University of Maryland, Baltimore County

**Cost Benefit Analysis of a Hypothetical Safe Consumption Site in Baltimore City: Revisited post Covid -19 Pandemic**

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**Abstract**

**Background:** Since the global pandemic, there has not been an updated cost benefit analysis for a hypothetical safe consumption site in Baltimore City, Maryland. This paper seeks to analyze how the Covid -19 pandemic has impacted the cost -saving effects estimated in the 2017 CBA titled *Mitigating the Heroin Crisis in Baltimore, MD, USA: a Hypothetical Supervised Injection Facility* by Irwin et al. (2017). However, instead of only focusing on heroin related externalities, this analysis will focus on all fatalities related to any opioid in Baltimore City.

**Methods:** I use data from the Baltimore City Fire Department, Maryland Department of Health as well as data on existing safe consumption sites in Canada to revisit a 2017 CBA conducted for Baltimore City. This analysis uses cost estimates to estimate the impact of a safe consumption site in zip code 21217 for the following categories: overdose mortality, overdose morbidity, and medication assisted treatment enrollment for opioid dependence.

**Results:** I predict that the annual cost for a safe consumption site would be approximately $1.8 million but would generate $10.8 million in savings yielding an annual net benefit of roughly $13.5 million when using the Irwin et al. cost estimate methods. This would mean that for every $1 put towards a safe consumption site, it would generate $5.91. When updating the analysis using the value of a statistical life, for every $1 put towards the safe consumption site, it would yield $105.37 in benefits. My estimates indicate that a safe consumption site would prevent 13 overdose fatalities, 593 ambulance deployments, 423 emergency department visits, and 147 days’ worth of inpatient hospital stays annually. Additionally, the safe consumption site would refer about 44 PWUD into medication-assisted treatment annually.

**Conclusion:** A safe consumption site in Baltimore City would save lives and cut down on unnecessary health care costs.

# **I. Introduction**

Drug overdose fatalities continue to rise in the United States. The CDC’s National Center for Health Statistics reported an estimated 100,306 drug overdose deaths in the U.S. during the 12-month period ending in April 2021 (2021). This shows an increase of 28.5% from the 78,056 deaths during the same period in the year 2020 (CDC, 2021). The opioid and heroin epidemic has increased during the Covid-19 pandemic in the U.S. demonstrating that this is an issue that needs immediate attention and intervention. In Baltimore City alone, there was a 13% increase in opioid related deaths from CY 2019 to CY 2020 (Maryland Department of Health, 2021). In order to decrease the negative externalities associated with the epidemic, a harm-reduction model could be a potential solution. Safe consumption sites (SCS) are harm reduction tools used to decrease the direct and indirect harms associated with substance abuse with an emphasis on injection drug use (Vearrier, 2019). Other countries have seen great success with the implementation of this harm reduction tool (Potier, 2014), and the U.S. could be underutilizing this intervention. There are numerous health impacts for people who use drugs (PWUD) and communities alike. Safe consumption sites decrease the barriers to care and treatment for PWUD and are aimed at reaching the most marginalized groups of PWUD.

Overdose fatalities continue to rise. Unsafe needle use and disposal as well as public and semi-public injections are still common practices. The CDC has estimated that the U.S. spends roughly $78.5 billion every year on the opioid and heroin crisis (2022). Even with this large volume of money being spent on decreasing drug trafficking and drug use, there has been no decrease in overdose fatalities in the United States (Osler, 2020). Since the beginning of the Covid-19 pandemic, which has negatively impacted overdose deaths, there has not been an updated cost-benefit analysis (CBA) conducted for Baltimore City, Maryland that looks at the costs and savings related to the opioid epidemic. In 2017, Irwin et al conducted a CBA for a hypothetical SCS in Baltimore City. They estimated the costs and benefits of opening a SCS based on the number of unintentional fatalities due to heroin overdoses. For my analysis, I will improve upon the 2017 study in three ways: (a) update the CBA for the Covid -19 pandemic, (b) extend the analysis to all opioid related deaths in Baltimore City, and (c) bring the value of a life saved up to date by using the current Department of Health & Human Services (HHS) valuation technique.

# **II. Background & Literature Review**

Safe consumption sites are a harm reduction tool that is being utilized all over the world with approximately 120 operating sites. In November of 2021, New York City opened the doors to the first sanctioned SCS in the U.S. (Mays & Newman, 2021), and the U.S. News Associated Press released a report saying Rhode Island is not far behind (2021). The majority of the research based on these sites has shown that SCS decrease overdose fatalities, needle sharing related infections, unnecessary emergency service usage, and increases enrollment into medicated assisted treatment (Potier et al., 2014). As a harm reduction tool, its goal is to decrease fatal and non-fatal overdoses, needle sharing related infections, and emergency service usage, as well as increase the probability of PWUD enrolling into treatment.

## **Impacts of Safe Consumption site**

Safe consumption sites operate under the harm reduction model meaning their intended use is to decrease the harms associated with substance abuse. The sites have the ability to impact individuals and communities alike by increasing public health and decreasing the direct and indirect harms associated with substance abuse.

### **Personal Impacts for Users**

Safe consumption sites are intended to reach the most marginalized groups of PWUD and decrease their risk of overdose, viral and bacterial infections, as well as increase their access to treatment. Evidence shows that SCS decrease fatal and non -fatal overdoses, needle sharing related infections, and increase enrollment into treatment (Potier et al., 2014).

#### **Fatal and Non -Fatal Overdoses**

Available literature surrounding SCSs show that there have been no reported deaths at a SCS (Potier et al., 2014). In 2003, Vancouver, Canada opened its first safe consumption site. Since then, overdose deaths near the site decreased from 253 to 165 per 100,000 persons living near the site annually (Ng, et al., 2017). This success is not isolated to Vancouver. The NYC Department of Health and Mental Hygiene put out a press release saying the SCS in NYC averted 59 overdoses within the first three weeks of operation (2021). One reason for this success can be brought back to the medical staff onsite that have the ability to reverse overdoses using overdose reversal drugs and other treatment strategies such as oxygen treatment. Another factor associated with a decrease in overdoses is the PWUD ability to inject their drugs slowly and without fear of being caught. At an unsanctioned safe consumption site in the U.S., over 80% of the clients reported having to rush injections when not using the site (Kral & Davidson, 2017). Safe consumption sites give PWUD a sense of security because PWUD are safe from arrests and criminalization related to their drug use while visiting the site. Staff onsite also educate users on safe injection practices which helps decrease the probability of overdose as well as infections.

#### **Needle Sharing Related Infections**

The impact of safe consumption sites on needle sharing related infections like HIV and HCV are largely dependent on the state’s rate of transmission. In areas with a high prevalence of needle sharing and high HIV and HCV transmission rates, SCS’s are going to have the most impact when it comes to decreasing infections. Risky needle sharing behaviors are the main contributing factor for higher rates of HIV and HCV in PWUD (Belackova et al., 2018). Safe consumption sites aim to educate users on safe injection practices, offer clean injection supplies, and proper needle disposal in order to decrease transmission.

