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COMMITTEE REPORT

NO: P005 DATE: May 6, 2019

PUBLIC SAFETY COMMITTEE

TO: **Mayor & Council** DATE: **May 1, 2019**

FROM: **Fire Chief** FILE: **2640-01**

SUBJECT: **Opioid Responses Update**

RECOMMENDATION

The Surrey Fire Service recommends that Council receive this report for information.

INTENT

The purpose of this report is to update Council on several of the City of Surrey's responses to the overdose ("OD") crisis.

BACKGROUND

In 2016, British Columbia's provincial health officer declared a public health emergency in response to steadily rising opioid-related ODs and deaths. Despite continued efforts across the province, the number of drug ODs and related fatalities continue on a progressive, widespread scale. BC Coroner's data as of April 2019 identifies 1,510 OD deaths in the Province of British Columbia. Following Vancouver and ahead of Victoria, Surrey has consistently had the second highest number of deaths in the province due to the OD crisis.

DISCUSSION

In response to the crisis, the City has initiated several Surrey projects in an effort to curb and ultimately reverse the rate of OD and related fatalities.

City Centre Response Plan

Beginning in 2016, to address the issues of homelessness, mental health, and Fentanyl use in a comprehensive and collaborative manner to enhance public health and safety, the City of Surrey, Surrey Fire Service ("SFS"), Surrey RCMP, Fraser Health and several community partners developed the City Centre Response Plan ("CCRP") in order to address housing, addictions,

mental health and crime issues in the vicinity of 135A Street. The CCRP was comprised of three key components:

1. An enhanced service presence based on the Surrey Outreach Team ("SOT");
2. Introduction of SafePoint - a safe supervised consumption site; and
3. Initiation of an Emergency Housing First program.

The plan was implemented in three phases starting January 1, 2017.

1. December 2016, SOT was mobilized, operating primarily in the area from 104th Avenue to 108th Avenue and City Parkway to King George Boulevard. SOT conducted daily operational briefings as well as a weekly management round table with representation from all project partners focused on homelessness, addiction, mental health and fire safety concerns on and around 135A Street;
2. In mid-2017, two supervised consumption sites were established in Surrey: SafePoint, located in the OD concentration area of 135A Street, is operated in partnership with the Lookout Emergency Aid Society and Quibble Creek Sobering and Assessment Centre across from Surrey Memorial Hospital provides supervised consumption services to clients; and
3. The City of Surrey, BC Housing, Fraser Health Authority and Lookout Housing and Health Society ("Lookout") worked together to address the urgent need for housing and support for individuals who are homeless in City Centre. Three buildings of short-term transitional accommodations were opened in July 2018. Meals and a range of services are provided to residents. The buildings are operated with 24/7 on-site management and will be replaced by 250 units of permanent affordable housing once additional sites have been identified and the additional modular homes with support services have been built.

While there is a noticeable decrease in the incidence of ODs and OD deaths in the area of 135A Street in Surrey ("Central Core"), in the City the overall fatal OD deaths has increased from 179 in 2017 to 213 in 2018, a 19% increase. The University of the Fraser Valley study "Opioid Intervention Strategies in Surrey, British Columbia: An Evaluation of the Trends and Treatments" (Appendix "I"), identified that while the number of non-fatal ODs has decreased in the City Centre area, the ODs in the rest of the City increased. The number of fatal ODs decreased in the Central Core while they continued to rise elsewhere, suggesting that the CCRP has had impact.

The University of the Fraser Valley study "Opioid Intervention Strategies in Surrey, British Columbia: An Evaluation of the Trends and Treatments" - Key Findings:

<u>Overdoses</u>

- In general, there was an increase in OD rates across the entire City from before 2017 to a peak in 2017. In contrast, the Central Core and adjacent areas saw a decline in rates since the implementation of phase two of the CCRP (supervised consumption sites).
- Overall, there was a decrease in ODs throughout the City in the final six months of 2018. This corresponds to the implementation of phase three of the CCRP (the housing phase). It should be noted that this pattern was replicated throughout the City and not just in the Central Core.

Opioid-related Deaths

- There was a dramatic increase in deaths across the three-year period 2016-2018 which was disproportionate to the increased incidence of ODs;
- As with ODs, the proportion of deaths increased in low risk areas relative to the City Core areas, accounting for the increased fatal ODs City wide; and
- The Central Core area had the highest overall death rates across the three-year period.

Property Crimes

- Generally, in the Core area the recorded number of property crimes decreased by about 11% in the period after January 1, 2017; and
- The distribution of property crimes across drug-risk areas remained proportionately consistent. Those areas that had the highest incidences and rates of property crime also had the highest likelihood of opioid-related ODs and deaths.

Statistics Canada Update

While current statistics speak to the number of ODs occurring in BC, there is a scarcity of information related to the characteristics of those most a risk of experiencing an OD.

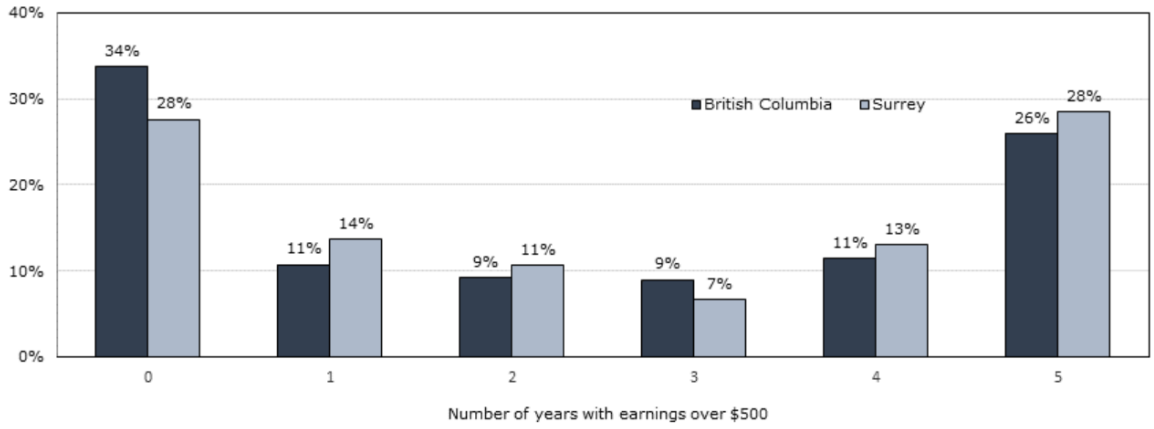
In November 2017, Statistics Canada, in partnership with the City of Surrey, undertook a pilot project to address this conspicuous data gap in efforts to better understand those at the heart of the crisis. The project leveraged various administrative databases containing key information surrounding fatal and non-fatal ODs within the City of Surrey to assess the typology of the opioid crisis including, but not limited to, those who use drugs alone or do not call 911 when in need.

Baseline information was collected from BC Emergency Health Services and the SFS, combined with Fraser Health, Surrey RCMP and BC Coroners Service at the individual level. This was integrated with additional administrative data available via Statistics Canada's Social Data Linkage Environment including tax, census, health and immigration data.

Employment

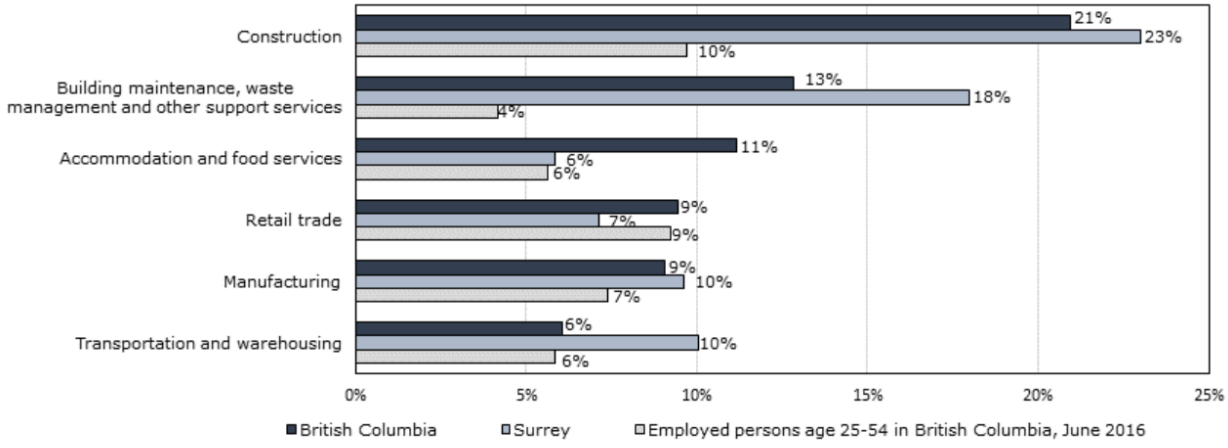
Preliminary results showed that the majority of OD deaths appear to be persons who have occupied a position of economic vulnerability for a considerable portion of their lives, characterized by little or no formal employment and increasing reliance on social assistance over time. However, there is a subset of the male portion of the population that had sustained employment ("Table 1") and substantial earnings over the previous 5 years, with one quarter of these working in the construction industry ("Table 2").

Table 1 – Number of years employed in the 5 years prior to death



Source: BC Coroners Service Data, 2011 to 2016; T4 Data, 2006 to 2015.

Table 2 – Industry of last main job in the 5 years prior to death

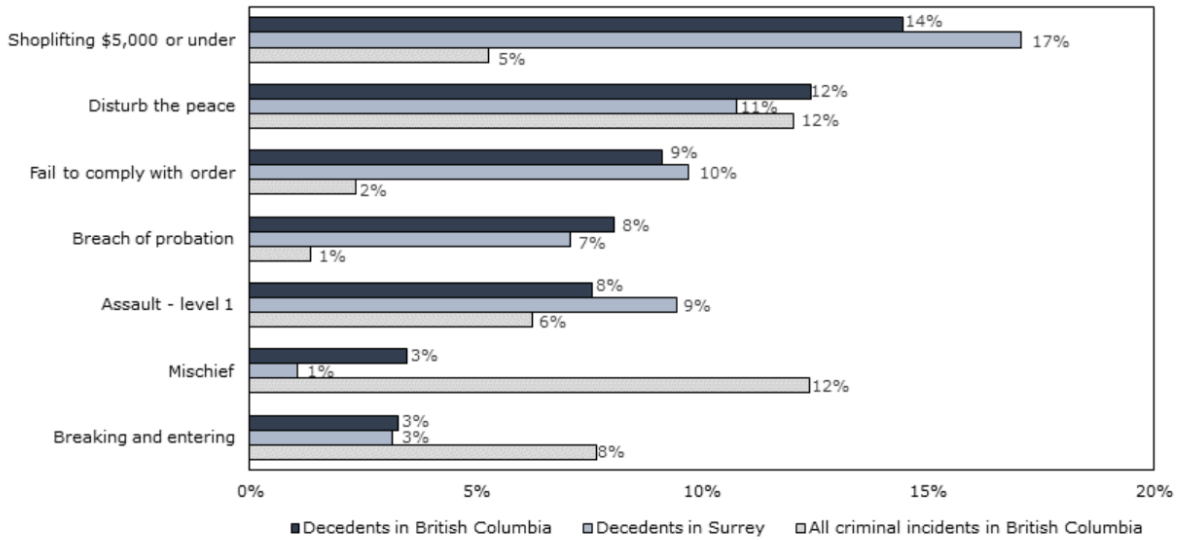


Source: BC Coroners Service Data, 2011 to 2016; T4 Data, 2006 to 2015.

Contact with Police

While the majority of decedents (persons deceased due to OD) did not have contact with police (N=64%), 36% of decedents in Surrey were accused in a criminal incident in the 24 months preceding their fatal OD. Further, 11% of individuals who fatally OD in Surrey had four or more contacts with the police in the 24 months preceding their death as shown in Table 3. The majority of those contacts were for non-violent incidents such as shoplifting items valued at $5,000 or under, offences against administration of justice, namely failure to comply with an order and breach of probation, 11% of these contacts were for drug related offences, of which 2% were for drug trafficking.

Table 3 – Reasons for contact with the police in the 24 months prior to death

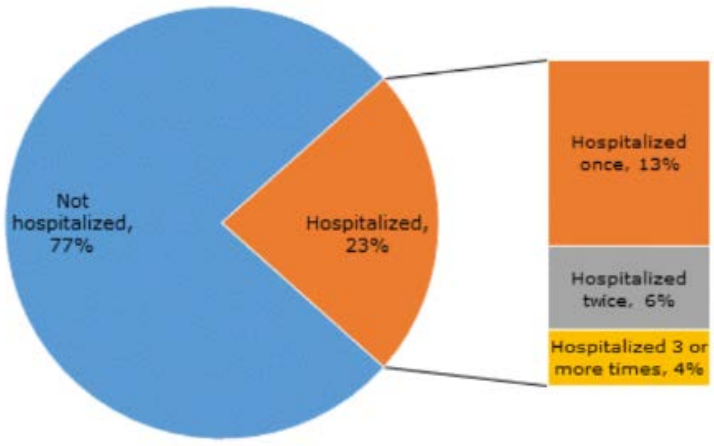


Note: Includes individuals who had a contact with the police in British Columbia in the 24 months preceding their overdose death. All criminal incidents in British Columbia include data from 2009 to 2016.
Source: BC Coroners Service Data, 2011 to 2016; Uniform Crime Reporting (UCR) Survey, 2009 to 2016.

Hospitalizations and Emergency Department Visits

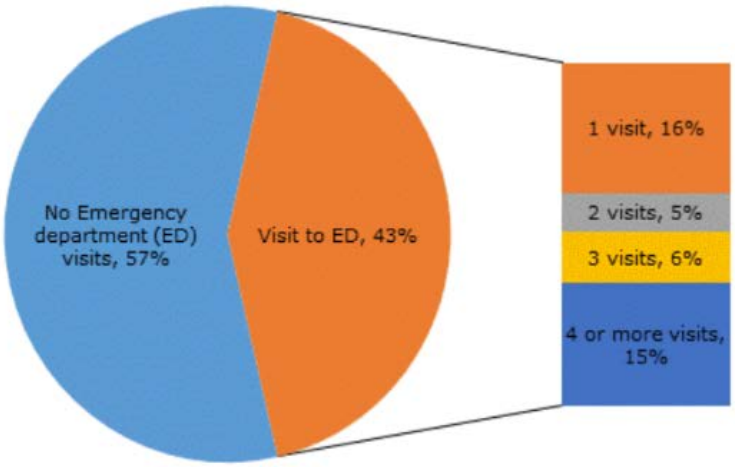
As shown in Table 4, approximately one quarter of decedents were hospitalized in the 12 months prior to death. The majority of those who were hospitalized were hospitalized only once during that year. Table 5 indicates that approximately 43% of decedents visited the emergency department in the 12 months prior to death. Multiple visits to an emergency department were not uncommon.

Table 4 – Hospitalization in the 12 months prior to death, Surrey



Source: BC Coroners Service Data, 2011 to 2016; Discharge Abstract Database, 2009/2010 to 2016/2017.

Table 5 – Emergency department visits in the 12 months prior to death, Surrey



Source: BC Coroners Service Data, 2011 to 2016; National Ambulatory Care Reporting System, 2009/2010 to 2016/2017.

Inclusion of financial, employment and health administrative data such as social service agency, criminal justice and health care services in subsequent research will help to provide a more complete picture of income sources and other potential points of intervention.

Current Initiatives

Opportunities include targeting disproportionally represented demographics like construction and service industry workers. Examples of interventions are the "Second Responder" and "Construction Trades Education" programs currently in development.

1. **Second Responder Program**
   First responders have been playing a key role in BC's OD crisis, largely through the administration of life-saving measures including naloxone for individuals who have overdosed. Many jurisdictions have implemented initiatives where first responders also have the opportunity to follow-up with people post-OD and provide information, resources, and referrals to treatment or recovery services. In Huntington, West Virginia quick response teams have visited the same locations where ODs occurred within 72 hours to achieve a 30% uptake in accessing heath related services resulting in a 50% reduction in OD deaths.

   Such a 'Second Responder' program is being developed with an initial follow-up by a firefighter and a public health nurse post-OD, followed by referral to a health care professional to discuss the most appropriate clinical treatment or recovery support options, based upon each individual's needs and preferences.

   Merging OD death data with OD incident data is required to determine the frequency of OD incidents that occurred prior to OD deaths at the same addresses. Matching 139

records from one year of RCMP and 18 months of Fire OD death responses located indoors revealed that 43% - or 66 addresses had at least one OD incident prior to the death. The program in Huntington, West Virginia was successful in reducing the rate of death by 50%. A potential rate of success may be achieved through Second Responder visits that could contribute to reversing the increasing trend of OD deaths in Surrey.

2. **Construction Trades Education Program**
   As harms become more fully understood in the construction trades, workers can be targeted with worker safety messaging including anti-opioid interventions. SFS is currently developing a plan to coordinate resources from Preventable BC to construction projects as inspections are performed as part of Construction Fire Safety Plan requirements.

   The Construction Trades Education Program provides an additional opportunity to directly target interventions highlighted by the research of Statistics Canada.

Data to Action Summit

Now that the initial Statistics Canada data analysis is completed, it is timely to address the key policy questions that arise from this analysis and begin to design new responses to reduce the risk of OD and death in our community.

The data generated by the project is critical to identify the primary risks and characteristics of those individuals most at risk of opioid use or OD. This purpose will be achieved by bringing together key thought leaders and decision influencers in a forum that allows them to understand the data from the Statistics Canada/City of Surrey Opioid Data Collection/Fraser Health Chief Medical Health Officer and Community Response Project and to formulate and recommend new policy and programs based on the project findings.

In June 2019, the City of Surrey is hosting a forum to operationalise data and to develop policy and programming that is evidence lead.

Surrey Community Action Team Leadership

On December 1, 2017, the Ministry of Mental Health and Addictions launched an Overdose Emergency Response Centre ("OERC"). The goal of the OERC is to spearhead urgent action at the community level to prevent further deaths and to support people using substances and people struggling with addiction to access supports, treatment and recovery services where appropriate. Located at Vancouver General Hospital, the OERC will be the Provincial hub for regional and Community Action Teams ("CAT") collaborating on targeted local strategies.

The purpose of the Surrey CAT is to act as a platform for collaboration, discussion and decision-making related to the opioid OD response within the municipal boundaries of Surrey. The Surrey CAT members communicate, coordinate and deliver local projects in order to provide a robust strategic response to the needs of those most at risk of OD.

Indicators of success for the Surrey CAT will be a reduction in opioid OD incidences and deaths. The Surrey CAT is co-chaired by Fraser Health and SFS and meets once a month.

Predicting Overdoses

"Predicting Illicit Opiate Drug Overdoses in the City of Surrey" (Appendix "II") a study by the University of the Fraser Valley, evaluated the spatial and temporal distribution of the incidence of ODs and deaths attributable to opioid abuse within the City of Surrey from 2016 to 2018. It was produced to examine the understanding that incidents tend to cluster around specific nodes and pathways within a city.

The study of more than 5,100 opioid overdoses and deaths ("OO&Ds") and 32,000 property crimes against 68 recovery house locations and income assistance payment dates scrutinized where and when OO&Ds and property crimes took place from 2016 to 2018 in Surrey, B.C.

Key findings from the research revealed:

- Within three days of income assistance cheques being distributed, daily ODs were 37% higher and daily property crime incidents were 15% lower than during the rest of the month;
- There is a clear city-wide pattern of people receiving income assistance cheques, using them to buy drugs, and then turning to property crime when they run out of money;
- About 70% of reported ODs and 90% of OD deaths occurred within 500 metres of a recovery home in 2016 and 2017. The effect of income assistance cheques on property crime was also more pronounced in neighbourhoods with more recovery homes; and
- Predictive analytics show promise in helping to more accurately forecast future OD incidents.

Working with Microsoft and its Azure Databricks cloud computing analytics platform, the researchers also examined if daily OD incidents could be predicted with any degree of certainty. Predictive modeling techniques were applied to data from October 2016 to August 2018 related to the north Surrey neighbourhood with the highest concentration of ODs. The results are worthy of future development and expansion and could be used as a starting point for data-driven discussions on how to enable responders to be more proactive on OD events.

Cluster App

SFS has developed a business intelligence crowd sourcing tool to identify the time, location, and summary details of OD incidents occurring in clusters within close proximity of each other.

The Overdose Cluster Analysis Application is based on fire incident data and has potential as a near real-time, data-driven response to addressing the opioid problem in the City.

The current tool gives precise geolocation (provided on a map) and time of OD. The application can identify clusters of 4 incidents occurring within a 1-kilometre distance over a 4 hour period. It also triggers at double the rate of ODs over a period of 4 hours.

The benefits are that responses are faster and more effectively targeted, public health workers can reach persons in medical distress with the appropriate assistance, and police can actively respond to drug trafficking.

The Cluster App was recently awarded a $10,000 grant as a finalist in the Phase 1: Propose & Develop stage of MaRS Discovery District's Opioid Data Challenge and is currently in the Phase 2: Extension stage to develop the application of data sources and/or methodology Province-wide to demonstrate wide-range applicability. We are currently in discussions with the RCMP to establish a similar application to detect and report real-time fatal overdoes.

SUSTAINABILITY CONSIDERATIONS

The objectives of the update contained within this report supports the City of Surrey's Sustainability Charter 2.0. In particular, this work relates to Sustainability Charter 2.0 themes of Inclusion, Public Safety and Health and Wellness. Specifically, it supports the following Desired Outcomes ("DO") and Strategic Direction ("SD").

- Social Infrastructure and Innovation DO25 – Surrey has a culture of collaboration and innovation to solve complex social problems;
- Social Infrastructure and Innovation SD20 – Foster a culture of collaboration and the generation of new ideas and methods for solving complex problems;
- Community Safety and Emergency Services DO5: Surrey is recognized and perceived as a leader in establishing and maintaining collaborative partnerships for community safety and well-being; and
- Health Services and Programs DO5: Services and programs are responsive to shifting health and social needs, and local and external factors.

CONCLUSION

Despite varied and continued harm reduction efforts across the Province, the number of drug ODs and related fatalities continues to rise in the City of Surrey. City staff are conducting numerous projects to apply action to research as well as help inform existing and future project and policy recommendations in an effort to curb and ultimately reverse the rate of OD and related fatalities.

Len Garis
Fire Chief

Appendix "I" Opioid Intervention Strategies in Surrey, British Columbia: An Evaluation of the Trends and Treatments
Appendix "II" Predicting Illicit Opiate Drug Overdoses in the City of Surrey: Impacts of Opioid Use in Neighborhoods

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APPENDIX "I"

Opioid Intervention Strategies in Surrey, British Columbia:

An Evaluation of the Trends and Treatments

Paul Maxim, Len Garis, Chris Biantoro, Andy Fink

May 2019

UNIVERSITY OF THE FRASER VALLEY
SCHOOL OF CRIMINOLOGY & CRIMINAL JUSTICE

UNIVERSITY OF THE FRASER VALLEY
CENTRE FOR PUBLIC SAFETY & CRIMINAL JUSTICE RESEARCH

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Executive Summary

In the past few years, the Province of British Columbia has experienced a substantial increase in the number of opioid-related overdoses and deaths. In absolute numbers, illicit drug overdose deaths related to opioid use increased from 294 in 2010 to 1,489 in 2018. Much of this appears due to the introduction of synthetic narcotics such as oxycontin and fentanyl. The situation became sufficiently dire that the Province declared a public health emergency in 2016 (Otterstatter et al. (2018)).

Second only to downtown Vancouver, the City of Surrey has faced the brunt of that increase. City Centre —a traditional core area of Surrey—has been a prime focal point for those addicted to synthetic narcotics. Recently, the area around 135A Street has seen a dramatic spike in the number of homeless people and the creation of a "tent city." Parallel with this, overdoses, opioid-related deaths and petty crime in the area placed a strain on the City's emergency response services.

In late 2016, the City of Surrey created a "City Centre Response Plan" (CCRP) to address the effects of that crisis. The plan was targeted at the City Centre area with the focus being on and around 135A Street. The CCRP was comprised of three key components: an enhanced service presence based on the *Surrey Outreach Team* (SOT); the Introduction of *SafePoint*, a safe supervised consumption site; and, the initiation of an *Emergency Housing First* program. The plan was implemented in three phases starting January 1, 2017.

The question this study addresses is, to what degree have the interventions had an impact on opioid-related overdoses, deaths and rates of property crime in the targeted area?

Overall, the results of the CCRP intervention are best judged as being ambiguous. While the number of overdoses has deceased in the area, so too did overdoses in the rest of the City. On the other hand, the number of opioid-related ***deaths decreased in the Central Core*** while they continued to rise elsewhere, suggesting that the CCRP might have had some impact along that dimension. Property crimes remained relatively stable both before and after the introduction of the CCRP throughout the entire City.

Complicating matters is the fact that many of the overall trends, both before and after the introduction of the CCRP in City Centre, are mirrored in other parts of Surrey—in areas that had pre-existing high and low rates of opioid-related events. Consequently, it is difficult to identify what impact the CCRP might have had in the targeted area in contrast to broader social trends and other, macro-policy interventions introduced by the City and other levels of government.

In summary, among the key findings, we would note the following.

OVERDOSES

- The Core Area census tracts (CTs) experienced slightly more than two-fifths of the total number of recorded overdoses over the entire four-year period.

- The relative distribution of overdoses remained reasonably consistent across risk areas although the percentage distribution went up slightly in "Low" risk areas and down slightly in the "High" and "Very High" risk areas.
- The adjacent CTs accounted for an additional 11% of the reported overdoses, with the remainder being spread across the rest of the City
- In general, there was an increase in overdose rates across the entire city from before 2017 to a peak in 2017. In contrast, the Central Core and adjacent CTs saw a slight decline in rates in phase two of the CCRP (Period 2).
- Overall, there was a decrease in overdoses throughout the City in the final six months of 2018. This corresponds to the implementation of phase three of the CCRP (the housing phase). It should be noted, however, that this pattern was replicated throughout the City and not just in the Central Core.

OPIOID-RELATED DEATHS

- There was a dramatic increase in deaths across the three-year period 2016-2018 which was disproportionate to the increased incidence of overdoses.
- As with overdoses, the proportion of deaths increased in the "Low" risk areas relative to the "Very High" risk and Core areas.
- The two Central Core CTs had the highest overall death rates across all periods examined.
- In the City as a whole, all three intervention periods saw higher deaths per month than occurred in the pre-intervention period.
- While the overall death rate increased in the Core and adjacent CTs in the intervention period, none of the core CTs experienced the consistent pattern of increases in deaths that was seen in the rest of the City.

