University of Virginia | Frank Batten School of Leadership and Public Policy

# Health, Addiction, and Crisis

## The Overdose Epidemic in The City of Richmond

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**Prepared for the Office of Mayor Levar M. Stoney**

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## Client

This report was prepared for the Mayor's Office in Richmond, Virginia.

## Disclaimer

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

## Honor Pledge

On my honor, as a student, I have neither given nor received aid on this assignment.

Jessica Meyers

## Glossary

Opioids: Opioids are natural, synthetic, or semi-synthetic chemicals that interact with nerve cells to reduce pain and activate reward centers in the brain. The most common opioids are heroin, fentanyl, tramadol (brand name: Ultram), methadone, oxycodone (brand name: Oxycontin), hydrocodone (brand name: Vicodin), codeine, and morphine (Centers for Disease Control and Prevention, 2021a).

Opioid Use Disorder (OUD): OUD is a chronic use of opioids that impacts a person's daily life. It includes a strong desire to consume opioids, increased tolerance, and withdrawal symptoms when use is stopped (Dydyk et al., 2021).

Lethal Dose: The amount of a substance that will cause death.

Fentanyl: Fentanyl is an incredibly potent, synthetic opioid (National Institute on Drug Abuse, 2021). Fentanyl's lethal dose is just 2% of heroin's lethal dose. It contributes to 9 out of 10 fatal overdoses in Richmond.

Respiratory Depression: Opioid overdoses become fatal when the victim is unable to regulate breathing for extended periods of time. This inability to breathe is called respiratory depression.

Naloxone (name brand: Narcan): A life-saving medication (often administered as a nasal spray or injection) that reverses overdose symptoms for 20-90 minutes. This provides crucial time for overdose victims to be taken to the Emergency Department (Hawk et al., 2015).

Overdose Education and Naloxone Distribution (OEND): OEND programs educate people at risk of overdose and bystanders on how to prevent, recognize, and respond to an overdose. These programs distribute naloxone and teach participants how to administer the drug (Walley et al., 2013).

## Acronyms

**OEND**: Opioid Overdose Education and Naloxone Distribution
**OUD**: Opioid Use Disorder
**SUD**: Substance Use Disorder
**HHS**: Department of Health and Human Services
**DBHDS**: Department of Behavioral Health and Developmental Sciences
**RBHA**: Richmond Behavioral Health Authority
**VDH**: Virginia Department of Health
**RCHD**: Richmond City Health District
**VCU**: Virginia Commonwealth University
**ER/ED**: Emergency Room/Department
**SAARA**: Substance Abuse and Addiction Recovery Alliance of Virginia
**MAT**: Medication-Assisted Treatment
**OBOT**: Office Based Opioid Treatment
**RAA**: Richmond Ambulance Authority

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## Executive Summary

More than 200 people have died of a fatal overdose every year since 2020 in Richmond. Even when accounting for population, Richmond's rate is staggeringly high. The City's 2020 fatal overdose rate per 100,000 was 70% higher than the Virginia average (Virginia Department of Health Medical Examiner, 2021). This is a significant disproportionality that few other areas in the state are experiencing. Further, the overdose epidemic shows no signs of stopping. Between 2019 and 2020, there was a 150% increase in overdose deaths (Thrasher, 2021). Overall, this tragedy costs the City of Richmond more than $2 billion every year (Luo, 2021). Without effective policy action, fatal overdose rates will continue to rise, and more lives will be lost.

The cause of high overdose rates can be attributed to practically one substance: fentanyl. 9 out of every 10 fatal overdoses in Richmond are caused or contributed to by fentanyl (Virginia Department of Health Medical Examiner, 2021). Those who die of an overdose in Richmond are more likely to be male, Black, and over the age of 25 (Karr, 2021; U.S. Census Bureau, 2020b). Most overdoses in 2021 were concentrated in Gilpin, East End, and Southside by the Midlothian Turnpike and along I-95 (Richmond Ambulance Authority, 2021).

Naloxone is an important tool in reducing fatal overdose rates. Naloxone (brand name: Narcan) is an opioid antagonist that swiftly reverses respiratory depression caused by overdose. The drug provides crucial time for overdose victims to be taken to the Emergency Department for medical attention (Hawk et al., 2015). The antagonist's ability to block opioid receptors means it can reverse overdose symptoms caused by fentanyl, the major driver of Richmond City's high fatal overdose rate. Community-based naloxone distribution, called overdose education and naloxone distribution (OEND) programming, leverages naloxone's antidote capability. OEND programs educate people at risk of overdose and bystanders on how to prevent, recognize, and respond to an overdose. These programs distribute naloxone to participants and teaches them how to administer the drug (Walley et al., 2013). OEND programming is an evidence-based strategy to save lives and reduce fatal overdoses (Davidson et al., 2015; Doe-Simkins et al., 2009, 2014; Naumann et al., 2019; Walley et al., 2013; Wheeler et al., 2015; Yokell et al., 2011).

This report thus considers four options to expand OEND programming in Richmond: 1) A naloxone grant program, 2) Naloxone vending machines in areas of high overdose rates, 3) Naloxone training for all City Hall staff, and 4) Expanded OEND programming for those released from Richmond Jail. Each alternative is evaluated based on cost-effectiveness, administrative burden, and equity. I recommend the Mayor's Office implement the naloxone grant program as it is the most cost-effective, has the lowest administrative burden, and has high to moderately high targeting towards those that face disproportionate risk of overdose relative to the compared alternatives. The grant alternative will strengthen existing naloxone distribution infrastructure and leverage existing community buy-in. The implementation of this program will include a diversion of funds from the Health Equity Fund. A City Hall staff lead and a point person from the Richmond Opioid Task Force will work together to carry out the grant process.

It should be noted that one policy intervention alone will not be enough to reverse the opioid crisis in Richmond. Rather, the naloxone grant program is the most practical place for the city to start. I strongly encourage the Mayor's Office to explore additional policy interventions in the naloxone and addiction prevention/recovery space. The Mayor's Office must strategically leverage the knowledge, connections, and know-how of stakeholders on the Richmond Opioid Task Force and other harm reduction/recovery organizations to identify future paths for intervention.

## Problem Statement

215 Richmond residents died of a fatal overdose in 2020. In 2021, this rate is expected to be even higher at 244 deaths (Virginia Department of Health Medical Examiner, 2021). These numbers are not just reflective of a high population in Richmond. Richmond makes up 2.5% of the Virginia population yet represents over 9% of Virginia's overdoses (U.S. Census Bureau, 2020b; Virginia Department of Health Medical Examiner, 2021). Between 2019 and 2020, there was a 150% increase in overdose deaths (Thrasher, 2021). Overdose deaths even outpace homicides caused by gun violence (Burkett, 2021; R. Williams, 2021). Over 215 people in Richmond will likely die of an overdose by the end of 2022 (see Figure 1).

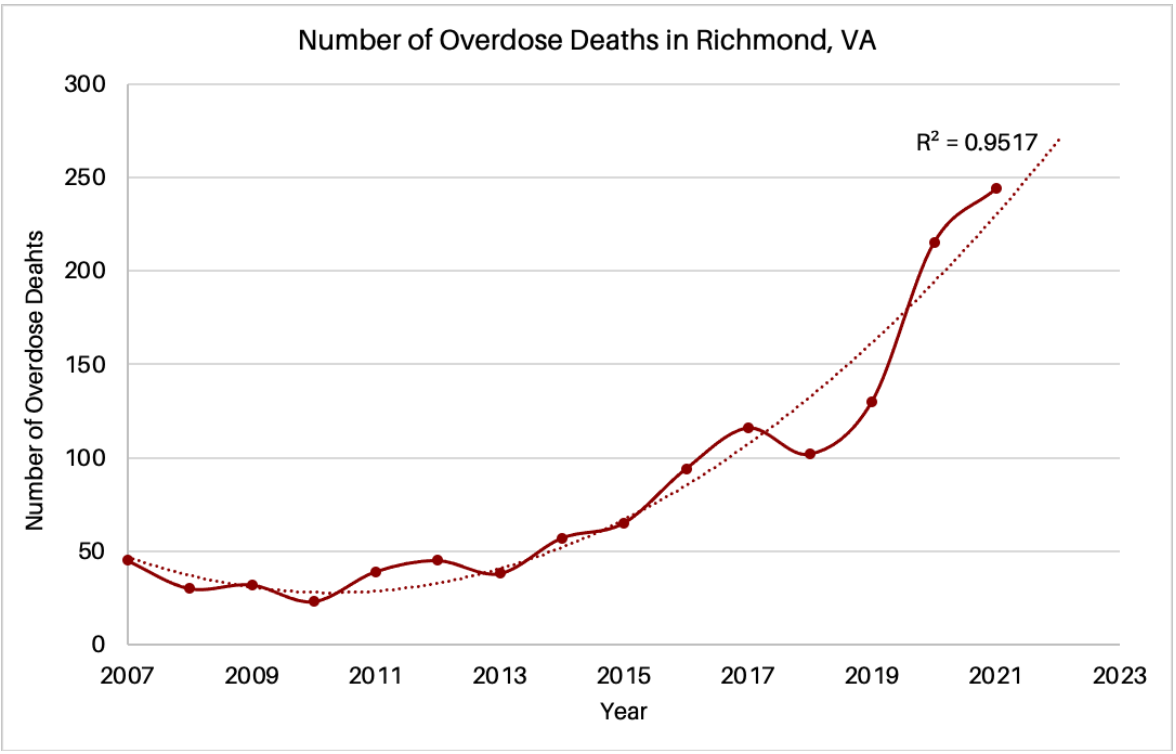



Figure 1: Using a line of best fit, there are over 250 predicted overdose deaths by the end of 2022 (Virginia Department of Health Medical Examiner, 2021).

These rates are also extremely high as compared to the rest of Virginia even when accounting for population. Richmond's recent fatal overdose rates have been 70% higher than the Virginia average (Virginia Department of Health Medical Examiner, 2021). Richmond has some of the largest year-to-year overdose increases in the state (Virginia Department of Health Medical Examiner, 2021). It is clear that Richmond has been hit hard by the opioid crisis both internally and as compared to other areas of Virginia. Put simply, absent effective policy action, fatal overdoses will continue to rise, and more lives will be lost in Richmond.