#### **Rehabilitation**

A secondary benefit for individuals who use SCS’s is the access to resources for medicated assisted treatment programs as well as rehabilitation programs. In the city of Vancouver, a 2007 study found that injection drug users who used the local SCS were 30% more likely to enter detoxification services after the sites opening (Wood, et al., 2007). The researchers used a Cox regression to determine whether or not the SCS was the cause of enrollment into detoxification services (Wood, et al., 2007). The increased likelihood of entering detoxification services might be especially valuable given that SCS users end to be young. In 2019, another group of researchers found that on average, frequent users of the SCS in Vancouver were younger than non-frequent users (Kennedy et al., 2019). This finding was not unique to this study. In the city of Ottawa, Canada an SCS is accountable for tracking services and reporting quarterly results to the Ontario Provincial Government (DelVillano et al., 2019). Their report shows that 75% of their clients identified as male and most (60%) were between 25 and 45 years old (DelVillano et al., 2019). Additionally, 12% of clients reported they were between 18 to 25 years old (DelVillano et al., 2019). This is an important aspect to note considering that users who frequent the SCS’s are younger and more likely to enroll into detoxification programs showing that the negative externalities associated with early substance abuse can potentially be mitigated for younger users which can increase their chances of recovering and becoming more productive members of society.

### **Impacts on Communities**

Safe consumption sites have the ability to address the public health issues related to the opioid and heroin epidemic that effect communities. When PWUD have no safe place to use, public and semi -public injections are their only options. With public and semi -public injection comes improper needle disposal which includes practices such as littering used syringes, selling used syringes, or giving away used syringes. Improper needle disposal is not only an issue for PWUD but also for people who live in communities with a high prevalence of injection drug use. Common places for PWUD to inject include public restrooms, parking lots, stairwells, abandoned buildings, and parks. Over a two year period, an unsanctioned safe consumption site in an anonymous city in the U.S. reported to have averted 2,300 instances of public injection in the neighborhood (Kral, et al., 2017).

## **Impacts on Hospitals**

Emergency departments all around the country experience overcrowding which has only gotten worse during the Covid -19 pandemic implying that resources for people with non-Covid related emergencies is scarce. Regardless of ability to pay and insurance status, all patients who enter an emergency department are required to be seen and stabilized before being discharged according to the Centers for Medicare & Medicaid Services (2021). In 2020, approximately 28 million people were uninsured (Keisler-Starkey & Bunch, 2021). Safe consumption sites have the ability to lessen this burden on hospitals by treating and preventing overdoses and infections thus decreasing preventable emergency service usage.

### ***Emergency Medical Service Use***

Because medical staff is present onsite at the SCS with equipment, there is less of a need for emergency medical services to be deployed. Overdoses have the ability to be treated without emergency service utilization outside of the medical staff at the SCS. In 2008, a research study was published that used an ecological study of the patterns associated with ambulance use among opioid related overdoses before and after Sydney, Australia opened an SCS (Salmon et al., 2010). The study found that ambulance utilization decreased by 68% in the vicinity of the SCS which was a 7% greater decrease than what was observed in the rest of New South Wales (Salmon et al., 2010). A similar study conducted using data from near a Vancouver SCS shows similar results. The average monthly ambulance calls that required naloxone treatment for suspected overdoses had decreased by 67% (Ng, et al., 2017).

### ***Emergency Room Use and Inpatient Hospital Admissions***

Another added benefit of having medical staff present at the SCS is that they have the ability to treat wounds and minor infections before they become serious and require severe medical attention that results in a trip to the emergency room. These sites also reduce skin and soft tissue infections (SSTI) because there are medical staff on site that provide wound care and medical referrals to treat infections before they become serious. In Vancouver, they found that hospital stays from Insite (an SCS) users were 67% shorter on average after the implementation of the site (Irwin et al., 2016). According to the National Healthcare Quality and Disparities Report, emergency department visits involving opioid diagnosis is continuing to increase in the U.S. as well as hospital inpatient stays involving opioid related diagnoses (2019). Because of the injection supplies given to users at SCS’s, there is a decreased probability that a PWUD will contract HIV, HCV, and other bloodborne transmittable diseases which decreases the need for hospital stays due to untreated infections. This in turn may improve the rates at which PWUD are using emergency departments as well as improve the rates of inpatient hospitalizations.

## **Impacts on Non -Users**

The notion of safe consumption sites may leave community members feeling uneasy due to the fact that SCS decrease the legal barriers for substance abuse and seemingly invite the behavior of substance abuse into communities. However, according to a systematic literature review conducted in 2014 that reviewed 75 relevant articles, there was no evidence that suggested an increase in drug trafficking, crime rates, and drug use surrounding SCS’s in Canada and Australia (Potier et al.). In regard to crime rates, the study found that crime rates either stayed the same or decreased slightly. For example, in the city of Vancouver researchers used autoregressive integrated moving average (ARIMA) techniques to determine whether or not the SCS had an impact on total, violent, or property crimes (Myer & Belisle, 2017). The results of the study shows that the SCS had no statistically significant impact on total crime, violent crimes, or property crimes (Myer & Belisle, 2017).

## **Political Feasibility & The Current Political Climate**

As of now, there are two sanctioned safe injection sites in the U.S. Rhode Island has put legislation in place to start a pilot program for one safe injection site beginning this year (CY 2022). More states are leaning towards accepting harm reduction as a means to battle the opioid and heroin epidemic. States like California, Washington, and Maryland are amongst some of the states that have begun researching the cost effectiveness of a safe injection site in their major cities (San Francisco, Seattle, and Baltimore, respectively) (Irwin et al., 2017; Hood, et al., 2019; Irwin et al., 2017). Colorado and Pennsylvania have also expressed serious consideration for opening SCS in major cities like Denver and Philadelphia. Following an inquiry from the Associated Press, the Department of Justice has expressed that they are reviewing and evaluating the notion of safe places for supervised illicit drug consumption (Peltz & Balsamo, 2022). Currently, SCS are legal under state law but illegal under federal law. Just as states are allowed to make marijuana legal for medical purposes, they also have the ability to sanction SCS in their states. However, just as marijuana is federally illegal, so are safe injection sites (DOJ, 2021).

 In the public eye, safe injection sites are still very much stigmatized. More recent studies have looked into public perception of SCS as well as the impact of brief targeted education surrounding how SCS work and their targeted goals. Mrazovac et al found that there is a positive correlation between targeted education and attitudes towards SCS (2020). Additionally, the public’s perception of SCS increase when they are referred to as “Overdose Prevention Sites” rather than Safe Injection Sites or Safe Consumption Sites (Socia et al., 2021).

## **Cost-Benefit Analyses of Safe Consumption Sites in the U.S.**

 There have been multiple cost benefit analysis’ that have been performed for hypothetical safe consumption sites in major cities in the U.S., including cities such as Seattle, Washington; San Francisco, California; and Baltimore City, Maryland. All of these CBAs have shown positive net benefits.

#### **Seattle, Washington**

 The CBA conducted for Seattle, Washington estimated the cost savings associated with averted fatal and non-fatal overdoses, drug related infections, HIV and HCV, as well as the benefits of increased enrollment into medication-assisted treatment (Hood, et al., 2019). This CBA estimated that clinical management of overdoses would save the healthcare system $897,327 annually for their base program estimation. Adjusting the overdose rate as well as the size of the SCS, the authors found that an SCS could bring in annual net benefits anywhere from $1.8 million to $5.7 million (Hood, et al., 2019).

#### **San Francisco, California**

The CBA conducted for San Francisco, California estimated the cost savings associated with five outcomes: averted HIV and HCV infections, reduced SSTI, averted overdose deaths, and increased medication-assisted treatment enrollment. This CBA estimated that for each dollar spent on the SCS it would yield $2.33 in savings annually amounting to net benefits of $3.5 million annually (Irwin et al., 2017).