PROPERTY CRIMES

- In the aggregate, the recorded number of property crimes decreased by about 11% in the period after January 1, 2017.
- The distribution of property crimes across drug-risk areas remained proportionately consistent. It is also the case that those areas that had the highest incidences and rates of property crime also had the highest likelihood of opioid-related overdoses and deaths.

Background

Canada has seen a major increase in synthetic opioid use over the past few years (Fischer et al. 2006). In 2017, the national rate for opioid-related deaths was approximately 10.9 per 100,000 population, or about 4,000 deaths in total. In the first six months of 2018, the death rate had increased to an estimated 11.2 per 100,000.[1] . This puts us second only to the United States in terms of known use and deaths (United Nations 2018). British Columbia has experienced the brunt of that pattern with the estimated death rate of 30.9 per 100,000 population for 2017 and 30.6 in 2018. In absolute numbers, illicit drug overdose deaths increased from 294 in 2010 to 1,489 in 2018. The increase in both reported overdose cases and deaths in British Columbia led the Province to declare a public health emergency in 2016 (Otterstatter et al. 2018).

Much of the increase in opioid fatalities can be attributed to the introduction of new types of synthetic narcotics such as oxycontin and fentanyl. Fentanyl, for example, is a stronger analgesic than traditional opioid painkillers (up to 100 times stronger than morphine) and when incorporated into a time-released patch was initially considered minimally addictive. Drugs such as oxycontin and fentanyl were initially available through a prescription only. In recent years, however, they and analogous compounds have become a major component of the illicit drug trade.

Users initially learned how to extract and concentrate fentanyl from patches and, more recently, it and several derivatives, such as carfentanil, have become available on the black market in powder and pill form. It has been determined that nearly all street "heroin" sold in Vancouver contains fentanyl (Woo 2018). Regardless, it has been estimated that about one-third of those having died recently due to opioid overdoses had a prescription (Gomes et al. 2018), although current restrictions on opioid-for-pain prescriptions appear to be changing that pattern (Smolina et al. 2019).

Not only are increases in overdoses and deaths associated with opioid abuse, rates of property crime are typically believed to increase as users seek the financial resources to support their habits. Second only to Vancouver, the City of Surrey has faced the brunt of the consequences of that shift in drug use. A traditional core area of Surrey—City Centre —has experienced an inordinate increase in social problems including opioid abuse. In the past couple of years, the area around 135A Street has seen a dramatic spike in the number of homeless people and the creation of a "tent city." Handling the concentration of homelessness, overdoses, opioid-related deaths and petty crime has placed a strain on the City's emergency services.

In 2016, the City of Surrey drew up a "City Centre Response Plan" (CCRP) to help mitigate the effects of that strain, particularly in the City Centre area. The plan was implemented from January 1, 2017 to date. While there are many issues the CCRP tries to address, the questions this report addresses are limited in focus. Specifically, to what degree has that intervention had an impact on opioid-related overdoses, deaths and rates of property crime in the targeted area?

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[1] https://www.canada.ca/en/health-canada/services/substance-use/problematic-prescription-drug-use/opioids/data-surveillance-research/harms-deaths.html

Surrey City Centre Response Plan

The Surrey *City Centre Response Plan* (CCRP) was brought forward and endorsed by City Council in December 2016, to address several issues relating to the public safety situation in the area around 135A Street. At the time, opioid-related overdoses and deaths were spiking, and the area was experiencing a substantial influx of homeless people, many of whom were living in tents on and around 135A Street. Concerns were raised that, among other things, a lack of adequate housing was conflating drug abuse issues.

The Surrey CCRP consisted of three basic components:

1. An enhanced service presence based on the *Surrey Outreach Team* (SOT),
2. The Introduction of *SafePoint*, a safe supervised consumption site; and,
3. The initiation of an *Emergency Housing First* program.

The Surrey Outreach Team was established in January 2017 as a pilot project and consisted of twelve Surrey RCMP officers who are on site and service the area 24 hours a day, seven days a week, along with four Bylaw officers who were available ten hours a day.[2] The SOT worked out of a construction trailer located on 135A Street. In collaboration with the police officers there are members of Fraser Health and Emergency Health Services to assist in the outreach process. Overall, the outreach team brings together general policing, bylaw enforcement, ambulance, fire, and social services to work with individuals who have settled in the area.

Surrey's first supervised injection site, SafePoint, was opened in June 2017 on 135A Street next to the Gateway Shelter. Safepoint is managed by the Lookout Emergency Aid organization and is open 16 hours a day. The facility is staffed by four individuals including a registered nurse. Subsequently, the Quibble Creek Sobering and Assessment Centre opened for service on 94A Street adjacent to Surrey Memorial Hospital.

Staff at the City of Surrey began working with BC Housing in the early part of 2017 to address the shortage of accommodation for an entrenched group of homeless individuals within the City. In mid-2017, the Province established a Rapid Response to Homelessness program that involved a partnership between the Province, municipal governments and non-profit housing organizations. Following from that partnership, the Surrey identified potential sites to establish 40 to 50 housing units. Emergency Housing was opened in June 2018 and consisted of a series of modular units to accommodate 200 individuals.

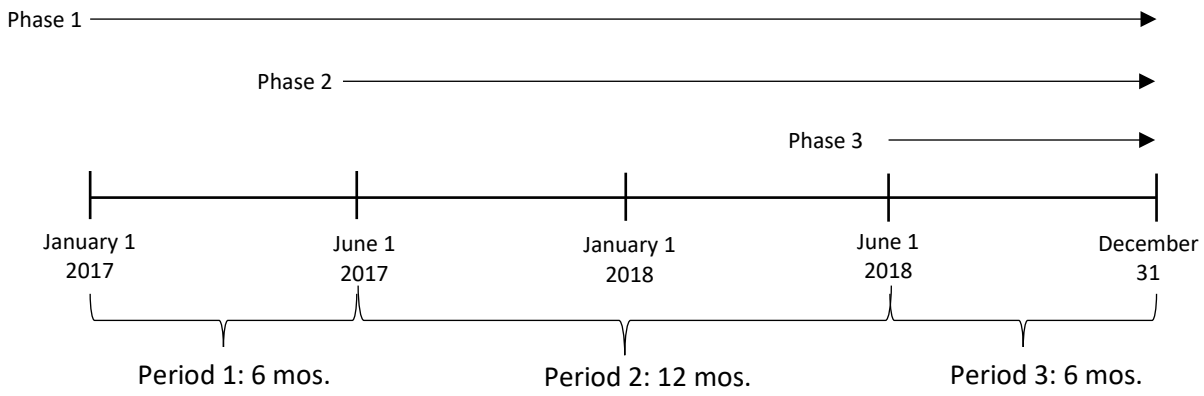
To summarize, there are three key intervention phases on which this analysis focuses:

1. January, 2017: Initiation of SOT Surrey Outreach Team
2. June, 2017: Initiation of SafePoint, a supervised consumption site
3. June 2018: Creation of Workforce Housing for 200 people

A graphic depiction of the timelines for these three phases is presented in Figure 1.

[2] The SOT worked primarily in the area from 104th to 108th Avenues between City Parkway and King George Boulevard. They operated out of a Command Centre on 135A Street.

FIGURE 1: TIMELINES FOR PROJECT IMPLEMENTATION



Method

TARGET AREAS

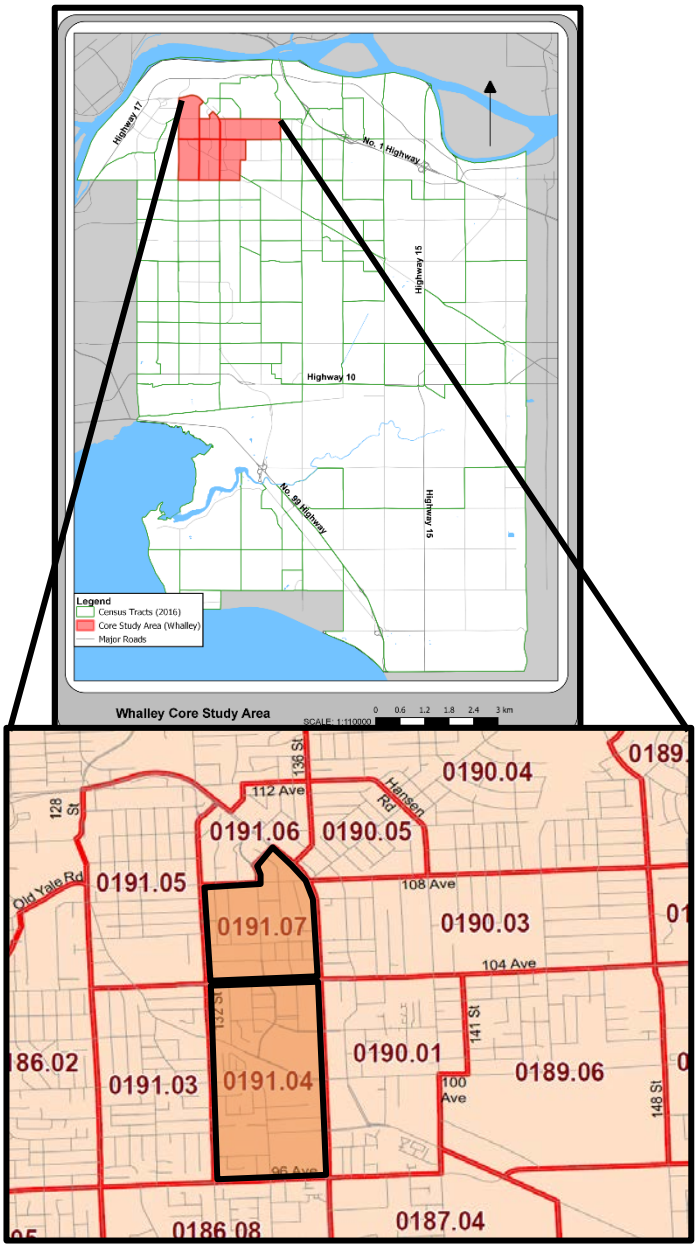
Prior analysis by emergency responders in the City of Surrey noted that several "hotspots" existed within the City where opioid overdoses and opioid-related deaths appeared to be concentrated. The area with the highest concentration corresponded with the primary City Centre region of Surrey, largely corresponding to the historical boundaries of Whalley.

For Census purposes, Statistics Canada breaks down the geographical areas of cities into units known as census tracts (CTs) that generally follow neighbourhoods or reasonably homogeneous areas bounded by major roads or key physical features such as rivers. The boundaries of CTs are determined by a committee of local specialists such as town planners, educators or health officials. Typically, CTs have a population of between 2,500 and 8,000 people.

The primary census tracts relating to City Centre are identified in Figure 2. Overall, the City of Surrey was broken into 95 census tracts in the 2016 Census. For the purposes of this analysis, the key CTs that correspond to both the City Centre and the region with the highest concentration of opioid-related incidents are the six CTs labelled 191.03, 191.04, 191.05, 191.07 to the west of King George Blvd and the tracts 190.01 and 190.03 to the east of King George Blvd. The two primary, or Core, CTs on which we will focus are **191.07** and **191.04**. These are indicated by the darker orange fill in Figure 2. The first tract (**191.07**), is bounded roughly by 108 Avenue in the north and 104 Avenue in the south, and 132 Street in the west and King George Blvd in the east. The second tract (**191.04**), is immediately south of 191.07 and is bounded by 104 Avenue in the north and 96 Avenue in the south, and again, 132 Street in the west and King George Blvd in the east.

The remaining four CTs (191.03, 191.05, 190.01 and 190.03) are immediately adjacent areas that we will use as comparators along with the remainder of the City. These four adjacent areas were selected because they too had higher than average numbers of opioid-related overdose incidents.

FIGURE 2: DISTRIBUTION OF CENSUS TRACTSWITH THE CITY OF SURREY WITH CORE STUDY AREA HIGHLIGHTED



It was because of the confluence of several factors—the extremely high incidence of opioid-related incidents, a large influx of homeless people and high property crime rates—that the City of Surrey created a formal City Centre Response Plan (CCRP) commencing in January 1, 2017.

IDENTIFYING "HOTSPOTS"

It is not uncommon in much geographical analysis to identify so-called "hotspots" or locations of extreme events. These may range from highly localized concentrations of disease in epidemiology to high crime locations in criminology. Nominally, these locations coincide with the notion of outliers in general statistical analysis. As with the concept of an outlier, there is no formal academic

definition of a hotspot although there are several conventions or rules of thumb that one might apply.

A robust statistical approach to distributing regions is found in John Tukey's box plot approach. Here, we divide the data into quartiles and define outliers as 1.5 times the interquartile range (IQR) beyond the median or second quartile. Specifically, this report uses the data on reported opioid overdoses prior to 2017 to provide a baseline. For the years 2015 and 2016 the number of reported opioid-related overdoses was determined for each CT and divided by the population of the census tract to establish an overdose rate. Those CTs were then divided into four groups or strata identified as having low, moderate, high or very high overdose rates.

Specifically, the four strata were estimated as follows:

- *Low*: below the first quartile of rates of overdoses
- *Moderate*: first to third quartiles or the interquartile range of rates of overdoses
- *High*: third quartile to 1.5 times the IQR above the median or second quartile of rates of overdoses
- *Very High*: beyond 1.5 times the IQR above the median of rates of overdoses

These ranges are depicted in Figure 3.

FIGURE 1: BOX PLOT OUTLINING RISK CUT-POINTS

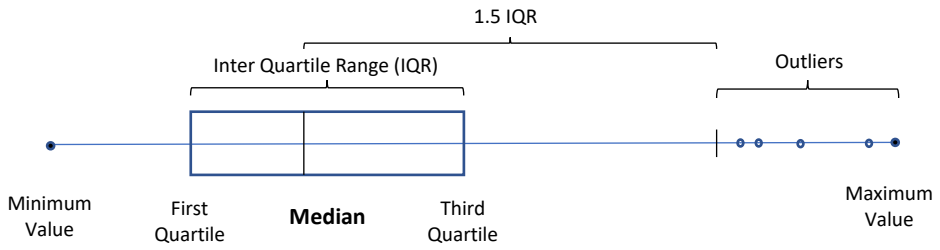
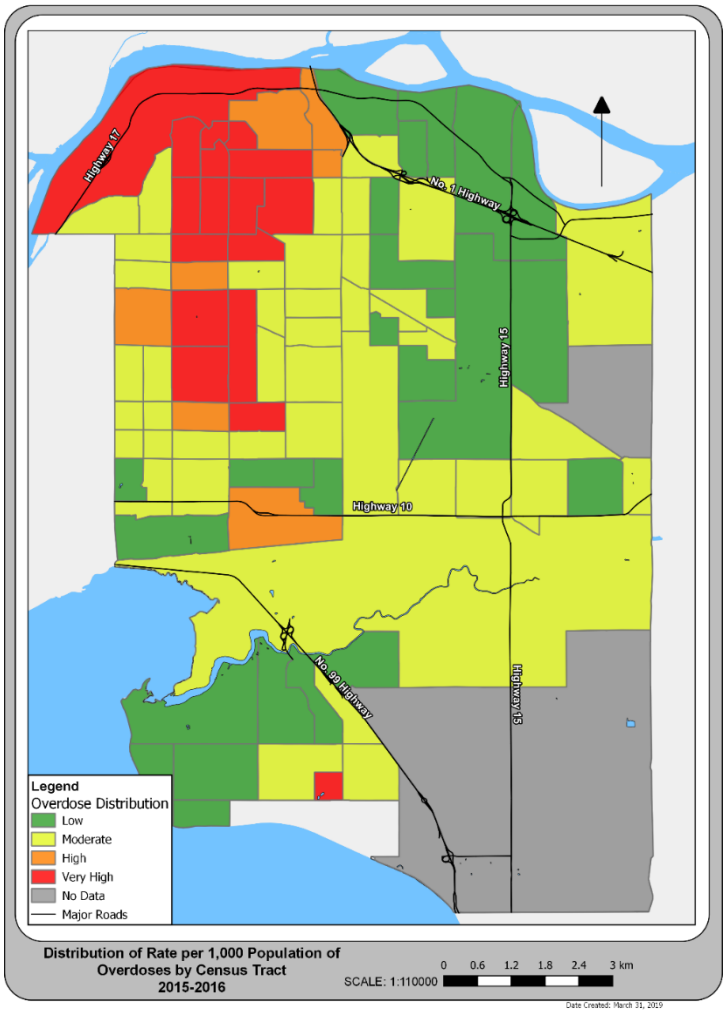


FIGURE 2: DISTRIBUTION OF OPIOID-RELATED OVERDOSES BY CENSUS TRACT, 2015-2016



The 95 census tracts within the City of Surrey are mapped out in Figure 4 based on the reported opioid-related overdose rate per 1,000 population.[3] Using the categorizing schema discussed above, 24 CTs were ranked as "Low" (green); 48 as "Moderate" (yellow); 13 as "High" (orange); and, 10 were ranked as "Very high" (red). Most of the "Very High" areas are in the northern portion of the city, astride King George Boulevard.

[3] We used opioid-related overdoses as opposed to death to develop an area "risk" typology because, while aggregate deaths were spiking within the City of Surrey, their incidence in any on subarea was quite small. Consequently, there was a much higher rate of statistical instability across areas. Furthermore, the correlation between rates (and numbers) of overdoses and deaths is extremely high. Thus, rates of overdoses provide an excellent proxy for the likelihood of an area also having high rates of opioid-related deaths.

Population data (denominator) for the rates were drawn from the 2016 Census of Canada.

As can be seen in Figure 4, the hotspots—those areas marked as red or having "very high" overdose rates—are concentrated in the north and west portions of the city. While the primary focus of attention has been the City Centre area where the very highest rates of overdoses were recorded, it is evident that rates of overdoses were also high in those areas along the western sections of Highway 17, and on both sides of King George Boulevard going as far south as 96 Avenue. There is also a local hotspot in the southern border of the City bounded by 20 and 16 Avenues on the north-south axis, and 148 and 152 Streets on the east-west axis. Generally, the remainder of Surrey experienced low to moderate rates of opioid-related overdoses.

Since the primary area of concern has been the spike in opioid-related overdoses and deaths in the City Centre area, one might wonder why our analysis includes the remainder of the City. The answer is that to understand what any impact an intervention in City Centre might have had, we need to compare outcomes with what was happening in the City at large. For example, while emergency housing was being provided in the City Centre area in response to the tent city on 135A Street, numerous Recovery Houses were being established in other areas of the City around the same time in an attempt to help those with drug problems. Most of those were in the hotpots outside City Centre.[4]

Many of those Recovery Houses outside the City Centre area provided services similar to those of the Emergency Housing First program. That is, they provided shelter in a permanent structure, many had onsite naloxone kits, and some of the registered Houses had full or part-time counsellors available. The point being made is that while changes were occurring in the City Centre area, the remainder of the City did not stay static regarding its response to the crisis. As we will see later, the overall question thus becomes whether the impact of the intervention in City Centre is significantly different than what was happening elsewhere in Surrey.

[4] By December 31, 2018, there were 68 service Recovery Houses identified by Surrey Fire Department in the City of Surrey including the 55 that were registered through British Columbia's Assisted Living Registry and were allowed under the City of Surrey's Business License Bylaw (Rehal, J. 2016. "Corporate Report: Recovery Homes Update." edited by Bylaw Enforcement & Licensing Services. Surrey, British Columbia: City of Surrey.) An additional 90 informal or nonregistered Recovery Houses have also come to the attention of the Surrey Fire Department.

The Broader Context

SOCIAL CHARACTERISTICS

Surrey is the ninth largest city in Canada having a recorded population count of slightly under 518,000 in the 2016 Census. The landscape is quite varied, encompassing a range of properties from farm lands to suburban residential areas to clusters of retail and industrial development. The City Centre area has become a major downtown core, second only to the City of Vancouver in the lower mainland of British Columbia. As with many other Canadian cities, it is also ethnically and socio-economically diverse.

The geographical distribution of overdoses within the City tends to follow the distribution of several key social-economic characteristics. As with many other large cities, Surrey's primary drug fault lines parallel the social and economic well-being of its residents. Some of the key correlates are presented in Table 1.

Essentially, the overdose rate increases as individual and family income decreases. The highest overdose risk areas also correlate with those areas that have the highest proportions of lone parent households, people living alone and the proportion of low-income households. Those areas also tend to have higher proportions of residents who do not have English as their mother tongue.

TABLE 1: SELECTED SOCIO-ECONOMIC CHARACTERISTICS AND RATES OF OPIOID-RELATED OVERDOSES

	Opioid-related Overdose Rate			
Characteristic	Low	Moderate	High	Very High
Percent population under 14-years	16.9	18.0	18.0	15.8
Percent population over 65-years	16.6	14.3	11.5	14.2
Average age	41.2	39.0	37.6	39.6
Median individual income*	36,496	29,918	26,994	26,051
Median family income*	101,130	81,194	72,620	62,802
Percent English as mother tongue*	56.9	46.6	44.0	44.1
Percent "other" as mother tongue*	39.5	48.5	50.4	50.4
Percent lone parent households*	17.9	22.0	25.0	30.2
Percent living alone*	5.8	7.5	7.8	12.6
Percent low-income households*	8.3	11.3	12.9	19.3

*Statistically significant a $p<.05$

In these respects, Surrey differs little from other Canadian cities or, in fact, other cities throughout the world that have significant illicit drug-use problems.

OVERDOSES AND DEATHS

Before we focus on the interventions taking place in the target area of City Centre, it is worthwhile examining what was occurring within the City of Surrey as a whole regarding opioid-related incidents during the four-year period under study. Again, the broad context for Surrey's CCRP was that opioid-related overdoses and deaths were spiking during 2015 and 2016. Within the 95 CTs that comprise the City of Surrey, there were 1,584 overdose incidents recorded in 2015 and 2,614

incidents recorded in 2016. The number increased to 2,784 in 2017. At the same time, the number of ascribed opioid-related deaths in 2015 was 82. This would increase to 151 in 2017.[5]

While the latter part of this report will focus on the impact of the CCRP specifically, this section will provide a general overview of what was happening in the City at large over the four-year period of January 1, 2015 to December 31, 2018. Since the CCRP was introduced in January 2017, it is worthwhile taking an overview of what was happening throughout the City before and after the introduction of the CCRP in City Centre.

The number of *overdoses* by risk area is listed in Table 2. For the sake of comparison with the later analysis, the seventeen "Very High" risk areas have been sub divided into the core City Centre and surrounding area (six CTs), and the other eleven "Very High" risk areas.

Together, there were 4,193 overdoses prior to January 1, 2017 and 4,560 afterward. As can be seen, the six CTs that comprise City Centre and the immediately surrounding area experienced the highest absolute number of overdoses. The "Moderate" risk areas ranked second regarding the absolute number of overdoses, but it ought to be recalled that those numbers were distributed over a greater number of CTs (n=47). Two observations regarding Table 2 are most germane: first, in the aggregate, the number of overdoses did not drop post January 1, 2017. Second, the relative distribution of overdoses remained reasonably consistent across the risk categories. The percentage distribution went up slightly in the "Low" risk areas and down slightly in the "Very High" risk areas. The core areas that included City Centre and its surrounding areas saw a proportionate increase in overdoses from 43% prior to January 1, 2017 to 47% afterward.

TABLE 2: NUMBER AND PERCENT OF OVERDOSES BY PERIOD

	Period (Number)		Period (Percent)	
Risk Category	**2015-16**	**2017-18**	**2015-16**	**2017-18**
Low (n=24)	154	229	3.7	5.0
Moderate (n=47)	1,134	1,264	27.0	27.7
High (n=7)	356	306	8.5	6.7
Very High (n=11)	747	616	17.8	13.5
Core Area (n=6)	1,802	2,145	43.0	47.0
Total	4,193	4,560	100.0	100.0

A similar pattern is seen in Table 3 which presents the number of opioid-related *deaths* in Surrey. It should be noted, however, that Table 3 differs from Table 2 in that mortality data were not available for 2015. The mortality data show a slightly different profile than the overdose data. That is, the proportion of deaths increases in the "Low" and "Moderate" risk areas and proportionately decreases in the "Very High" and Core areas. The increase in the "Low" category is partially a

[5] Unfortunately, we did not have access to opioid-related death statistics for 2015. Informal reports suggest they were lower than in 2016. Regardless, it was clear that just as overdoses were on the increase throughout the City, so were opioid-related deaths.

function of the fact that the base number of two ODs in 2016 was so low. Thus, even a small numeric increase would result in a more significant percentage increase.

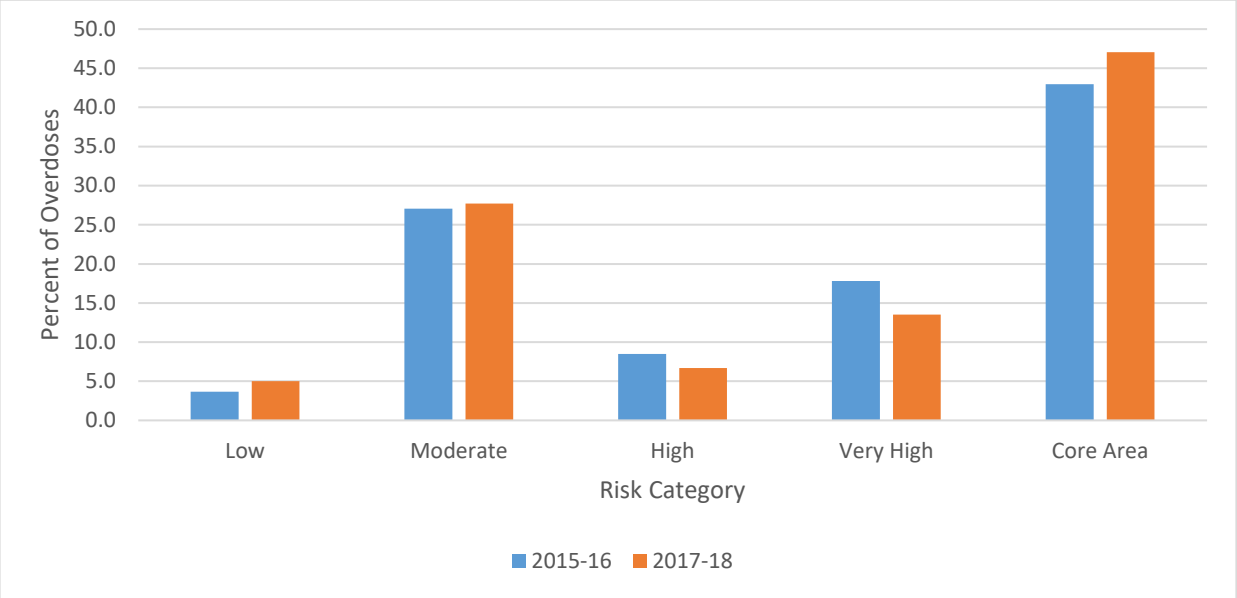
TABLE 3: NUMBER AND PERCENT OF DEATHS BY PERIOD

Risk Category	Period (Number)		Period (Percent)	
	2016	2017-18	2016	2017-18
Low (n=24)	2	32	2.4	10.1
Moderate (n=47)	29	121	35.4	38.2
High (n=7)	9	32	11.0	10.1
Very High (n=11)	16	49	19.5	15.5
Core Area (n=6)	26	83	31.7	26.2
Total	82	317	100.0	100.0

More likely, the proportionate shift to the lesser risk areas may be due to the distribution of resources throughout the City. It is reasonable to hypothesize that more individuals in the "Low" to "Moderate" risk areas were relative novices to opioid use and consequently less likely to be in a supportive group of more knowledgeable fellow users. Furthermore, services such as Recovery Houses and naloxone kits are less likely to be available in those areas. While it is recognized that opiate use is endemic, community resources are generally directed to those areas known to be proportionately more problematic.