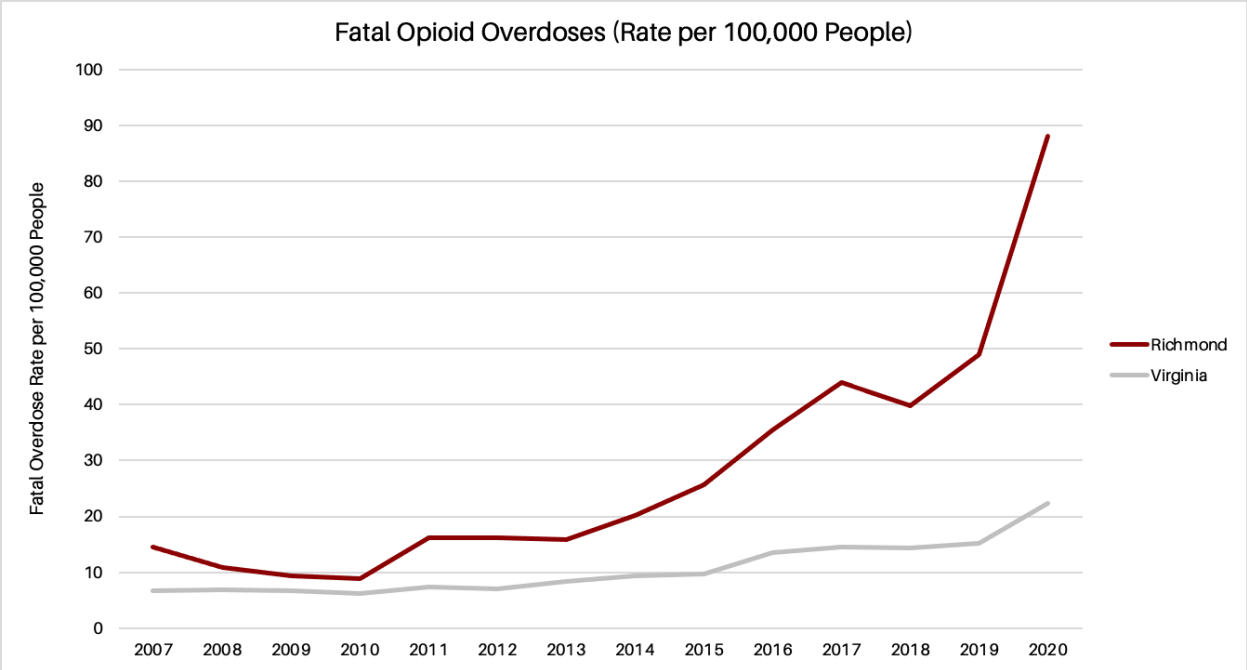



Figure 2: Since 2013, Richmond has experienced sharp increases in overdoses as compared to the rest of the state (Virginia Department of Health Medical Examiner, 2021).

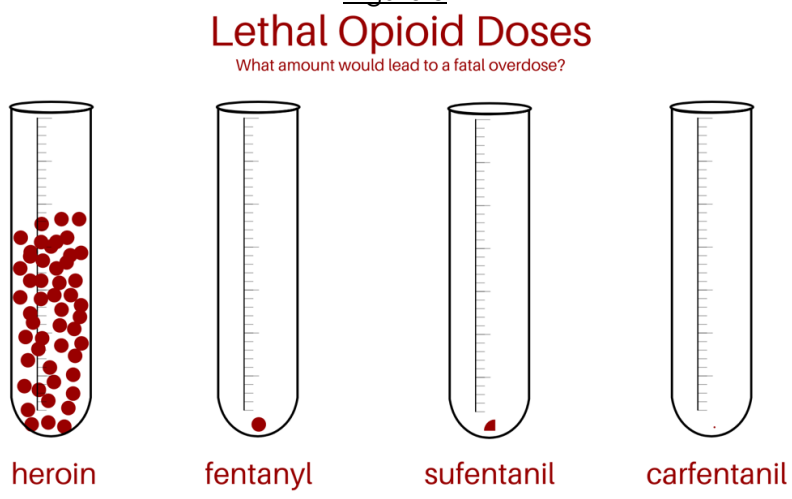
## Background on Richmond's Overdose Crisis

1. What is driving fatal overdose rates?

Opioids are the leading cause of fatal overdose.[1] In the first six months of 2021, opioids made up over 94% of overdoses in Virginia (Virginia Department of Health: Office of the Chief Medical Examiner, 2021). Of all opioid overdoses, fentanyl is the leading driver. Fentanyl is an incredibly potent, synthetic opioid that can be prescribed or distributed illegally (National Institute on Drug Abuse, 2021). About 9 out of every 10 fatal overdoses in Richmond are caused by or contributed to by fentanyl (Virginia Department of Health Medical Examiner, 2021). A majority of those deaths are caused by illicitly-produced, as opposed to prescribed, fentanyl. There is no other single substance that even comes close to that rate. For reference, cocaine ranks second, making up 43% of Richmond overdoses (about half the rate of fentanyl). Richmond's fentanyl problem is one of the worst in the state. Drawing on data from 2019, Richmond had one of the highest rates of fatal fentanyl overdoses in Virginia per 100,000 residents (Virginia Department of Health Medical Examiner, 2021).

What makes fentanyl such a significant driver? The answer lies in its potency. Compared to other opioids, the amount of fentanyl needed to cause death is significantly lower. Figure 3 demonstrates this difference succinctly by comparing the fatal dosage of heroin, fentanyl, sufentanil, and carfentanil (Li, 2018).[2] If you take the amount shown in the picture (or more), this will lead to a fatal overdose. A significantly larger amount of heroin needs to be consumed to cause a fatal overdose as compared to fentanyl.

Figure 3




[1] See Appendix A to learn more about what opioids are, how they work, and how they are accessed.
[2] Sufentanil and carfentanil are analogs, or "similar in chemical structure or pharmacologic effect", to fentanyl (Centers for Disease Control and Prevention, 2021a). All mentions of "fentanyl" include fentanyl and its analogs.

In fact, fentanyl's lethal dose is just 2% of heroin's lethal dose. With an increase of illicit fentanyl in Richmond's drug supply, there is a significantly higher likelihood of fatal overdose due to its potency (Dennis, 2021).

2. What are risk factors for a fatal overdose?

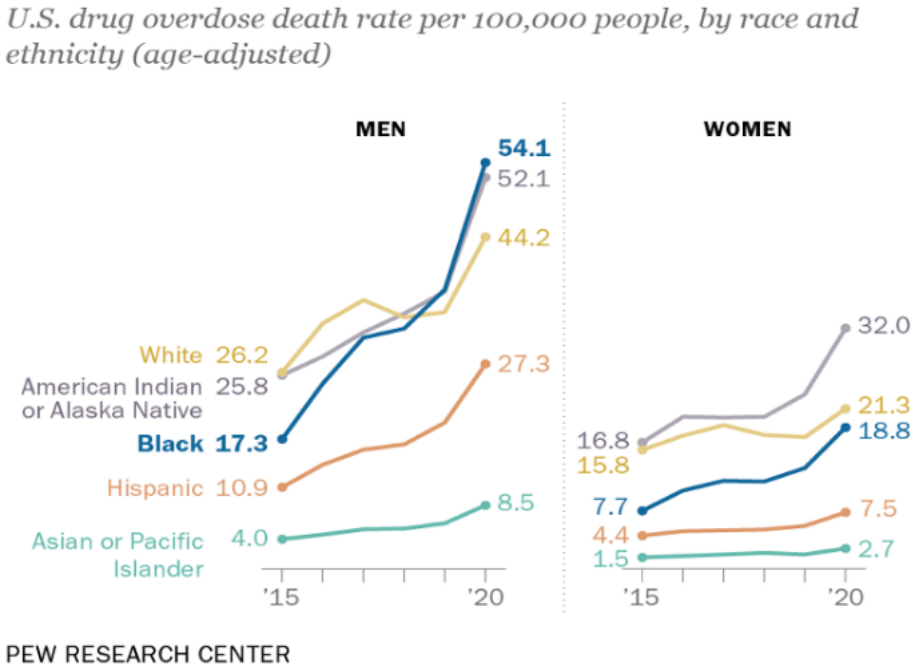
The risk factors for a fatal opioid overdose are complex and interconnected. There is not one characteristic that can perfectly predict an overdose death. Risk factors are a result of interconnected individual, situational, and organizational contexts (Frisher et al., 2012). With that being said, there have been some reported identifiable characteristics that help assess overdose risk (Barocas et al., 2019; Doggui et al., 2021; Webster, 2017).

Individuals have a higher likelihood of fatal overdose if they experience the following:

- Psychiatric disorder diagnosis (especially bipolar disorder or schizophrenia)
- Experience of emotional trauma
- History of substance use disorder (SUD)
- History of suicide attempts
- Use of multiple substances at once
- Use of illicit drugs chronically and a lack of treatment
- Experience frequent overdoses
- Experience high stress
- Recently underwent detoxification
- Diagnosis of a substance use disorder in the past 6 months. This is the single strongest predictor of a fatal overdose. Specifically, opioid use disorder (OUD), which is a subset of SUD, is a high risk factor for a fatal overdose (World Health Organization, 2021)

Opioid use disorder is a "chronic use of opioids that causes significant distress or impairment." Opioid use disorder affects over 2 million people across the nation. This is as many people with psoriatic arthritis in America. OUD includes a strong desire to consume opioids, increased tolerance, and withdrawal symptoms when use is stopped (Dydyk et al., 2021). Tolerance and withdrawal symptoms are two strong diagnostics of OUD. Increased tolerance is defined as a repeated exposure to a substance resulting in decreased effect. Withdrawal is classified as 3+ negative physical symptoms following the cessation of opioid use (Centers for Disease Control and Prevention, 2017).

Figure 4




Socioeconomic factors and identity also play a role in overdose risk. Men are two times more likely to die of an overdose than women. Those between the ages of 25 and 35 are also placed at a higher risk of a fatal overdose (National Center for Drug Abuse Statistics, 2021). Among women, American Indian and Alaska Native women are the most likely to experience a fatal overdose. For men, Black men are at a disproportionate risk (National Center for Drug Abuse Statistics, 2021). In fact, fatal overdoses among Black men have more than tripled between 2015 and 2020 (Gramlich, 2022a). No other race or ethnicity has seen increases at such a rate (see Figure 4; Gramlich, 2022a).

Opioid overdose is also connected with broader socioeconomic conditions. Those who are unemployed, experiencing poverty, uninsured, and have lower education attainment rates are more likely to die of an opioid overdose (Altekruse et al., 2020). Multiple studies have identified an association between higher fatal overdose rates and poorer economic conditions (Brown & Wehby, 2019; Pasarín et al., 2004; Venkataramani et al., 2020). Work by economists Anne Case and Angus Deaton found that the deterioration of social and economic conditions leads to increased deaths of despair among predominantly lower-educated, white, and poor populations.[3] Deaths of despair include deaths by alcohol, suicide, and drug abuse, including opioid use disorder. They determine deaths of despair, including fatal opioid overdoses, are a function of broader social contexts in addition to individual physical and social determinants of health (Deaton & Case, 2017). In alignment with these findings, the COVID-19 pandemic has accelerated rates of overdose deaths, likely a result of turbulent economic and social circumstances (Gramlich, 2022b; South et al., 2020).

