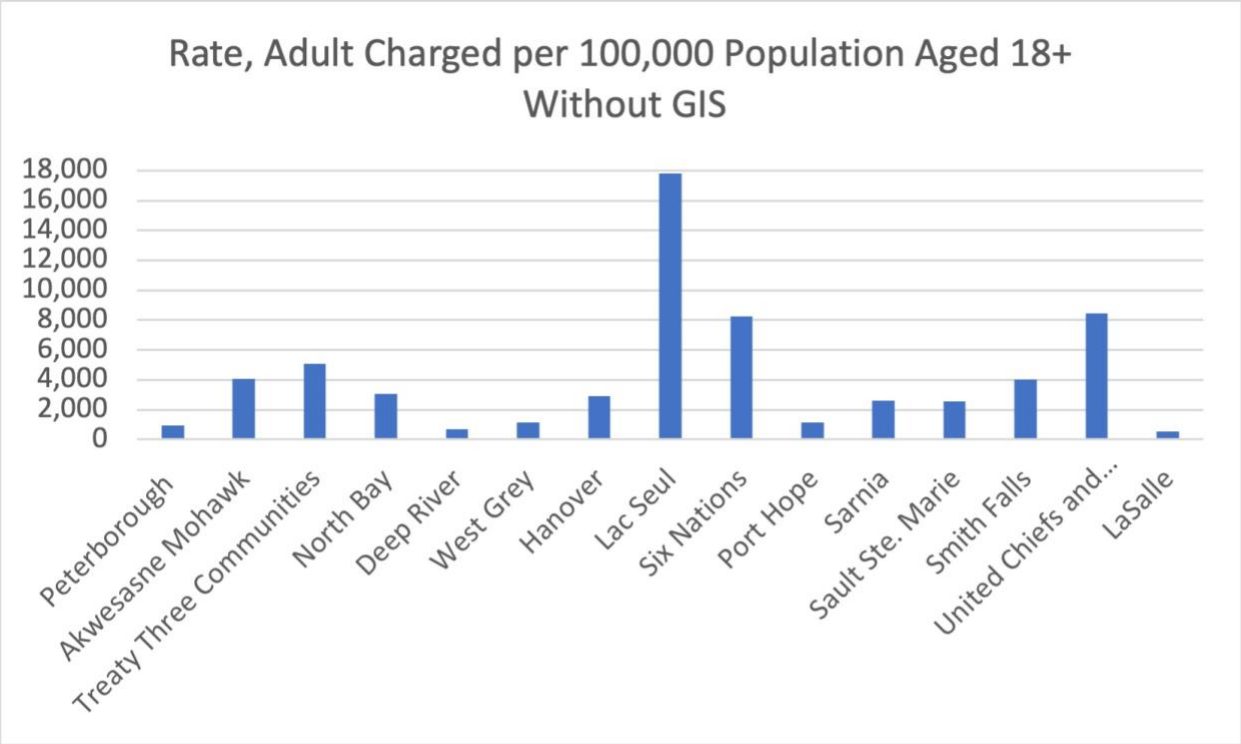


Figure 14.

Youth are the remaining four categories and each of the categories had their own unique differences. Beginning with *number of total, youth charged,* we have a *p-value* of

.022066, which reaches the threshold of $p < .05$. Toronto was an outlier again, with over 2000, compared to the next lowest at 1300, as seen in Figure 15. In contrast, in Figure 16 communities without GIS were below 160, demonstrating the possibility of a population factor. Furthermore, we see significant results in the category of *rate, youth charged per 100,000 population aged 12 to 17 years*. This category had significant results, with a *p-value* of < .00001, which reaches the threshold of $p < .05$. However, as we saw with the category of rate, charged 12+, Lac Seul is a predominant outlier, once again raising questions about the community. Looking beyond the outlier, we see relative consistency between communities in Figure 17 and Figure 18. We see significant results in the third youth category as well, *total, youth not charged*. This category had significant results, with a *p-value* of .014512, which reaches the threshold of $p < .05$. Since this category is based on a total, we once again see higher numbers for communities such as Toronto in Figure 19, which have larger populations than smaller communities who do not have GIS, as seen in Figure 20. Finally, we have the rate version of the previous category, *rate, youth not charged per 100,000 population aged 12 to 17 years.* This category had significant results, with a *p-value* of < .00001., which reaches the threshold of $p < .05$. As with previous youth categories, Lac Seul was an outlier, bringing into further question the community and its policing, as it outpaced other communities without GIS by 15,000 (see Figure 22). Similarly to previous youth statistics, communities with and without GIS had similar charts (see Figure 21 and Figure 22).