For the sake of clarity, the data in Tables 2 and 3 are replicated in the figures below. Figures 5 and 6 represent both the number and percent of opioid-related overdoses by area risk category. Again, the slight drop in the "High" and "Very High" risk areas and the increase in the Core Areas is noticeable. Determining why this shift has occurred is beyond the analytical scope of this report. The change might simply be due to random fluctuation; it might be due to street uses migrating to the City Centre region where social networks and availability might be more accessible; or, it may be due to other systematic factors.

FIGURE 5: PERCENT OF SURREY DRUG OVERDOSES BY RISK CATEGORY



The data on opioid-related deaths from Table 3 are graphically illustrated below. Again, these charts are not directly comparable to those depicting the overdose patterns due to the unavailability of data for 2015.

FIGURE 6: NUMBER OF SURREY DRUG OVERDOSES BY RISK CATEGORY

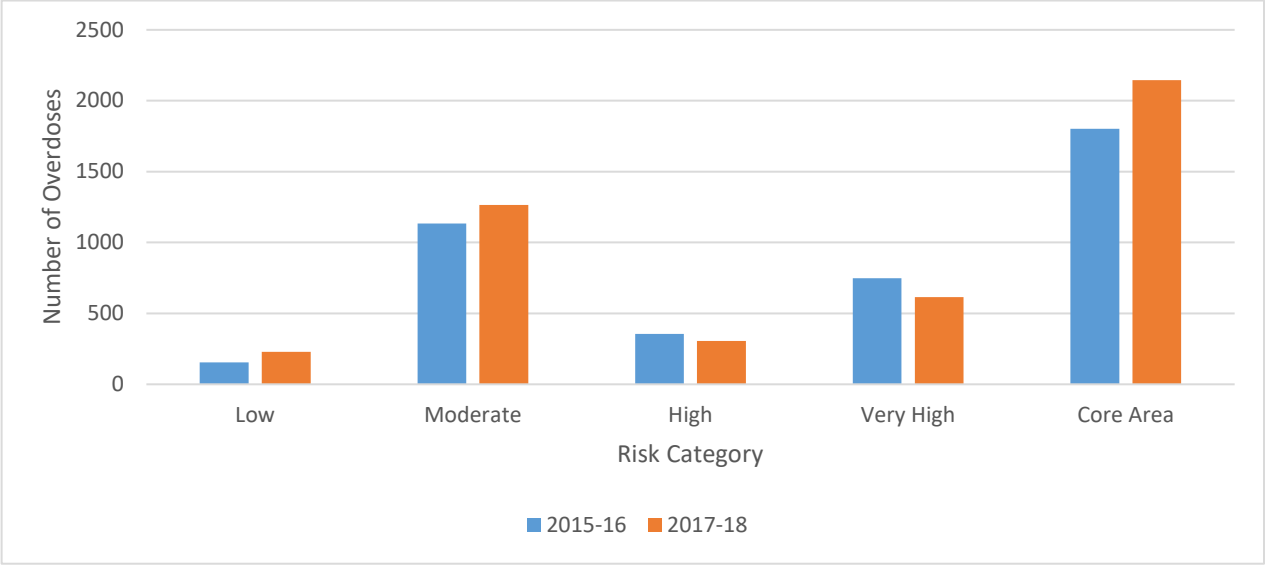
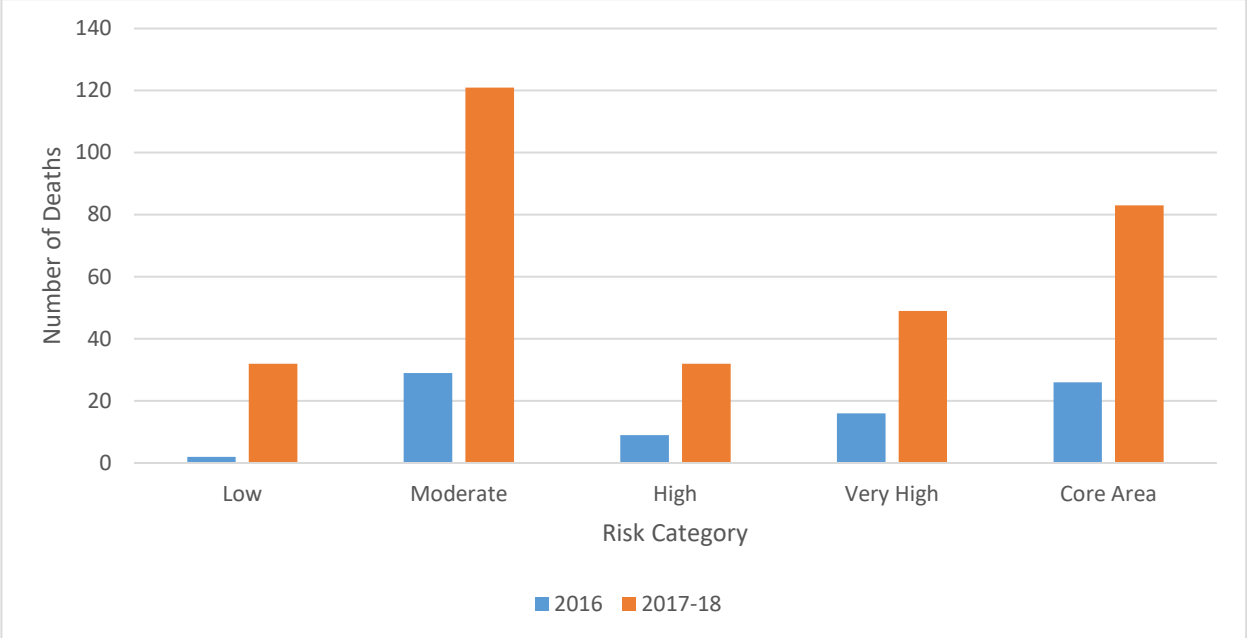


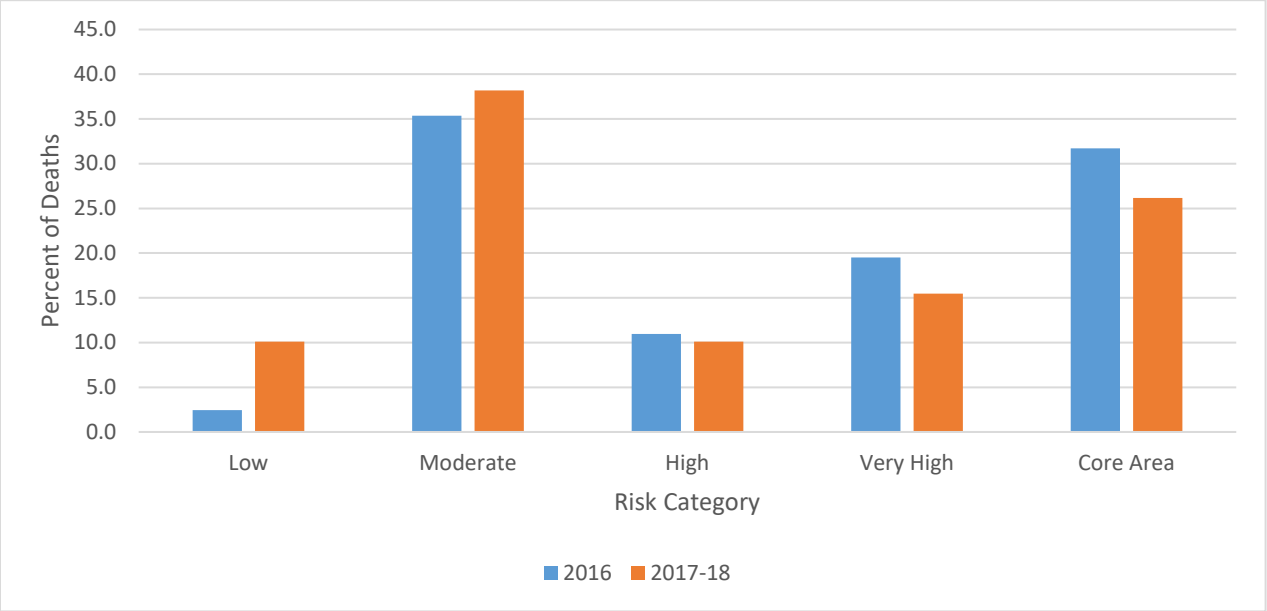
Figure 7 shows the number of deaths both before and after the start of the CCRP intervention. While the before and after time durations are not comparable, it is still evident that there was an increase in deaths post 2017.

FIGURE 7: NUMBER OF SURREY DRUG DEATHS BY RISK CATEGORY



This trend is more obvious in Figure 8 where we can examine the proportionate distribution of deaths across risk areas. What becomes clear from Figure 8 is the trend toward proportionately lower deaths in the higher risk areas, and a proportionate increase in the lower and moderate risk areas. One obvious explanation for this is that programs such as the CCRP, along with the availability of Recovery Houses and, likely, naloxone kits, is greater in the high as opposed to the low risk areas. This would be a reasonable outcome where the distribution of resources tends to be greater in those areas perceived as having a greater need. The consequence may be, however, that lower risk areas tend to be de-emphasized.

FIGURE8: PERCENT OF SURREY DRUG DEATHS BY RISK CATEGORY



CRIMES

One of the major concerns with the increases in opioid-related deaths and overdoses is that they are a proxy for an increase in the underlying rate of drug use. This, in turn, is suspected to drive property crime rates as users require increased resources to make their purchases. This is not an unusual conjecture since it is well known that social pathologies tend to cluster along both social and geo-spatial dimensions.[6]

Data on selected crimes within the City of Surrey were collected for the years 2015 to 2018 inclusive. The crime data are limited to a series of property crimes only: break and entering into a business; residential break and enter; shoplifting; and, motor vehicle thefts. Crimes against the

[6] As far back as the 1920s, social scientists were wondering if there were spatial and temporal patterns to criminal and deviant behaviour. Sociologists at the University of Chicago noted that the application of ecological principles to the distribution of anti-social behaviour explained a substantial amount of the variation in the distribution of such behaviours, including drug abuse (see Park (1967); Hawley (1943); Shaw et al. (1929). For a more recent discussion, see Diplock (2016).

person and other offences are not considered in this analysis. On average, there were approximately five known property crimes per day (around 35 per week) within the City.

Once again, the data were divided into two periods: before and after January 1, 2017. The numbers of crimes were sorted according to the overdose-related risk areas and are presented in Table 4.

Unlike the data relating to overdoses and deaths, the recorded number of property crimes *decreased* by about 11% in the period after January 1, 2017. On the other hand, the distribution of crimes stayed remarkably consistent by risk area across the two periods under consideration. Essentially, the aggregate number of crimes did not vary significantly within each of the risk categories. When the data were analysed based on rates within CTs, those areas that had the highest likelihood of overdoses and opioid-related deaths also had the highest incidences and rates of property crime.

TABLE 4: NUMBER AND PERCENT OF OVERDOSES BY PERIOD

Risk Category	Period (Number)		Period (Percent)	
	2015-16	2017-18	2015-16	2017-18
Low (n=24)	4,977	4,694	14.0	14.9
Moderate (n=47)	16,224	14,428	45.6	45.8
High (n=7)	2,816	2,370	7.9	7.5
Very High (n=11)	6,268	5,094	17.6	16.2
Core Area (n=6)	5,289	4,940	14.9	15.7
Total	35,574	31,526	100.0	100.0

The patterns exhibited in Table 4 can be more clearly seen in the following figures. As Figure 9 shows, the number of crimes reported decreased in all the regional risk categories. The proportional distribution, however, remained both substantively and statistically consistent as illustrated in Figure 10.

FIGURE 9: NUMBER OF PROPERTY CRIMES BY RISK CATEGORY

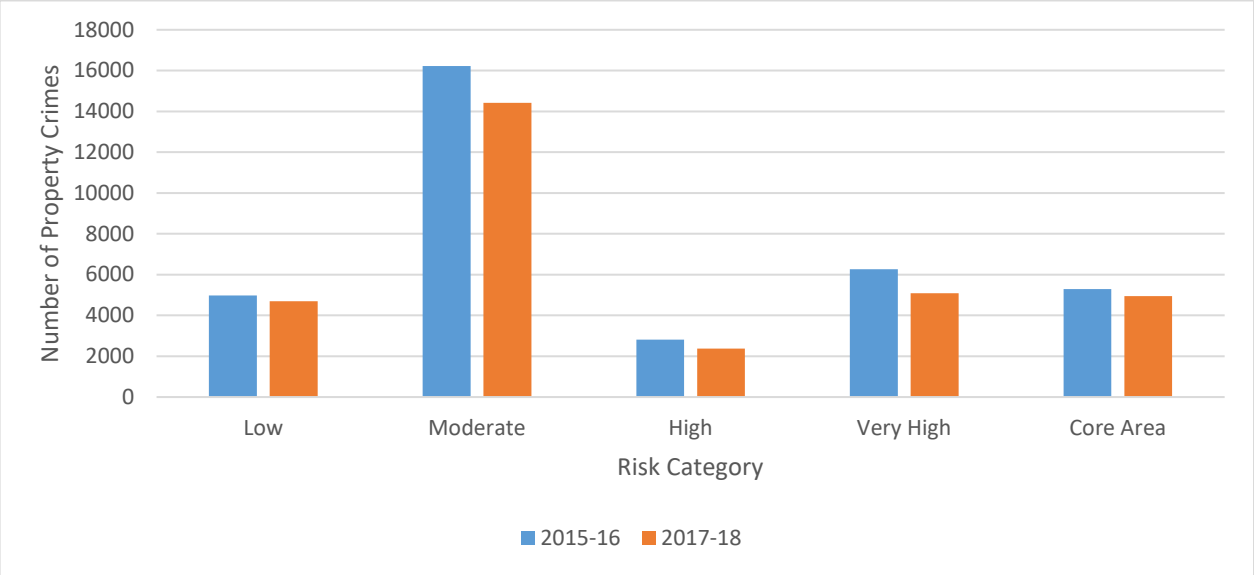
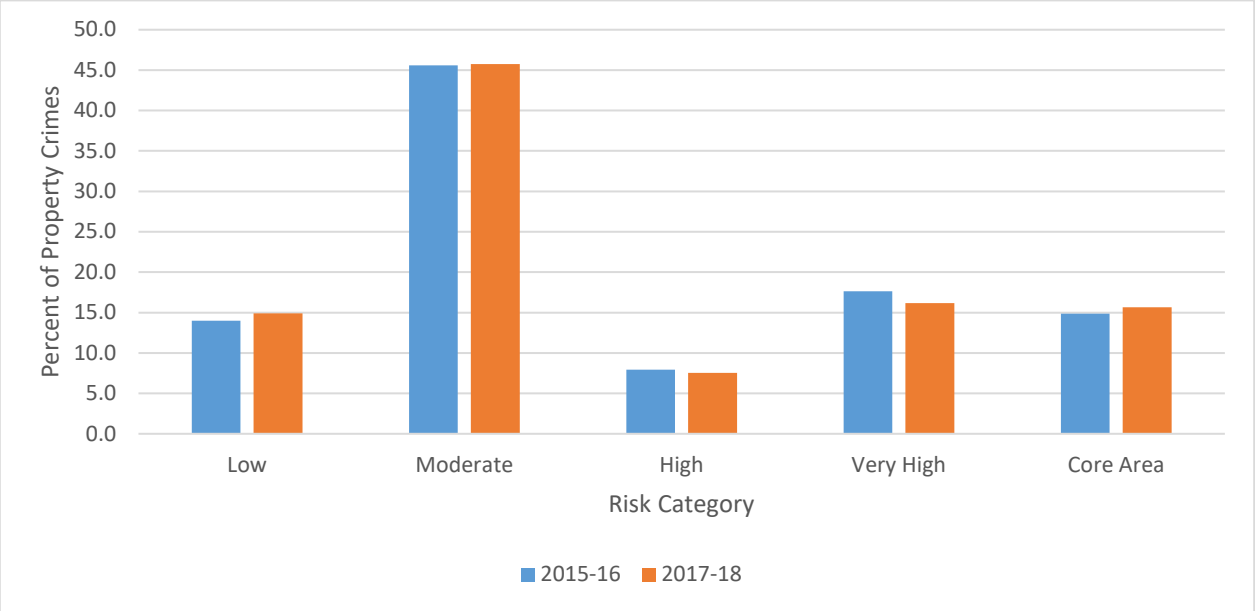


FIGURE 10: PERCENT PROPERTY CRIMES BY RISK CATEGORY



SUMMARY

The City of Surrey, along with the East side of Vancouver have experienced the worst of the opioid crisis. Over the four years for which we have data, it is evident that opioid-related incidents have not abated substantially. When we take a macro perspective looking at the period prior to and after 2017, several things become evident. Specifically, regarding overdoses:

- The aggregate number of overdoses increased across the city from prior to, to after January 1, 2017.
- The relative distribution of overdoses remained reasonably consistent across risk areas although the percentage distribution went up slightly in "Low" risk areas and down slightly in the "High" and "Very High" risk areas.

Regarding deaths:

- There was a dramatic increase in deaths across the three-year period 2016-2018 which was disproportionate to the increased incidence of overdoses.
- As with overdoses, the proportion of deaths increased in the "Low" risk areas relative to the "Very High" risk and Core areas.

The pattern for property crimes differed somewhat from that of overdoses and deaths. That is:

- In the aggregate, the recorded number of property crimes decreased by about 11% in the period after January 1, 2017.
- The distribution of property crimes across drug-risk areas remained proportionately consistent. It is also the case that those area that had the highest incidences and rates of property crime also had the highest likelihood of opioid-related overdoses and deaths.

Opioid-related Incidents in Surrey

As indicated previously, the geographical focus of the City's intervention corresponds broadly to a Core Area containing two central census tracts identified as CTs **191.04** and **191.07**. In this analysis, we examine whether there has been a change in the incidence of opioid incidents over the period of the intervention within those zones.

To reiterate, there are three key intervention phases on which this analysis focuses. These are:

1. January 2017: Initiation of SOT Surrey Outreach Team
2. June 2017: Initiation of SafePoint, the supervised consumption site
3. June 2018: Creation of Workforce Housing for 200 people

As part of a comparative design, we can use these three intervention points to create four periods for analysis. The initial or base period is *prior* to the City of Surrey's CCRP intervention which was initiated on January 1, 2017. The first intervention starts on January 1, 2017 at which point the SOT is put into service. The second intervention period starts June 1, 2017 after which the safe consumption site was operationalized in conjunction with the SOT. The third intervention period starts June 1, 2018 with the implementation of the Workforce Housing project. Again, this last intervention is in addition to the previously implemented SOT and safe consumption site interventions.

To summarize, observations were taken over four periods—the baseline and three intervention phases:

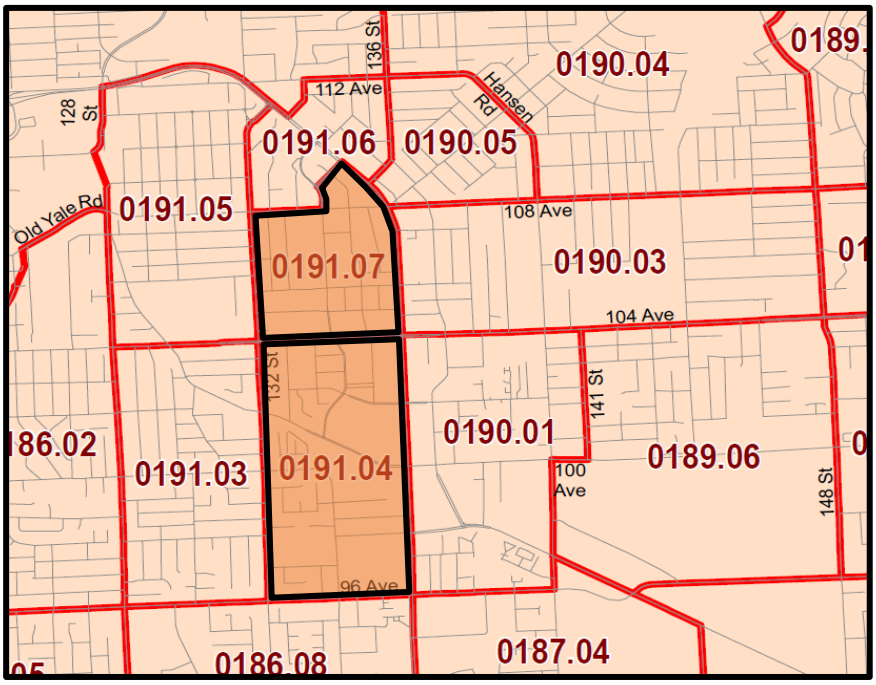
- Period 0 (2015 and 2016);
- Period 1 (January 1, 2017 to May 30, 2017);
- Period 2 (June 1, 2017 to May 30, 2018); and,
- Period 3 (June 1, 2018 to December 31, 2018).

It is only possible to understand the impact of an intervention when it is compared to something else. Typically, in true experimental designs, the comparison is generally known as a control group. The control group is one which is not exposed to the intervention. Since the current situation does not constitute a true experimental design, we resort to an alternate approach which is to contrast the experimental or target group with a series of comparators. In this case, to provide a context for interpreting the data in the Core Areas (CTs 191.04 and 191.07), data are provided for four neighbouring census tracts (190.01, 190.03, 191.03 and 191.05). All six of those areas were identified as "Very High" risk in the previous sections of this report. The second comparator we use consists of all other CT areas within the City of Surrey (that is, the remaining 89 census tracts).[7]

[7] For a discussion of various approaches to evaluating nonexperimental design, see Gertler et al. (2016); Khandker et al. (2010); and Province of Ontario (2007)

For reference, the locations of the two core and four adjacent CTs are identified in Figure 11. The two core areas are highlighted in a darker orange.

FIGURE 11: WHALLEY CORE CENSUS TRACTS



OVERDOSES

The incidence of opioid-related overdoses is reported in Table 5. Here, both the absolute numbers of overdoses are reported along with the rate per 1,000 population within the respective areas. The base population (denominator) for the rates is taken from the 2016 Census. Arguably, the population figures are somewhat problematic since many of the incidents of overdosing were among transient individuals who may not have been captured by the Census. While the inclusion of transient individuals into the population count may be an issue, it is likely that the resident population still provides a reasonable base from which to compare relative rates across geographical zones (CTs).

There are two key items to note from Table 5. First, the two Core Area census tracts account for slightly more than one-third of the total number of recorded overdose incidents over the four-year period (2,942 out of 8,753). The adjacent CTs account for an additional 11% of the reported incidents and the remaining 55% of incidents are spread across the rest of the city.

A second point to note is that while the total number of incidents varies across CTs, the overall pattern across time remains remarkably similar regardless of location.

TABLE 5: NUMBER OF OPIOID-RELATED OVERDOSES IN TARGET AREA (CTS) RATES PER 1,000 POPULATION IN PARENTHESES

	Period				
Core Area	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
191.04	481	133	250	68	932
	(69.5)	(19.2)	(36.1)	(9.8)	(134.6)
191.07	863	352	620	175	2,010
	(219.3)	(89.5)	(157.6)	(44.5)	(510.8)
Total	1,344	485	870	243	2,942
	(123.8)	(44.7)	(80.1)	(22.4)	(270.9)
Adjacent Area	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
190.01	135	57	101	17	310
	(15.0)	(6.3)	(11.2)	(1.9)	(34.4)
190.03	197	86	113	52	448
	(28.6)	(12.5)	(16.4)	(7.5)	(65.0)
191.03	75	16	32	10	133
	(13.3)	(2.8)	(5.7)	(1.8)	(23.7)
191.05	51	13	38	12	114
	(12.6)	(3.2)	(9.4)	(3.0)	(28.3)
Total	458	172	284	91	1,005
	(17.9)	(6.7)	(11.1)	(3.6)	(39.3)
Surrey (Other)	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
Remaining CTs	2,391	667	1,395	353	4,806
	(5.0)	(1.4)	(2.9)	(0.7)	(10.0)

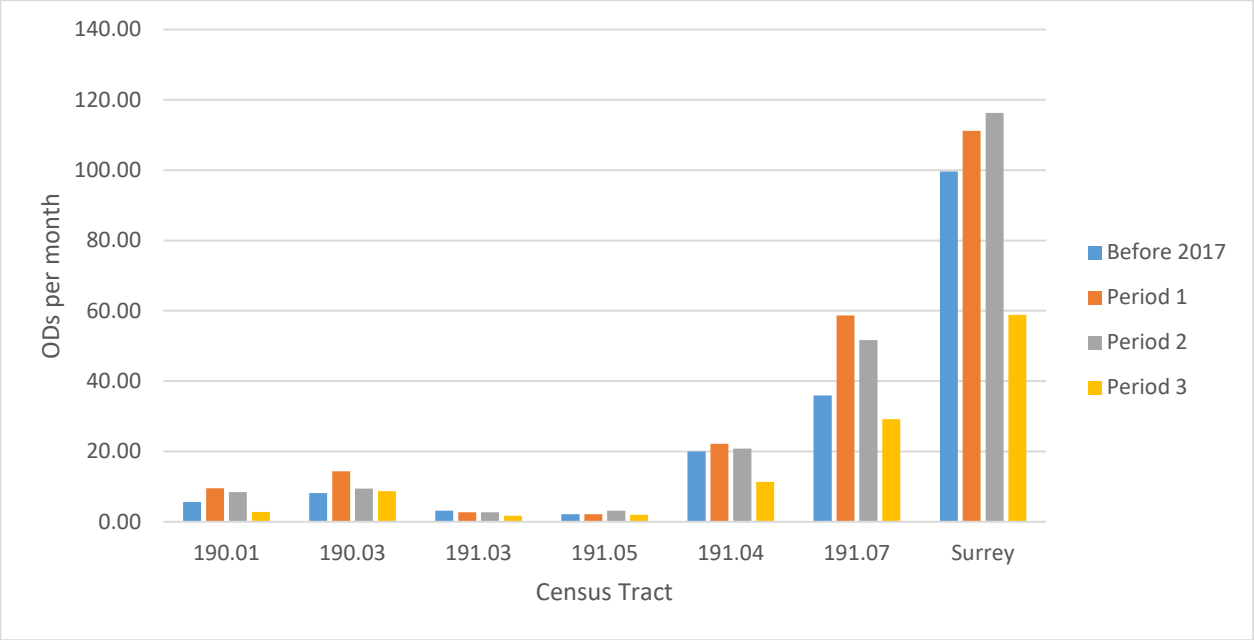
As might be expected, the total number of overdoses in Period 0 (the pre-intervention phase) is greater than for the other three segments since it incorporates data from the two previous years, 2015 and 2016. Similarly, there is a "bump" in incidents in Period 2. This is also not unexpected since Period 2 covers a 12-month duration while Periods 1 and 3 are only 6 months in duration. To correct for the differences in time across the intervention periods, incident rates *per month* were calculated and presented in Figure 12.