#### **Baltimore City, Maryland**

The 2017 CBA conducted for Baltimore city is the CBA that is being used as a baseline for this cost analysis that I am performing. This is one of the only current CBA that estimates the cost savings associated with more than three outcome categories aside from the San Francisco study (Irwin et al., 2017). This study estimates the cost savings associated with averted HIV and HCV infections, SSTI, overdose mortality, overdose morbidity, as well as an increased enrollment into medication-assisted treatment. The authors predict that for an annual cost of $1.8 million, the SCS would generate $7.8 million in benefits (Irwin et al., 2017).

 Overall, available research and literature shows positive benefits for SCS. This analysis hopes to add to previous cost benefit analyses by including the benefits and costs associated with all opioid use post pandemic for a more accurate picture of the impacts of a SCS.

# **III. Methodology**

The current study is an extension of the 2017 study conducted by Irwin et al. This study will calculate the financial and health costs and benefits, post Covid -19 pandemic using data from the calendar year (CY) 2020, for a hypothetical SCS. The original hypothetical site was modeled after Insite, a Vancouver SCS which is roughly 1,000 squared feet, has 13 booths for injections, and operates 18 hours per day (Irwin et al., 2017). Insite served 170,731 visits by 5,111 individuals in the year 2019 which are their most recent updated numbers (Insite, 2019). To keep this analysis as accurate as possible, I will be using the updated values even though they are not for the CY 2020. Additionally, this analysis will focus on all opioid related overdoses, not just heroin related overdoses like in the 2017 CBA. Heroin deaths have decreased since 2017 in Baltimore City while overall opioid related deaths have increased (MDH, 2021). For a more accurate estimate of the costs and benefits, I find that it would be helpful to include all overdoses related to all opioids since users who utilize SCS are not only abusing heroin; they are abusing all types of opioids. As another addition to the 2017 study, I will use the HHS valuation of a life in addition to the present value methodology that Irwin et al used in 2017 in order to apply standard CBA practice.

There are six measures of cost savings in the 2017 study: prevention of HIV, HCV, SSTI, and overdose deaths, reduced overdose-related medical costs, and referrals to medication-assisted treatment. In this extension, I will estimate the cost savings associated overdose mortality, overdose morbidity, and enrollment into medication-assisted treatment. The original 2017 study assesses each model’s dependence on important variables with a sensitivity analysis that I will replicate for the three variables of interest. For the sensitivity analysis, I will increase and decrease the chosen variable by 50% and report the outcome (Irwin et al., 2017). In addition to replicating the original sensitivity analysis, I will also conduct additional sensitivity analyses for fluctuations in median income as well as the high, central, and low values of a statistical life.

# **IV. Collected Data**

 To estimate the cost savings associated with averted overdoses as well as the benefits associated with enrollment into medication-assisted treatment, I will be using data from the Maryland Department of Health, Baltimore City Fire Department, and data from various cost reports related to established SCS around the world.

## **Overdose Mortality and Morbidity Data**

Each year the Maryland Department of Health produces a report to show the trends in the number of unintentional drug and alcohol related intoxication deaths that occur in the state during the evaluation period (Maryland Department of Health, 2021). The trends are examined by different indicators: age at the time of death, race and ethnicity, gender, place if death, and the substances related to death. Additional overdose related data was taken from the Baltimore City Fire Department: this data includes the location and date of clinically administered naloxone for the year 2020 (McCarren, 2022; Maryland, 2021). This data is being used to find the area with the highest concentration of naloxone distribution in Baltimore City, Maryland. The rationale for finding the highest concentration of naloxone distribution is to find where the most overdoses occur in Baltimore City as well as where the demand is the highest for emergency services. These rates will help find a 500 meter radius for the hypothetical SCS as well as help find the number of averted services that will be used to calculate cost savings for averted emergency service usage. The rationale behind using a 500 meter radius is to stay consistent with previous CBAs that look at the impacts of SCS.

# **V. Results**

## **Cost and Benefit Estimates**

To ensure that the estimates stay consistent with the previous 2017 CBA, I will be using the same cost estimate formulas as Irwin et al, however I will update the sensitivity analysis as well as the overdose mortality estimates. Overdose mortality has increased in recent years as have the values associated with the services used by PWUD. Additionally, the benefits related to emergency service utilization as well as the benefits associated with lives saved will be much higher since the previous study only accounted for heroin use while this study accounts for all opioids.

## ***Cost of the Facility***

The authors of the 2017 CBA estimated that it would cost roughly $1.5 million to open and operate a new SCS in Baltimore City that is the same size as the Insite facility in Canada (Irwin et al., 2017). I convert this cost to 2022 dollars using the inflation rate. This brings the cost to approximately $1.7 million for the facility. Just as Irwin et al. did, I will convert this $1.7 million into annual levelized payments over the span of a 25 year lifetime using the following equation:

$$C=\frac{iP}{1-(1+i)^{-N}}$$

where *C* is the levelized annual upfront cost, *I* is a standard 10% interest rate, *P* is the $1.7 million total upfront cost, and *N* is the estimated lifetime of the SCS (Irwin et al., 2017). This brings the annual upfront cost to $187,285.72. In addition to the annual levelized payment, Insite has an annual operating cost of $1.5 million (Irwin et al., 2017). Just as the authors of the previous study did, I will adjust this operating cost by multiplying Insite’s operating costs by an updated 9% cost of living adjustment from Vancouver to Baltimore (Irwin et al., 2017). This brings the annual operating costs to approximately $1.64 million. So, the total annual cost is equal to $1,822,285.72 (see Appendix A).

## ***Overdose Mortality Benefits: Present Value***

Due to HIPAA laws, I do not have access to the exact coordinates of incidents where emergency service providers clinically administered naloxone for the year of 2020. In order to compensate for this, I used data from the Baltimore City Fire Department Clinically Administered Naloxone Data set (Maryland, 2021). This data shows the number of incidents where naloxone was distributed as well as the zip code and date of occurrence. I used STATA to find the zip code with the highest concentration of clinically administered naloxone incidents for the year 2020 [figure 1]. As seen in figure 1, zip code 21217 has the highest concentration with 342 incidents of clinically administered naloxone in the year 2020. This accounts for 17.1% of all naloxone distributions in Baltimore city during the evaluation period. Zip code 21217 has approximately a one mile radius which is equal to 1,604.34 meters. In order to complete the cost estimate calculations, I needed to find a 500 meter radius to place my hypothetical SCS. Assuming that naloxone distribution incidents were spread evenly among the area of interest, I found that there are approximately 106 clinically administered naloxone incidents per every 500 meter radius in the zip code 21227. This accounts for 5.31% of all naloxone distributions in Baltimore City. Additionally, in 2020 in Baltimore City, there were 964 opioid related overdose fatalities (Maryland Department of Health, 2021). I assume that a conservative 50 opioid related fatalities happened in this 500 meter radius by assuming that the naloxone distribution is the same as the overdose distribution where roughly 5.31% of overdose fatalities happen within this 500 meter radius. This 5.31% is relatively consistent with the 2017 CBA where it was estimated that 5% of all distributions in Baltimore City happened in their estimated 500 meter radius (Irwin et al., 2017). This 0.31 percentage point increase is expected with how overdose trends have increased since 2017.