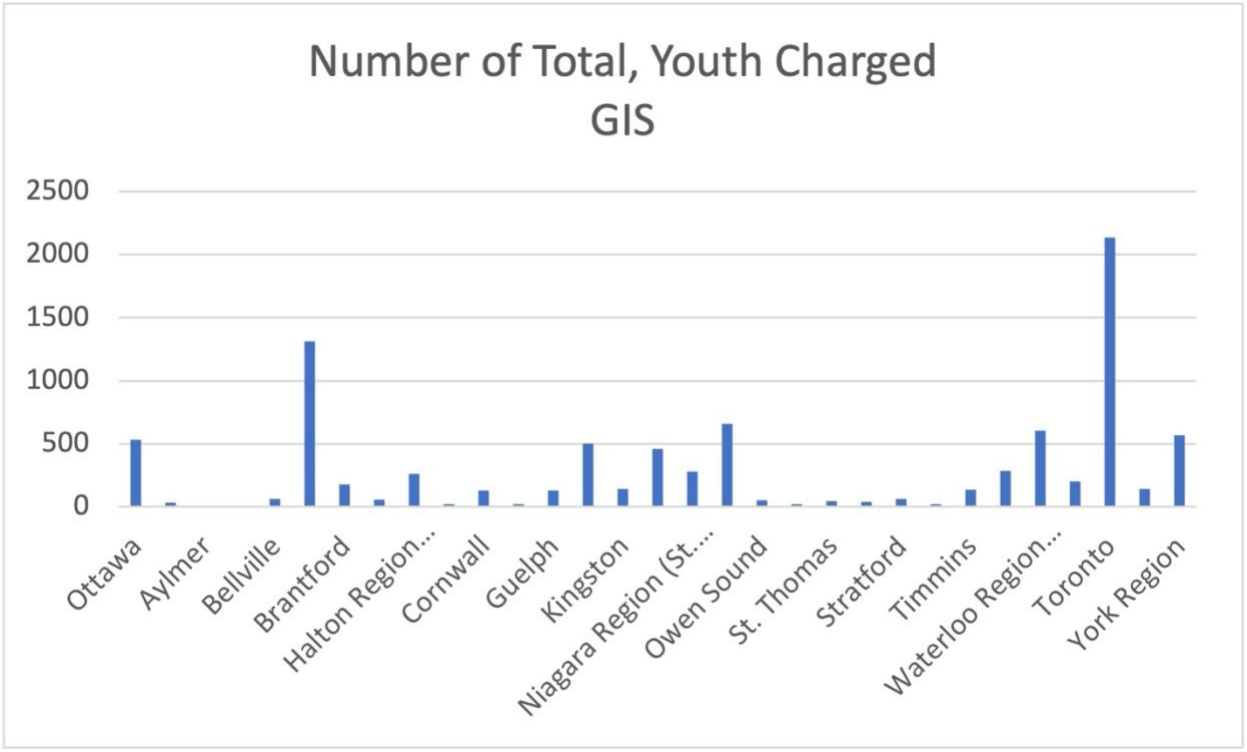


Figure 15.