In Figure 12, the bars represent the number of reported overdoses *per month* for each of the four periods. This corrects for the differing durations of the periods under consideration. What Figure 12 indicates is that there was an overall increase in the rate of overdoses from before 2017 to peak in 2017, and then decrease in the final six months of 2018. When a statistical test was conducted on the pattern of overdoses over time across the three comparator regions (Core Area, Adjacent CTs and the remainder of Surrey), there are is a statistically significant differences using a commonly

accepted probability level of .05.[8] The overall pattern is a little complex but an examination of standardized residuals suggested that while all three regions experienced an *increase* in overdoses in Period 1, both the Core Area and the Adjacent CTs saw a *drop* in overdoses in Period 2 while the remainder of the City continued to experience a relative increase. There was, however, a substantial decrease in both the absolute and relative number of overdoses in Period 3 in all parts of the City.

From the perspective of the intervention, the results are not unambiguous. All parts of the City saw a significant drop in overdoses in Period 3. In the Core and Adjacent areas, however, it appears that the decline started to occur in Period 2 (the 12 months from June 1, 2017 to May 30, 2018).

FIGURE 12: OVERDOSES PER MONTH BY CORE CENSUS TRACT



DEATHS

Beyond reducing the number of overdoses, it was hoped that the CCRP intervention would reduce the number of opioid-related deaths which were occurring in the City. As indicated in the previous sections of this report, the number of deaths generally increased in tandem with reported overdoses. With deaths, we should recall that the pre-intervention exposure period (Period 0) consists only of the calendar year 2016 since data from the previous year were unavailable for analysis.

Over the three-year period (2016-2018 inclusive) there were 399 identified opioid-related deaths for which locational data were available.[9] While that number is clearly tragic, it should be noted

[8] Chi-square 15.3; 15 d.f.; p-value=0.018

[9] There was a total of 403 deaths identified; however, a census tract location could only be assigned to 399. Consequently, the latter tally was used in this analysis.

that breaking down the statistics by place and time can soon result in small numbers. Consequently, we would advise some caution when drawing conclusions from these data.

A breakdown of both the number and rates of deaths per 1,000 population is presented in Table 6. This parallels the format of Table 5 which provides information on overdoses. As with overdoses, however, the Core area and surrounding CTs experienced an inordinate number of fatalities in comparison with the rest of Surrey. Again, because of durational differences in the intervention periods, it is easier to interpret the results if we look at deaths per month.

TABLE 6: NUMBER OF OPIOID-RELATED DEATHS IN TARGET AREA (RATE PER 1,000 POPULATION OF OPIOID-RELATED DEATHS IN TARGET AREA)

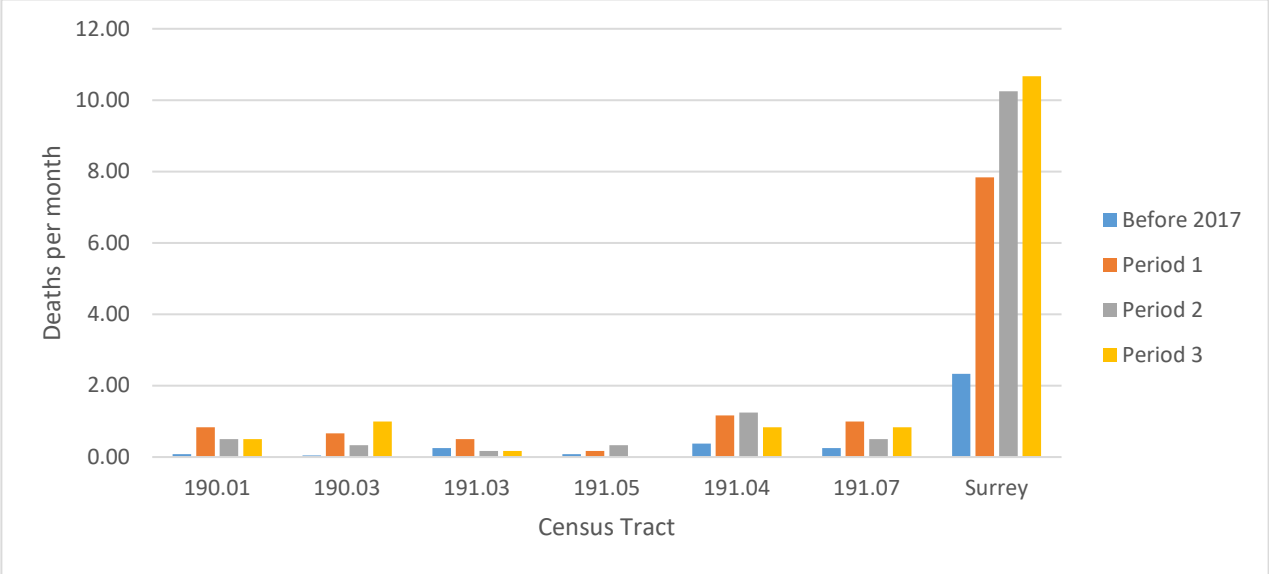
	Period				
Core Area	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
191.04	9	7	15	5	36
	(1.3)	(1.1)	(2.2)	(0.7)	(5.2)
191.07	6	6	6	5	23
	(1.5)	(1.5)	(1.5)	(1.3)	(5.8)
Total	15	13	21	10	59
	(1.4)	(1.2)	(1.9)	(0.9)	(5.4)
Adjacent Area	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
190.01	2	5	6	3	16
	(0.2)	(0.6)	(0.7)	(0.3)	(1.8)
190.03	1	4	4	6	15
	(0.1)	(0.6)	(0.6)	(0.9)	(2.2)
191.03	6	3	2	1	12
	(1.1)	(0.5)	(0.4)	(0.2)	(2.1)
191.05	2	1	4	0	7
	(0.5)	(0.2)	(1.0)	(0.0)	(1.7)
Total	11	13	16	10	50
	(0.4)	(0.5)	(0.6)	(0.4)	(2.0)
Surrey (Other)	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
Remaining CTs	56	47	123	64	290
	(0.1)	(0.1)	(0.3)	(0.1)	(0.6)

In Figure 13, the bars represent the number of reported overdoses *per month* for each of the four periods. This corrects for the differing durations of the intervention periods. What we see in Figure 13 is that there is a substantial amount of variability across census tracts. This is again a function of the relatively small numbers. However, a couple of consistent patterns emerge. The first is that among the cluster of "Very High" risk CTs around the Central Core, the two primary CTs (191.04 and 191.07) generally have the highest deaths per month. In all instances, the intervention periods see higher deaths per month than we find in the pre-2017 period. Within the three intervention

periods, however, there does not appear to be any systematic trend. That is not the case for the remaining parts of Surrey where the number of deaths per month increased from the pre-2017 period through the three intervention periods.

Again, the numbers of deaths are relatively few, so it is inadvisable do draw an incontrovertible statistical conclusion at this point. If there is an emerging pattern, however, it is that none of the core CTs experienced the consistent pattern of increases in deaths over the intervention period (2017-2018) that is seen in the rest of the City.

FIGURE 13: DEATHS PER MONTH BY CORE CENSUS TRACT



PROPERTY CRIMES

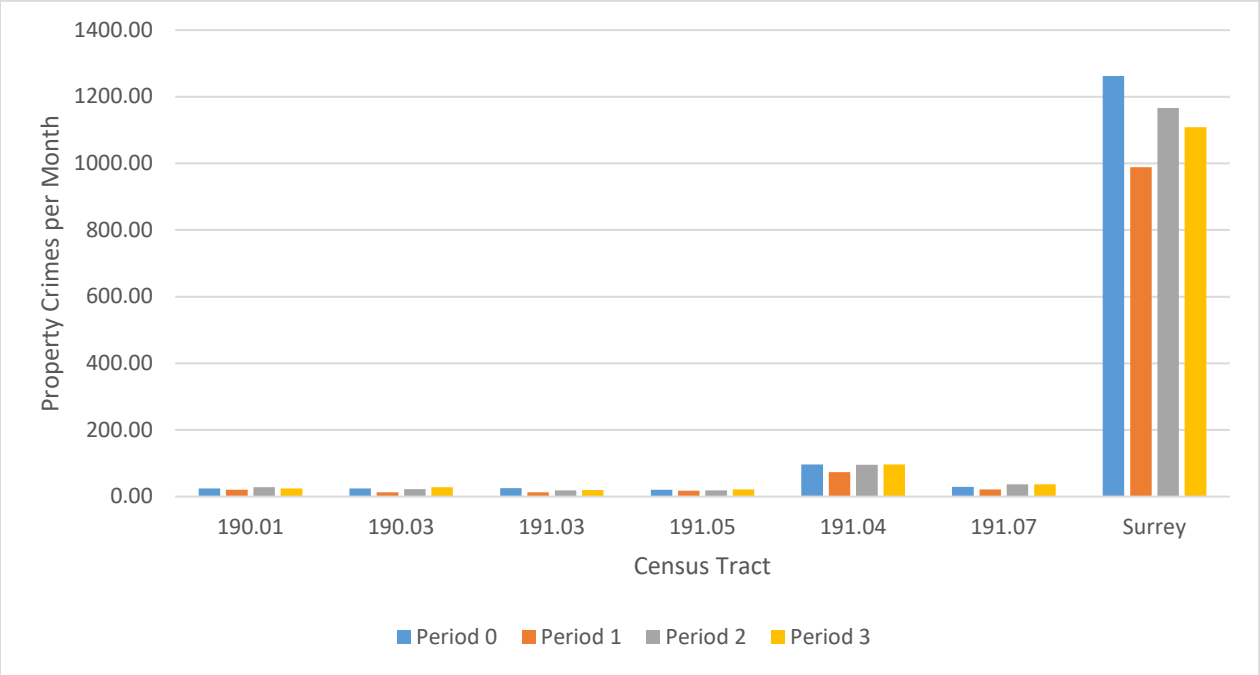
The third element under consideration beyond opioid-related overdoses and deaths is property crimes. The number of reported crimes during the period under consideration is presented in Table 7. As with opioid-related overdoses and deaths, property crimes within Surrey are reported disproportionately in the core Whalley area of the City.

Again, due to the differing durations of the interventions, the number of reported crimes per month were calculated and presented in Figure 14. The remarkable aspect of Figure 14 is that, despite the substantial variations in opioid-related overdoses and deaths illustrated in Figures 12 and 13, property crime rates appeared remarkably consistent with time.

TABLE 7: NUMBER OF PROPERTY CRIMES IN TARGET AREA (RATES PER 1,000 POPULATION IN PARENTHESES)

	Period				
Core Area	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
191.04	2,323	438	1,146	579	4,486
	(335.5)	(63.2)	(165.5)	(83.6)	(647.8)
191.07	702	129	437	219	1,487
	(178.4)	(32.8)	(111.1)	(55.6)	(377.9)
Total	3,025	567	1,583	798	5,973
	(278.5)	(52.2)	(145.8)	(73.5)	(550.0)
Adjacent Area	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
190.01	580	121	333	145	1,179
	(64.4)	(13.4)	(37.0)	(16.1)	(131.0)
190.03	576	78	269	167	1,090
	(83.5)	(11.3)	(39.0)	(24.2)	(158.1)
191.03	618	76	226	116	1,036
	(110.0)	(13.5)	(40.2)	(20.6)	(184.3)
191.05	490	108	227	126	951
	(121.4)	(26.8)	(56.3)	(31.2)	(235.7)
Total	2,264	383	1,055	554	4,256
	(88.6)	(15.0)	(41.3)	(21.7)	(166.6)
Surrey (Other)	**Period 0**	**Period 1**	**Period 2**	**Period 3**	**Total**
Remaining CTs	30,285	5,934	13,998	6,654	56,871
	(62.9)	(12.3)	(29.1)	(13.8)	(118.1)

FIGURE 14: PROPERTY CRIMES PER MONTH BY CORE CENSUS TRACT



SUMMARY

This section provides a more refined examination of the impact that the CCRP may have had on the rates of overdoses, deaths and property crimes in the Central Core or target area. To more fully appreciate the impact that the CCRP may or may not have had on what was happening in the Core, we contrasted patterns in those two key CTs with a series of adjacent CTs that had been identified as "High Risk" zones, and the remainder of the City.

While the overall pattern we find in this analysis differs little from the macro "before-after" analysis of the previous section, there are some nuances that become more evident. To summarize the results, for overdoses, we find that:

- The two Core Area census tracts experienced slightly more than two-thirds of the total number of recorded overdoses over the entire four-year period
- The adjacent CTs accounted for an additional 11% of the reported overdoses, with the remaining 55% being spread across the rest of the City
- In general, there was an increase in overdose rates across the entire city from before 2017 to a peak in 2017. In contrast, the Central Core and adjacent CTs saw a slight decline in rates in phase 2 of the CCRP (Period 2).
- Overall, there was a decrease in overdoses throughout the City in the final six months of 2018. This corresponds to the implementation of phase three of the CCRP (the housing phase). It should be noted, however, that this pattern was replicated throughout the City and not just in the Central Core.

Regarding deaths:

- The two Central Core CTs had the highest overall death rates across all periods examined.

- In the City as a whole, all three intervention periods saw higher deaths per month than occurred in the pre-intervention period.
- While the overall death rate increased in the Core and adjacent CTs in the intervention period, none of the core CTs experienced the consistent pattern of increases in deaths that was seen in the rest of the City.

Unlike overdoses and deaths, while there were annual fluctuations, property crimes remained relatively consistent across all parts of Surrey.

Demographics of Opioid-Related Deaths

Unfortunately, limited information is available on where opioid-related deaths occur and on the personal characteristics of the victims. Over the three-year period, 2016-2018 inclusive, 403 deaths were recorded within the City of Surrey.[10] This analysis will focus on the known characteristics of those victims.

GENDER

Consistent with other data relating to opioid-related mortality, most victims in Surrey are males. What does stand out, however, is the dramatic proportionate increase in male deaths in comparison to females over time. As Table 8 indicates, while the number of female overdose victims increase by about 60% (32 v. 20) over the three-year period, the increase in the number of male victims increased by about 114% (136 v. 63). Consequently, while the male to female death ratio was about 3.15:1 in 2016, it increased to 4.25:1 in 2018. Male deaths not only increased in absolute numbers, they also increased at a much greater rate than deaths among females.

TABLE 8: GENDER OF VICTIM BY YEAR

	Year		
Gender	2016	2017	2018
Female	20	21	32
Male	63	131	136
Total	83	152	168

AGE

The variation in age among victims is quite wide. As Table 9 illustrates, for the three years under investigation, victims have ranged from those in their mid-teens to senior citizens. Most, however, are individuals around 40 years of age. Unlike gender, the age profile of the victims has been relatively stable with time.

[10] A total of 403 opioid-related deaths were recorded in Surrey. This number is contrasts with the previous geographical analysis where there was census tract information on the location of 399 cases.

TABLE 9: AGE OF VICTIM BY YEAR

Age	Year		
	2016	2017	2018
Minimum	19	14	17
Maximum	67	81	66
Average	39.4	41.9	38.5
Standard Deviation	10.4	13.0	11.7
No. of Cases	83	152	168

RACE

Table 10 provides a breakdown of victims by race. Most of the victims of opioid-related overdoses are classified either as "Caucasian," South Asian or Aboriginal. This is not surprising since those groups are highly proportionate to the overall population in the Surrey area. The biggest increases in deaths has occurred among Caucasians, where the number jumped by close to 100% from 2016 to 2017 and 2018 (53 to 101 and 94 respectively). A similar pattern can be found among South Asians where there was a doubling in the number of deaths from 2016 to 2017 (13 to 27) and a further 60% increase from 2017 to 2018 (27 to 43). While the proportion of deaths is quite small in relation to Caucasians and South Asians, the pattern among other ethnic/racial groups in the area appears stable over time. This is also the case for Aboriginal people who compose the third largest identifiable group of victims.

TABLE 10: RACE OF VICTIM BY YEAR

Race	Year		
	2016	2017	2018
Aboriginal	12	10	17
Asian	0	5	4
Black	4	6	5
Caucasian	53	101	94
Hispanic	1	0	3
Middle Eastern	0	1	1
South Asian	13	27	43
Unknown	0	2	1
Total	83	152	168

LOCATION OF DEATH

Limited information is also available on the location where the victim was located.[11] As Table 11 illustrates, about three-quarters of the victims, are found in a residence of some type. An additional 10% are found outside on a "street" location. The remainder are found in a variety of locations from parks to motor vehicles to hospitals. What is not known, with perhaps the exception of a hospital setting, is whether the victims were alone or in the company of others when they overdosed.

TABLE 11: LOCATION OF DEATH BY YEAR

Location	Year		
	2016	2017	2018
Barn	0	1	0
Commercial Residence	0	8	6
Commercial Washroom	1	1	1
Government Institution	0	0	1
Hospital	1	4	8
Residence	63	117	126
Street	13	14	14
Vehicle	3	5	8
Wooded Area-Field/Park	2	1	4
Total	83	151	168

SUMMARY

Limited information was available on overdose victims. In summary, however:

- The majority of victims were male. Mortality rates increased substantially in 2017-2018 over 2016, with rates among women increasing by about 50% while rates among men doubled.
- The average age of victims was about 40 years-of-age, although there was considerable variation from those in their late teens to individuals beyond retirement age.
- Most victims were identified as "Caucasian" and the mortality rate among that group doubled after 2016. South Asians were the second largest racial group with their mortality rate doubling from 2016 to 2017 and further increasing by 60% from 2017 to 2018. There was no identifiable pattern among the other groups identified.
- Three-quarters of the victims were discovered in residences with an additional 10% found on a "street" location.

[11] Information was missing on one victim in 2017; hence, the total of 151 as opposed to 152 in the previous tables.

Conclusions

The "opioid crisis" has taken a substantial toll on the citizens of Surrey and of British Columbia as a whole. Beyond the human tragedy resulting from overdoses and deaths, opioid dependency has placed a strain on the City's resources and on the broader social fabric. Overall, it is a social tragedy for which there appear to be few easy policy solutions. It is also evident that opioid addiction and its consequences are complex phenomena that require a significant amount and diversity of resources if they are to be addressed successfully. While opioid addiction cuts across all social strata, it is perhaps among the itinerant poor that it is most evident.

In British Columbia and, increasingly, throughout much of the rest of Canada, local municipalities are trying to respond in a significant manner. Typical responses include such developments as the establishment of safe consumption sites, increasing the number of Recovery Houses, better training for first responders to deal with overdose situations, and the broader distribution of naloxone kits. All of these efforts and more are taking place within Surrey.

The establishment of a "Tent City" in City Centre merely highlighted how the problem was focused in one area of Surrey. In response, City Council created Surrey's Centre City Response Plan to try to mitigate some of the consequences of street-level drug use. The plan consisted of three main components: an enhanced service presence based on the *Surrey Outreach Team* (SOT); the Introduction of *SafePoint*, a safe supervised consumption site; and, the initiation of an *Emergency Housing First* program. The plan was implemented in three overlapping phases starting January 1, 2017.

Looking at the data, it is not unambiguously evident that the CCRP had an impact above and beyond the other activities that were occurring within the City more broadly. It is the case that in the Period 3 (the final six months of 2018), the number and rate of *overdoses* in the City Centre area declined substantially. Then, again, they simultaneously declined throughout most of the rest of the city.

On the other hand, the rate of opioid-related *deaths* appeared to stabilize or even decline in the Core Area while they increased in the rest of the City. This was particularly the case in Period 3 when the Emergency Housing First component was implemented. It is still too early to conclude that the Emergency Housing component of the CCRP was responsible for the decline in opioid-related deaths. Six months is a short duration particularly since part of that time involved putting the housing units in place. A longer follow-up would help to provide more insight into the impact of that implementation. The collection of on-site, qualitative research would also be of substantial benefit in determining the relationship between the resources expended by the City, how people took advantage of those resources, and what impact they had on drug use and its consequences.

The third component examined—property crimes—appeared to be relatively time-invariant across all regions of the City. Areas with high reported crime rates continued to have high rates while areas with lower rates continued to report lower rates.

It should also be noted that the impact of the CCRP might extend beyond the three indicators examined in this study. Again, further monitoring over a longer duration and a detailed collection of qualitative data would assist in that assessment.

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Appendix

OVERDOSES PRE-2017

FIGURE 3A: NUMBER OF OVERDOSES BY CENSUS TRACT

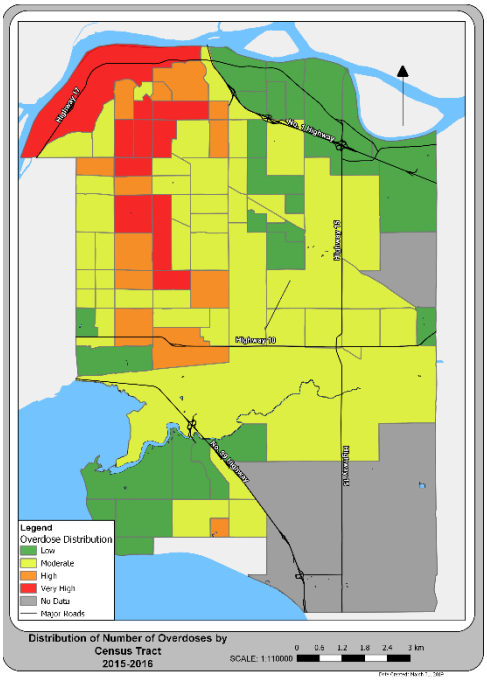
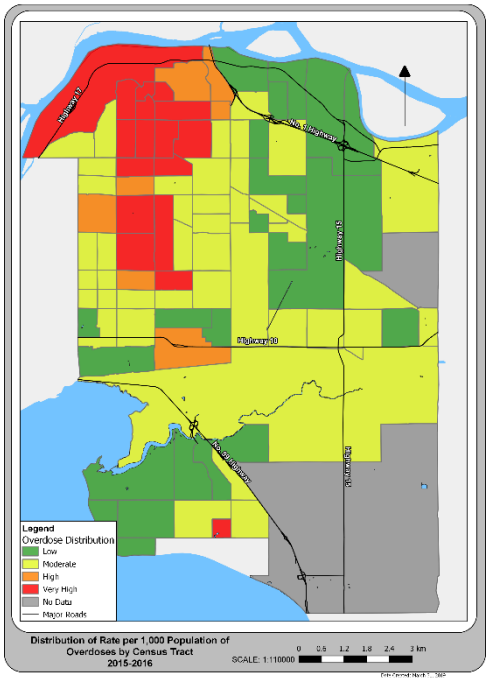


FIGURE 1B: RATE OF OVERDOSES BY CENSUS TRACT



OVERDOSES POST-2017

FIGURE 4A: NUMBER OF OVERDOSES BY CENSUS TRACT

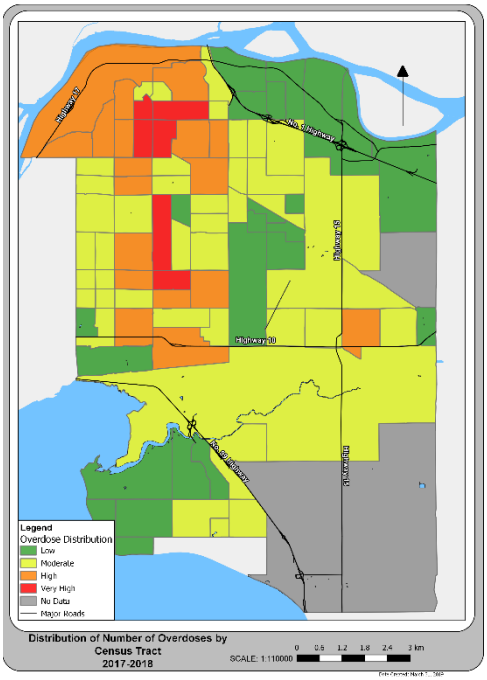
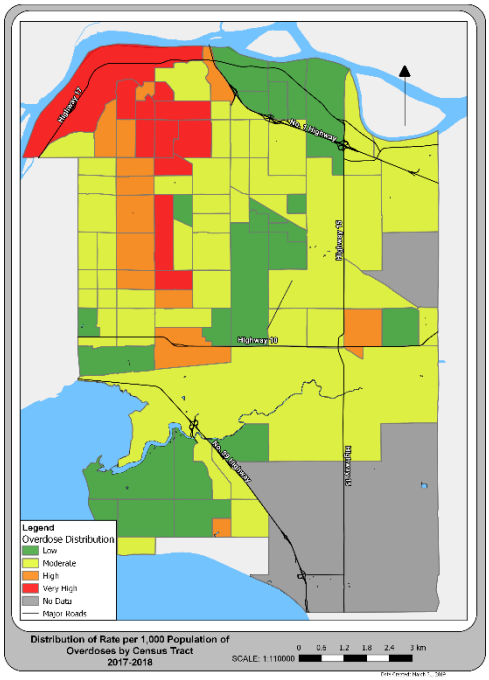