I calculate the present value of overdose deaths averted by the SCS (*S* OD) according to the following equations:

**𝑆OD=𝑟𝑛𝐷𝑉**

where *r* is the rate of overdose death reduction expected within 500 m, *n* is the 5.31% share of naloxone administrations concentrated within a 500 meter radius in Baltimore, *D* is the total number of overdose deaths in Baltimore, and *V* is the present value of a single life saved (Irwin et al., 2017). I calculate the present value of a life saved in Baltimore city by using the reported median annual income for Baltimore City residents, assuming that the average estimated number of years until retirement is 30 years, as well as using a discount rate of 3% (Irwin et al., 2017). This puts the value of a single life saved at $640,915. Using the above equation, this brings the total benefits from averted overdoses within a 500 meter radius of the hypothetical SCS to $8,431,503 annually with approximately 13.2 overdoses prevented annually. For variables and sources see appendix B.

## ***Overdose Mortality Benefits: Value of a Statistical Life***

In order to update the 2017 methodology and apply standard CBA practices to this analysis, I will also be using the value of a statistical life (VSL) used by the Department of Health & Human Services (HHS). In 2020 dollars, HHS updated the VSL estimates for future earnings and inflation using a 2013 baseline VSL. HHS estimated that the central VSL estimate (in 2020 dollars) for the year 2022 is approximately $11.6 million (2017). In 2022 dollars, this brings the VSL to $12.9 million. The next step for using VSL is to the adjust the values for real income growth over the span of the lifetime of the project using the following formula:

$$VSL\left(year y\right)= VSL\left(year x\right) × (1+real income growth rate)^{elasticity \* (y – x)}$$

Where the *VSL(year y)* is the VSL for the future year*, VSL(year x)* is the VSL in the specified dollar year (2022), real income growth is the predicted annual rate from the congressional budget office long-term growth forecast, and the income elasticity is the proportional change in VSL given a change in income, 1.0 using the HHS guidelines (U.S. Dept. HHS, 2017) (see appendix C).

To calculate the annual estimated benefits, I took the average VSL over the 25 year lifetime of the facility (approximately $14.4 million). To calculate the annual benefit associated with averted overdose deaths, I used the following formula:

**𝑆OD=𝑟𝑛𝐷𝑉\***

where *r* is the rate of overdose death reduction expected within 500 m, *n* is the 5.31% share of naloxone administrations concentrated within a 500 meter radius in Baltimore, *D* is the total number of overdose deaths in Baltimore, and *V\** is the average annual VSL. This brings the estimated average annual benefit to approximately $189.7 million dollars per year.

## ***Overdose Morbidity Benefits***

As shown through previous literature and studies, SCS decrease emergency service usage substantially. This comes from users having a safe place to use drugs, as well as the education they receive while in the facility on safe injection practices in order to prevent overdoses, skin infections, as well as viral, blood borne infections. Before the 2017 CBA conducted for Baltimore City, no other cost analyses have included overdose morbidity benefits in their cost saving estimates. However, these benefits should not be ignored when considering the averted health care costs that can be achieved.

It has been estimated that an ambulance is used for approximately 46% of all non-fatal overdoses in Baltimore City (Pollini et al., 2006). Over a six year evaluation period for a Medically Supervised Injection Centre (MSIC) in New South Wales, there were only a reported 13 ambulance transportations from the facility (National Centre, 2007). Meaning an overwhelming majority of incidents were able to be treated at MSIC without the intervention of outside emergency medical services.

In order to estimate the impact of averted emergency service use, I will use the exact number of injection visits that Insite had in the year 2019: 170,731 (Insite, 2019). In 2019, 1,314 of those injection visits resulted in an overdose which brings their onsite overdose rate to 0.77 percent. Irwin et al. reported that the rate of ambulance calls at MSIC was 0.79% which is the value I will be using. I used the following formula to estimate the cost savings associated with averted ambulance use in Baltimore City:

$$S\_{a}=Io\left(C\_{o}-C\_{i}\right) A$$

where *Sa* is the annual savings due to the SCS reducing ambulance calls for overdoses, *I* is the annual number of injections in the SCS, *o* is the per-injection rate of overdose, *Co* and *Ci* are the rates of overdose ambulance calls outside and inside the SCS, respectively, and *A* is the average cost of an overdose ambulance call (Irwin et al., 2017). This brings the estimated cost savings to $415,120 annually with approximately 593 averted incidents per year. The lower end cost for an ambulance ride in Baltimore City is $700 which is the value used in this assessment. While this savings is large, it is important to note that the ambulance call rate at a SCS is extremely low (less than one percent) and the ambulance call rate for an overdose that happens outside of the SCS is roughly 50%. This is going to give a large savings estimate. For variables and sources see appendix D.

Pollini et al. reported in their study that one third of ambulance calls related to an overdose resulted in a trip to the emergency department, and 12% of ambulance calls for an overdose resulted in an inpatient hospital stay (2006). To estimate the cost savings associated with averted emergency department visits and inpatient hospital stays, respectively, I will use the following formulas:

$$S\_{er}=Io\left(t\_{o}-t\_{i}\right) F$$

where *Se*r is the annual savings due to the SCS reducing emergency room visits for overdoses, *I* is the annual number of injections in the SCS, *o* is the rate of non-fatal overdose, *to* and *ti* are the rates of ER visit for overdose when the overdose occurs outside and inside the SCS, respectively, and *F* is the average cost of an overdose emergency room visit (Irwin et al., 2017). This brings the cost savings to $573,340 annually with approximately 423 averted instances per year. For variables and sources see appendix E.

The following formula is used for averted hospital stays:

$$S\_{h}=Io\left(a\_{o}-a\_{i}\right) E$$

where *Sh* is the annual savings due to the SCS reducing hospitalization for overdose, *I* is the annual number of injections in the SCS, *o* is the rate of non-fatal overdose, *ao* and *ai*are the rates of hospitalization for overdose when the overdose occurs outside and inside the SCS, respectively, and *E* is the average expense of an overdose hospital stay (Irwin et al., 2017). This brings the cost savings to $398,193.41 annually with approximately 147 averted instances per year. For variables and sources see appendix F.

## ***Medication-Assisted Treatment Benefits***

A secondary goal of an SCS would be to expose PWUD to rehabilitation and medication-assisted treatment programs. Using statistics from MSIC, a study conducted on retention rates for medication-assisted treatment for opiate dependence (Timko et al., 2015), and the 2017 CBA, I use the following formula to estimate the benefits associated with an increase in enrollment in MAT:

$$S\_{MAT}=Nr f\left(b-1\right)T$$

where *N* is the number of PWUD who use the SCS, *r* is the percent of SCS clients who have been shown to access treatment as a result of SCS referrals, *f* is a conservative 37% estimate for retention in medication-assisted treatment, *b* is the average cost-benefit ratio Irwin et al. reported for medication-assisted treatment (2007), and *T* is the annual cost of treatment. It is important to note that I am using a much more conservative value for retention in medication-assisted treatment programs since through my own research, I found the range to be between 37% and 95%. Additionally, the average yearly cost for medication-assisted treatment has increased since the 2017 study was published, so I have updated the cost as well. This brings the total cost savings to $943,113 annually. For variables and sources see appendix G.

## **Sensitivity Analysis**

Variables related to overdose mortality, morbidity, and medication-assisted treatment enrollment fluctuate yearly so in order to account for these fluctuations and increase the validity of my estimates I performed a sensitivity analysis on the variables of interest. To do this I created upper and lower bound estimates by increasing and decreasing the variables by 50 percent. Increasing and decreasing these values by 50 percent gives the ability to show that even with sharp increases and decreases, SCS can still provide positive net benefits.