This connection between socioeconomic conditions and overdose rates extends to housing and incarceration. A study in Boston found that homeless adults were 9x more likely to suffer from

[3] This deterioration is classified as falling marriage rates and labor force participation coupled with increased reports of pain, poor physical health, and poor mental health.

a fatal overdose as compared to housed adults (Baggett et al., 2013). Risk is also elevated for those released from prison or jail. Overdose is the leading cause of fatality following prison release (Waddell et al., 2020). People who are released from prison are 12-40x more likely to die from an opioid overdose the two weeks following release as compared to the general population (Ranapurwala et al., 2018; Waddell et al., 2020). This number remains as high as 11x one year after release and 8x at complete follow-up after release (Ranapurwala et al., 2018).

3. Richmond and Overdose Risk Factors

Fentanyl: The presence of fentanyl is disproportionately high in Richmond, explaining why overdose rates are higher in the City as compared to other Virginia counties. Richmond had the second highest rate of fentanyl overdoses in Virginia in 2020. Richmond also has a fentanyl overdose rate 18% higher than the state average (Virginia Department of Health Medical Examiner, 2021). This disparity is expected to increase over time.

Race, Gender, and Age: Those who die of overdose in Richmond are more likely to be male, Black, and over the age of 25. There are significant racial disparities in Richmond overdose rates. In the first half of 2021, Black people made up about 57% of overdoses while making up only 47% of the Richmond population (Karr, 2021; U.S. Census Bureau, 2020b). This disproportionately has been worsened by the pandemic. Black patients made up a higher proportion of those presenting with an opioid overdose in VCU emergency departments at the beginning of the pandemic as compared to previous years (T. A. Ochalek et al., 2020).

Location: Using data from the Richmond Ambulance Authority (RAA) regarding naloxone disbursement rates, most overdoses in 2021 were concentrated in Gilpin, East End, and Southside by the Midlothian Turnpike and along I-95 (see Figure 5A).[4] A majority of 2021 disbursement occurred in Gilpin and East End. In connection to Case and Deaton's work, areas of high overdose response rates are also those with the highest poverty rates (see Figure 5B). This aligns with what we know to be true about overdose risk factors and economic insecurity.

[4] While naloxone will be described in much greater detail later, naloxone is essentially an opioid antagonist that reverses overdose symptoms for 20-90 minutes (National Harm Reduction Coalition, 2020). It is used by emergency authorities in response to an overdose in order to revive the victim.

Distribution of Narcan Administration across Richmond, January-June 2021

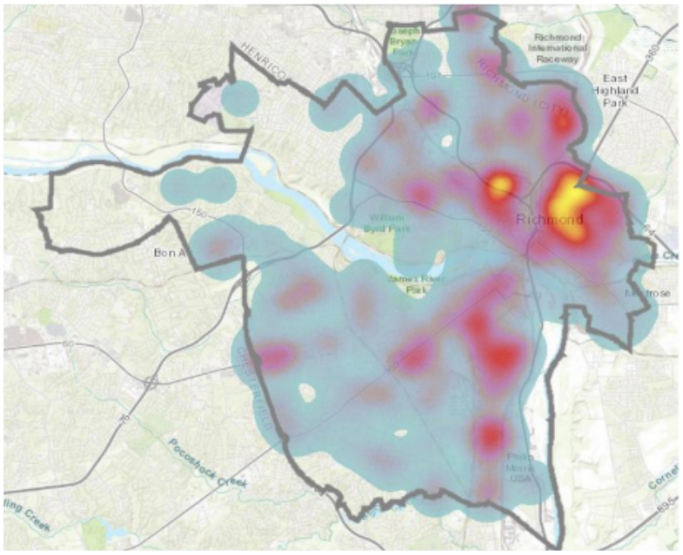



Figure 5A: East End and Southside had the highest rates of Richmond Ambulance Authority naloxone disbursement (Richmond Ambulance Authority, 2021).

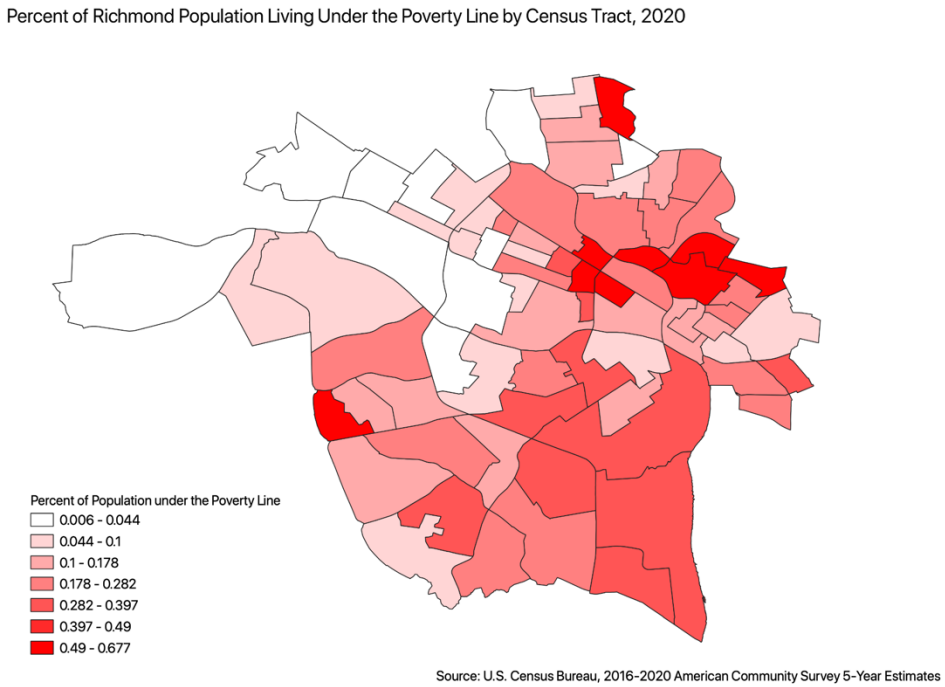



Figure 5B: Areas of Richmond with the highest poverty rates are also the areas with the highest overdose rates (U.S. Census Bureau: American Community Survey, 2020).

Homelessness and Incarceration: In turning to local socioeconomic conditions, conversations with those at SAARA and VDH reveal that Richmond overdoses are concentrated among people who are unhoused, as well as those recently released from prison. Due to a lack of available data on this in Richmond, these accounts cannot be verified with local external sources but are largely supported by findings nationally and in other urban contexts (Baggett et al., 2013; Ranapurwala et al., 2018; Waddell et al., 2020; Yamamoto et al., 2019). Richmond also has higher rates of homelessness as compared to other counties. This may also explain why overdose rates are higher in Richmond than other parts of Virginia (U.S. Census Bureau, 2020c). It is important to highlight that the issues of overdose, homelessness, and incarceration are inextricably linked to both race and economic status (National Alliance to End Homelessness, 2021). While studies have not yet examined how each of these characteristics intersect to affect overdose risk, these factors together likely compound the risk of fatal overdose.

4. Costs of the Crisis

There are a variety of consequences and costs associated with fatal overdoses (see Figure 6). It should be noted that, while these categories are separated for clarity, there is significant overlap between and within each section. It is important to remember that the effects of the opioid epidemic are pervasive and systemic. It is difficult to disentangle familial and societal level effects.[5]

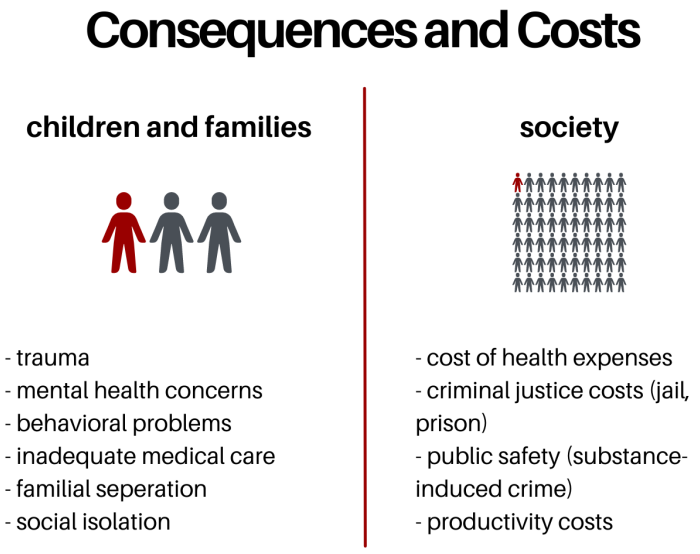



Figure 6: The impacts of fatal overdose are tragic, pervasive, and severe.

[5] Due to this project's focus on mortality, the individual level costs of addiction are included in Appendix B.

Children and Families

The children of parents with opioid use disorder suffer. It's estimated that two million children have at least one parent with opioid use disorder (Winstanley & Stover, 2019). These children experience higher rates of educational delays and higher rates of mental health and behavioral problems. They also face an increased risk of substance use disorder later in life, accidental drug poisoning, and inadequate health maintenance like dental care (Smith et al., 2016; Winstanley & Stover, 2019). Further, the number of children living away from a parent as a result of opioid use disorder has increased over time. Between 2000 and 2015, foster care cases related to drug misuse increased 66% (Maclean et al., 2020). This has a significant impact on a child's physical, emotional, and mental health (Winstanley & Stover, 2019).

Community and Social

There is a significant public health cost to opioid use disorder. Virginia's Medicaid program spent over $25 million on opioid use and misuse in 2013. This number is likely much higher in 2021. These costs include opioid use treatment, rehab, and emergency responses to overdose (VCU Health & Virginia Association of Health Plans, 2016). In addition, there are increased healthcare costs for co-morbid chronic diseases associated with opioid use: HIV/AIDS, Hepatitis B, kidney failure, liver failure, and cancer. There are also public safety and criminal justice costs. The Joint Legislative Audit and Review Commission of Virginia estimated that substance abuse cost Virginia $613 million in 2006, disproportionately affecting the public safety sector at 96% (Joint Legislative Audit and Review Commission, 2008). This includes the costs of crime, motor vehicle crashes, and fires resulting from substance use disorder. These estimates also include the subsequent costs of prosecution for these crimes. Finally, there is a productivity cost to the opioid epidemic in terms of lost earnings, lower productivity, and decreased labor force participation. The City of Richmond loses between $247 to $521 per person in productivity losses due to the opioid epidemic (Virginia Commonwealth University: Center on Society and Health, 2020). That is about $56,000,000 in productivity losses alone (U.S. Census Bureau, 2020b).

**In total, the overdose epidemic cost the City of Richmond $2.4 billion in 2020 alone (Luo, 2021).**

5. What are current efforts to address the opioid crisis in Richmond?

Governmental Efforts

There are a variety of efforts in Richmond to address the opioid crisis. In addition to a task force assembled by Mayor Stoney, Richmond currently oversees a website and media campaign called Opioid Solutions RVA with Chesterfield, Hanover, and Henrico counties. This website

provides education on opioid use disorder and overdose signs. The site also provides information on treatment resources and prevention efforts, like the administration of naloxone – a life-saving drug to treat opioid overdose (Richmond Government, 2019). The Commonwealth of Virginia also has a program called REVIVE!, an overdose education and naloxone distribution (OEND) program.