FIGURE 2B: RATE OF OVERDOSES BY CENSUS TRACT



DEATHS PRE-2017

FIGURE 5A: NUMBER OF DEATHS BY CENSUS TRACT

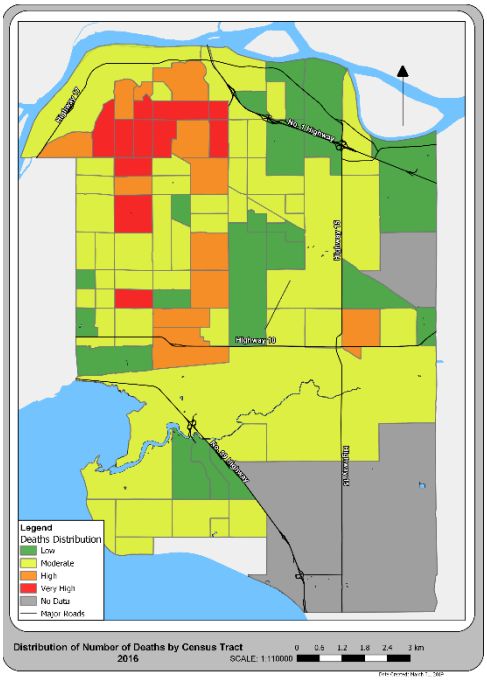
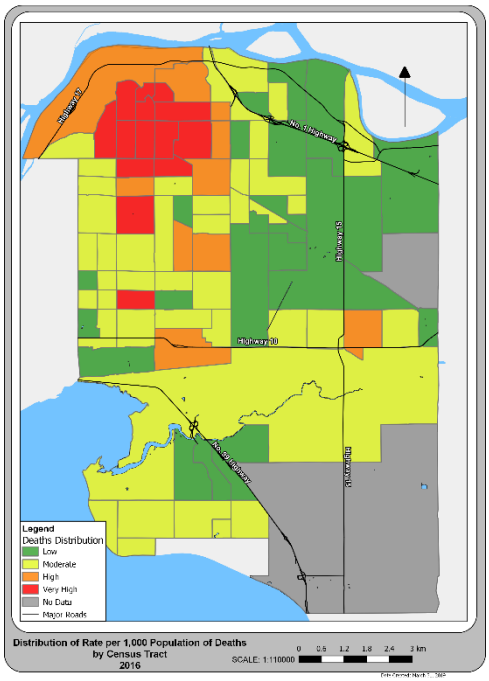


FIGURE 3B: NUMBER OF DEATHS BY CENSUS TRACT



DEATHS POST-2017

FIGURE 6A: NUMBER OF DEATHS BY CENSUS TRACT

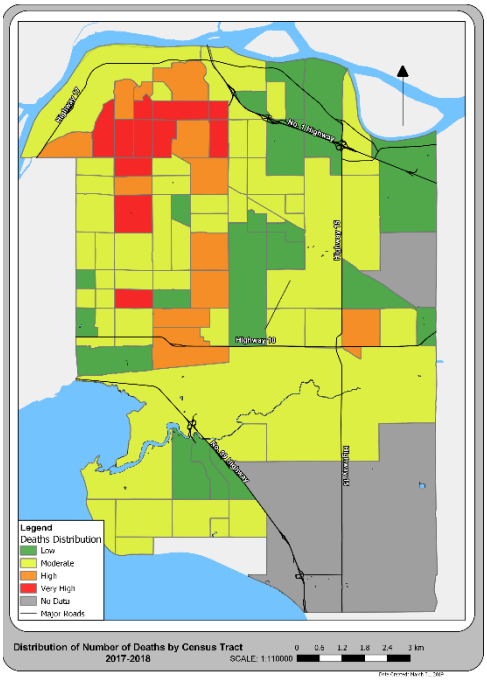
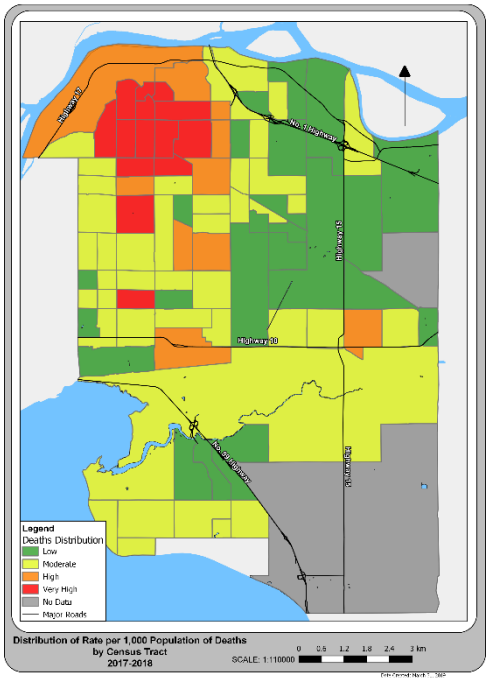


FIGURE 4B: RATE OF DEATHS BY CENSUS TRACT



CRIMES PRE-2017

FIGURE 7A: NUMBER OF CRIMES BY CENSUS TRACT

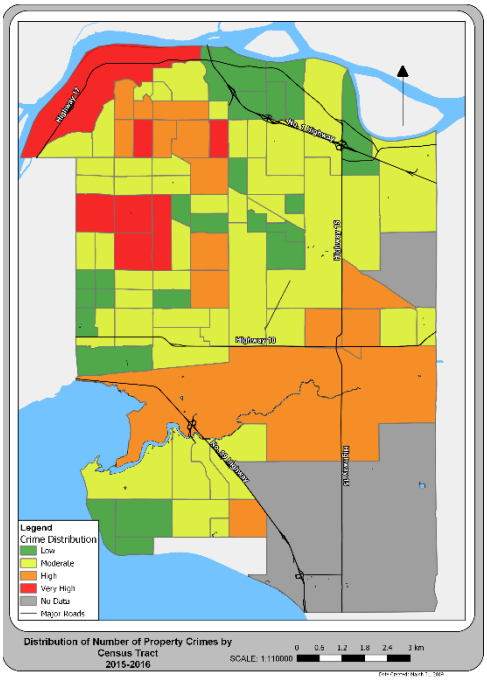
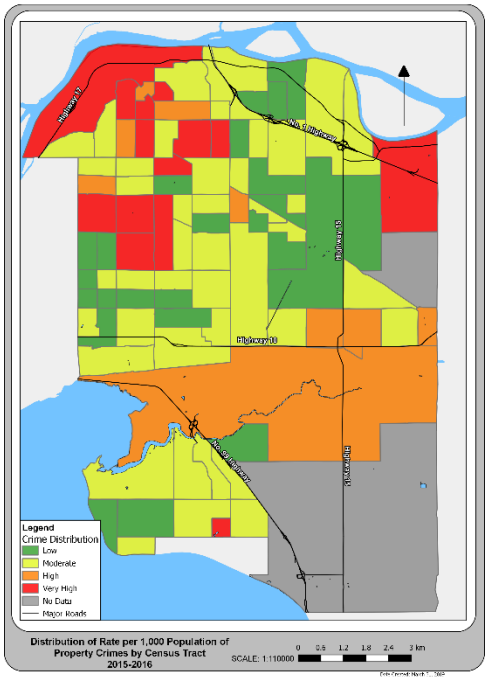


FIGURE 5B: RATE OF CRIMES BY CENSUS TRACT



CRIMES POST-2017

FIGURE 8A: NUMBER OF CRIMES BY CENSUS TRACT

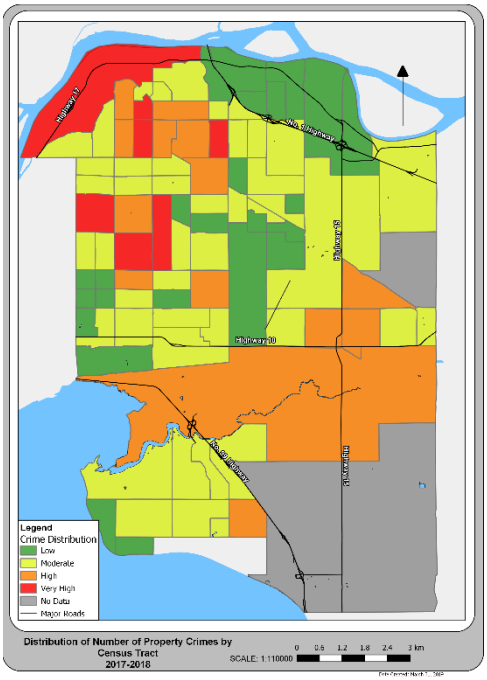
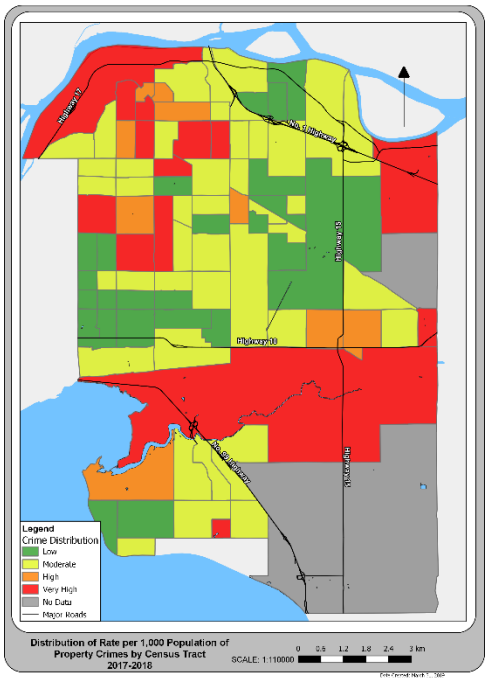


FIGURE 6B: RATE OF CRIMES BY CENSUS TRACT



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APPENDIX "II"

Predicting Illicit Opiate Drug Overdoses in the City of Surrey

Impacts of Opioid use in Neighbourhoods

Paul Maxim, Len Garis, Joseph Clare, Hubert Duan, Andrew Fink

February 2019

UNIVERSITY OF THE FRASER VALLEY
SCHOOL OF CRIMINOLOGY & CRIMINAL JUSTICE

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Executive Summary

This study examines the spatial and temporal distribution of the incidence of overdoses and deaths attributable to opioid abuse within the City of Surrey from 2016 to 2018. As the general epidemiological literature reports, the distribution of overdose incidents and deaths is neither random in space nor time. Spatially, these incidents tend to cluster around specific nodes and pathways within a city. In this regard, the City of Surrey is no different. There is also a strong association with the time of day when these occurrences take place and the day in the month when social assistance payments are made.

In the first part of the analysis, we find an association between the incidence of overdoses and deaths and the location of both regulated and unregulated recovery homes. Most overdose incident events are clustered in the northwest section of the City and along the King George Boulevard corridor bordered between 108 Avenue and 64 Avenue. This is where there is a disproportionate clustering of both recovery houses and addicts. Recovery houses are generally located close to where their potential clients exist and, in turn, potential clients are attracted to those same locations.

The micro-spatial association between overdoses, deaths and the location of recovery homes is complex, however. Perhaps the best way to visualize the relationship is to imagine a doughnut. There is a depression in rates of overdoses and deaths in the center of the doughnut (that is, where the house exists). Beyond that centre, there is a steep rise in incidents and then a gradual tapering off. Most overdoses and deaths occur within 500 meters of a recovery house.

In the second part of the analysis, a strong relationship is found between overdoses, deaths, crime and the distribution of social assistance payments. Overdoses and deaths peak within the first three days of the distribution of payments. Inversely, monthly property crime rates decline during that period. This pattern replicates findings from studies in both Vancouver and the United States where a significant “cheque effect” has been found and provides an opportunity for policy reform.

The third part of this analysis addresses the question of whether it is possible to use these findings to assist in the construction of a predictive model of when and where overdoses and deaths are likely to occur. While the results are preliminary in this instance, there is evidence to suggest that efforts to build a predictive model may pay dividends.

The study concludes with a series of policy recommendations based on the above findings.

Introduction

The incidence of deaths due to opioid overdoses in Canada has increased substantially in the past few years (Fischer et al. 2006). In 2017, the national rate for opioid-related deaths was approximately 10.9 per 100,000 population, or about 4,000 deaths in total. In the first six months of 2018, the death rate had increased to an estimated 11.2 per 100,000.[1] British Columbia has experienced the brunt of that pattern with the estimated death rate of 30.9 per 100,000 population for 2017 and 30.6 in 2018. In absolute numbers, illicit drug overdose deaths increased from 294 in 2010 to 1,489 in 2018. The increase in both reported overdose cases and deaths in British Columbia led the Province to declare a public health emergency in 2016 (Otterstatter et al. 2018).

A major driver of that increase in opioid deaths has been the introduction of synthetic narcotics such as oxycontin and fentanyl. Fentanyl, for example, is a stronger analgesic than traditional opioid painkillers (up to 100 times stronger than morphine) and when incorporated into a time-released patch was initially considered minimally addictive. Originally, fentanyl was available through a prescription only but, in recent years, it has become a major component of the illicit drug trade. Users initially learned how to extract and concentrate fentanyl from patches and, more recently, it and several derivatives (e.g., carfentanil) have become available on the black market in powder and pill form. It has been estimated that nearly all street "heroin" sold in Vancouver contains fentanyl (Woo 2018). Regardless, it has been estimated that about one-third of those having died recently due to opioid overdoses had a prescription (Gomes et al. 2018), although current restrictions on opioid-for-pain prescriptions appear to be changing that pattern (Smolina et al. 2019).

The Province has responded in various ways including providing greater availability to Opioid Antagonist Therapy (OAT). In September 2018, more than 21,000 prescriptions were written for an opioid antagonist such as naloxone. This is an increase from slightly more than 15,000 prescriptions written in September 2015.[2] Besides widening the availability of OATs in pharmacies, ambulance attendants, firefighters and police officers have increasingly been supplied with naloxone to respond to overdoses. Unfortunately, some of the more recent opiate analogues such as carfentanil, are sufficiently toxic that they could pose a health risk to emergency responders who might come in physical contact with the substances.

To help curtail the upward trend in opioid overdoses, Health Canada approved two supervised consumption sites in Surrey in 2017. The first, *Safepoint*, is located at 135A Street and the second, the *Quibble Creek Sobering and Assessment Centre*, is located near King George Boulevard and 94 Avenue. The location of supervised consumption sites is often subject to debate due to trade-offs in the needs of users, and local residents and property owners. In the case of *Safepoint*, substantial consideration was given to input from potential users of the site.

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[1] https://www.canada.ca/en/health-canada/services/substance-use/problematic-prescription-drug-use/opioids/data-surveillance-research/harms-deaths.html

[2] http://www.bccdc.ca/resource-gallery/Documents/Educational%20Materials/Epid/Other/BC_OD_Response_Monthly_Infographic.pdf

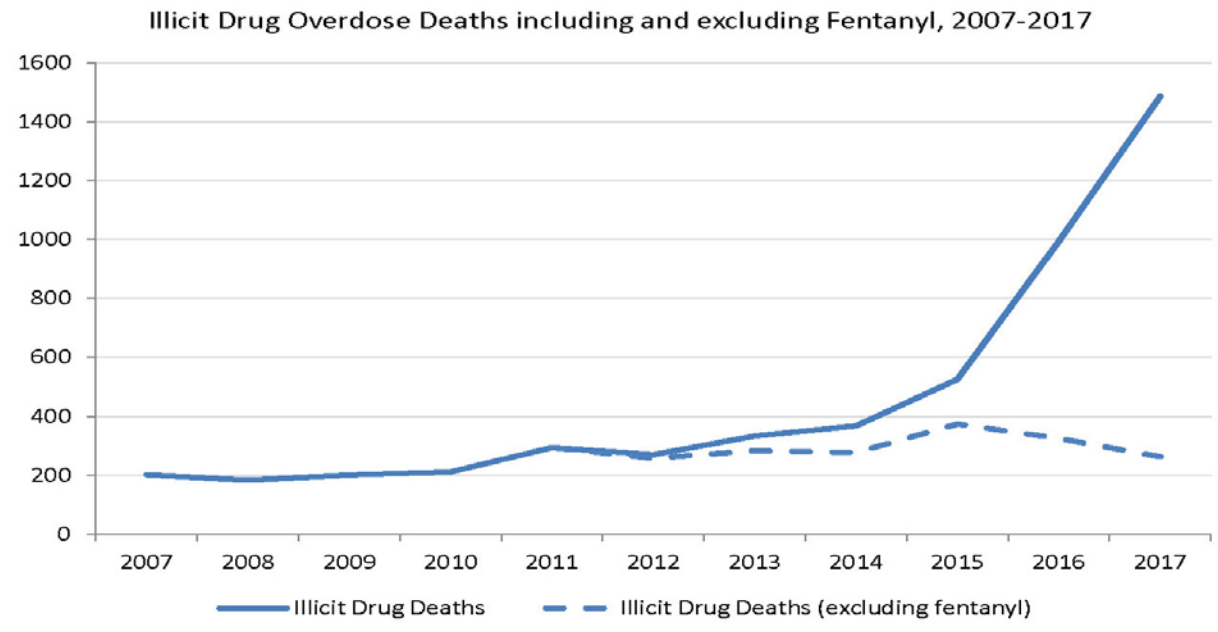
The social implications of opioid dependency and drug use in general go well beyond the impact on individual users: addiction affects the entire community. In this study, we focus on the impact of opioid use on neighbourhoods. Specifically, we will examine three questions. That is,

i. What is the relationship between the location of recovery houses and the location of opioid overdoses in conjunction with a soft treatment?
ii. Is there a relationship between social assistance, opioid overdoses and property crime?
iii. Can the neighbourhood or geo-spatial distribution of overdoses be predicted?

Background

Until recently, the geo-spatial analysis of opioid deaths by epidemiologists and healthcare researchers had been limited to higher geographical aggregates such as cities or, more often, provinces and states (Cordes 2018). The primary reason for this is that, historically, opioid deaths were significantly fewer than is currently the case and rates often varied little from year to year. The introduction of higher potency opioid-based narcotics such as oxycontin and, more recently, fentanyl, acted as a major disruptor to that pattern. Evidence for this can be seen in Figure 1 which illustrates the increased rate in opioid-related deaths in British Columbia from 2007 to 2017 (BC Coroners Service). Currently, BC appears to have the highest rates for both opiate overdoses and deaths in Canada. As previously indicated, the absolute numbers known to public health officials increased from 294 in 2010 to approximately 1,489 in 2018.

FIGURE 1



Source: BC Coroners Service Illicit Drug Overdose Deaths in BC January 1, 2008 to December 31, 2018

Within Canada, British Columbia has faced the brunt of that increase. However, the steep incline in opioid-related deaths is not limited to BC or Canada for that matter. Several parts of the United States have become "hotspots" for synthetic opioid use in recent years. Much of this was due to the relative availability of oxycontin which soon gained the moniker, "hillbilly heroin." Because of the spike in usage in parts of the US, some micro spatial analysis has been used for policy purposes in an attempt to mitigate opioid-related deaths. For example, Dodson et al. (2018) examined the impact of differentially supplying pharmacies with naloxone in Pittsburgh. Here, the researchers identified cases of suspected nonfatal opioid overdoses where naloxone was administered from April 2013 through December 2016 by the city's Bureau of Emergency Medical Services. They used spatial modeling to identify peak use areas to optimize naloxone distribution among pharmacies in the city. Pharmacies were differentially selected to create a geographical solution that minimized travel cost and increased accessibility for communities hit hardest. According to the authors, "this reconfiguration shaved roughly more than two tenths of a mile off the average distance to the closest pharmacy offering naloxone, which may not sound like much, but [it] provides crucial minutes for acquisition and administration."

Analogous research in San Francisco by Rowe and his associates (2016) also confirmed the benefits of having lay-person access to naloxone in selected areas as a key element in reducing overdose-related mortality. On the other hand, the researchers noted that alternative delivery methods appear necessary to address overdoses that occur in areas with a less concentrated risk, such as suburban and rural localities.

Similarly, Des Jarlais and colleagues (2018) identified injection "hotspots" in New York City to focus on HIV and Hepatitis C virus (HCV) transmission. While they concluded that HIV transmission was likely to be a random occurrence largely because it is at an "end of epidemic" stage, HCV transmission still appeared concentrated in certain locations. Using this information, the authors suggested, could allow for a more targeted use of resources to address disease transmission associated with intravenous drug use.

More pertinent to the current analysis, Heavey et al. (2018) examined the impact of New York State allowing police officers and firefighters to administer naloxone in addition to EMS personnel. The study was conducted in Erie County, NY which includes the City of Buffalo. The analysis focused on over 600 instances where either police officers or firefighters were first responders to an overdose incident. Overall, the "results suggest that police and fire personnel are effectively evaluating the scene upon arrival at an overdose and are administering naloxone within the recommended indications."

The study also indicated that while interventions by police or fire personnel were effective in stabilizing patients, secondary or follow-up responses by EMS personnel were often required to fully resuscitate the patient.

Obviously, locating where opioid use and opioid overdose is most likely to occur is a key element to conducting an adequate spatially-focused response to the problem. Some earlier research used calls to poison control centres to obtain that information (Smith et al. 2008). A somewhat different tact was taken by Bearnot and his colleagues (2018). These researchers used crowdsourced data to identify discarded needle hotspots in Boston.

Most recent studies reported in the literature use calls for service (such as through 911) as a primary tool to identify specific neighbourhoods or locations where opioid overdoses are most likely to be concentrated. Tracking 911 calls makes sense because, as the BC Coroners' Service (2018) has noted, over 86% of overdose deaths occurred indoors; 58 % in private residences; 24% in other residences including social and supportive housing, shelters and hotels; 4% in other inside locations; while 12% occurred outside in vehicles, sidewalks, streets, parks and other public spaces.

Theory Directed Responses

To provide an organizational framework to our thinking about how to respond to where and when drug overdoses take place and some of the consequences of drug-taking behaviour, we can turn to a body of theory generated by sociologists over the past century. As far back as the 1920s, social scientists were wondering if there were spatial and temporal patterns to criminal and deviant behaviour. Sociologists at the University of Chicago noted that the application of ecological principles to the distribution of anti-social behaviour explained a substantial amount of the variation in the distribution of such behaviours, including drug abuse (see Park (1967); Hawley (1943); Shaw et al. (1929)) .

One theoretical stream that has descended from the social ecology framework is what is now referred to as crime-pattern theory. Here, the key assertion is that individuals are largely opportunistic and take advantage of easy criminal opportunities as part of their daily routines. As Diplock (2016) notes: "offenders will commit crimes along their typical daily routes (known as paths) between their houses, places of work or school, recreational locations, and other hang-out areas (known as nodes)."

Typically, crimes are not spatially random events but occur near nodes and gradually taper off as the distance from the node increases. This insight illustrates the importance of knowing where crimes occur and where offenders normally travel, in order to strategically target crime prevention interventions (Diplock 2016). Practical responses to this insight range from differential police patrolling, to the greater physical and electronic surveillance of high crime-prone neighbourhoods, to neighbourhood watch schemes. Wilson and Kelling's broken-windows theory reinforces this notion (Kelling and Coles 1997). By fixing broken windows, cleaning up graffiti and removing other signs of "social disorder," a message is sent to potential offenders that crime and other activities are not acceptable in that area.

It has been suggested that such interventions may lead to crime displacement where offenders travel further to commit crimes (Gallagher and Wilcox 2013). However, displacement also imposes a cost that many potential offenders appear not willing to pay. As Cornish and Clark (1986) noted, offenders tend to be rational actors who examine their environment and immediate situation to estimate a balance of perceived rewards and risks. In the case of drug users, some may find the increased cost an incentive to seek a treatment or maintenance program that alleviates the requirement of raising funds to purchase drugs from street vendors. Recent research examining evaluation studies suggests that the magnitude of displacement effects is over emphasized and that when they do occur, their impact is minimal (Guerette and Bowers 2009).

There is good reason based on the existing research and theory to assume there will be a non-random pattern to the overdose problems even in a small geographic area. There is a likelihood that

this is related to 'nodes' that drug users are moving between, which is likely to include recovery houses. Understanding more about the spatial relationships between these patterns is fundamental to undertaking targeted prevention-focused interventions that simultaneously aim to maximize the utility of City resources and minimize the potential for loss of life.

Geographical Distribution of Overdoses: Recovery Houses and the Location of Opioid Overdoses

As indicated in the literature review, drug use and consequent drug overdoses are not randomly distributed in most cities. Significant proportions of overdoses and overdose-related deaths tend to be clustered in certain locations or neighbourhoods. Thus, for example, Dodson et al. (2018) and Rowe (2016) are able to explore models for the optimal distribution of naloxone supplies based on patterns of overdoses.

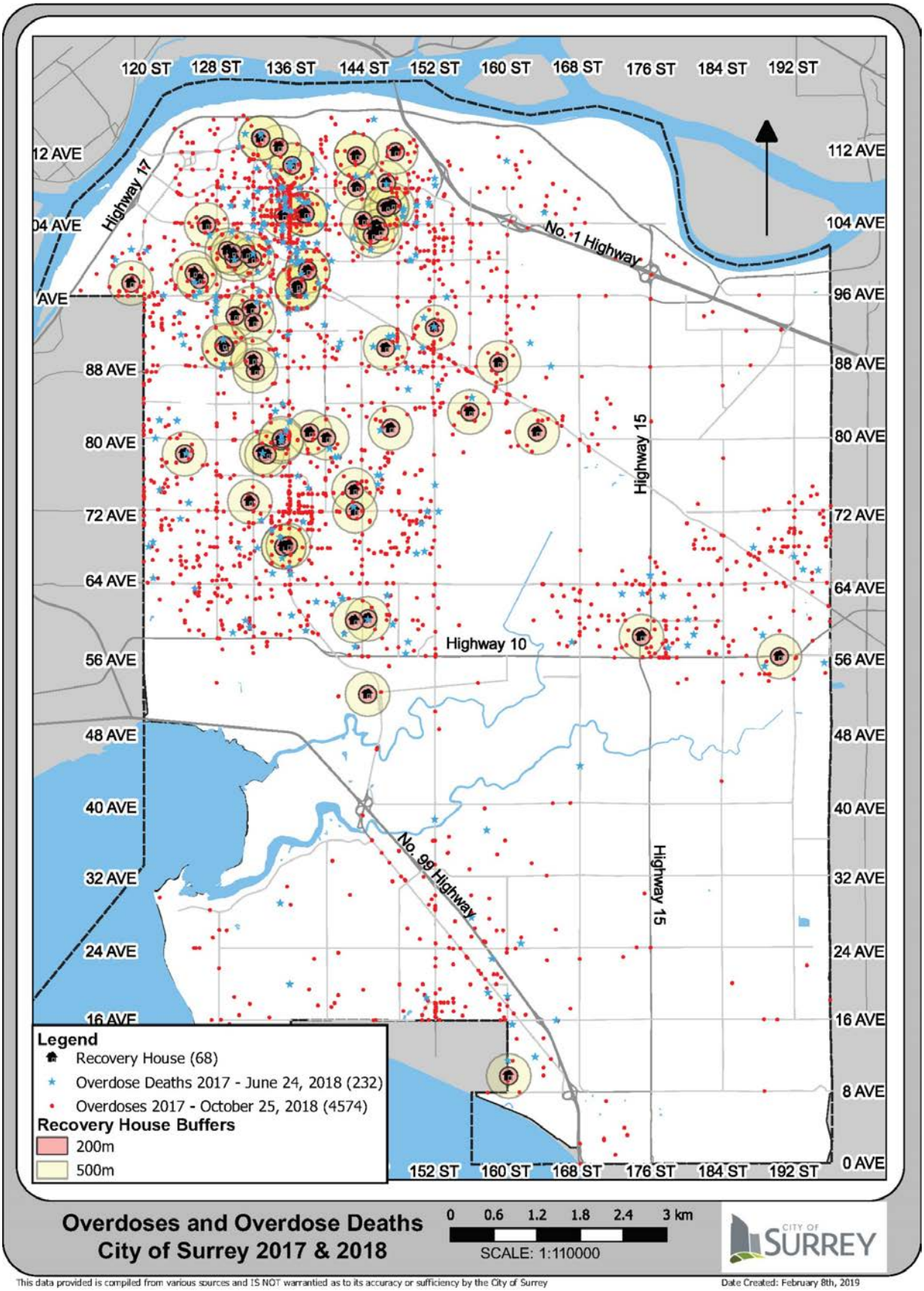
Figure 2 shows the distribution of 4,574 overdoses during the period January 1, 2017 to October 25, 2018, and 232 opioid-related deaths during the period January 1, 2017 to June 24, 2018, in the City of Surrey (the red dots and blue stars respectively). While incidents occur in all residential areas of the City, there is a higher preponderance of events in the northwest sector of the City and along the King George Boulevard corridor bordered between 108 Avenue and 64 Avenue. It is in those areas that responses need to be disproportionately, although not exclusively, focused.