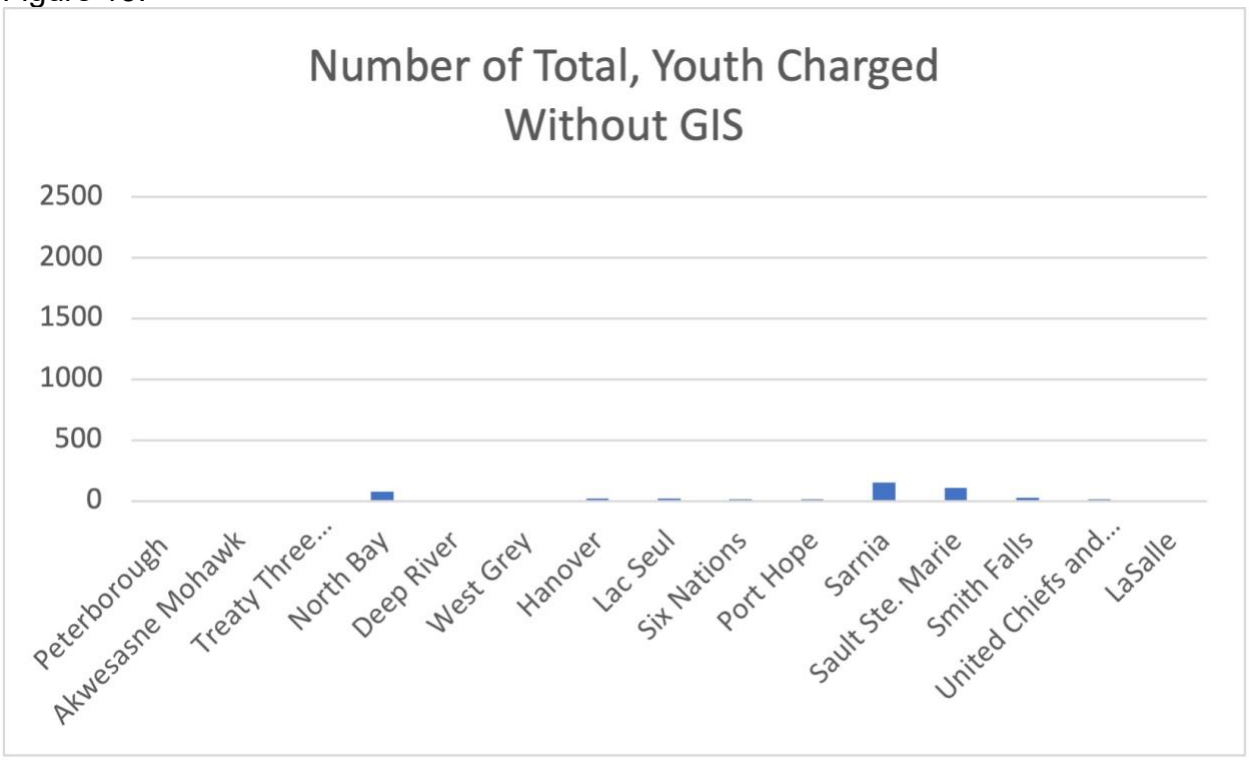


Figure 16.