- Richmond City Health District (RCHD - a part of the Virginia Department of Health): Provides a free, 30-minute virtual training twice a week on naloxone administration. Participants receive naloxone following the completion of their training (Richmond City Health District, 2021). RCHD has an hour-long, in-person naloxone training once a month. RCHD has walk-in naloxone dispensing twice a month (participants need to undergo REVIVE! training or do a brief 5-minute training session).
- Richmond Behavioral Health Authority (RBHA), a Community Service Board (CSB) licensed by the Virginia Department of Behavioral Health and Developmental Services (DBHDS), provides an hour-long naloxone training in-person every three weeks. RBHA also has a 24/7 hotline for crisis response to health emergencies, including information on overdose response (Richmond Behavioral Health Authority, 2021).

Clinical Setting Efforts

At Virginia Commonwealth University's Emergency Department, a few physicians and nurses are spearheading a bridge program where physicians connect patients who present with overdose to recovery services (T. Ochalek, personal communication, October 21, 2021). This program is yet to be officially implemented, but demonstrates a strong potential for Richmond ED's to connect people suffering from OUD with clinical resources. In addition, there are a variety of organizations that offer medication-assisted treatment (MAT) in Richmond.[6] One method of administering MAT is through office-based opioid treatment (OBOT) facilities. Over 10 OBOT facilities exist in Richmond City (Virginia Department of Medical Assistance Services, 2021).

Non-Profit Efforts

There are also a variety of harm reduction and non-profit organizations that work in this area. The Substance Abuse and Addiction Recovery Alliance (SAARA) of Virginia is a state-wide organization based in Richmond working to help those who suffer from substance abuse. They provide a wide variety of services in this area from educational support to naloxone distribution to innovative peer interventions. They are currently rolling out "Project Recover,", a program

[6] MAT uses medication (buprenorphine, methadone, and naltrexone) and counseling/behavioral therapy to treat opioid use disorder (OUD). It is regarded as one of the most effective means of recovery for those suffering from OUD (U.S. Food and Drug Administration, 2019).

where Certified Peer Recovery Specialists (CPRS) attend opioid response calls with Richmond Ambulance Authority and Richmond Police Department (Dobrogosz, 2021).[7] SAARA also has a "warm-line" where people can call to gain information on recovery services, treatment options, and information on OUD (SAARA of Virginia, 2021). Harm reduction sites in Richmond, like Health Brigade, provide needle exchange programs, distribute naloxone, and educate people on the signs of overdose. In particular, Health Brigade has a mobile van unit that operates three days a week at N. Thompson St., Lucks Field, and by the Corner of Dinwiddie and Jefferson Davis. They offer free services, including a needle exchange program and the disbursement of naloxone, wound care, syringes, and community service referrals (Health Brigade, 2022). Finally, there are over 15 recovery homes in Richmond. Recovery homes help facilitate the recovery process and provide support services like peer recovery and behavioral therapy (VARR - Virginia Association of Recovery Residences, 2020). One example of a recovery home is the McShin Foundation. They have over 100 beds and use a peer support model to aid in the recovery process (McShin Recovery Resource Foundation, n.d.).

Overall, a variety of efforts exist in tandem to combat the opioid crisis; however, in talking to Richmond leaders in the governmental, clinical, and non-profit settings, grassroot efforts lack consistent funding year-to-year. This makes coordination and reliability difficult. Specifically, every stakeholder expressed a need for expanded naloxone and recovery service availability in The City of Richmond. Many stakeholders also highlighted the interconnectedness of opioid overdoses with social conditions, including housing and food stability.

[7] A peer recovery specialist is someone who struggled with substance abuse themselves and is in successful recovery. They provide "non-clinical, person-centered informed support" (Virginia Peer Recovery Network, n.d.).

# Literature Review: Evidence for Addressing Fatal Overdoses

1. A Framework for Intervention from Health and Human Services

With increased public attention on the opioid epidemic over the past fifteen years, a variety of effective responses have been curated by federal agencies, including the U.S. Department of Health and Human Services and the National Institute of Health (National Institute of Health, 2021; U.S. Department of Health and Human Services, 2017). The Department of Health and Human Services (HHS) developed an evidence-based, multi-faceted strategy to combat the opioid crisis. Their evidence-based intervention strategy was revealed in 2017 and has been updated annually since (U.S. Department of Health and Human Services, 2017). The five priorities detailed in their approach, evidenced in Figure 7, synthesize the most effective strategies in addressing the opioid crisis and reducing overdose deaths.


Figure 7. The Department of Health and Human Services curated an evidence-based, multi-faceted approach to address the opioid crisis.

It's important to consider how each of these categories best apply to the Richmond area. Data and research practices are relatively strong in Richmond with a variety of organizations in academic, public, and non-profit spaces collecting data. Departments at Virginia Commonwealth University have dedicated extensive research and time to evaluate the Richmond opioid crisis. Researchers at VCU, including Dr. Taylor Ochalek and Dr. Mishka Terplan, have conducted significant work in this area over the past four years. In terms of data, public and private data is collected by the Richmond Police Department, Virginia Department of Health, Richmond Ambulance Authority, and VCU hospitals (T. A. Ochalek et al., 2020;

Richmond Ambulance Authority, 2021; Terplan, 2017; Virginia Department of Health Medical Examiner, 2021)

This report will thus prioritize the other facets of HHS' strategy. In turning to pain management strategies, these are longer-term, statewide approaches whereas the urgency of this crisis calls for interventions sooner rather than later. Further, deaths caused by illegally-produced opioids surpassed deaths caused by prescription opioids in 2015 with this trend only increasing for every year thereafter in the state (Virginia Department of Health: Office of the Chief Medical Examiner, 2021). In fact, a majority of fentanyl overdoses are due to illicitly produced fentanyl that is imported from other countries rather than prescription fentanyl (Virginia Department of Health: Office of the Chief Medical Examiner, 2012). These facts suggest that opioids are produced outside of the Richmond locality and are accessed by consumers outside of medical settings. Given this, the approach of pain management/prescription regulation is not the best course of action for the City of Richmond.

That leaves priorities one and four: better addiction prevention, treatment, and recovery services and better targeting of overdose-reversing drugs. Given the rapid increase in overdose rates and the urgent nature of the opioid epidemic in Richmond, I recommend the Mayor's Office pursue the targeting of overdose-reversing drugs, also known as naloxone, as a first step. Naloxone will give people the opportunity to pursue treatment and recovery. For some, without an overdose-reversing drug, they are never even given the chance. In this sense, policy interventions can be viewed as a way to triage the fall-out of the opioid crisis. Put simply, we need to keep people alive long enough to get to treatment. With that being said, a comprehensive approach to the opioid crisis would be a continuum of care where there is a bridge between harm reduction services (like naloxone provision) to longer-term recovery resources (Michigan Department of Health and Human Services, 2020). Naloxone is the first part of that bridge. Mitigation cannot begin without this element. For these reasons, the remainder of this project will explore efficacious naloxone distribution strategies. I will revisit future steps in the addiction prevention, recovery, and treatment space in a later section.

2. What is naloxone?

Naloxone (brand name: Narcan) is a life-saving overdose reversal drug that saves millions of lives each year (Hawk et al., 2015; Terplan, 2017). When someone overdoses, they experience an inability to breathe called respiratory depression. The time it takes from drug consumption to respiratory depression varies by drug, but it is incredibly quick. With heroin, it could be minutes until someone stops breathing. For fentanyl, it could be seconds. Given the quick nature of respiratory depression, it is essential to get overdose victims to the hospital as quickly as possible to assist in reversing overdose symptoms. That is where naloxone comes in. Naloxone works in just two to three minutes after administration (Anne Arundel County

Department of Health, 2017). It blocks the binding of opioid receptors for 20-90 minutes and reverses respiratory depression, providing crucial time for overdose victims to be taken to the Emergency Department for extended care (Hawk et al., 2015). It is worth underscoring that naloxone's ability to block opioid receptors means it can target overdose symptoms caused by fentanyl, a major driver of Richmond's high fatal overdose rate. Naloxone's ability to reverse opioid-induced respiratory depression in just 2-3 minutes has made it an increasingly powerful tool in saving lives. Further, it is incredibly safe. Naloxone has no effect on someone who hasn't taken opioids, so it's reasonable to use naloxone on any suspected overdose case (Kerensky & Walley, 2017). Overall, naloxone is a safe drug that is extremely effective in reversing overdose symptoms (Wheeler et al., 2015). These characteristics make it an incredibly valuable tool in addressing the opioid epidemic (Wheeler et al., 2015).

3. Naloxone Disbursement: Overdose Education and Naloxone Distribution Programs

Given its powerful antidote qualities, harm reduction programs started to incorporate naloxone in their overdose response toolkit in the mid-90's through overdose education and naloxone distribution (OEND) programs. OEND programs educate people at risk of overdose and bystanders (think opioid users at risk of overdose and family/friends of opioid users) on how to prevent, recognize, and respond to overdose. OEND programs teach people how to administer naloxone and then distributes naloxone to every participant (Walley et al., 2013). Participants can then use that naloxone if they witness a suspected overdose. This peer-to-peer element is important since nearly 40% of overdose deaths happen when someone else is present (Centers for Disease Control and Prevention, 2022). Bystanders have the potential to save lives.

As an important note, naloxone is safe to carry through different temperature ranges. It is recommended that the opioid antagonist is stored at room temperature, but research has found that extreme temperatures do not significantly impact the efficacy of the drug (Estephan et al., 2020). This more readily allows people to carry naloxone with them or store it in their car. The drug also has a shelf life of two to three years (Bureau of Justice Assistance & Office of Justice Programs, 2014; Emergent Devices Inc., 2020). These qualities make it an extremely easy, reliable, and dispensable medication for almost anyone, from emergency responders to peers to family members, to administer.