Impact of Recovery Houses

Figure 2 also indicates where recovery houses are located (the black house icons). The relationship between illicit drug use and recovery houses is complex: some have referred to it as the “chicken and egg” situation. On the one hand, agencies tend to locate recovery houses in sections of a city where their potential clients are located. On the other hand, those houses act as a magnet for users seeking assistance. The result is that a strong geo-spatial correlation develops between the location of drug users and recovery houses, and that relationship further strengthens with time. An analysis of data from City of Surrey Fire Services demonstrates that in 2016 and 2017, approximately 70% of reported overdose incidents occurred within 500 meters of recovery houses. Additionally, over 90% of overdose deaths occurred within the same distance Griffioen (2018).

In Figure 2, we have created 200-meter and 500-meter circles around where recovery houses are located (the pink and yellow circles respectively). The recovery houses are identified by the small house icons at the centre of the circles. From this, it is relatively easy to see the clustering of incidents of both overdoses (red dots) and deaths (blue stars). Again, the relationship between recovery houses and overdoses (and deaths) is complex. One of the advantages offered by many recovery houses is that there are staff members who offer programing and oversight of the residents. These staff are also trained to administer naloxone in many instances. Consequently, while overdose calls for service cluster around recovery houses, there is a decrease in incidents within the space immediately adjacent to the houses themselves.

FIGURE 2


120 ST
128 ST
136 ST
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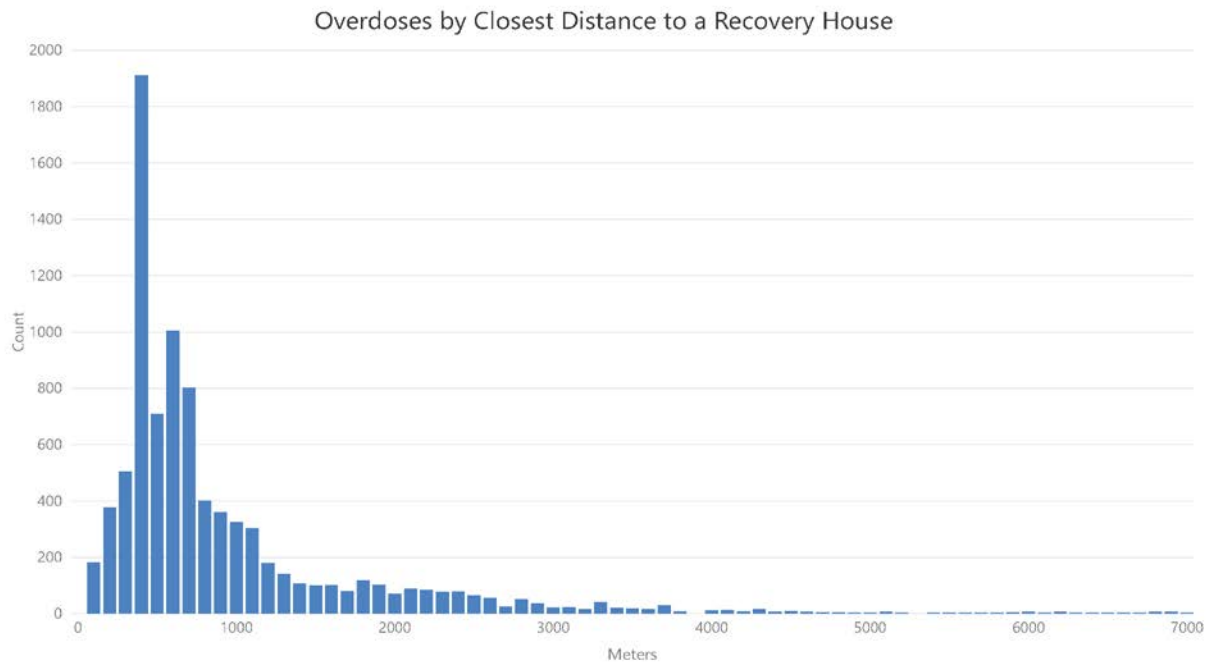
152 ST
160 ST
168 ST
176 ST
184 ST
192 ST
12 AVE
04 AVE
AVE
88 AVE
80 AVE
72 AVE
64 AVE
56 AVE
48 AVE
40 AVE
32 AVE
24 AVE
16 AVE
112 AVE
104 AVE
96 AVE
88 AVE
80 AVE
72 AVE
64 AVE
56 AVE
48 AVE
40 AVE
32 AVE
24 AVE
16 AVE
8 AVE
0 AVE
Highway 17
No. 1 Highway
Highway 15
Highway 10
No. 99 Highway
Highway 15
Legend
Recovery House (68)
Overdose Deaths 2017 - June 24, 2018 (232)
Overdoses 2017 - October 25, 2018 (4574)
Recovery House Buffers
200m
500m
Overdoses and Overdose Deaths
City of Surrey 2017 & 2018
0 0.6 1.2 1.8 2.4 3 km
SCALE: 1:110000
CITY OF SURREY
This data provided is compiled from various sources and IS NOT warrantied as to its accuracy or sufficiency by the City of Surrey
Date Created: February 8th, 2019

As part of the analysis, we measured the point-to-point distances between the exact location of overdose incidents and where they occurred relative to the location of the known recovery houses.[3] From that, we could find the shortest distance between the incident and the *closest* recovery home.[4]

That distribution is illustrated in Figure 3. The bottom or X-axis of Figure 3 presents the distance in meters from the closest recovery house in multiples of 100 meters.

As Figure 3 shows, the first 100 meters in and around the recovery house has few calls to respond to an overdose incident. Overdose incidents, however, spike in the next 100 meters and tend to drop consistently thereafter. This pattern is not uncommon where patterns of events are "accidental" as opposed to systematic. It is also consistent with what we know about the distribution of opioid use as outlined in the theory section above. These results are also consistent with previous studies such as that by Griffioen (2018).

FIGURE 3



We can also examine the spatial distribution of deaths due to overdoses. Again, we are looking at the point-to-point distance from where the death reportedly occurred to the closest recovery house. Figure 4 shows this distribution. Overall, the pattern is very similar to that observed in

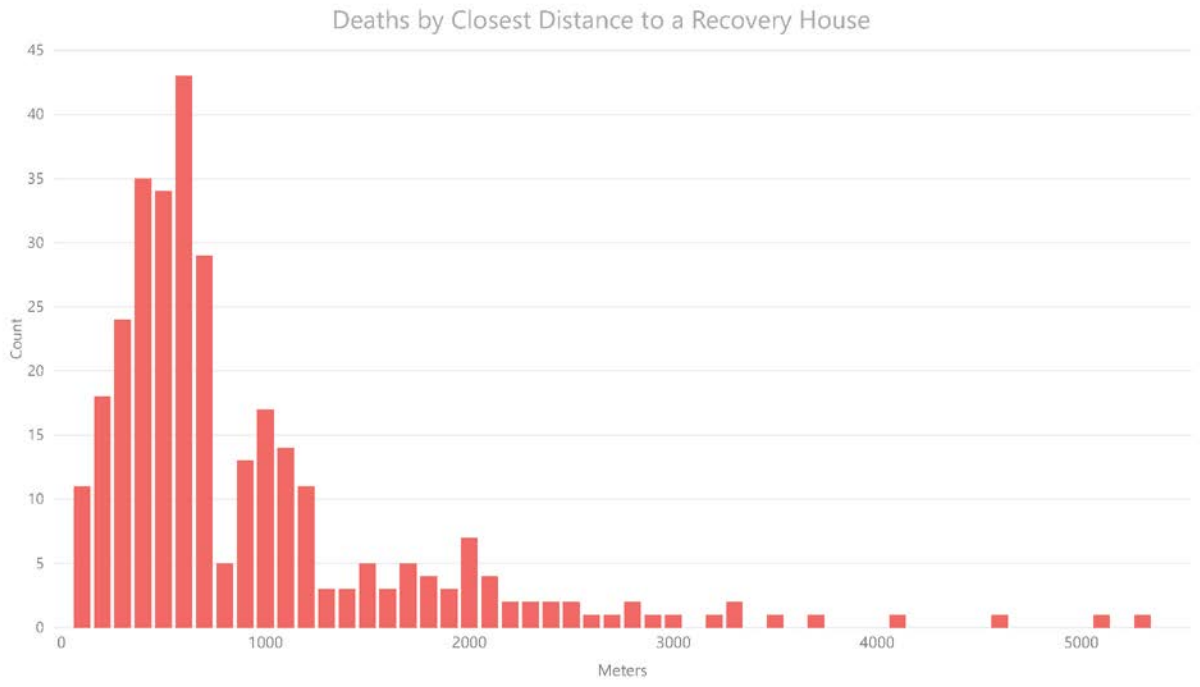
[3] We used the 68 service recovery houses identified by Surrey Fire Department in the City of Surrey including the 55 that were registered through British Columbia's Assisted Living Registry and were allowed under the City of Surrey's Business License Bylaw (Rehal, J. 2016. "Corporate Report: Recovery Houses Update." edited by Bylaw Enforcement & Licensing Services. Surrey, British Columbia: City of Surrey.)

[4] Distances are measured using the Haversine formula as the shortest between two points on the map or, to use the vernacular, "as the crow flies." An alternate approach could include driving or street distances as one sees on Google Maps and other mapping applications. Distances between an overdose event and each of the 55 recovery houses in the city were calculated with the shortest absolute distance being selected.

Figure 3, with the main differences being that the number of deaths is significantly smaller than overdose incidents and the peak number of occurrences tends to be somewhat further away from the nearest recovery house.

Both analyses—the one relating to overdoses and the one relating to deaths—suggest that a greater potential exists to use the location of recovery houses as a variable or factor to help mitigate the likelihood of overdoses and opioid-related deaths. The "doughnut hole" phenomenon of fewer than expected events at or immediately proximal to the recovery houses examined in this analysis suggest that the services provided by many recovery houses (such as the availability of counsellors and naloxone) might be having an impact in the immediate geographical area. As we indicated previously, there is a chicken and egg phenomenon relating to the location of recovery houses. Initially, some houses were located in known hotspots where there were significant concentrations of illicit opioid users. This was an attempt to bring a service to potential clients and, clearly, many do so. On the other hand, the presence of a recovery home may serve as a magnet to attract drug users to that general locale.

FIGURE 4



So far, the analysis has focused on formal recovery houses that meet the requirements of British Columbia's Assisted Living Registry. There are an additional 90 houses that have come to the attention of the Surrey Fire Department, largely through random inspections. Some of these houses may have been full-service locations at one point. Most, however, are primarily lodging spaces for addicts with no on-site staff.

The distribution of overdoses (Figure 5) and deaths (Figure 6) in proximity to these "nonrecovery" houses show a similar pattern to the previous sample of full-service homes. The incidence of both overdoses and deaths are relatively low within the immediate proximity of the residence and then

climb steeply to about a half kilometer away. After that point, both overdoses and deaths taper off with distance.

FIGURE 5

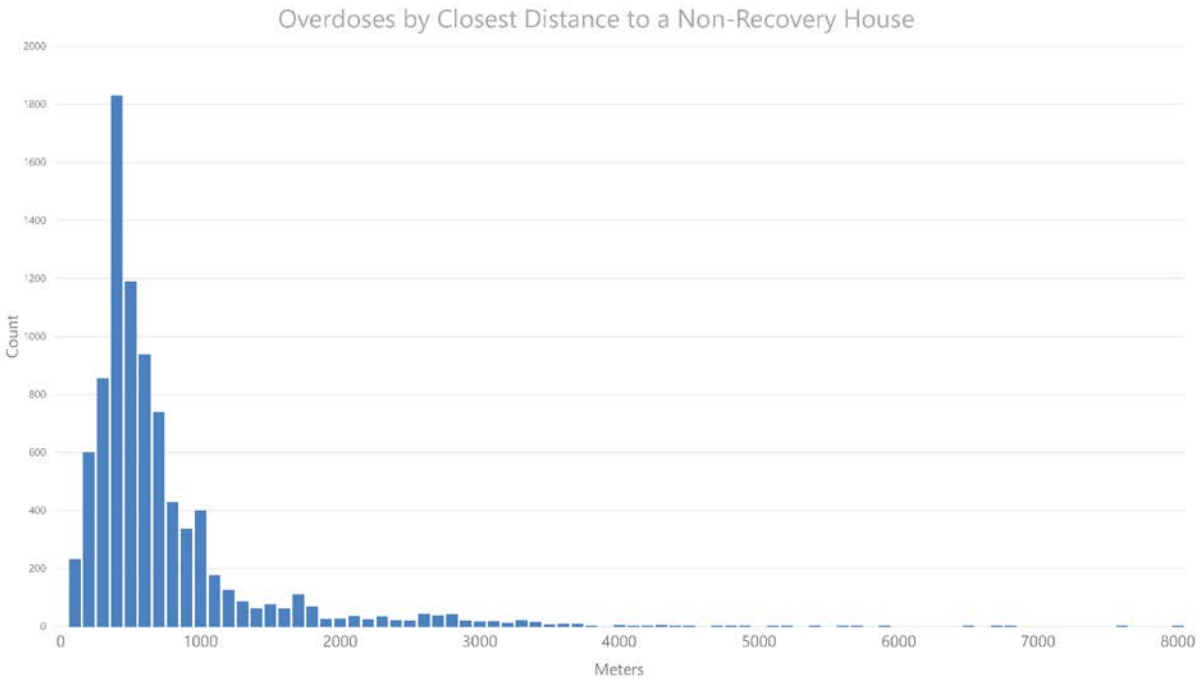
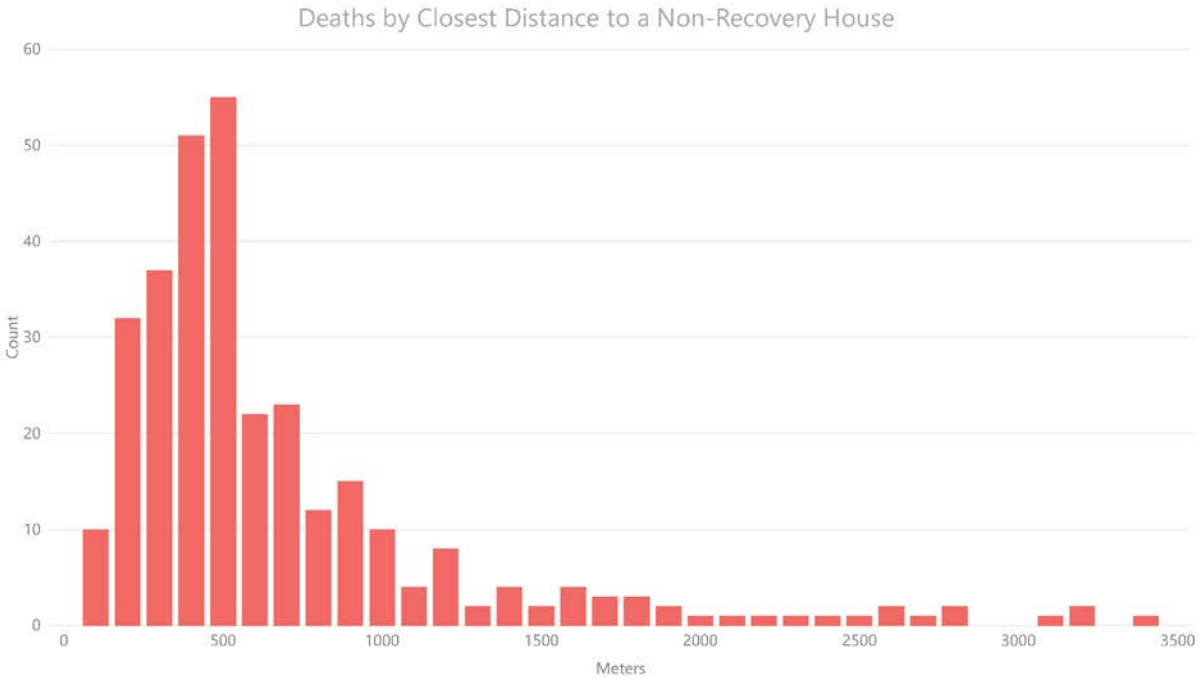


FIGURE 6



The question we might now pose is, theoretically, how can we account for this pattern of overdoses and deaths around recovery houses? Previously in this report, we focused on crime-pattern theory as a model for explaining why addicts might cluster in certain locations within a city. That perspective is a specific element within the broader theoretical context known as routine activities theory.

Routine activity theory as outlined by Cohen and Felson (1979) suggest that three key conditions are required for a crime to occur: a motivated offender, a suitable target or victim, and the absence of a capable guardian. It is the convergence of these three elements, according to Cohen and Felson, that result in a criminal event. Building on this framework, Eck (2003) suggest there is a role for a "handler" and a "place manager"– people or institutions that can exert control over potential offenders and possible crime locations. This theoretical framework can be extended to inform our understanding of the behaviour of addicts and drug consumption sites. Specifically, within the current context, Eck's model suggests that the insertion of a handler could mitigate the behaviour of addicts and a capable guardian can oversee site locations.

Simply put, handlers can influence offenders (or, in this instance, addicts); place managers can control places. Drawing from this perspective, it is possible to see recovery houses and their staff as playing the role of the handler who intervenes with addicts and a "place manager" that provides oversight of the surrounding locale.

The first application of this perspective allows us to appreciate what we have termed the "doughnut" pattern of overdoses and deaths around recovery houses. In their roles as handlers and place managers, recovery houses and their staff have an impact on the behaviour of addicts near their immediate location. The broader implication is that expanding the outreach role of recovery houses could further influence the likelihood of overdoses and deaths in the broader neighbourhood. That is, consideration should be given to expanding the roles and capacities of recovery houses beyond their immediate settings.

Analysis of Incidents Proximal to Pre and Post-Health and Safety Intervention

A "soft intervention" was made by what Eck would refer to as "super controllers"[5] to enhance the capacity of existing recovery houses in being more effective and enhancing their reach. For a sample of recovery houses, inspections were made by Surrey Fire Services in conjunction with a Fraser Heath public health nurse. Standards and by-law infractions were noted by Fire Services and assistance was provided to the site to mitigate any infractions. This included recommendations to improve the overall safety standards of the site as well as providing information and training on such relevant matters as the use of OATs by the Fraser Health public health nurses.

In all there were 166 care workers supervising 565 persons residing in these homes despite having a capacity of 863. Regarding the fire inspections, most of the registered houses were satisfactory on

[5] "Super controllers" are external agencies that have more and significantly broader powers of oversight. Formal super controllers exercise their authority "within an established institutional setting that defines who influences whom, in which ways, and under what circumstances" (Sampson et al. 2010: 41).

most items. For example, of 58 houses, an average of 84% of the inspection items were rated as being "satisfactory." Among the items deemed "unsatisfactory", however, were such things as not having a fire safety plan in place (48% unsatisfactory); where required, the unavailability of a fire department connection (46% unsatisfactory); issues with laundry rooms (39% unsatisfactory); smoke alarm issues (37% unsatisfactory); fire alarm panel issues (36% unsatisfactory); emergency lighting problems (26% unsatisfactory); exit sign and light issues (18% unsatisfactory); and, occupancy load issues (13% unsatisfactory).

Fire Department inspectors were also accompanied by public health nurses from Fraser Health. As with the fire inspectors, they found most homes to be functioning relatively satisfactory. Approximately 93% of the houses had naloxone on site although as part of their inspection activities, the public health nurses distributed an additional 204 kits, or about 3 per location. On a more problematic note, 73% of the houses did not have a training regimen in place. Consequently, training was provided to a total of 256 individuals or about 3.8 per site.

The underlying notion was that this "soft treatment" or intervention approach would improve the effectiveness of the recovery houses by reducing instances of overdoses and mortality at and in the immediate vicinity of the site.

We endeavored to conduct an exploratory study to retrospectively see whether those interventions might have had any impact on overdose and mortality outcomes. In doing this, the data were divided into pre and post-treatment records. That is, we examined the relative incidence of overdose and mortality events at or near the houses before the inspection by Fire Services and the incidence after the inspection. The distribution of overdoses both pre and post intervention is depicted in Figure 7. The results of the quantitative analysis are presented below in Tables 1 and 2 which relate to overdoses and deaths respectively.

TABLE 1: OVERDOSE INCIDENTS BY DISTANCE, PRE AND POST-INTERVENTION

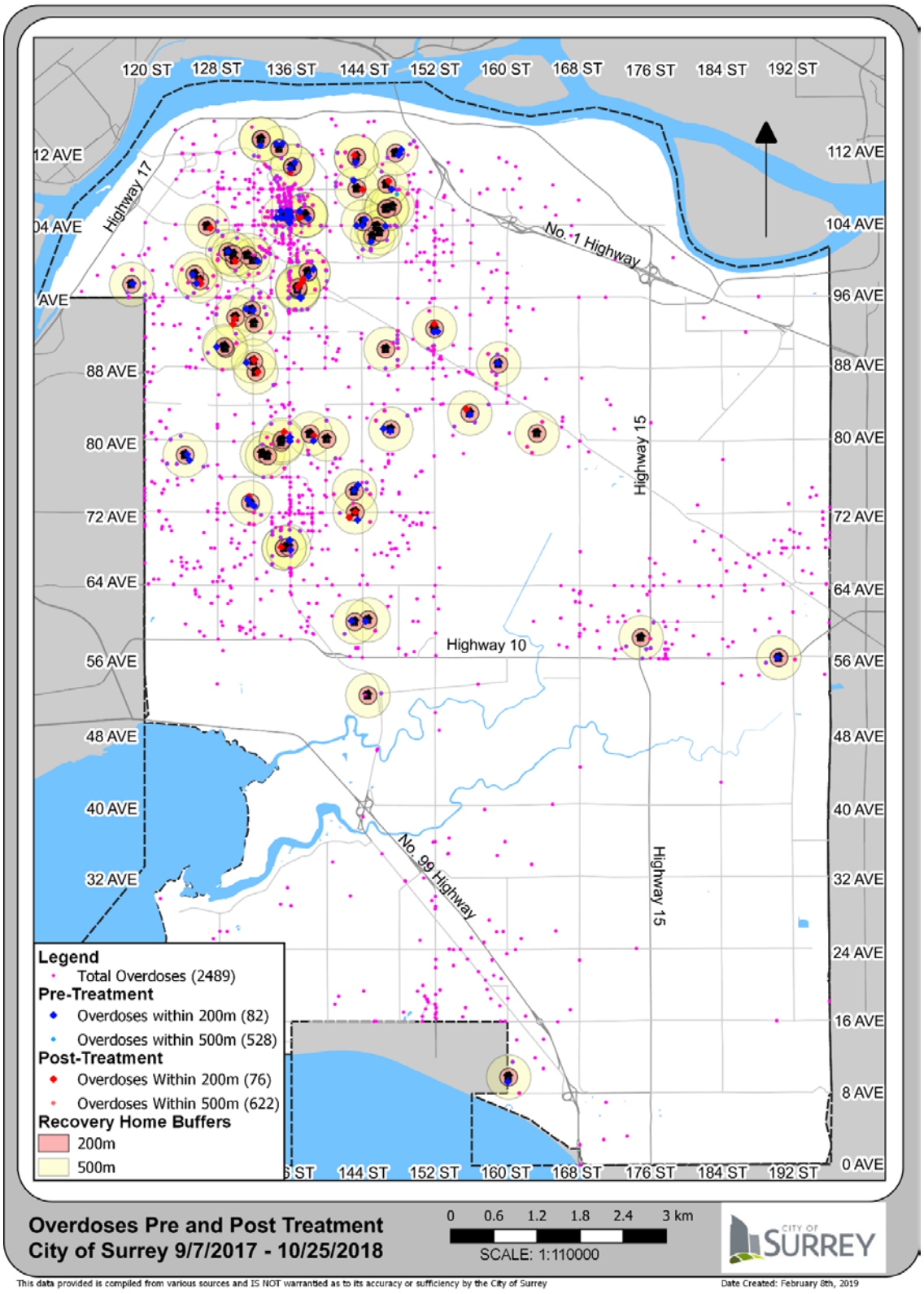
Category	Count	Percent of Total
Incidents Pre-intervention Within 200m	82	6.1
Incidents Post-intervention Within 200m	76	5.7
Incidents Pre-intervention Between 200-500m	446	33.3
Incidents Post-intervention Between 200-500m	546	40.8
Incidents Pre-intervention Within 500m	528	39.4
Incidents Post-intervention Within 500m	622	46.5
Incidents Beyond 500m	189	14.1
Total Incidents Over Period (9/7/17-10/25/18)	1339	100.0

TABLE 2: DEATHS BY DISTANCE, PRE AND POST-INTERVENTION

Category	Count	Percent of Total
Deaths Pre-intervention Within 200m	3	5.4
Deaths Post-intervention Within 200m	5	8.9
Deaths Pre-intervention Between 200-500m	13	23.2
Deaths Post-intervention Between 200-500m	14	25.0
Deaths Pre-intervention Within 500m	16	28.6
Deaths Post-intervention Within 500m	19	33.9
Deaths Beyond 500m	21	37.5
Total Deaths Over Period (12/7/17 - 6/24/18)	56	100.0

Overall, from this analysis, it does not appear that the intervention had the planned effect since there was no appreciable pattern decrease in either the incidence of overdoses or deaths within the vicinity of the recovery houses. For overdoses within 200m of a house, there was a reduction of about 0.4% (82 v. 76). In all other instances, however, the number of incidents increased in the post intervention period. We are somewhat constrained in our conclusions, however, as there was no planned comparison or control group within the analysis. That is, since the observations were made over time, it is not clear if the post period incidences might not have been even higher had the intervention not taken place. We do know, however, that the overall rates of opioid-related overdoses and deaths increased in British Columbia over the period of observation.