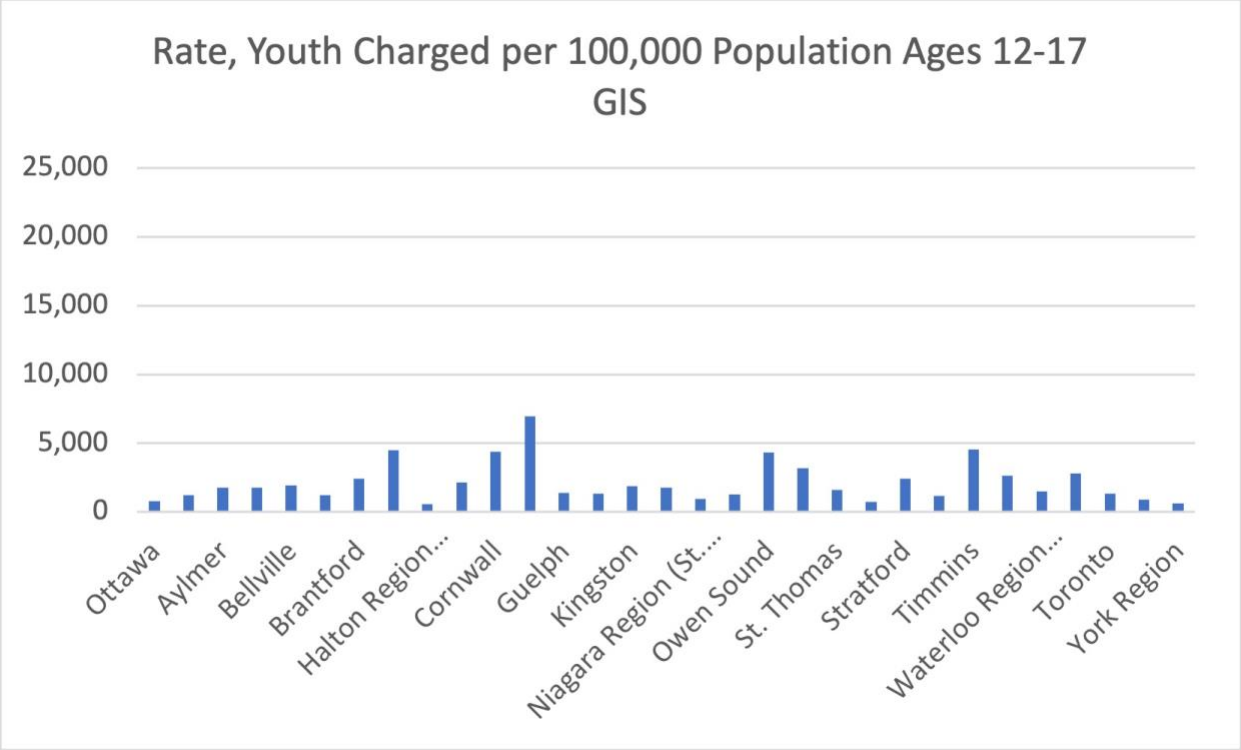


Figure 17.

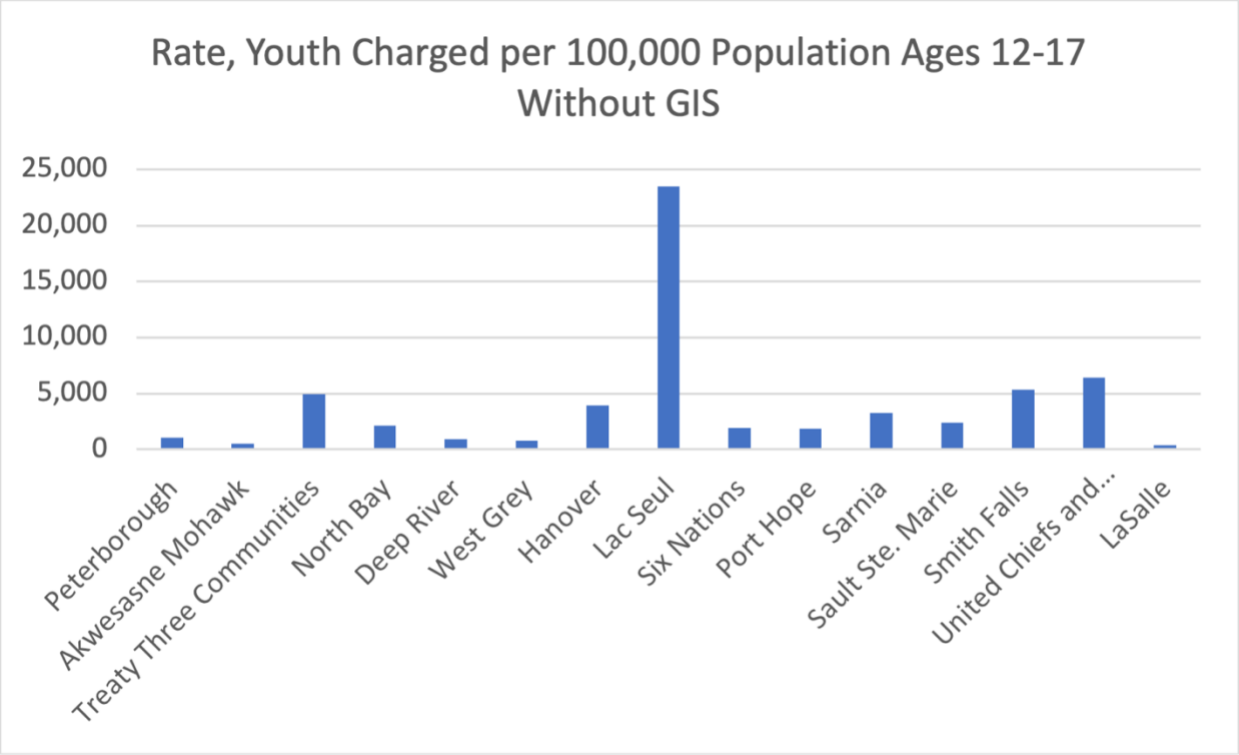


Figure 18.