## ***Overdose Mortality: Present Value***

The original calculation estimated that an SCS in Baltimore City would prevent 13.2 overdoses annually which came out to an overall benefit of $8,431,503. To perform this sensitivity analysis for the upper bound, I increased the number of overdose deaths in Baltimore City to 1,446 deaths annually. This calculation estimated that 19.7 fatal overdoses would be prevented with an overall benefit of $12,647,255 annually for the upper bound. As for the lower bound estimate, the number of deaths related to opioids was decreased to 482 deaths annually. This calculation estimated that 6.6 fatal overdoses would be prevented annually which yielded $4,215,752 in benefits per year. See appendix H.

To further explore how the impact of an averted overdose, I decided to decrease the median income per capita in Baltimore City by 25% and 75% to show just how much the value of a life saved can fluctuate while still giving positive net benefits. As seen in Table 1, the net benefits based on 13.2 averted overdoses ranges from approximately $1 million to $8.4 million.

|  |
| --- |
| ***Table 1. Present Value of an averted overdose with Median Income Fluctuation for Baltimore City*** |
| **Income** |  **Annual Benefit**  |
| Median Income Per Capita in Baltimore City | $8,431,503.03 |
| Median Income Per Capita in Baltimore City decreased by 50% | $6,323,627.27 |
| Median Income Per Capita in Baltimore City decreased by 75% | $1,053,938  |

## ***Overdose Mortality: Value of a Statistical Life***

Following the guidelines of The Department of HHS, I will also conduct a sensitivity analysis using a low, central, and high value that is given by the department (2017). I will adjust the values to 2022 numbers in order to get the most accurate estimation, and use the baseline calculation for the number of averted fatal overdoses: 13.2 per year. For the lower bound, the average VSL is equal to approximately $6.7 million per year (U.S. Dept. HHS, 2017). The upper bound average VSL is approximately $21.9 million per year (U.S. Dept.HHS, 2017). This sensitivity analysis gives a range of benefits estimating from approximately $2.3 billion to $7.5 billion per year.

## ***Overdose Morbidity***

The baseline calculation for overdose morbidity yielded an annual savings of $1,386,654 consisting of savings from 593 averted ambulance deployments, 423.44 emergency room visits, and 147.37 days of inpatient hospitalizations related to overdoses. The individual savings of those three categories was $415,120, $573,340, and $398,193, respectively.

 The sensitivity analysis for averted ambulance deployments gave an upper bound of 889.5 deployments and a lower bound of 296.5 deployments totaling to annual savings of $622,680 and $207,560, respectively. See table 2 for the breakdown.

The sensitivity analysis for averted emergency department visits gave an upper bound of 635.16 visits and a lower bound of 211.72 visits totaling to annual savings of $860,011 and $286,670, respectively. See table 2 for the breakdown.

The sensitivity analysis for averted inpatient hospital stays gave an upper bound of 221.05 days and a lower bound of 73.68 days totaling to annual savings of $597,290 and $199,097, respectively. See table 2 for the breakdown and see appendix I for variables and sources.

**Table 2. Overdose Morbidity Sensitivity Analysis**

|  |  |  |
| --- | --- | --- |
|   |  **Upper Bound**  |  **Lower Bound**  |
| **Overdose Morbidity** |   |   |
| ***Averted Ambulance Deployments*** | $622,680.46  | $207,560.15  |
| ***Averted Emergency Room Visits*** | $860,010.51  | $286,670.17  |
| ***Averted Inpatient Hospital Stay Days*** | $597,290.11  | $199,096.70  |

## ***Medication-Assisted Treatment***

The baseline calculation for medication-assisted treatment benefits yielded an annual savings of $943,123 estimating that 44.9 individuals would enroll and stay in medication-assisted treatment. The sensitivity analysis for medication-assisted treatment enrollment gave an upper bound of 67.4 PWUD enrolling into medication-assisted treatment and a lower bound of 22.5 PWUD enrolling in medication-assisted treatment with an estimated savings of $1,414,684 and $471,561, respectively. For variables and sources see appendix J.

## **Overall Results using the Present Value of a Life**

### ***Median Per Capita Income***

With the yearly cost of the facility totaling up to $1,822,286 (including the annual levelized payment as well as the operating costs), the annual savings for the baseline calculation estimates using the present value of a life add up to $10,761,280. According to this estimate, for every $1 spent, the SCS yields $5.91 in savings for a total of $8,938,994 in annual net benefits (see table 3). Using a 3% discount rate over the span of 25 years yields a net present value of $124,440,617 in benefits. This calculation estimates that an SCS would prevent 13.2 fatal overdoses, 593 ambulance deployments, 423.4 emergency room visits, and 147.37 inpatient hospital days annually. Additionally, 44.9 PWUD would enroll and complete medication-assisted treatment.

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| ***Table 3. Estimated Baseline Results using the Present Value of a Life*** |  |  |
| **Estimated Savings** | **Estimated Costs**  | **Benefit to Cost Ratio** | **Net Benefits - Annually** | **Net Benefits - Total** |
| $10,761,279.68  | $1,822,285.72  | *$5.91* | **$8,938,993.95**  | **$235,555,816.11** |

For the upper bound cost and benefit estimates using the present value of a life, the yearly savings add up to $14,364,111 compared to the same facility costs. This makes the net present value for the upper bound $218,392,655 in total benefits. This calculation estimates that for every $1 spent, the SCS yields $8.88 in savings (see table 4). This calculation estimates that an SCS would prevent 19.7 fatal overdoses, 889.5 ambulance deployments, 631.16 emergency room visits, and 221.05 inpatient hospital days annually. Additionally, 67.4 PWUD would enroll and complete medication-assisted treatment.

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| ***Table 4. Estimated Upper Bound Results using the Present Value of a Life*** |
| **Estimated Savings** | **Estimated Costs**  | **Benefit to Cost Ratio** | **Net Benefits - Annually** | **Net Benefits - Total** |
| $16,186,396.69  | $1,822,285.72  | $8.88  | **$14,364,110.97**  | **$369,199,589.26** |

For the lower bound cost and benefit estimates using the present value of a life, the yearly savings add up to $3,573,178 compared to the same facility costs. This makes the net present value for the lower bound $30,488,578 in total benefits. This calculation estimates that for every $1 spent, the SCS will yield $2.96 in savings (see table 5). This calculation estimates that an SCS would prevent 6.6 fatal overdoses, 296.5 ambulance deployments, 211.72 emergency room visits, and 73.68 inpatient hospital days annually. Additionally, 22.5 PWUD would enroll and complete medication-assisted treatment.

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| ***Table 5. Estimated Lower Bound Results using the Present Value of a Life*** |
| **Estimated Savings** | **Estimated Costs**  | **Benefit to Cost Ratio** | **Net Benefits - Annually** | **Net Benefits - Total** |
| $5,395,465.56  |  $ 1,822,285.72  | $2.96 | **$3,573,179.84**  | **$101,912,042.78** |

### **Median Income Fluctuations**

 As a part of this sensitivity analysis, I wanted to account for all possible scenarios where a variable may fluctuate, including the level of income for PWUD. When using the present value of a life to estimate the benefits associated with averting a fatal overdose, it is important to note that the level of income for the average user in Baltimore City may be much lower than the median income of the City as a whole. According to DeCuir et al, injection drug use and needle sharing is most common in disadvantaged neighborhoods (2018). This implies that the people who need access to SCS are most likely coming from a lower socioeconomic status. Safe consumption sites are meant to bridge the gap of access to substance use disorder care meaning they target marginalized groups of people. In order to show just how valuable an SCS can be, I decided to do a sensitivity analysis where I lowered the median income by 50% and 75% to show that even with a very conservative estimate for the value of a life, the SCS will still bring in positive net benefits. While the value of a life should not fluctuate based on socioeconomic status, level of income, or health status; this sensitivity analysis is purely used to show that no matter how you calculate the value of a life, the benefits are still positive.