FIGURE 7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AVE
112 AVE
104 AVE
96 AVE
88 AVE
80 AVE
72 AVE
64 AVE
56 AVE
48 AVE
40 AVE
32 AVE
24 AVE
16 AVE
8 AVE
0 AVE
Highway 17
No. 1 Highway
Highway 15
Highway 10
No. 99 Highway
Legend
Total Overdoses (2489)
Pre-Treatment
Overdoses within 200m (82)
Overdoses within 500m (528)
Post-Treatment
Overdoses Within 200m (76)
Overdoses Within 500m (622)
Recovery Home Buffers
200m
500m
Overdoses Pre and Post Treatment
City of Surrey 9/7/2017 - 10/25/2018
0 0.6 1.2 1.8 2.4 3 km
SCALE: 1:110000
CITY OF SURREY
This data provided is compiled from various sources and IS NOT warrantied as to its accuracy or sufficiency by the City of Surrey
Date Created: February 8th, 2019

Social Assistance, Overdoses and Property Crime

This section examines the relationship between overdoses, selected property crime incidents and income assistance payment dates. Across the City of Surrey and within the Province of British Columbia more generally, the media have reported on large spikes in overdoses which have occurred shortly after the distribution of social assistance payments. The Canadian Press (2018), for example, reported on a spike in drug overdoses occurring on Friday, October 26, 2018, only two days after an income payment date the previous Wednesday, October 24, 2018.[6]

While the literature on the relationship on the timing of social assistance payments and drug overdoses is not extensive, a group of researchers in Vancouver has examined some aspects of the issue (see: Zlotorzynska et al. (2014); Krebs et al. (2016); Wang (2016); and, Otterstatter et al. (2016)). Using data relating to intravenous drug users at Vancouver's *Insite*, Zlotorzynska et al. (2014) found a significant relationship between the rate of nonfatal overdoses and the issuance of assistance payments. Overall, the risk of an injection resulting in an overdose doubled during the three days beginning with the issuance of the assistance payments.

While not focusing on overdosing specifically, the analysis of Krebs et al. (2016) of prospective cohorts of HIV-positive and HIV-negative illicit drug users discovered a strong relationship between social assistance payments and the *intensity* of drug use. As these researchers noted, while the intensity of drug use increased immediately after the receipt of a social assistance payment, there was "a lower likelihood of increased drug use intensity in the 7–10 days prior to cheque issue."

Further analysis by Otterstatter et al. (2016) confirmed this temporal pattern of drug use at the aggregate or provincial level. Using BC Coroner's data for the period 2003-2013, Otterstatter and his colleagues concluded that about "77 avoidable deaths were attributable to the synchronized disbursement of income assistance cheques over the five year period." In aggregate, this research makes a strong case for a relationship between when social assistance payments are received, and both the incidence of drug overdoses and deaths.

In parallel with the notion that overdose incidents are related to social assistance payments, there is also evidence that an inverse relationship exists with rates of property crime. The rationale is relatively straightforward: when social assistance payments are received, individuals have access to a legitimate source of funds to support their addictions, so overdoses increase while property crimes decrease. Once their legitimate monetary sources run out, drug users resort to crime to support their addictions. In this section, we explore this proposition in some detail.

The previously cited literature provides strong evidence for a linkage between the timing of when social assistance is received and drug overdoses (the so-called "cheque effect"). In this study, we are providing a complement to this research by looking at an aggregate relationship between these elements for the City of Surrey. *That is, our focus is not on individual drug users but rather on patterns at the aggregate or community level.* Furthermore, we will also examine the aggregate relationship between the receipt of social assistance payments and crime rates.

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[6] For a listing of payment dates, see: British Columbia. 2019. "Income Assistance Payment Dates."

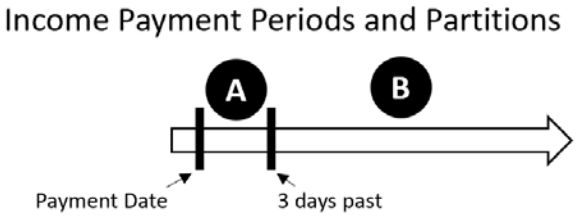
As in the previous analyses, we used overdose data as recorded by Surrey Fire Services. The crime data for the City of Surrey are limited to a series of property crimes only: break and entering into a business; residential break and enter; shoplifting; and, motor vehicle thefts. Crimes against the person and other offences are not considered in this analysis. On average, there were approximately 7.1 known overdoses per day across the city (about 50 per week) and about 45 property crimes per day (around 317 per week). As will be shown in the next section, these statistics vary considerably according to when social assistance payments are made.

We start the next section with a discussion of how a test of the relationship is constructed and then proceed to analyze the relationships between overdoses, crime incidents and social assistance payment dates.

Approach and Hypothesis

There are several ways in which the temporal analysis can be approached. To keep matters relatively straightforward, we chose to partition the daily overdose and crime incidents within the City of Surrey based on income assistance payment dates. That is to say, the data are divided into two temporal segments or partitions. Partition A is the daily incident counts within three days *of* the income assistance payment dates (the payment day plus the three following). Partition B is the daily incidents counts four or more days after those dates (that is, the remainder of the month until the next payment date). Figure 8 illustrates an example of how this partition was created based on the income payment cycles. All incident data would fall either in Partition A or B.

FIGURE 8: EXAMPLE OF DATA PARTITION



City-wide Analysis

For the global date range of October 26, 2016 to October 25, 2018, there have been 5,171 overdoses and 32,454 property crime incidents, during the 2-year period across the entire city of Surrey. This equates to an average of over 7 overdoses and 44 crime incidents a day.

Based on the periodic income assistance payment dates, the daily overdose and crime incident counts are partitioned into A and B as defined in Table 3 across the entire City of Surrey for the global date range of October 26, 2016 to October 25, 2018. Since granularity of the incident counts is at the day level, there are consistent sample sizes for A and B. The sample overdose and crime incident means for A and B are provided in Table 3 as well.

TABLE 3: PARTITION LOGIC FOR CITY-WIDE ANALYSIS

Partition	Logic	Sample Size	Sample Mean (Overdose per day)	Sample Mean (Crime per day)
A	All incidents inclusively within three days of most recent income payment date	98	9.265	38.755
B	All incidents 4 or more days after most recent income payment date until the day prior to next payment	632	6.745	45.342

For example, consider the most recent payment date of January 24, 2018 with the next payment date being February 21, 2018. Incidents occurring inclusively between January 24 to 27 would fall in A, while incidents occurring from January 28 to February 20, 2018 would fall in B. This logic is extended for all payment cycles to partition the crime and overdose data entirely.

In validation of the hypotheses that overdose incidents are higher in A compared to B and that property crime incidents are lower in A compared to B. In other words, we put forward the two working hypotheses:

> For overdose incidents: the mean number of overdoses will be *greater* around the days surrounding assistance payments (A) than the remainder of the month (B).
>
> For property crime incidents: the mean number of crimes will be *lower* around the days surrounding assistance payments (A) than the remainder of the month (B).

Two tests, one parametric and one non-parametric, are used for analysis. The parametric Student's T-Test is considered which relies on the central limit theorem of normality of the mean, though the underlying distribution of incidents need not be normal, e.g. see (Rice, 2006). The non-parametric Wilcox Test is also considered which does not have any normality assumption (Siegel, 1956). Based on Table 3, the sample sizes are sufficient, and there are no concrete social or other indications that we are aware of in terms of questioning variable independence. Thus, assumptions are valid to perform these tests. The R programming language (R Development Core Team, 2008), run through Microsoft's cloud computing analytics platform Azure Databricks (Microsoft, 2018), is used to efficiently and effectively implement these tests.

City-wide Results and Discussion

After partitioning the data, statistical testing was conducted to determine whether there was a significant relationship between social assistance, through income payments, and incidences of drug overdose and crime. The general hypothesis is that within the first three days of the payments being made, the daily overdose counts would be higher in comparison with the remaining days of the month, while inversely, the crime incidents would be lower. This pattern can be visually demonstrated below in Figures 9 and 10, where indicated in red are the first three days of income assistance payments against the remaining days indicated in blue for daily overdoses and crime incidents respectively.

FIGURE 9: AVERAGE DAILY OVERDOSES BY DAY OF ASSISTANCE

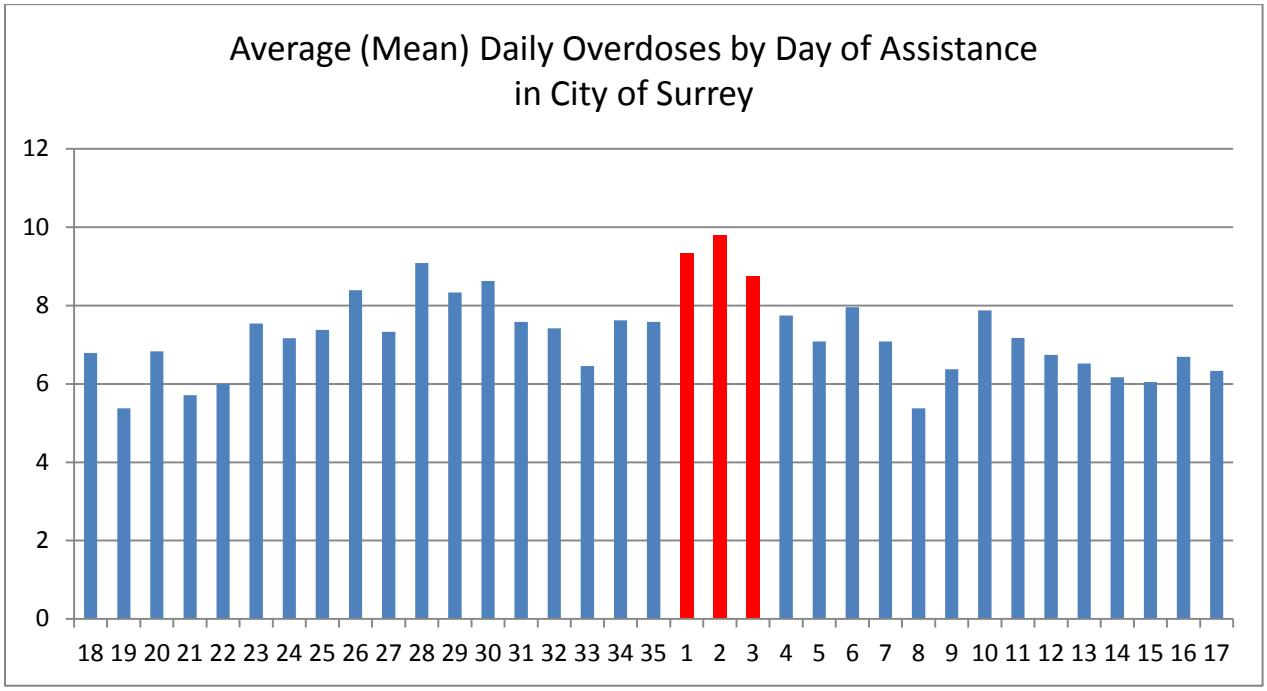


FIGURE 10: AVERAGE DAILY CRIMES BY DAY OF ASSISTANCE

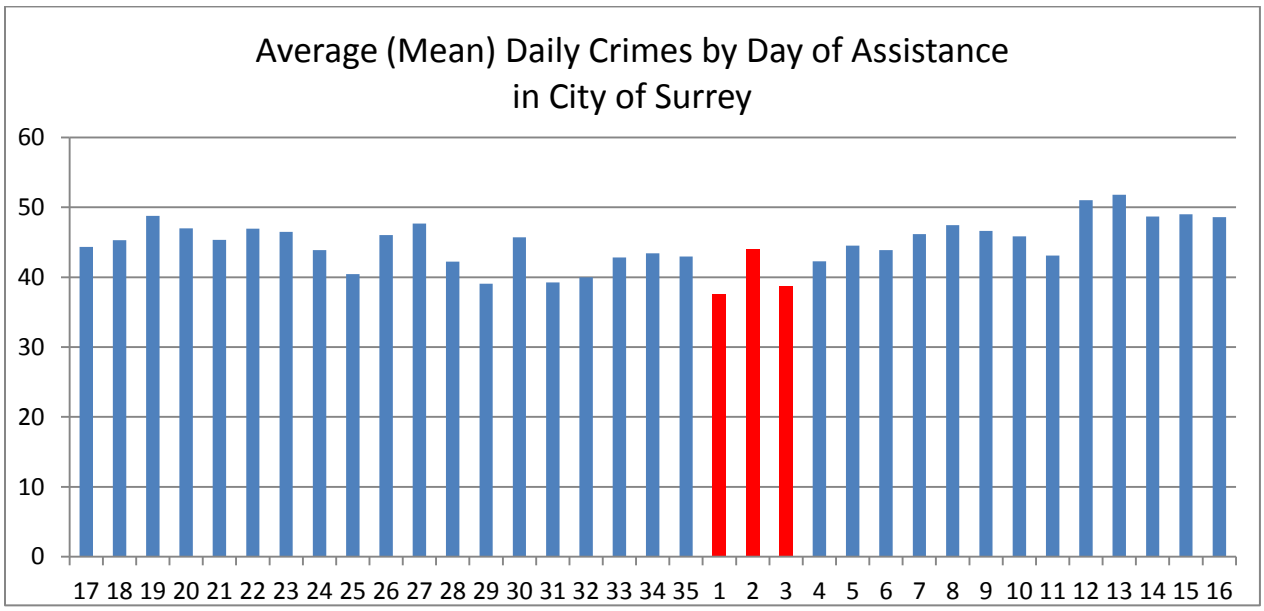
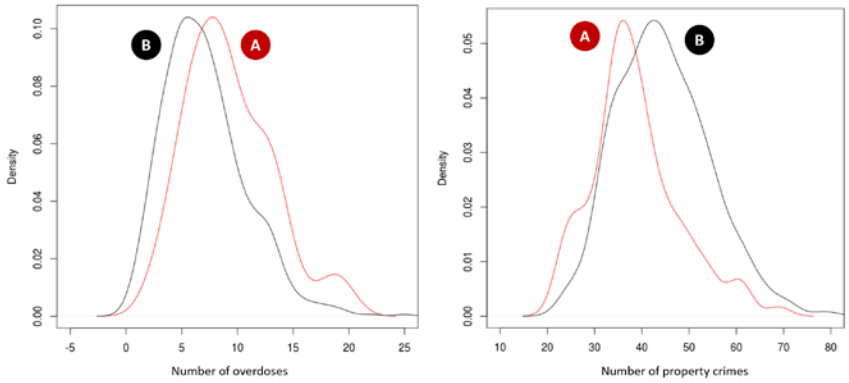


Table 3 shows the difference in sample means. Statistically significant results are found from both the T-Test and Wilcox Test for overdose and property crime incidents. Based on those results, we decided to accept our working hypotheses. That is, overdoses are statistically significantly higher around the days assistance cheques are distributed than in the remainder of the month, while property crimes are significantly lower during the distribution period.

To further illustrate the difference between incident occurrences within three days of income payment dates and occurrences afterwards, Figure11 highlights the density distributions between A and B for overdose and crime daily incidents. These results demonstrate the statistically significant alternative that within the first three days after income payments come out, there are higher overdose and lower property crime incidents across the entire City of Surrey.

In fact, from the statistically significant results found, there is an approximately 37% increase in daily overdoses during the first three days of the most recent income payments. Conversely, there is 15% decrease in daily crime incidents during the three days. These are noteworthy indications on the importance of income payments on overdose and crime rates across the entire city of Surrey.

FIGURE 11: DENSITY DISTRIBUTIONS FOR PARTITION A AND B OF OVERDOSE AND CRIME INCIDENTS



Across the City of Surrey and in the Province of BC, there have been recent media reports on large spikes in overdoses, which have occurred shortly after the assistance payments. One example as noted earlier was the Canadian Press report (Dyck, 2018) on a spike in drug overdoses occurring on Friday, October 26, 2018, only 2 days after an income payment date on Wednesday, October 24, 2018 (BC Government, 2018).

City of Surrey Region-level Analysis

Following city-wide analysis, based on location data as described earlier, specific rectangular regions in City of Surrey are constructed. They are based on varying distributions of recovery houses, as well as well-known concentration areas in Surrey where overdoses occur frequently. The same statistical testing is applied for daily crime and overdose incidents, occurring within each of these zones, partitioned using the income payment dates. The goal would be to determine whether statistically significant results of differing incident rates are present in proximity of recovery houses. This approach is based on report findings from Griffioen (2018).

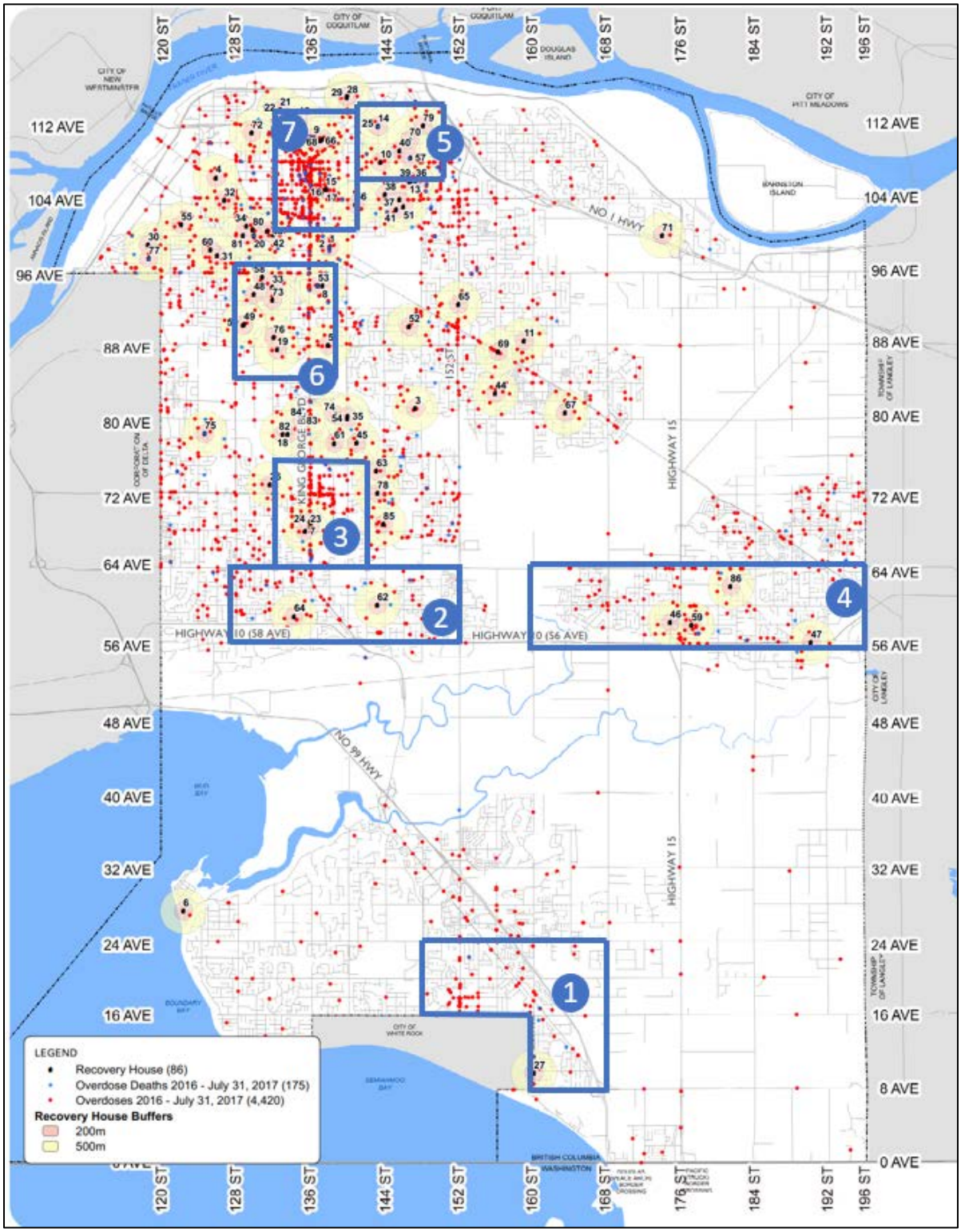
A total of seven regions in the City of Surrey are considered for this analysis. Their descriptions as well as geographical boundaries, given by the upper-left and lower-right boundary points from City of Surrey's COSMOS CAD coordinate system (City of Surrey, 2018), can be found in Table 4. Figure 12 illustrates the boundaries of these regions on a map of Surrey.

TABLE 4: DESCRIPTIONS ON CITY REGIONS CONSIDERED

ID	Upper Left Bound	Lower Right Bound	Approximate area	Description
1	(513722.0, 5432550.8)	(517735.1, 5429343.9)	148 ST / 24 AVE to 168 ST / 8 AVE	1 recovery home
2	(509625.8, 5440728.3)	(514510.4, 5439092.2)	128 ST / 64 AVE to 152 ST / HW 10	2 recovery houses
3	(510421.6, 5443133.6)	(512487.5, 5440735.7)	132 ST / 76 AVE to 142 ST / 64 AVE	3 recovery houses
4	(516124.2, 5440688.3)	(523314.7, 5439117.4)	160 ST / 64 AVE to 196 ST / 56 AVE	4 recovery houses
5	(512183.3, 5450550.8)	(514101.0, 5448778.4)	140A ST / 113 AVE to 150 ST / 104 AVE	7 recovery houses
6	(509624.3, 5447155.6)	(511248.6, 5444766.7)	128 ST / 96 AVE to King George / 84 AVE	10+ recovery houses
7	(510467.6, 5450707.9)	(512077.0, 5448339.7)	132 ST / 113B AVE to 140 ST / 102 AVE	Main King George 104 corridor

For example, Figure 12 illustrates a large concentration of recovery houses and overdoses around the King George corridor between 104th and 108th Avenue. This concentration is contained in Region 7 from Table 4.

FIGURE 12: DISTRIBUTION OF FOCUS REGIONS WITHIN CITY OF SURREY



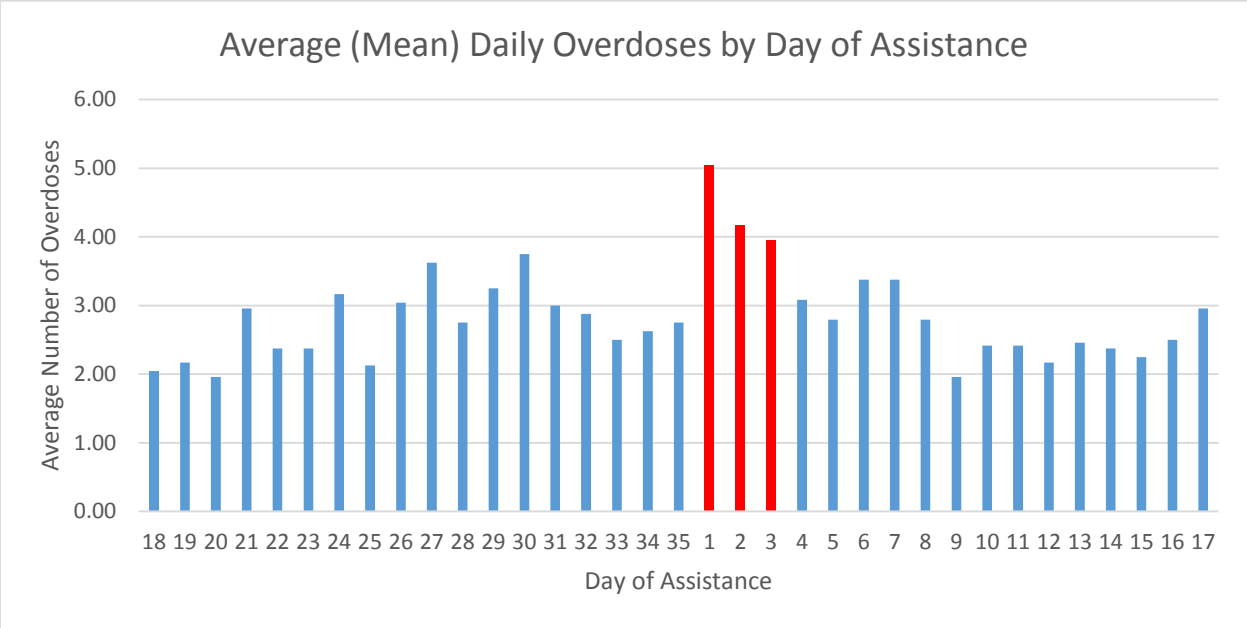
Region 7 Analysis on Overdoses, Crime and Assistance Payment Days

Analysis specific to Region 7, the primary concentration area of overdoses in Surrey, are shown below. A graphical depiction of daily overdose occurrences in this region between the same global date range October 26, 2016 to October 25, 2018, related to assistance payment dates, is illustrated in Figure 13 below. The first three days (social assistance payment date and the two following) are indicated by the red bars while the remaining days of the month are indicated in blue. As Figure 13 suggests, the first three days appear to have higher average overdoses than the remainder of the month. While the overall daily average for overdoses is 2.8, the average for the social assistance period (marked in red in Figure 13) is 4 overdoses per day. That number drops to 2.6 (the blue bars) for the remainder of the month.

From the regular partitions of A and B for daily overdoses in Region 7 as seen in Table 5, our statistical analysis suggests that the difference in the average number of overdoses per day between the partitions is statistically significant.[7]

Despite this difference between the two date partitions, it should be noted that there appears to be considerable cyclical variation from day to day. Regardless, the risk of overdosing is greater on those days associated with the distribution of social assistance payments.