4. Efficacy of Community-Based Naloxone Distribution

A Harm Reduction Coalition (HRC) survey found that 136 organizations distributed 152,283 naloxone kits and reported 26,463 overdose reversals between 1996 and 2014 (Wheeler et al., 2015). In other words, just 136 organizations were able to prevent over 26,000 fatal overdoses in less than a twenty-year period. It should be noted that these reported reversal rates are likely a lower bound. These numbers only include OEND participants that actually report the use of

their naloxone. Usually, this number is reported when a participant comes back to the organization to get a naloxone refill. Those who don't get a naloxone refill and/or aren't comfortable reporting are not captured here. Further, some organizations will ask participants if they used naloxone "to reverse at least one overdose," thus ignoring instances of several overdose reversals. In addition to the HRC survey, multiple other programs across the country have found a substantial number of overdose reversals due to OEND-distributed naloxone. An OEND program in San Francisco saved 355 lives over a six-year period (Enteen et al., 2010). An OEND program in Baltimore saved 75 lives over a 15-month period (Doe-Simkins et al., 2009). An OEND program in Massachusetts saved 320 lives over a three-year period (Doe-Simkins et al., 2009). An OEND program in Pennsylvania saved 246 lives over a three-year period (A. S. Bennett et al., 2011). Again, these are likely underestimates given the constraints outlined above. From Maryland to California to Baltimore to North Carolina to Pennsylvania to New York to Illinois, programs have found a substantial number of overdose reversals due to OEND-distributed naloxone (A. S. Bennett et al., 2011; Doe-Simkins et al., 2009, 2014; Enteen et al., 2010; Galea et al., 2006; Lankenau et al., 2013; Lewis et al., 2016; Maxwell et al., 2006; Piper et al., 2008; Tobin et al., 2009; Wagner et al., 2010; Walley et al., 2013; Wheeler et al., 2015; Yokell et al., 2011). OEND programming has unequivocally saved countless lives.

Several studies have also observed an association between greater naloxone distribution and lower fatal overdose rates (Davidson et al., 2015; Naumann et al., 2019; Walley et al., 2013). An observational case study in Chicago examined the effects of community-based naloxone distribution to people who use heroin. While overdoses quadrupled between 1996 and 2000, this trend reversed the year the take-home naloxone distribution was implemented. This decrease continued for every year after 2001, as seen in Figure 8 (Maxwell et al., 2006).

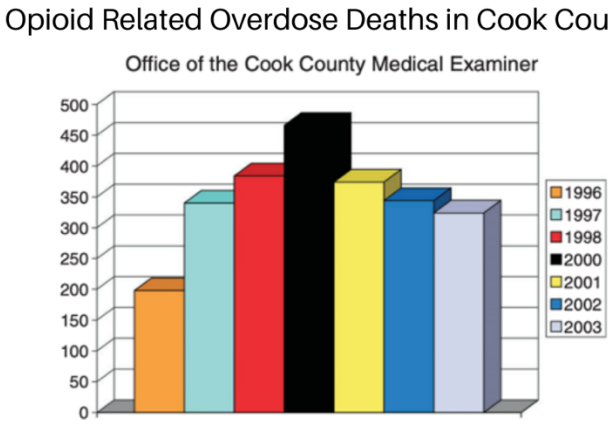


Figure 8. After Chicago implemented a community-based naloxone distribution, fatal overdose rates fell (Maxwell et al., 2006).

Another evaluation found that North Carolina counties that distributed 101+ naloxone kits per 100,000 people had fatal overdose rates 14% lower than counties with no distribution between 2013 and 2016. The authors also found that counties with 101+ kits per 100,000 people had a fatal overdose rate 3 percentage points lower than counties with 1-100 kits distributed per 100,000 people (Naumann et al., 2019). This suggests increasing community-based naloxone distribution in an area with existing distribution may further lower overdose rates.

Finally, in a 2012 study, researchers conducted a time series analysis on opioid overdose deaths in 19 Massachusetts counties with varying OEND implementation rates.[8] Between 2002 and 2009, 2,912 participants were trained through OEND programming in Massachusetts. Of those 2,912 participants, 327 reported at least one overdose reversal. The study found that opioid overdoses were reduced when there were higher rates of enrollment in OEND, demonstrated by Figure 9 below (Walley et al., 2013). The difference in fatal overdoses between high and low enrollment counties further suggests that increasing community-based naloxone distribution in an area with existing distribution may further lower overdose rates. It should be highlighted that Walley and co-authors caution that their results are not causal due to the observational nature of the study. Despite this, they urge public health officials to implement and expand OEND programming. While not definitively causal, this study has and continues to be strong evidentiary support for the effectiveness of OEND programs in reducing overdose deaths.

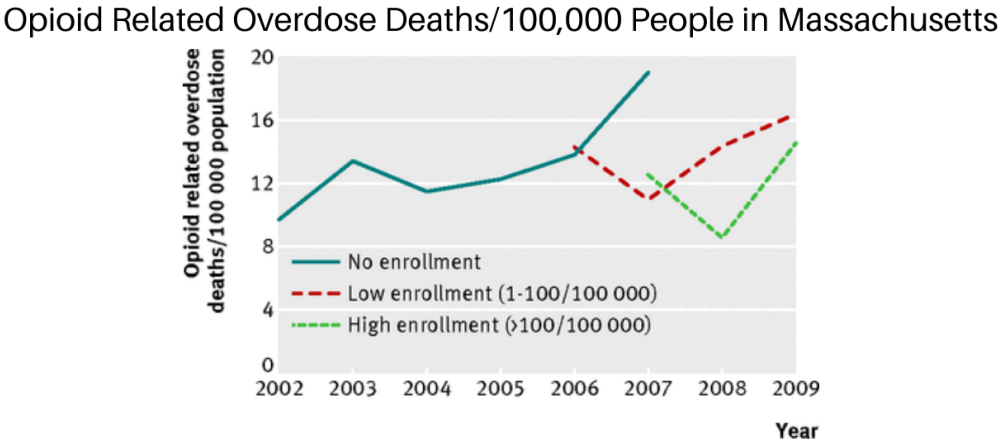



Figure 9. Higher OEND program enrollment was associated with reduced opioid overdoses in nineteen Massachusetts counties (Walley et al., 2013).

[8] The 19 Massachusetts counties in the study were those of significantly higher overdose risk.

5. What makes naloxone distribution strategies effective?

With strong evidence that community-based naloxone distribution saves lives, the next consideration is how to distribute naloxone effectively. This is especially true when time and place are essential. While naloxone works quickly, so does overdose. Therefore, people who are more likely to witness an overdose are the best for targeting naloxone distribution. Unsurprisingly, those more likely to witness an overdose are opioid users themselves and their social networks (Kerensky & Walley, 2017). 89% of drug users have witnessed an overdose before (Enteen et al., 2010). Drug users are also the ones most likely to use community-distributed naloxone (A. S. Bennett et al., 2018). A North Carolina study found that 83% of the people that reversed an overdose with community-distributed naloxone are people who use drugs. This is more than any other group (Rees et al., 2017). This 83% number has been replicated in another study, as well (Wheeler et al., 2015). The next highest group was friends and family of someone who uses drugs at 9.6% (Wheeler et al., 2015). Other literature has supported this. The social distribution of naloxone kits amongst those who are at high risk of overdose increases the use of naloxone for opioid reversal substantially (Keane et al., 2018). These findings strongly suggest that community-based naloxone distribution is significantly more likely to reverse an overdose when targeted towards people who use drugs, as well as their friends and family. It also suggests that certain risk factors mentioned earlier, such as findings that people recently released from incarceration are 12-40x more likely to die from an opioid overdose the two weeks following release, are important considerations for targeting naloxone distribution (Ranapurwala et al., 2018; Waddell et al., 2020).

## 6. Naloxone Concerns and Evidence-Based Responses

### Will the availability of naloxone lead people to use more drugs since they might view the naloxone as a safety net?[9]

Literature to date has not found a convincing link between expanded naloxone and an increase in risky drug-use behavior (Deiana & Giua, 2018; Galea et al., 2006; Maxwell et al., 2006; Piper et al., 2008; Rees et al., 2017). Further, large-scale naloxone distribution has reliably decreased fatal overdose rates after implementation (Albert et al., 2011). Only one study has found a link between risk compensation and naloxone, but it has several limitations (Doleac & Mukherjee, 2021). For one, this paper exploited variation in state-wide naloxone laws as an identification strategy as opposed to naloxone distribution itself. Further, the authors used Google Search trends of "Naloxone" and "drug rehab" as a proxy measurement for naloxone distributed and recovery interest. Finally, they find differing effects of naloxone on mortality across U.S. geographies. Given these substantial limitations, there is limited evidence that naloxone distribution leads to riskier drug use behaviors.

### Can a layperson still administer naloxone effectively without training?

Evidence has found that bystanders with limited to no naloxone training can successfully administer the drug. Further, there is no evidence that there are differences in successful overdose reversal rates between those trained and those not trained (Doe-Simkins et al., 2014).

### How does stigma affect distribution?

A New Hampshire study identified several user-specific barriers in naloxone distribution. OEND participants expressed resistance to administering naloxone due to negative withdrawal symptoms and fear of legal concerns (Bessen et al., 2019). Specifically, OEND participants feared calling 911 after responding to an overdose with naloxone as they feared cops would arrest them for drug paraphernalia. Other studies have found similar findings. Researchers conducted a series of focus groups in Massachusetts and Rhode Island in 2017 to evaluate how people with opioid use disorder and patients with chronic pain view pharmacy-based naloxone distribution. Participants noted a feeling of stigma in pharmacy settings, as well as fears of getting targeted by the police when carrying naloxone (Green et al., 2017). Thus, it is important to highlight in OEND training that Virginia is a Good Samaritan state where anyone who calls 911 because of an overdose is protected from criminal liability (Tingen Law, PLLC, 2018). Another interview-based study in 2021 found that some newly-abstinent opioid users refused to carry naloxone as it felt it labeled them as drug users (Bowles et al., 2021). These studies indicate that stigma is very real for people who use drugs and could limit participation in OEND

[9] The idea is that users may be more comfortable engaging in risky behaviors (consuming more drugs, more potent drugs, etc.) since they know they have naloxone as a life preserver in case of overdose. This could lead to higher overdose rates than if no naloxone was administered.

programming. This should be an important consideration in any community-based naloxone distribution program.

### Will people who use naloxone be willing to call 911? What happens if someone needs more than one dose of naloxone?

It is true that those who successfully use naloxone to reverse an overdose are significantly less likely to call 911 (A. S. Bennett et al., 2018; Doe-Simkins et al., 2014; Enteen et al., 2010). This is concerning since the half-life of naloxone is shorter than some opioids. This means that the life-saving effects of naloxone can be shorter than the overdose itself, necessitating the need for several doses of naloxone and emergency services (Koester et al., 2017; National Institute on Drug Abuse, 2017). Several doses may be necessary when someone takes a larger amount of a drug or a higher potency drug, like fentanyl (National Institute on Drug Abuse, 2017). Given this, it is important to highlight the possible need for multiple doses and the necessity of EMS in OEND training programs.

### What if naloxone is given to someone overdosing on something that isn't an opioid?

As mentioned before, naloxone has no effect on someone who hasn't taken opioids. It's reasonable to use naloxone on any suspected overdose (Kerensky & Walley, 2017).

### Will all distributed naloxone be used?

No. Gaps exist between the number of kits distributed and those used for overdose reversal (Wheeler et al., 2015). With that being said, incomplete take-up of naloxone for reversal is still better than no naloxone distribution at all. Further, as highlighted earlier, the reported reversal rates are likely a lower bound of actual reversal using OEND-distributed naloxone.