 For the 50% decreased estimate, the median income per capita is decreased to $16,350 bringing the present value of an averted overdoses to approximately $6.3 million per year. This is based on the original estimation of 13.2 averted fatal overdoses per year. According to this estimate, for every $1 spent, the SCS yields $4.75 in benefits for a total of $6,831,118 in annual net benefits. Using a 3% discount rate over the span of 25 years yields a net present value of $118,951,270 in benefits (see table 6).

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| ***Table 6. Estimated 50% Decrease in Median Income Results using the Present Value of a Life*** |
| **Estimated Savings** | **Estimated Costs**  | **Benefit to Cost Ratio** | **Net Benefits - Annually** | **Net Benefits - Total** |
| $8,653,403.92  | $1,822,285.72  | $4.75 | **$6,831,118.20**  | **$118,951,270.13** |

For the 75% decreased estimate, the median income per capita is decreased to $8,175 bringing the present value of an averted overdoses to approximately $1.1 million per year. This is based on the original estimation of 13.2 averted fatal overdoses per year. According to this estimate, for every $1 spent, the SCS yields $1.86 in benefits for a total of $1,561,429 in annual net benefits. Using a 3% discount rate over the span of 25 years yields a net present value of $27,189,390 in benefits (see table 7).

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| ***Table 7. Estimated 75% Decrease in Median Income Results using the Present Value of a Life*** |
| **Estimated Savings** | **Estimated Costs**  | **Benefit to Cost Ratio** | **Net Benefits - Annually** | **Net Benefits - Total** |
| $3,383,714.53  | $1,822,285.72  | $1.86 | **$1,561,428.81**  | **$27,189,390.47** |

## **Overall Results using the Value of a Statistical Life**

 As previously stated, using the VSL is an improvement upon the 2017 study in order for it to be up to HHS standards for CBA’s. When using the VSL, the estimated net benefits are much higher compared to the estimates when using the present value of a life. The annual estimated benefit for overdose mortality increases to $189.7 million. According to this estimate, for every $1 spent on SCS, the site yields $105.37 in benefits for a total of $190,192,824 in annual net benefits. Using a 3 percent discount rate over the span of 25 years for overdose morbidity benefits and medication-assisted treatment benefits; and using HHS guidelines for VSL, the SCS yields a net present value of $4,940,655,681 in benefits. See table 8.

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| ***Table 8. Estimated Results using the Value of a Statistical Life*** |
| **Savings** | **Costs**  | **Benefit to Cost Ratio** | **Net Benefits - Annually** | **Net Benefits - Total** |
| $192,015,109.99  | $1,822,285.72  | *$105.37* | **$190,192,824.27**  | **$4,940,655,681.40** |

For the upper bound cost and benefit estimates using the VSL, the yearly benefits add up to $289,250,721 compared to the same facility costs. This makes the net present value for the upper bound $7,516,160,985 in total benefits. This calculation estimates that for every $1 spent, the SCS yields $159.73 in benefits. See table 9.

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| ***Table 9. Estimated Results using the Upper Value of a Statistical Life*** |
| **Savings** | **Costs**  | **Benefit to Cost Ratio** | **Net Benefits - Annually** | **Net Benefits - Total** |
| $291,073,006.29  | $1,822,285.72  | $159.73 | **$289,250,720.57**  | **$7,516,160,985.21** |

For the lower bound cost and benefit estimates using the VSL, the yearly benefits add up to $89,027,313 compared to the same facility costs. This makes the net present value for the lower bound $2,310,352,392 in total benefits. This calculation estimates that for every $1 spent, the SCS will yield $49.85 in benefits. See table 10.

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| ***Table 10. Estimated Results using the Lower Value of a Statistical Life*** |
| **Savings** | **Costs**  | **Benefit to Cost Ratio** | **Net Benefits - Annually** | **Net Benefits - Total** |
| $90,849,598.88  | $1,822,285.72  | $49.85 | **$89,027,313.15**  | **$2,310,352,392.41** |

# **VI. Discussion**

Compared to Irwin et al.’s CBA conducted in 2017 for Baltimore City, this analysis finds the overall benefits to be 36% higher than their estimate when using the same cost method estimates. Using the VSL, this analysis finds the overall benefits to be 2322% higher. It is important to note that while the 2017 CBA had six benefit estimate categories compared to the four this analysis uses, Irwin et al. (2017), only conducted their estimates with respect to heroin use in Baltimore City, not all opioid use. They also only used the present value of a life which can be seen as an outdated practice due to the fact that this estimate values people of lower socioeconomic status as worth less than the average person. This is why it was important to include the VSL calculation even though it inflates the results. Alongside of including the VSL, I also account for income fluctuations in the present value of a life to give readers a comprehensive view of how valuable an SCS can be no matter how you calculate the value of a life saved.

The number of people that are projected to enter into, and complete, medication-assisted treatment in the Irwin et al. study is much higher than what I have estimated. However, this is due to the fact that I used a much more conservative estimate in the percent of PWUD who will complete treatment.

Due to the social programs already put in place in Baltimore City, I found that it may be redundant to estimate the benefits of a reduction in needle sharing related infections and SSTI like Irwin et al. did (2017). Including those categories in my CBA would have possibly produced an over estimation in net benefits. While a SCS in Baltimore City would aid the current social programs put in place (like needle disposal and distribution programs), the estimated benefits may not accurately reflect the impact of the SCS alone.

As for the differences in the number of averted instances for each category in the overdose morbidity section, the numbers used in the 2017 study had roughly the same number of users served, but 2017 had a much lower overdose rate (Insite, 2019). The overdose rate at Insite has increased by 0.65 percentage points from 0.113% in 2017 to 0.77% in 2019. This steep increase in the overdose rate at Insite caused the number of estimated ambulance deployments, emergency department visits, and inpatient hospital stay days averted to increase by approximately three times. The 2017 analysis estimated that the SCS would save 5.9 lives while I estimated 13.2 lives being saved, however this difference is expected since overdose rates in Baltimore City have increase since 2017 and this study accounts for overdoses related to all opioid use in 2020.

There are a number of limitations when it comes to this CBA. Due to the HIPAA laws, the overdose mortality and morbidity results are to be seen as estimates rather than fact. As previously explained, it is impossible to know exactly where each fatal and non-fatal overdose occurred in the city of Baltimore which is why I had to assume they were evenly spread across their respective zip codes. This is why the sensitivity analysis is an important part of the CBA. Additionally the associated costs for overdose morbidity are conservative estimates. This analysis would benefit from exact cost estimate reports for ambulance deployments, emergency room visits, and inpatient hospital stays due to an overdose in order to get a more accurate idea of the overall benefits.