FIGURE 13



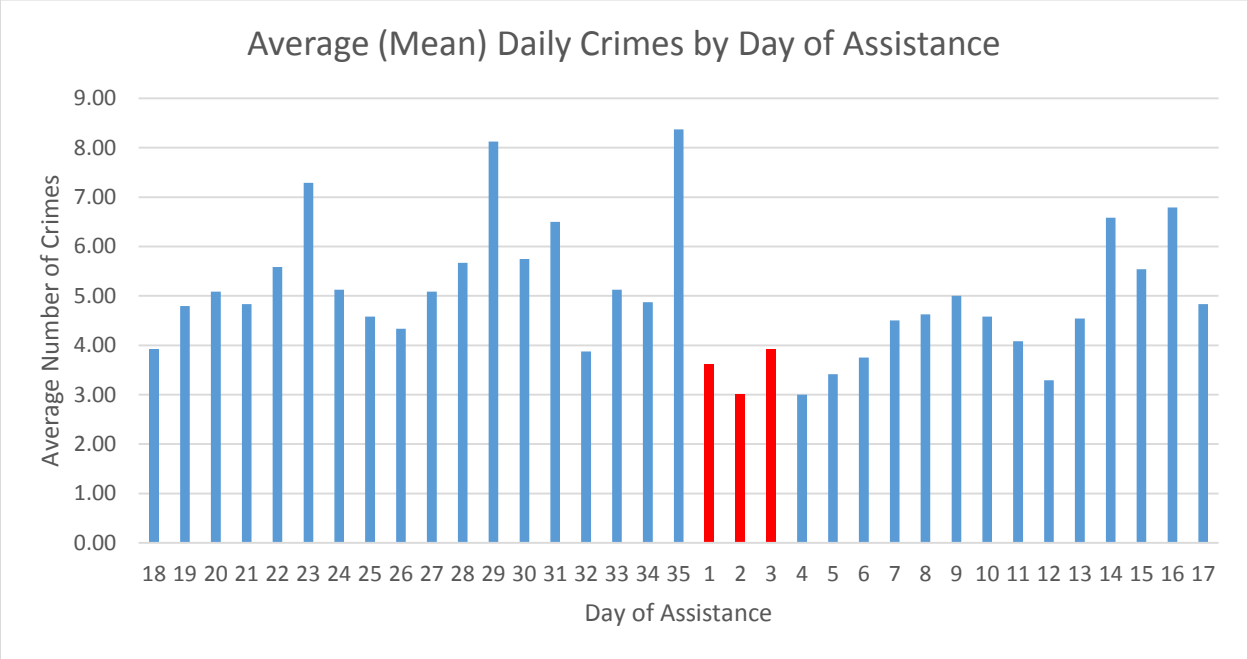
[7] Two-sample t-test, p<.001; Mann-Whitney (Wilcoxon) test, p <.001

TABLE 5: PARTITION LOGIC FOR REGION 7 ANALYSIS OF OVERDOSES

Partition	Description	No. of Days	Mean No. of Overdoses per Day
A	All incidents inclusively within three days of most recent income payment date	98	4.02
B	All incidents 4 or more days after most recent income payment date until the day prior to next payment	632	2.63

Regarding crime rates and income assistance, Figure 14, where as usual red indicates the first three days of income payments and blue the rest, suggests that the crime rates increase as we move beyond the payment dates in Region 7, similar to the city-wide analysis results. The overall trend in Figure 14 is the opposite to the pattern for overdoses.

FIGURE 14: AVERAGE DAILY CRIME BY DAY OF ASSISTANCE



Analysis was performed based on same partition into periods A and B as defined in Table 6 for Region 7. Unlike with overdoses, property crime occurrences increase the further one moves from the assistance payment dates. This is despite the weekday cycle within the data. On average, there are almost 1.5 times more property crime incidents reported in the period of partition B than in partition A. Once again, this difference is statistically significant based on generally accepted criteria.[8]

[8] Two-sample t-test, p<.001; Mann-Whitney (Wilcoxon) test, p <.001.

TABLE 6: PARTITION LOGIC FOR CITY-WIDE ANALYSIS TOTAL PROPERTY CRIMES

Partition	Description	No. of Days	Mean No. of Property Crimes per Day
A	All incidents inclusively within three days of most recent income payment date	98	3.39
B	All incidents 4 or more days after most recent income payment date until the day prior to next payment	632	5.01

All Regions Analysis on Overdoses and Assistance Payment Days

The seven regions for analysis provide a fair representation of the overdose and crime situations in the City of Surrey. Understanding how incident rates change based on income assistance payment dates in these regions, including the main concentration of overdoses in Region 7, could start to provide a generalized foundation with policy implications for the City of Surrey, in different areas or districts with varying socio-economic characteristics.

For regional level analysis, overdose and property crime daily incidents are grouped based on whether they occurred in each of the seven regions, and then partitioned into A and B based on income assistance payment dates. The same null hypotheses and alternatives framework and tests are considered, from the city-wide analysis. The same sample sizes are also present as incident counts are all reported at the day level. Altogether, assumptions for the statistical tests to be applied are valid. Table 7 provides the daily sample overdose and crime incident means for A and B within each of the areas.

TABLE 7: SAMPLE MEANS FOR REGION-LEVEL INCIDENTS

Sample Means Type	Region Partition	1	2	3	4	5	6	7
Overdose	A (pay period)	0.173	0.378	0.490	0.224	0.122	0.265	4.020
Overdose	B (Non pay period)	0.160	0.217	0.487	0.158	0.108	0.178	2.633
Property crime	A (pay period)	1.592	0.969	2.153	1.908	0.561	0.776	3.388
Property crime	B (Non pay period)	1.951	1.274	2.627	2.324	0.698	0.948	5.014

City of Surrey Region-level Results and Discussion

In each of the regions, there is consistently higher sample mean for overdoses in A compared to B, and lower sample mean of crime incidents. After applying the T-Test and Wilcox Test, three out of the seven regions demonstrated statistical significance in rejecting the null hypotheses and favoring the alternative of higher overdose incidents within three days of income payments. Even more, as a conservative measure of needing to reach the same conclusion from both tests, five out of the seven regions demonstrated statistical significant (based on the standard threshold of p = 0.05) in favoring the alternative of lower property crime incidents in A. If only the T-Test is considered, results from all seven regions would favor the alternative. Table 7 lists all the results on analysis for each of the areas.

These results, reported in Table 8, again demonstrate, even at the region-level, the clear data-driven insights that in areas with recovery houses, even ones with varying concentrations and number of houses, individuals are getting regular social assistance payments, presumably through the houses' landlords, to support their drug addictions and then overdosing, particularly in Regions 2, 6, and 7. They do not to turn to crime when legitimate money is available, thus contributing to lower crime rates across all of the City of Surrey, and within most regions within the city as well. As soon as it runs out, a few days from the payments coming in, crime rates go up again. More details on policy implications for these results will be addressed in the final section.

TABLE 8: REGION-LEVEL STATISTICAL RESULTS

Region	Overdose Working hypothesis: A (pay period) = B (Non-pay period)			Property Crime Working hypothesis: A (pay period) = B (Non-pay period)		
	P-Value (T-Test)	**P-Value (Wilcox)**	**Conclusion (p = 0.05)**	**P-Value (T-Test)**	**P-Value (Wilcox)**	**Conclusion (p = 0.05)**
1	0.385	0.372	No significant difference	0.009	0.009	**Statistically significant**
2	0.008	0.003	**Statistically significant**	0.004	0.021	**Statistically significant**
3	0.486	0.239	No significant difference	0.014	0.003	**Statistically significant**
4	0.110	0.112	No significant difference	0.018	0.004	**Statistically significant**
5	0.359	0.507	No significant difference	0.039	0.233	No significant difference
6	0.049	0.008	**Statistically significant**	0.049	0.057	No significant difference
7	< 0.001	<0.001	**Statistically significant**	<0.001	<0.001	**Statistically significant**

Can the Neighbourhood or Geo-spatial Distribution of Overdoses be Predicted?

Predictive Modeling

Part of this project was conducted in conjunction with Microsoft which provided access to their Azure platform to address the question of whether daily overdose incidents could be predicted with any degree of certainty. Predictive modeling techniques are applied for Region 7, which has the main concentration of overdoses in City of Surrey.[9] This paper highlights the high-level steps to perform predictive modeling on overdose incident data. A more extensive overview on the modeling techniques can be gathered from (Duan 2014). The iterative process in applying model techniques can be reviewed at Microsoft (2017) using the Team Data Science Process.

The general goal of predictive modeling is to develop a statistical algorithm or model to predict a specific data field, known as the label. In the case of this paper, the label is the number of daily overdose incidents within a region. A widely used algorithm for this type of analysis is known as Random Forest, which builds an ensemble of decision trees or nodes. The individual trees reflect predictions for specific characteristics or variables through binary logic (such as yes or no). The Random Forest approach provides an overall prediction based on a democratic voting process, known as the ensemble approach (Breiman 2001).[10]

To develop such a model, historical data, known as a training set, is used that contains the known label field along with other variables or characteristics, known as features. The trained algorithm can then be applied to new data to predict the label. In practice, to evaluate and understand how accurate the algorithm performs, historical data are divided into a training and a testing set. The model would be built from the training set and it would make predictions based on the testing data. Since the labels from the testing set are known, they can be compared against the algorithm's predictions to determine accuracy and performance of the overall model.

In the context of this paper, the label or characteristic of interest is the number of daily overdose incidents that take place within a given location. The historical dataset contains daily incident counts along with the following predictive characteristics:

- Seasonality, including month and day
- Day of the week
- Days since last income assistance payment
- Property crime type incident counts (that is, Break and Enter, Shoplifting, Motor Vehicle Theft)
- Total property crime incident counts

[9] A similar approach could be applied for other regions and even for the entire city given sufficient data.

[10] Other examples of algorithms used in industry and academy are linear regression, support vector machines, and neural network, which are usually defined in a mathematical nature. An excellent introduction to these techniques is provided in Bishop, Christopher M. 2006. *Pattern recognition and machine learning*. New York: Springer.

- Crime and overdose incidents for previous day, the previous two days, and the previous week

The training data set is drawn from incidents that occurred from October 26, 2016 to August 31, 2018, while the testing data drawn from incidents that occurred from September 1, 2018 to October 25, 2018. This distinction is illustrated in the following Table 9.

TABLE 9: TRAINING AND TESTING SPLIT INFORMATION

	Split Date Range	Sample Size	Number of Features
Training set	October 26, 2016 to August 31, 2018	675	29 + label
Testing set	September 1, 2018 to October 25, 2018	55	29

A technique known as Random Forest is used as the modeling algorithm and to evaluate accuracy, the absolute difference between daily actual and predicted overdoses is calculated. This difference is known as the error. The analysis was run on Microsoft's cloud computing analytics platform, Azure Databricks (Microsoft 2018), that allows for efficient and effective calculations.[11]

Modeling results and discussion

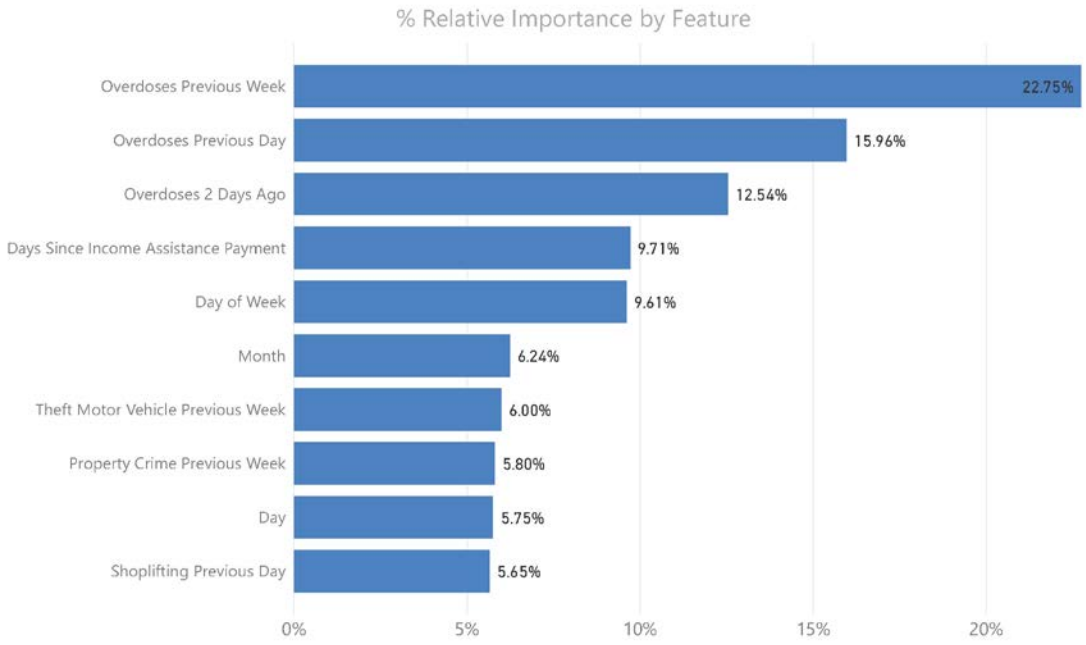
After the predictive modeling algorithm was built from the training set, data from the testing set was applied to the model algorithm. The error, which is the absolute difference between actual and predicted number of events, was then calculated. The predictive modelling error rate was estimated to be **1.13**.

The interpretation of this result is that had the model been used to predict overdoses from September 1, 2018 to October 25, 2018 in Region 7, it would have been only slightly over an overdose off from predicting the actual outcomes. Considering a daily average of approximately three overdoses in this region, and seven overdoses across the city, we feel this is a significant accomplishment. The question remains, however, as to whether this magnitude is sufficient to warrant operational interventions. That is, whether this estimate would warrant the financial and resource costs to have a significant impact on the number of overdose occurrences.

Figure 15 provides the relative importance of the top features in driving opioid overdose prediction as determined by Random Forest. The relative importance score of features are calculated as a function of how often the features are considered in the model's training process of individual Decision Trees that contribute to the most decisive splits in predicting number of overdoses.

[11] The specific routines were drawn from the Random Forest R library (Liaw & Wiener, 2002)

FIGURE 15: MAIN FEATURES RELATED TO OPIOID OVERDOSES



In addition, since the Random Forest model builds several Trees through ensemble modeling, a single Decision Tree can be visualized in order to illustrate the logic flow in starting to understand how Random Forest makes predictive decisions. Figure 16 shows the structure of decision-making that is constructed through a single Decision Tree. Random Forest is more complex since multiple Trees are considered with other variations. This approach is common in attempting to unravel the "black-box" of predictive modeling.

As expected from Random Forest's feature importance rankings, overdoses in the previous week and day, as well as days since last income payments are critical in driving overdose predictions. In addition, the structure of the Decision Tree in Figure 16 also reveals crucial information in splitting thresholds that may have genuine policy impacts. For example, if it is less than 2.5 days since last income payments, there would generally be higher overdoses, which aligns with the significant findings previously noted in this paper.

Below are some key thresholds in determining whether number of overdoses would be high as determined through the Decision Tree structure in Figure 16:

- Over 30.5 overdoses in the previous week
- Over 10.5 overdoses in previous day
- Week of day is Saturday or Sunday
- Over 5.5 property crimes in previous day

FIGURE 16: HIERARCHY OF CHARACTERISTICS RELATED TO OPIOID OVERDOSES

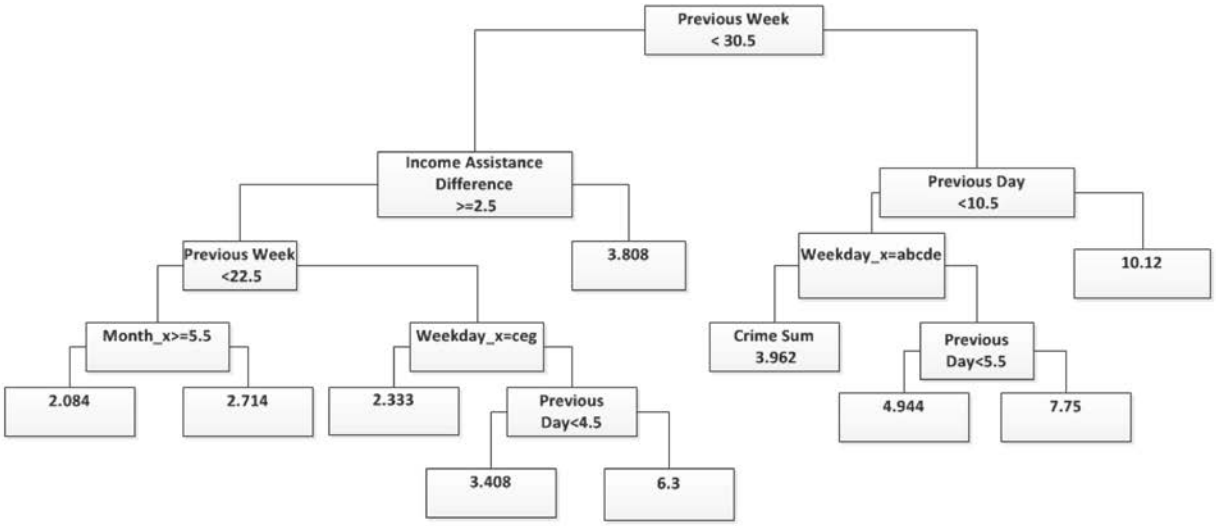
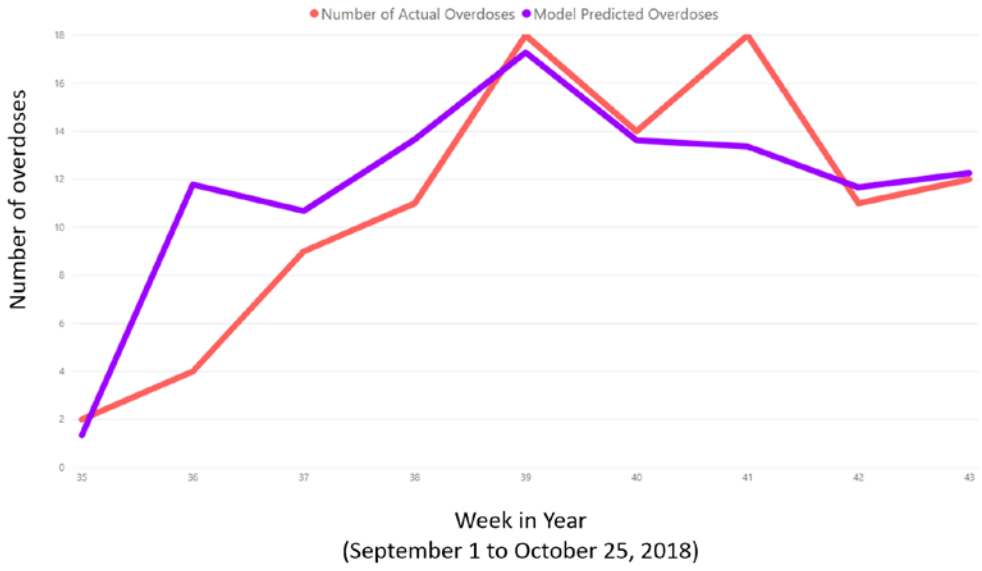


Figure 17 illustrates the weekly average of actual overdose incidents during the period of September 1, 2018 to October 25, 2018 and how the predictions compare. The predictive model can recognize the upward trend of overdoses from September 1 into a peak, namely, the next income payment date. The model can also return key features that contribute to predicting overdose occurrences (Liaw and Wiener 2002). Evidently, seasonality as well as days since last income payment are very important in the algorithm's predictions. Other key drivers include:

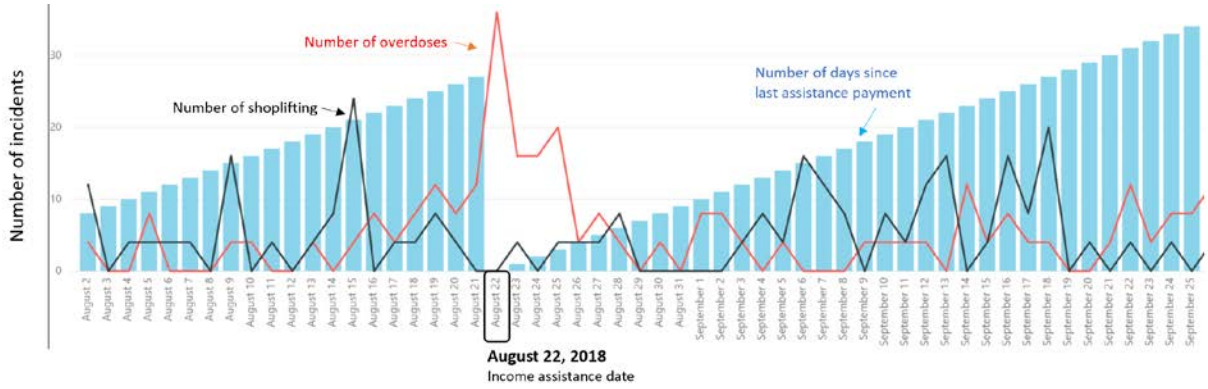
- Day of week
- Overdose incidents occurring in the previous day, 2 days, and week
- Shoplifting incidents
- Property crime incidents occurring in the previous week

FIGURE 17: PLOT COMPARING ACTUAL AGAINST PREDICTED OVERDOSES PER WEEK



The predictive modeling results for Region 7 look to be promising and worthy of future development to improve the model's accuracy and to expand into different regions. These results could be used to foster the start of data-driven discussions on how to enable responders to be more proactive on overdose incidents. Equipping them with possible predictive knowledge on where overdoses may occur next could allow for faster and more effective responses. The ability to marginally increase the accuracy of overdose occurrences predictions at specific locations and regions could enable responders to provide in-advance educational treatments, drop off overdose naloxone kits, or even have ambulances ready for response in high-risk areas.

FIGURE 18: PATTERN OF OVERDOSE AND CRIME



In conclusion, this section has highlighted the unfortunate pattern of income payments, overdose rates, and crime incidents of the opioid crisis in the City of Surrey. Whether it is across the entire city, or localized to specific regions with nearby recovery homes, individuals are overdosing at much higher rates once social assistance payments come in. Property crime rates go down as legitimate sources of money flow into the City. Based on the modeling analysis performed, shoplifting and overall recent property crime incidents are also found to be correlates of overdose occurrences. In other words, as soon social assistance monetary sources run out, crime increases, particularly shoplifting, which would appear to further support drug consumption and sometimes overdosing. Figure 18 illustrates this pattern through a visualization between August 2 and September 25, 2018 in Region 7.

Policy Recommendations

Based on our analysis of the distribution of opioid-related deaths, overdoses and crime, we have concluded that there are several major policy directions that might affect a reduction in incidents.

Social Assistance Payments, Overdoses and Crime

For opioid addicts, there are two major concerns: the first is obtaining a reliable supply of drugs, and the second is obtaining the resources to obtain that supply. For addicts who are at the stage where they wish to make a transition away from harmful opioids such as heroin, oxycontin or fentanyl, we have largely addressed the problem. Methadone therapy is readily provided through clinics nationwide and it is available at a reasonable price. Addicts on methadone maintenance therapy can lead functioning lives by satisfying the craving for alternate opioids.[12] Similarly, current pharmaceutical prices for methadone are not exorbitant even for those on social assistance. Newer therapeutic drugs, such as suboxone, are often less available and somewhat more expensive, but are still available to a substantial proportion of addicts seeking treatment.

The issue we have not addressed successfully is that of addicts who are not at the stage where they are willing or able to make the transition from what we typically refer to as "street drugs." For addicts, obtaining street drugs on the underground economy is fraught with problems relating to availability, quality assurance, and price. In the extreme, quality assurance issues lead to many of the overdose and mortality incidents we have addressed earlier. Price issues force many addicts, even those with regular employment or on social assistance, to seek ways to supplement their income. Typically, drug addicts resort to criminal or other forms of socially dysfunctional behavior to obtain the resources to buy their drugs.

While opioid overdoses and overdose-related deaths are an ongoing phenomenon, it is evident that a "spike" exists in these occurrences following the dates when social assistance payments are made. Similarly, crime rates fall when assistance payments are made. This observation is not unique to Surrey since the pattern has been noted in other jurisdictions. In parts of the US, this phenomenon is known as the "cheque effect."

We also note that in the period immediately prior to the distribution of social assistance payments, property crimes tend to increase. While property crimes are committed by many different types of people for many different reasons, it is logical to assume that some portion of that is due to addicts foraging for resources to support their habits as assistance payments have run out.

While there is currently little empirical evidence to show that altering assistance payments has a major effect, it is conceivable that a redistribution of social assistance payments would mitigate and, to some degree, "level out" the spikes in overdosing and property crime.

We do not know what the optimal distribution of payment might be; however, economic theory would suggest that redistributing payments over more periods would likely serve to smooth out

[12] We recognize the fact that, as opioid drugs themselves, methadone, buprenorphine, and Suboxone all have some inherent potential for abuse. For a substantial proportion of the addict population, however, they do provide a functional treatment option.

opioid purchases. This, in turn, would likely reduce the spike in overdoses. Clearly, a balance needs to be struck between the mechanics of distributing payments and the needs of the recipients. Currently, assistance payments are made monthly. Within the general labour market, however, salary payments are typically made weekly, biweekly, or monthly. A pilot project might be considered where assistance payments are increased to weekly and biweekly periods in tandem with general labour market practices.

Making "regulated" supplies of opiates available to addicts who are not ready to make the transition away from harmful drugs is another alternative. British Columbia has recognized this as a viable alternative with the creation of several safe consumption sites. The number of such sites, however, is clearly not adequate to undermine the underground economy in opiates.[13]

Recovery House Standards

In this study, we noticed that recovery houses appear to act as what Eck would term handlers and site controllers. Consequently, overdoses and deaths are lower in the immediate vicinity of the recovery house locations. Based on this finding, we might suggest that the role and responsibility of recovery houses be extended beyond their immediate confines. This would likely necessitate increasing the capacity of the homes by providing increased functional responsibility and training to staff and others associated with the houses.

Currently, there are two general groups of recovery houses operating in the City of Surrey. There are those that are registered through British Columbia's Assisted Living Registry (n=55) plus another group (n=12) that are allowed under the City of Surrey's Business License Bylaw. There are also houses that are essentially residential locations only that are not regulated (n=90) . While the latter group clearly fulfils a residential need for opiate addicts, greater oversight and regulation of those locations could have an impact on rates of overdose, deaths and crime rates at or near those sites. Besides ensuring that existing municipal and provincial health and safety standards for multiple dwelling units are enforced, standards relating to the availability of OATs, professional counselling, and the availability and disposal of drug paraphernalia might be considered or services be illuminated through active enforcement.

[13] Almost two decades ago, the government of Portugal instituted a policy of decriminalizing drug use and making legal supplies more available. While there have been implementation issues, the program has been considered largely successful. See: Domoslawski, A. (2011) Drug Policy in Portugal: The Benefits of Decriminalizing Drug Use. Warsaw: Open Society Foundation. Available at https://www.tni.org/files/publication-downloads/drug-policy-in-portugal-english.pdf

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