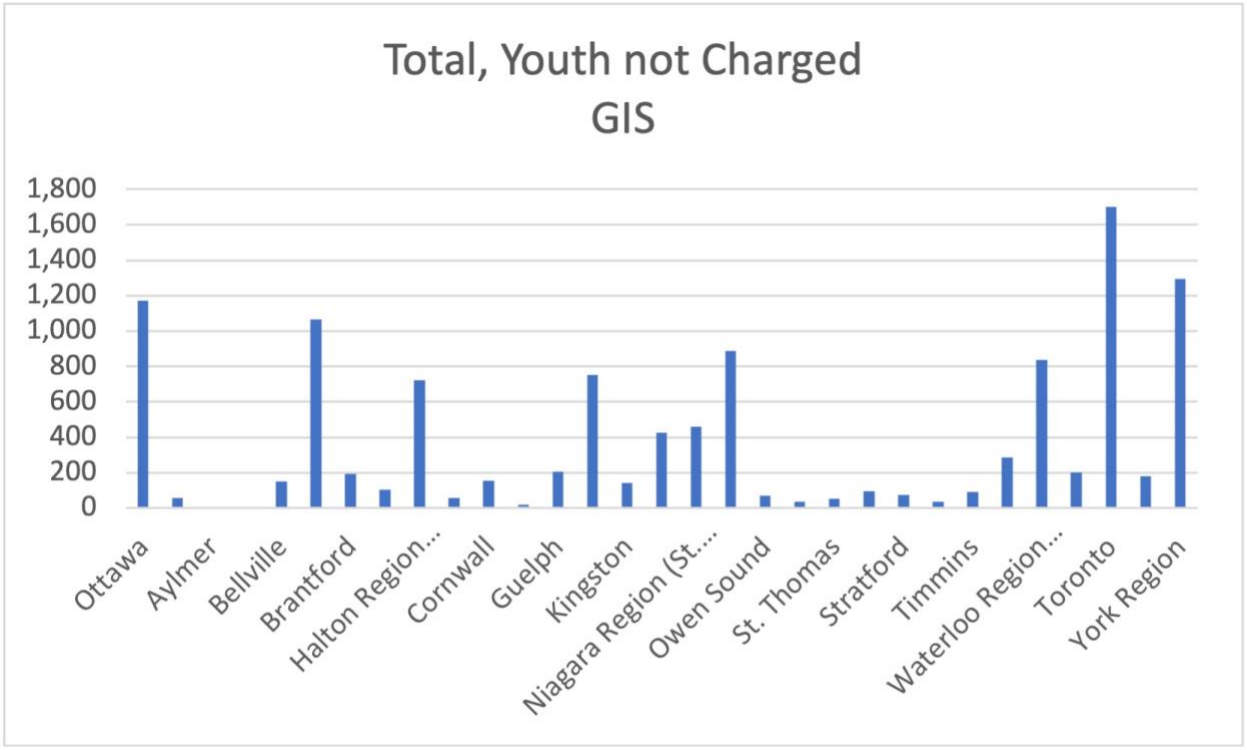


Figure 19.