## Criteria Overview

Given the insights gathered above, the remainder of this report will examine evidence-based, policy interventions to address high fatal overdose rates in The City of Richmond. Specifically, interventions will focus on how to best expand naloxone distribution in Richmond. Each policy alternative will be evaluated on the following three criteria: cost-effectiveness, administrative burden, and equity.

Cost-Effectiveness

Cost-effectiveness will evaluate the ratio of an alternative's 5-year real net present cost to the number of overdoses reversed as a result of the alternative's naloxone distribution over a 5-year span.

$$\text{Cost-Effectiveness} = \frac{\text{Cost}}{\text{Number of Overdoses Reversed}}$$

The expected reversal rate for each policy will be drawn from established literature and sourced data. Costs will consider both direct material/capital costs (i.e., cost of naloxone, machinery, etc.) and direct labor costs (i.e., time used to implement, train, etc.). The number of overdoses reversed serves to measure the number of lives saved by naloxone. After cost-effectiveness is evaluated, each alternative will be ranked. The most cost-effective option will be ranked 1 and the least cost-effective option would receive a ranking of 4.

Administrative Burden

Given limitations on how naloxone can be distributed under the Board of Pharmacy's Standing Order, other organizations will be necessary to implement a given policy alternative. This criterion will thus consider how difficult a policy intervention is to carry out. To quantify this criterion, the number of organizations/agencies involved and the number of steps necessary to fully implement the alternative will be aggregated. This will provide a proxy for administrative complexity.

$$\text{Administrative Burden} = \text{Number of Agencies or Organizations Involved} + \text{Number of Steps to Fully Implement in the First Year}$$

Using the administrative burden score, each alternative will then be scored using the following rubric.

| Summation of Steps and Organizations | Ranking | Description |
|---|---|---|
| 0-25 | 1 | Lowest Burden |
| 25-50 | 2 | Lower Burden |
| 50-75 | 3 | Higher Burden |
| 75+ | 4 | Highest Burden |

Equity

This criterion takes into account whether an alternative is targeted to groups that experience disproportionately high rates of fatal overdose. This criterion is evaluated using existing literature on individual and community-level overdose risk. Given this evidence, each alternative will then be scored using the following rubric.

| Ranking | Description |
|---|---|
| 1 | High degree of targeting |
| 2 | Highly likely, but not guaranteed, targeting |
| 3 | Possible, but unlikely, targeting |
| 4 | No targeting at all |

# Alternatives and Analysis

## Alternative 1: Divert Health Equity Funds to a Naloxone Grant Program

This alternative will divert $30,000 from the Health Equity Fund to finance a grant program specifically targeted to expanding naloxone distribution (City of Richmond, 2021a). This alternative leverages existing disbursement infrastructure through organizations like Health Brigade or SAARA, as well as these organizations existing relationship with disproportionately affected communities. Naloxone programs function on the buy-in from the communities they serve (Rural Health Information, 2020). The established relationship between existing non-profit/harm reduction organizations and these communities would be an asset in this policy intervention. Further, a grant program would carve a funding path for new, innovative OEND programming ideas for the City.

Evaluation of Alternative 1

### Cost-Effectiveness

Cost

Cost for this alternative was evaluated by first applying the amount of funding for the grant itself ($30,000). Labor costs were evaluated by finding the average compensation for Grant Coordinator and Grant Writer positions in Richmond in 2019 (City of Richmond: Department of Human Resources, 2019). From there, a fringe benefit rate of 38% was applied to evaluate total compensation for these positions (Virginia State University, n.d.). It is assumed that the compensation of one full-time staff member is equivalent to the labor cost needed to implement this grant. A yearly raise of 0.6% was applied to labor costs. 5-year real net present costs were evaluated to be $771,625.07 (see Appendix D1).[10]

Effectiveness

A meta-analysis was conducted across 14 different studies related to OEND programming. This analysis examined what proportion of each OEND program's distributed naloxone is used to actually reverse an overdose (A. S. Bennett et al., 2011; Doe-Simkins et al., 2009, 2014; Enteen et al., 2010; Galea et al., 2006; Lankenau et al., 2013; Lewis et al., 2016; Maxwell et al., 2006; Piper et al., 2008; Tobin et al., 2009; Wagner et al., 2010; Walley et al., 2013; Wheeler et al., 2015; Yokell et al., 2011). These rates were then used to calculate an average community-

[10] Throughout all cost calculations, a discount rate of 3% and an inflation rate of 2.9% was applied. All labor costs included a yearly raise of 0.6% and were evaluated on total compensation (a fringe benefit rate of 38% was applied to base pay, if necessary). See Appendix C for all cost estimation assumptions.

distributed naloxone reversal rate. This number was then applied to a yearly program participant amount to estimate the number of overdose reversals caused by OEND programming.

To estimate participation numbers in Richmond OEND programming, I used a survey from the Centers for Disease Control and Prevention (Wheeler et al., 2015). This study surveyed non-profit groups to find how many people they train per year in naloxone. The average was about 400 people per organization. I then applied the OEND average reversal rate to that participant amount to find the number of overdose reversals in a given year for one organization. Then, this number was multiplied by three to account for three organizations receiving grant funding. The three organization assumption drew from a Foundation Report that found the median grant size for an organization with less than $1,000,000 in assets was $5,000 (Foundation Source, 2021). As a conservative assumption, I assumed the average grant size in this program was double that amount. Thus, three organizations would receive the grant.[11] Given these assumptions, three organizations would avert about 1,462 overdoses in a five-year span as a result of new OEND programming (see Appendix D2).

$771,625.07/1,462 overdoses reversed using naloxone = $527.78 per overdose reversed

### Administrative Burden

For this alternative, about five total organizations would be involved including the Mayor's office, the Department of Behavioral Health and Developmental Services (DBHDS) to distribute naloxone, and the three organizations receiving funding. From there, I calculated the number of steps to administer the grant including rule determination, application assessment, and fund provision. The total number of steps was 10 (see Appendix D3).

Administrative Burden = Number of organizations involved + Steps to implementation = 15

| Summation of Steps and Organizations | Ranking | Description |
|---|---|---|
| 0-25 | 1 | Lowest Burden |
| 25-50 | 2 | Lower Burden |
| 50-75 | 3 | Higher Burden |
| 75+ | 4 | Highest Burden |

### Equity

For this alternative, it is unclear how a given program would target those most vulnerable to overdoses. It would depend on the program itself. With that being said, after various

[11] Total grant amount/Average grant size = $30,000/$10,000 = 3

interviews with non-profits that distribute naloxone in Richmond and literature on OEND programming, these groups make a very intentional effort to go to areas of high risk, especially geographically high risk areas (Health Brigade, 2022). Due to the fact that this is not guaranteed, but likely, I will give this alternative a score of 2.

| Ranking | Description |
|---|---|
| 1 | High degree of targeting |
| 2 | Highly likely, but not guaranteed, targeting |
| 3 | Possible, but unlikely, targeting |
| 4 | No targeting at all |

## Alternative 2: Naloxone Vending Machine

Naloxone vending machines have rapidly increased in use over the past year. Localities in Kentucky, Washington, Ohio, Pennsylvania, New York, Indiana, California, Michigan, and Nevada have implemented naloxone vending machines. Philadelphia unveiled a machine as recently as February 2022 to provide on-demand naloxone service. While studies have not been able to research this recent policy intervention directly, the existing literature supports that vending machines better leverage what we know to be efficacious about naloxone distribution. Namely, vending machines better support concerns around privacy, stigma, and locational access as opposed to in-person training (Bowles et al., 2021; Green et al., 2017; Kirby et al., 1999; C. Williams & Metzger, 2010).

This alternative includes two parts: the development of a working relationship with the Board of Pharmacy Commissioner and the roll-out of three, free-to-use naloxone vending machines in Richmond areas with disproportionately high overdose rates. As it stands right now, Virginia Board of Pharmacy language seems to require person-to-person naloxone disbursement and particular data collection measures (Virginia Board of Pharmacy Naloxone Protocols, 2021). With that being said, other states like Ohio have released statutes that say the disbursement of naloxone from a machine is entirely acceptable in an "emergency situation" given that particular information is collected (Ohio Administrative Code, 2021). With these constraints, the first part of this alternative requires relationship-building with the Board of Pharmacy Commissioner to allow for the first ever pilot program of machine-dispensed naloxone in Virginia.

If allowed, these machines would go into areas with disproportionately high overdose rates. These areas would be Richmond's East End, Gilpin, and in Southside by Hillside Court and Oak Grove (see Figure 5A). Each area would have one free-to-use naloxone access point for a total of three throughout Richmond. The Mayor's Office would provide funding for each access point. The responsibility of restocking would fall on the Richmond City Health District or Richmond Behavioral Health Authority. Because there is a lack of data on naloxone vending machine efficacy, Richmond should prioritize collecting data after the access point opens. There is a risk that usage of the machine, so assessment of these metrics should continue throughout the pilot year to identify necessary interventions (i.e., increased awareness of the machines). A workgroup will assess if the program should continue after the pilot year based on efficacy measures.

Evaluation of Alternative 2

## Cost-Effectiveness

Cost

Caracole, an organization in Ohio, shared their budget in a 2022 meeting regarding naloxone vending machines (Caracole, 2022). Much of the cost for a Richmond naloxone vending machine is replicated from their budget with a few adjustments to address shortcomings. For one, their supplies category did not cover the cost of naloxone in Virginia (~$125/box). The supply line was adjusted to account for how much naloxone would be used in Richmond by scaling the naloxone disbursement in Cincinnati to Richmond's population (U.S. Census Bureau, 2020a, 2020b). This budget line also assumed that other supplies (safe smoking kits, band aids, personal protective equipment, etc.) would cost about $500 per month. I also adjusted lines related to marketing, variance in the "Other" category, machine costs, and labor costs.[12] For labor costs, I assumed two full-time positions would be necessary for both restocking and data collection/analysis purposes. Labor costs were evaluated by finding the average compensation for all City of Richmond employees in 2019 (City of Richmond: Department of Human Resources, 2019). From there, a fringe benefit rate of 38% was applied to evaluate total compensation (Virginia State University, n.d.). A yearly raise of 0.6% was applied to labor costs. After the first year (year 0), all up-front costs such as machine installation were removed from costing estimates. Consulting costs were also decreased by half after year 0. Overall, the real net-present value of the naloxone vending machine was $2,314,603.14 over a five-year period (see Appendix E1).

Effectiveness

I first evaluated the efficacy of a naloxone vending machine rollout in Las Vegas (Clark County, NV) in 2019. I also evaluated the roll-out of the vending machine in Cincinnati. For Nevada, I used CDC mortality data at the county and year level to view rates of unintentional overdose deaths (Centers for Disease Control and Prevention, National Center for Health Statistics, 2020). The efficacy of the Nevada vending machine was evaluated by first comparing overdose trends in Clark County with its surrounding counties (namely, San Bernardino County) pre- and post-2019. Then, I constructed a synthetic control using counties in all surrounding states of Nevada.[13] The synthetic control drew 98% from San Diego, California, so I directly compared San Diego and Clark County.