# **VII. Conclusion**

Since the beginning of the Covid -19 pandemic, there has not been an updated CBA for a hypothetical safe consumption site in Baltimore City. Additionally, there has not been a cost analysis conducted that takes into account all forms of opioid use in Baltimore City, and uses VSL to estimate benefit. This CBA finds that for every $1 spent on the SCS, it will generate $5.91 in savings when using the present value of a life, however, when using VSL, this analysis finds that for every $1 spent, the SCS will generate $105.37 in benefits. All of the scenarios analyzed for this hypothetical SCS show positive net benefits ranging from roughly $130 million annually to $289 million annually. This analysis also shows that the SCS would prevent 13.2 fatal overdoses, 593 ambulance deployments, 423.4 emergency room visits, and 143.4 days of inpatient hospital stays related to opioid use. Additionally, 44.9 PWUD would successfully enroll into medication-assisted treatment. Overall, according to this analysis a SCS in Baltimore City has the potential to save lives and save costs.

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# **Appendix**

**Appendix A**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Description** | **Value** | **Source** |
| *C* | annual levelized payment | **$ 187,285.72** | (Irwin et al., 2017) & calculations by author |
| *i* | standard interest rate | 10% | (Irwin et al., 2017) |
| *P* | total upfront cost adjusted for inflation -in $ | $1,700,000 | (Irwin et al., 2017) |
| *N* | lifetime of the facility -in years | 25 | (Irwin et al., 2017) |

**Appendix B**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Description** | **Value** | **Source** |
| *SOD* | value of averted overdoses | **$8,431,503.03** | (Irwin et al., 2017) |
| *r* | rate of overdose death reduction expected within 500 m | 25.70% | (Irwin et al., 2017) |
| *n* | share of naloxone administrations concentrated within a 500 meter radius in Baltimore | 5.31% | Calculated by author |
| *D* | total number of opioid related overdose deaths in Baltimore | 964 | (Maryland Department of Health, 2021) |
| *V* | value of a single life saved | $640,914.83 | Calculated by author |
| *N* | average number of years until retirement | 30 | (Irwin et al., 2017) |
| *W* | median wage for Baltimore City | $32,699 | Census Bureau |
| *R* | discount rate | 3% |  |

**Appendix C**

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Low Estimate** | **Central Estimate** | **High Estimate** |
| 2022 | $6,059,470.93 | $12,984,580.56 | $19,765,417.08 |
| 2023 | $6,107,946.70 | $13,088,457.21 | $19,923,540.42 |
| 2024 | $6,156,810.27 | $13,193,164.87 | $20,082,928.74 |
| 2025 | $6,206,064.75 | $13,298,710.19 | $20,243,592.17 |
| 2026 | $6,255,713.27 | $13,405,099.87 | $20,405,540.91 |
| 2027 | $6,305,758.98 | $13,512,340.67 | $20,568,785.24 |
| 2028 | $6,356,205.05 | $13,620,439.39 | $20,733,335.52 |
| 2029 | $6,407,054.69 | $13,729,402.91 | $20,899,202.20 |
| 2030 | $6,458,311.13 | $13,839,238.13 | $21,066,395.82 |
| 2031 | $6,509,977.62 | $13,949,952.04 | $21,234,926.99 |
| 2032 | $6,562,057.44 | $14,061,551.65 | $21,404,806.40 |
| 2033 | $6,614,553.90 | $14,174,044.06 | $21,576,044.85 |
| 2034 | $6,667,470.33 | $14,287,436.42 | $21,748,653.21 |
| 2035 | $6,720,810.09 | $14,401,735.91 | $21,922,642.44 |
| 2036 | $6,774,576.57 | $14,516,949.80 | $22,098,023.58 |
| 2037 | $6,828,773.18 | $14,633,085.39 | $22,274,807.77 |
| 2038 | $6,883,403.37 | $14,750,150.08 | $22,453,006.23 |
| 2039 | $6,938,470.60 | $14,868,151.28 | $22,632,630.28 |
| 2040 | $6,993,978.36 | $14,987,096.49 | $22,813,691.32 |
| 2041 | $7,049,930.19 | $15,106,993.26 | $22,996,200.85 |
| 2042 | $7,106,329.63 | $15,227,849.21 | $23,180,170.46 |
| 2043 | $7,163,180.27 | $15,349,672.00 | $23,365,611.82 |
| 2044 | $7,220,485.71 | $15,472,469.38 | $23,552,536.72 |
| 2045 | $7,278,249.59 | $15,596,249.13 | $23,740,957.01 |
| 2046 | $7,336,475.59 | $15,721,019.12 | $23,930,884.67 |
| 2047 | $7,395,167.40 | $15,846,787.28 | $24,122,331.74 |
| **Total** | **$174,357,226** | **$373,622,626** | **$568,736,664** |
| **Total Benefits** | **$2,301,515,377.87** | **$4,931,818,666.86** | **$7,507,323,970.67** |

**Appendix D**

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| --- | --- | --- | --- |
| **Variable** | **Description** | **Value** | **Source** |
| *Sa* | annual savings due to the SCS reducing ambulance calls for overdose | **$415,120.30** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | [(Insite, 2019)](http://www.vch.ca/public-health/harm-reduction/supervised-consumption-sites/insite-user-statistics) |
| *o* | the per-injection rate of overdose | 0.77% | [(Insite, 2019)](http://www.vch.ca/public-health/harm-reduction/supervised-consumption-sites/insite-user-statistics) |
| *C0* | overdose ambulance calls outside | 45.90% | (Pollini et al., 2006) |
| *Ci* | overdose ambulance calls inside | 0.79% | (Irwin et al., 2017) |
| *A* | average cost of an overdose ambulance call | $700 | [(Emergency Medical, 2022)](https://www.baltimorecountymd.gov/departments/fire/ems/#:~:text=The%20fees%20are%20%24700%20or,%2410%20per%20mile%20of%20transport.) |

**Appendix E**

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| --- | --- | --- | --- |
| **Variable** | **Description** | **Value** | **Source** |
| *Ser* | annual savings due to the SCS reducing emergency room visits for overdose | **$573,340.34** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | [(Insite, 2019)](http://www.vch.ca/public-health/harm-reduction/supervised-consumption-sites/insite-user-statistics) |
| *o* | the per-injection rate of overdose | 0.77% | [(Insite, 2019)](http://www.vch.ca/public-health/harm-reduction/supervised-consumption-sites/insite-user-statistics) |
| *t0* | rates of ER visit for overdose when the overdose occurs outside SCS | 33% | Pollini et al., 2006) |
| *ti* | using ambulance call rate as an upper bound | 0.79% | (Irwin et al., 2017) |
| *F* | the average cost of an overdose emergency room visit | $1,354 | [(Rienzi, 2014)](https://hub.jhu.edu/gazette/2014/september-october/focus-baltimore-city-ems/) |

**Appendix F**

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| --- | --- | --- | --- |
| **Variable** | **Description** | **Value** | **Source** |
| *Sh* | annual savings due to the SCS reducing hospitalizations for overdose | **$398,193.41** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | [(Insite, 2019)](http://www.vch.ca/public-health/harm-reduction/supervised-consumption-sites/insite-user-statistics) |
| *o* | the per-injection rate of overdose | 0.77% | [(Insite, 2019)](http://www.vch.ca/public-health/harm-reduction/supervised-consumption-sites/insite-user-statistics) |
| *a0* | rates of hospitalization for overdose when the overdose occurs outside SCS | 12% | Pollini et al., 2006) |
| *ai* | using ambulance call rate as an upper bound | 0.79% | (Irwin et al., 2017) |
| *E* | the average cost of an overdose emergency room visit | $2,702 | [(Ellison, n.d.)](https://www.beckershospitalreview.com/finance/average-hospital-expenses-per-inpatient-day-across-50-states.html) |