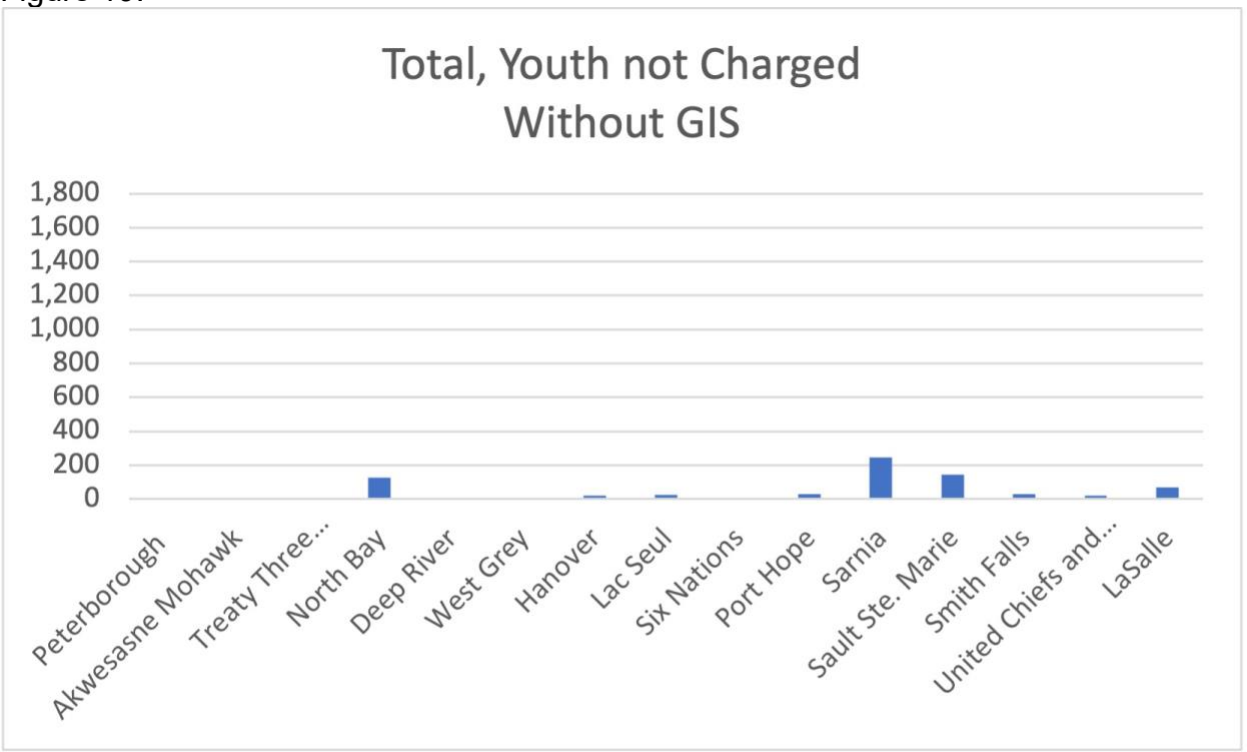


Figure 20.

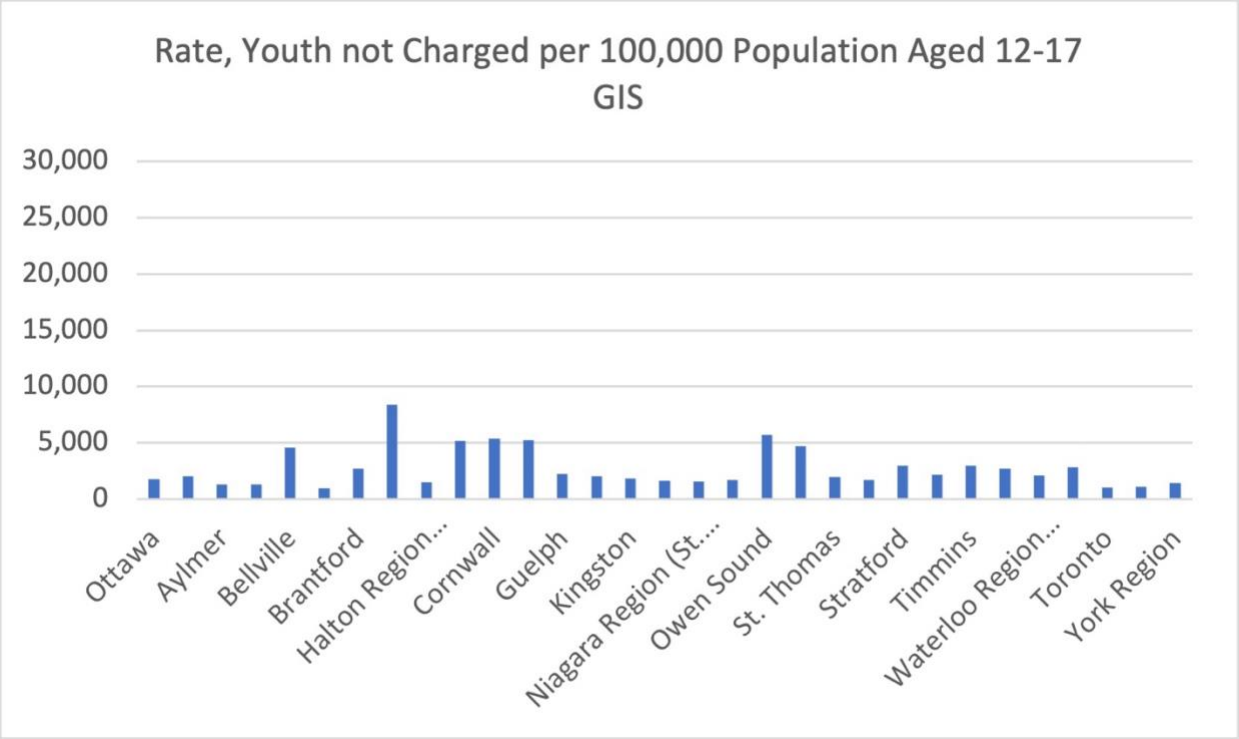


Figure 21.