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[12] For marketing, Caracole's original documentation was only about ½ of what they actually spent. The original documentation did not include labor costs, but they announced they were hiring a new staff member to solely work on machine restocking.

[13] In this context, a synthetic control is a weighted average of counties that had similar pre-2019 fatal overdose trends to Las Vegas. This allowed me to compare the post-2019 fatal overdose trend between Las Vegas and the synthetic control.

These estimates were used to compare Clark County overdose rates before and after 2019 to both San Bernardino (a bordering county) and San Diego (98% of the synthetic control). We observe that Clark County had similar pre-trends to both San Diego and San Bernardino. Further, we assume that the counties' overdose rates would have developed in a similar way without naloxone vending machines. Given this, Clark County had 110 less overdose deaths than what we would have expected to see as compared to San Bernardino (see Appendix E2b). Similarly, Clark County had 117 less overdose deaths as compared to San Diego (see Appendix E2b). Assuming that just 2% of this difference is attributable to the machines alone, it is found that a naloxone vending machine is likely to avert 11 overdose deaths in 5 years using these estimates (see Appendix E2).

For Ohio, I used Caracole's machine use data to estimate how much naloxone was distributed in a year span and then applied a naloxone reversal rate that was 5% higher than the OEND meta-analysis rate (Caracole, 2022). I adjusted this rate by 5% to account for the fact that machines are more likely to specifically target people who use drugs. To evaluate the total efficacy rate, the measurements from Ohio and Nevada were averaged together. It should be noted that the Ohio measurement has a more attributable efficacy rate given that it was drawn directly from an existing vending machine's usage and OEND studies. To account for this, Ohio's efficacy is weighted at 75% whereas Nevada's efficacy is weighted at 25%. A naloxone vending machine is likely to avert about 2,357 overdose deaths in a 5-year span (see Appendix E2).

$2,314,603.14/2,357 overdoses reversed using naloxone = $981.87 per overdose reversed

### Administrative Burden

This alternative involves eight total organizations including the Board of Pharmacy, necessary health agencies, construction organizations, and a vending machine distributor (Caracole, 2022). Steps included relationship-building with the Board of Pharmacy and the coordination of naloxone, harm reduction supplies, construction equipment, necessary adjustments to the machine, machine restocking, data collection and analysis, among others.[14] All in all, this included about 135 steps (see Appendix E3).

Administrative Burden = Number of organizations involved + Steps to implementation = 143

| Summation of Steps and Organizations | Ranking | Description |
|---|---|---|
| 0-25 | 1 | Lowest Burden |
| 25-50 | 2 | Lower Burden |
| 50-75 | 3 | Higher Burden |
| 75+ | 4 | Highest Burden |

### Equity

The naloxone vending machines will be placed in areas of particularly high overdose rates. This provides geographic targeting. Further, through the supply of harm reduction materials, this alternative specifically targets those who use drugs. Evidence shows that people who use drugs are significantly more likely to experience an overdose, witness an overdose, and use distributed naloxone to reverse an overdose (Caudarella et al., 2016; Doggui et al., 2021; Enteen et al., 2010; Pizzicato et al., 2020; Rees et al., 2017; Wheeler et al., 2015). Given both geographic and community targeting, this alternative is given a score of 1 with a high degree of targeting. This alternative has an incredibly strong consideration of disproportionate effects.

| Ranking | Description |
|---|---|
| 1 | High degree of targeting |
| 2 | Highly likely, but not guaranteed, targeting |
| 3 | Possible, but unlikely, targeting |
| 4 | No targeting at all |

[14] Steps were increased for Board of Pharmacy relationship building to represent time and difficulty.

## Alternative 3: Naloxone Training for City Hall Staff

This alternative would provide overdose education and naloxone distribution (OEND) programming to all City of Richmond governmental employees. This includes 3,839 employees across 24 departments under the executive branch of Richmond City government (Stoney, 2022). There will be three separate priority levels used. These priority levels will determine which departments get OEND training first. The levels are determined through a subjective measure of which departments are more likely to encounter someone with high overdose risk. Police, Fire and Emergency, and Parks, Recreation and Community Facilities are priority level #1 as they have the highest contact with overdose risk whether through emergency calls or in person at community centers/park locations. There are a total of about 1,522 people between these three departments (Stoney, 2022). From there, Housing and Community Development, Library, Social Services, Office of Community Wealth Building, Citizen Service and Response, Emergency Communication, and Justice Services departments are under level #2 due to their interaction with citizens, but not necessarily those of high overdose risk (although this might be the case with some departments). This level includes about 805 employees. All other departments make up priority level #3 at 1,512 employees. Those in Public Utilities, Public Works, and Planning and Development Review make up 75% of the staff in level #3. As for the training itself, the Mayor's Office will fund the time for training and naloxone. The Department of Behavioral Health and Developmental Services (DBHDS) will conduct the trainings and actually distribute the naloxone.

Evaluation of Alternative 3

### Cost-Effectiveness

Cost

There are 3,839 employees according to the City of Richmond's 2022 budget (Stoney, 2022). The loss in work time for these employees was calculated by multiplying the 2 hour training time with the per hour total compensation rate of an average City of Richmond employee.[15] A fringe benefit rate of 38% was then applied (City of Richmond: Department of Human Resources, 2019; Virginia Department of Behavioral Health and Developmental Services, n.d.; Virginia State University, n.d.). The cost of naloxone for each employee was included in costing (Clemans-Cope et al., 2020). Finally, the labor costs of training for DBHDS employees were calculated. Given an assumption on the number of classes necessary to train all staff and using an average administrator salary from GlassDoor, the monetized time for DBHDS employees was calculated (GlassDoor, 2022; Virginia State University, n.d.). A similar method was used to estimate the time of scheduling/administration; in this case, the average Richmond City

[15] The trainings are between 1-1.5 hours according to the DBHDS website. I conservatively assumed a 1.5 hour training time with a 15-minute buffer before and after training.

employee compensation measure was applied. After the first year, labor and supply costs would look different for this program. After year 0, only City employees entering the workforce would need to be trained and supplied with naloxone. Bureau of Labor Statistics data was used to estimate how many employees a state government, on average, loses every year (Bureau of Labor Statistics, 2022). Using that loss rate and assuming almost immediate subsequent hiring, I could estimate the number of employees that need naloxone training each year. Further, the same method from year 0 was applied to all subsequent years to value the time away from work, cost of naloxone, cost of training to DBHDS employees, and cost of administration/scheduling.

Finally, I also accounted for police and fire having a higher-than-average naloxone replenish rate. It is likely that police and fire would have greater contact with those who are experiencing overdoses due to their role in emergency response (Davis et al., 2014). To account for this, I applied the average OEND reversal rate from the meta-analysis to the number of sworn police officers and all fire employees in Richmond City (City of Richmond, n.d.; Stoney, 2022). This would provide an estimate on how much naloxone would need to be replaced each year. Using these robust measurements, 5-year net present costs were calculated to be $996,056.47 (see Appendix F1).

Effectiveness

Efficacy calculations were split into two parts: the reversal rate for police and fire and the reversal rate for the rest of the City Hall population. This distinction is made since police and fire having a higher likelihood of encountering an overdose as compared to the general population (Davis et al., 2014). In starting with police and fire, a study from 2015 found that when police encountered an overdose, naloxone successfully reversed the overdose 45% of the time (Rando et al., 2015). Another 2016 study found that about 54.5% of police offices will encounter at least one overdose every year (Wagner et al., 2016). In applying these rates to the total number of police and fire officials from the costing section, it's found that police and fire will successfully reverse about 292 overdoses in a year given that they have naloxone on their person.

In turning to City Hall reversal rates, a study from 2018 evaluated the difference in naloxone refill rates between non-opioid users and those who use opioids (A. S. Bennett et al., 2018). The non-opioid user refill rate will be used as a proxy for the general population's naloxone reversal rate and, subsequently, the remainder of the City Hall population (i.e., City employees who are not sworn police officers or fire officials). Overall, it is estimated that the entirety of City Hall (Police, Fire, and all other departments) will reverse about 1,596 overdoses in a five-year span (see Appendix F2).

$996,056.47/1,596 overdoses reversed using naloxone = $623.95 per overdose reversed

### Administrative Burden

This alternative includes the Mayor's Office, DBHDS to coordinate training/naloxone, and the 24 departments across the Richmond executive branch (Stoney, 2022). This leads to a total organizational count of 26. Then, the step count was evaluated to estimate time for coordination and funding. Each department was given one step to account for their respective coordination. These steps also included the coordination of a contract with police and fire to replenish their naloxone on a monthly basis. All in all, these steps encapsulate coordination, training, and replenishment of the highest naloxone users. This added up to 34 steps (see Appendix F3).

Administrative Burden = Number of organizations involved + Steps to implementation = 60

| Summation of Steps and Organizations | Ranking | Description |
|---|---|---|
| 0-25 | 1 | Lowest Burden |
| 25-50 | 2 | Lower Burden |
| 50-75 | 3 | Higher Burden |
| 75+ | 4 | Highest Burden |

### Equity

For this alternative, there is no active targeting. The City Hall population is representative of the general population in terms of overdose encounters. This alternative did not take into account any locational, socio-economic, or identity-based disparities in overdose risk. An argument could be made that targeting exists since police and fire interact with communities that experience overdoses at higher rates; however, it is unclear how this would look in reality (Davis et al., 2014). In fact, these encounters could even increase disparities depending on officer preferences of how often/when to administer naloxone, as well as who to give naloxone to (Berardi et al., 2021). For these reasons, this alternative is given a score of 4.

| Ranking | Description |
|---|---|
| 1 | High degree of targeting |
| 2 | Highly likely, but not guaranteed, targeting |
| 3 | Possible, but unlikely, targeting |
| 4 | No targeting at all |

## Alternative 4: Expanded Naloxone Training for those released from Richmond Jail

Currently, the Virginia Department of Health provides OEND training on a weekly basis to those released from Richmond Jail. The population that receives training is picked by the jail itself. The jail picks people that are deemed at risk for substance use disorder (J. Karr, personal communication, February 18, 2022). Conversations with those at VDH suggest that this program has high potential. So far, they have trained about 80 people and already have one anecdotally-reported reversal (J. Karr, personal communication, February 18, 2022). That is a reversal rate of about 1.25% without any official data collection, suggesting a high efficacy of this program. Thus, this policy intervention expands OEND programming availability to all released inmates as opposed to just those identified by the jail. Given that their strategy for assessing SUD risk is unclear, expanded programming will provide needed and targeted naloxone to an incredibly vulnerable population (Ranapurwala et al., 2018). VDH will conduct the naloxone training 3x a week for this population and the Mayor's Office would provide funding for the naloxone.