**Appendix G**

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| **Variable** | **Description** | **Value** | **Source** |
| *Smat* | annual health care and crime savings | **$943,122.60** | (Irwin et al., 2017) |
| *N* | number of monthly unique Insite injection room clients | 2100 | (Irwin et al., 2017) |
| *r* | %of SCS users who access MAT as a result of SCS referrals | 5.78% | (MSIC, 2003) |
| *f* | treatment retention factor (low and high end 37% -94%) | 37% | (Timko, et al., 2015) |
| *b* | cost benefit ratio for MAT | 4.5 | (Irwin et al., 2017) |
| *T* | average cost of 1 year of MAT | $6,000.00 | (Thomas, 2022) |

**Appendix H**

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| **Upper Bound (Increased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *SOD* | value of averted overdoses | **$12,647,254.54** | (Irwin et al., 2017) |
| *r* | rate of overdose death reduction expected within 500 m | 25.70% | (Irwin et al., 2017) |
| *n* | share of naloxone administrations concentrated within a 500 meter radius in Baltimore | 5.31% | Calculated by author |
| *D* | total number of opioid related overdose deaths in Baltimore | 1446 |  |
| *V* | value of a single life saved | $640,914.83 | Calculated by author |
| *N* | average number of years until retirement | 30 | (Irwin et al., 2017) |
| *W* | median per capita income | $32,699 | Census Bureau |
| *R* | discount rate | 3% |  |
|  |  |  |  |
|  |  |  |  |
| **Lower Bound (Decreased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *SOD* | value of averted overdoses | **$4,215,751.51** | (Irwin et al., 2017) |
| *r* | rate of overdose death reduction expected within 500 m | 25.70% | (Irwin et al., 2017) |
| *n* | share of naloxone administrations concentrated within a 500 meter radius in Baltimore | 5.31% | Calculated by author |
| *D* | total number of opioid related overdose deaths in Baltimore | 482 |  |
| *V* | value of a single life saved | $640,914.83 | Calculated by author |
| *N* | average number of years until retirement | 30 | (Irwin et al., 2017) |
| *W* | median per capita income | $32,699 | Census Bureau |
| *R* | discount rate | 3% |  |

**Appendix I**

|  |
| --- |
| **Upper Bound for Averted Ambulance Deployments (Increased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *Sa* | annual savings due to the SCS reducing ambulance calls for overdose | **$622,680.46** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | (Insite, 2019) |
| *o* | the per-injection rate of overdose | 0.77% | (Insite, 2019) |
| *C0* | overdose ambulance calls outside | 45.90% | Pollini et al., 2006) |
| *Ci* | overdose ambulance calls inside | 0.79% | (Irwin et al., 2017) |
| *A* | average cost of an overdose ambulance call | $700 | (Emergency Medical, 2022) |
|  |  |  |  |
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| **Lower Bound for Averted Ambulance Deployments (Decreased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *Sa* | annual savings due to the SCS reducing ambulance calls for overdose | **$207,560.15** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | (Insite, 2019) |
| *o* | the per-injection rate of overdose | 0.77% | (Insite, 2019) |
| *C0* | overdose ambulance calls outside | 45.90% | Pollini et al., 2006) |
| *Ci* | overdose ambulance calls inside | 0.79% | (Irwin et al., 2017) |
| *A* | average cost of an overdose ambulance call | $700 | (Emergency Medical, 2022) |
|  |  |  |  |
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|  |  |  |  |
| **Upper Bound for Averted Emergency Room Visits (Increased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *Ser* | annual savings due to the SCS reducing emergency room visits for overdose | **$860,010.51** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | (Insite, 2019) |
| *o* | the per-injection rate of overdose | 0.77% | (Insite, 2019) |
| *t0* | rates of ER visit for overdose when the overdose occurs outside SCS | 33% | (Pollini et al., 2006) |
| *ti* | using ambulance call rate as an upper bound | 0.79% | (Irwin et al., 2017) |
| *F* | the average cost of an overdose emergency room visit | $1,354 | (Rienzi, 2014) |
|  |  |  |  |
|  |  |  |  |
| **Lower Bound for Averted Emergency Room Visits (Decreased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *Ser* | annual savings due to the SCS reducing emergency room visits for overdose | **$286,670.17** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | (Insite, 2019) |
| *o* | the per-injection rate of overdose | 0.77% | (Insite, 2019) |
| *t0* | rates of ER visit for overdose when the overdose occurs outside SCS | 33% | Pollini et al., 2006) |
| *ti* | using ambulance call rate as an upper bound | 0.79% | (Irwin et al., 2017) |
| *F* | the average cost of an overdose emergency room visit | $1,354 | (Rienzi, 2014) |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Upper Bound for Averted Inpatient Hospital Stay Days (Increased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *Sh* | annual savings due to the SCS reducing hospitalizations for overdose | **$597,290.11** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | (Insite, 2019) |
| *o* | the per-injection rate of overdose | 0.77% | (Insite, 2019) |
| *a0* | rates of hospitalization for overdose when the overdose occurs outside SCS | 12% | Pollini et al., 2006) |
| *ai* | using ambulance call rate as an upper bound | 0.79% | (Irwin et al., 2017) |
| *E* | the average cost of an overdose emergency room visit | $2,702 | (Ellison, n.d.) |
|  |  |  |  |
|  |  |  |  |
| **Lower Bound for Averted Inpatient Hospital Stay Days (Decreased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *Sh* | annual savings due to the SCS reducing hospitalizations for overdose | **$199,096.70** | (Irwin et al., 2017) |
| *I* | annual number of injections in the SCS | 170,731 | (Insite, 2019) |
| *o* | the per-injection rate of overdose | 0.77% | (Insite, 2019) |
| *a0* | rates of hospitalization for overdose when the overdose occurs outside SCS | 12% | Pollini et al., 2006) |
| *ai* | using ambulance call rate as an upper bound | 0.79% | (Irwin et al., 2017) |
| *E* | the average cost of an overdose emergency room visit | $2,702 | (Ellison, n.d.) |

**Appendix J**

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| --- |
| **Upper Bound (Increased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *Smat* | annual health care and crime savings | **$1,414,683.90** | (Irwin et al., 2017) |
| *N* | number of monthly unique Insite injection room clients | 2100 | (Irwin et al., 2017) |
| *r* | %of SCS users who access MAT as a result of SCS referrals | 5.78% | (MSIC, 2003) |
| *f* | treatment retention factor (low and high end 37% -94%) | 37% | (Timko, et al., 2015) |
| *b* | cost benefit ratio for MAT | 4.5 | (Irwin et al., 2017) |
| *T* | average cost of 1 year of MAT | $6,000.00 | (Thomas, 2022) |
|  |  |  |  |
|  |  |  |  |
| **Lower Bound (Decreased 50%)** |
| **Variable** | **Description** | **Value** | **Source** |
| *Smat* | annual health care and crime savings | **$471,561.30** | (Irwin et al., 2017) |
| *N* | number of monthly unique Insite injection room clients | 2100 | (Irwin et al., 2017) |
| *r* | %of SCS users who access MAT as a result of SCS referrals | 5.78% | (MSIC, 2003) |
| *f* | treatment retention factor (low and high end 37% -94%) | 37% | (Timko, et al., 2015) |
| *b* | cost benefit ratio for MAT | 4.5 | (Irwin et al., 2017) |
| *T* | average cost of 1 year of MAT | $6,000.00 | (Thomas, 2022) |