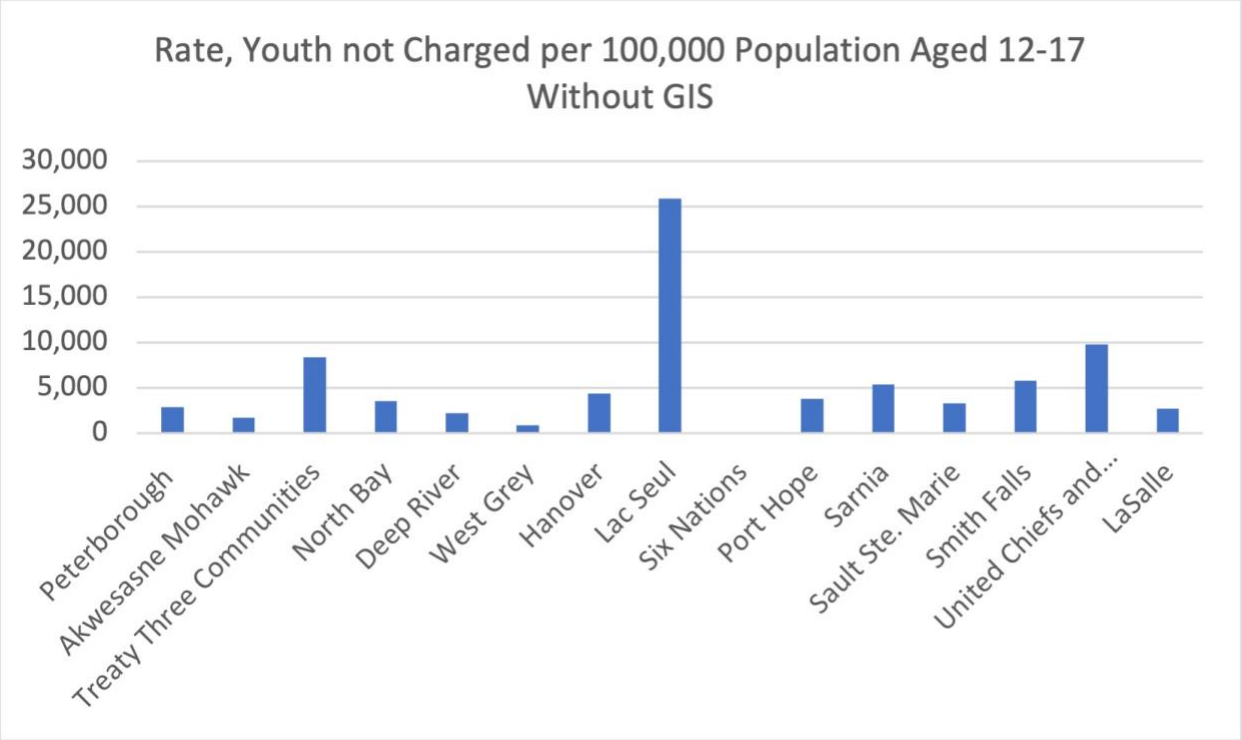


Figure 22.

# 5.0 Summary

Further research must be conducted to conclude whether or not GIS has an impact on crime statistics in communities with and without GIS. The preliminary research conducted in this statistical analysis highlights several significant categories that may be impacted by the use of GIS. However, the communities with GIS that had significant findings were also large cities, such as Toronto or York Region, indicating that there may be other factors such as population or resources. Furthermore, when analysing communities without GIS, we saw many signs that youth may be targeted by police, and that there are outliers such as the community of Lac Seul. Finally, race and poverty could not be explored in this data set, however it may be a factor in these statistics, as the literature summary demonstrated a potential for over-policing using GIS in cities such as Toronto.

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Statistics Canada. (2024, April 16). *Incident-based crime statistics, by detailed violations, police services in Ontario*. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3510018001