Evaluation of Alternative 4

### Cost-Effectiveness

Cost

To estimate costs for this program, it's essential to understand how many people exit Richmond Jail per year. Using 2014-2018 data from the Vera Institute of Justice, the average number of people discharged every year from Richmond Jail is 13,998 people (Vera Institute of Justice, 2018/2022). Studies have found that not every released inmate participants in OEND training and, even when some do, they do not necessarily agree to take naloxone home with them (Parmar et al., 2017; Wenger et al., 2019). Given this, I assumed a participation rate of 5% (see Appendix G1a). This number was estimated using data from a similar program in a San Francisco jail (Wenger et al., 2019). In combining the participation assumption with the Vera Institute discharge rate data, it is estimated that about 700 people released from Richmond jail would participate annually (see Appendix G1a).[16]

Using this participation number, naloxone costs are calculated to be $93,490 (Clemans-Cope et al., 2020). I assumed that there are 3 trainings per week for about 3 hours each (to account for travel/setup). Using Glassdoor's average salary of a VDH Public Health Educator and applying a fringe benefit rate, training costs came out to $14,000 per year (GlassDoor, 2017; Virginia Department of Behavioral Health and Developmental Services, n.d.; Virginia State University, n.d.). Finally, scheduling and administration costs were calculated using the average total compensation of a Richmond City government employee and assuming 5 hours of coordination per week (City of Richmond: Department of Human Resources, 2019; Virginia

[16] This applied the 5% participation rate to the total Richmond discharge rate of 13,998 people/year.

State University, n.d.). The 5-year net present costs are calculated to be $697,375.88 (see Appendix G1).

Effectiveness

Efficacy rates drew from two studies related to incarceration release and naloxone disbursement, one from San Francisco and the other from England (Parmar et al., 2017; Wenger et al., 2019). The San Francisco study reported a reversal rate of 32% (Wenger et al., 2019). The English program had a reversal rate of 19% among those who responded to a self-questionnaire (Parmar et al., 2017). The average of these two programs was 25.38%. In applying this reversal rate to the estimated 700 participants, there will be about 888 overdose reversals in 5 years as a result of this program (see Appendix G2).

$697,375.88 /888 overdoses reversed using naloxone = $785.31 per overdose reversed

## Administrative Burden

There are four organizations involved including the Mayor's Office, Richmond Jail, VDH (training), and DBHDS (naloxone disbursement). Step count included the evaluation of training scope, development of training materials, and the coordination of participant recruitment, naloxone distribution strategy, and staffing (see Appendix G3).

Administrative Burden = Number of organizations involved + Steps to implementation = 51

| Summation of Steps and Organizations | Ranking | Description |
|---|---|---|
| 0-25 | 1 | Lowest Burden |
| 25-50 | 2 | Lower Burden |
| 50-75 | 3 | Higher Burden |
| 75+ | 4 | Highest Burden |

## Equity

This alternative specifically targets a high-risk population. As mentioned before, people who are released from prison are 12-40x more likely to die from an opioid overdose the two weeks following release with these numbers remaining high for several years after (Ranapurwala et al., 2018; Waddell et al., 2020). Given these statistics, this policy clearly targets a high-risk population. For these reasons, this alternative is given a score of 1.

| Ranking | Description |
|---|---|
| 1 | High degree of targeting |
| 2 | Highly likely, but not guaranteed, targeting |
| 3 | Possible, but unlikely, targeting |
| 4 | No targeting at all |

## Recommendation

Given this analysis, I recommend the Richmond Mayor's Office pursue alternative 1, the naloxone grant program. This alternative will divert $30,000 from the Health Equity Fund (.6% of the overall Fund) to finance a grant program for expanded naloxone distribution. The grant program will strengthen existing naloxone distribution infrastructure and leverage existing community buy-in. Table 1 summarizes the analysis of each alternative given the established criteria of cost-effectiveness, administrative burden, and equity. Alternative 1 was the most cost-effective, had the lowest administrative burden, and likely has high/moderately high targeting towards those of high overdose risk. Based on sensitivity analyses, this initiative should have a goal of training 400 people per organization every year.

Table 1: Outcomes Matrix

| Criteria | Weights | Alternative 1: Grant Program | Alternative 2: Naloxone Vending Machine | Alternative 3: City Staff OEND | Alternative 4: Expanded Jail OEND |
|---|---|---|---|---|---|
| Cost-Effectiveness Analysis (CEA) | 50% | $527.78 | $981.87 | $623.95 | $785.31 |
| CEA Ranking | 50% | 1 | 4 | 2 | 3 |
| Administrative Burden | 35% | 1 | 4 | 3 | 3 |
| Equity | 15% | 2 | 1 | 4 | 1 |
| TOTAL | 100% | 1.150 | 3.550 | 2.650 | 2.700 |

As an important note, each of these options is extremely cost-effective and would be a viable way to save lives in Richmond. The most expensive option would only cost about $982. That is just $982 to save a person's life from a fatal overdose.

### Sensitivity Considerations

When examining the sensitivity of these findings, the naloxone vending machine consistently has some of the highest costs. The high labor costs associated with stocking, machine maintenance, and data collection drive this result. With that being said, alternatives 1, 3, and 4 are highly sensitive to changes in costing and efficacy assumptions (see Appendix H). Adding another full-time staff member to coordinate the grant program or decreasing the number of grant recipients to two instead of three leads to a practical tie between the three alternatives (Appendix H: Table H1, H2).

We also see high sensitivity to participant assumptions in the grant program. If each grant organization reaches about 200 participants in a year, as opposed to 400, then the City Staff and Expanded Jail OEND alternatives are respectively ranked #1 and #2 with incredibly close scoring (Appendix H: Table H3). These findings are also slightly sensitive to Jail OEND participation rates. A participation rate of 30% (as opposed to 5%) puts the jail program in the second most favorable score yet still behind the grant program (Appendix H: Table H4). Expanded Jail OEND would be the most favorable policy option if the participation rate was 30% *and* the grant program's participation reach was decreased to 200 participants (Appendix H: Table H5). Further, the rate of overdose encounters among police and fire significantly impacts the cost-effectiveness of alterative 3. A 25% overdose encounter rate among emergency responders (as opposed to 55%) leads alternative 3 to be ranked last (Appendix H: Table H6).

In summary, sensitivity analyses show that the naloxone vending machine remains a high-cost option, but not prohibitively so. In fact, the vending machine is more cost-effective than the City Staff OEND alternative when there is a 25% overdose encounter rate among emergency responders (as opposed to 55%). Alternatives 1, 3, and 4 are highly sensitive to cost and participant assumptions. This suggests that these three alternatives may all be suitable interventions for the Mayor's Office. Further, these findings indicate that the participation rate of an OEND program is one of the most important determinants of cost-effectiveness. The implementation of any alternative, including Alternative 1, should center on high community buy-in and participation.

## A Note on Future Interventions for the City of Richmond

These alternatives do not have to exist in isolation. A roll out of several of these programs, coupled with expanded treatment and recovery services, would be the most comprehensive approach to Richmond's overdose epidemic (Blanco et al., 2020). As highlighted in the HHS intervention framework, one alternative alone will not be enough to reverse the opioid crisis in Richmond. Rather, Alternative 1 is the most practical place for the Mayor's Office to start.

Given this, I strongly encourage the Mayor's Office to explore further policy interventions.[17] Specifically, the Office should continue to expand naloxone disbursement, as well as addiction and recovery services. For example, expanded funding for peer-based recovery homes, similar to the McShin Foundation's model, would be a viable future policy intervention (McShin Recovery Resource Foundation, n.d.). Another evidence-based intervention would be the expansion of medication-assisted treatment availability (see Appendix I for more information).

These are just a few possible interventions for Richmond City. Overall, the Mayor's Office must strategically leverage the knowledge, connections, and know-how of stakeholders on the Richmond Opioid Task Force and in harm reduction/recovery organizations to identify future paths for intervention. For example, the implementation of a yearly Richmond Opioid Task Force report could set a standardized process for collecting stakeholder input. This report could model Michigan's Task Force report (Michigan Department of Health and Human Services, 2020). This stakeholder connection is essential for a robust, effective approach to the overdose epidemic.

[17] The implementation of future interventions should draw from evidence-based state, local, national, and academic frameworks. Refer to overdose intervention strategies from the Annals of Internal Medicine, Journal of the American Medical Association, Translational Psychiatry, Project Lazarus in North Carolina, Washington state, and Michigan state.

## Implementation

To implement the naloxone grant program, funds must first be diverted from the Health Equity Fund for grant availability. Following this diversion, at least one City staff member will be designated to facilitate the grant process. This person will be the point person for the fund, but they will work with and be supported by a variety of other staff members. The Richmond Opioid Task Force should also appoint one member to serve as the Task Force lead on the grant program. The Task Force point person will provide support with the grant management process in terms of identifying relevant stakeholders, understanding community needs, and developing community buy-in around naloxone distribution. As mentioned before, the leveraging of community stakeholder knowledge is essential to effective policy intervention around overdose prevention. This point should not be overlooked in implementation, especially when stigma and community engagement significantly impact the success of naloxone distribution programs.

Prior to the announcement of the grant to the general public, the City and Task Force point (referred to from here on out as "the leads") will develop strategic goals and requirements for the grant. This step is important for detailing a clear grant vision and guarantees the fulfillment of any grant-reporting requirements at the local, state, and/or federal level (R. Bennett, 2020). This process will be similar to other grants that exist at the local level, but will be grounded to specifically naloxone disbursement by the Task Force point (City of Richmond, 2021b). There should also be a process established for evaluating the cost of the grant in terms of administration time and data collection. This will allow a better sense of what yearly expenditures look like for the grant outside of the designated $30,000 award.

At this step, the consideration of data evaluation and collection must be considered. The Task Force and City points should assess what data is necessary to effectively allocate grant funds. At a minimum, information on the organization's expected program participation rates, cost, population of focus, and strategy for community buy-in/participation must be gathered. Specifically, an organization's community engagement write-up should highlight what the organization plans to do to target high-risk communities and gain community trust, as well as how they will address concerns around stigma. These are some of the most important determinants of program efficacy.

The leads should also consider what data the grant-awarded organization(s) should collect during the program itself. At a minimum, this should include the number of unique participants, naloxone kits distributed, and reported overdose reversals. Finally, the leads should consider what a successful grant program would look like. For example, is success a certain number of naloxone kits distributed? Is it a certain reported overdose reversal rate? Is it some other

measure, perhaps the number of participants? Given sensitivity analyses, I recommend success is measured through both program participation rates and reported reversal rates; however, input from City and Task Force leads should be used to ultimately shape grant goals. Overall, these considerations are essential for setting a framework for program success. It also ensures a standardized evaluation of grant allocation and program efficacy (Pride Surveys, 2017).

It is important to highlight that harm reduction and public health organizations might have some friction with the data collection requirements. As opioid use is heavily stigmatized, there might be concern that any collection of data will lead program participants to use the services less (A. S. Bennett et al., 2020). For some participants, even if they know that everything is totally anonymized, the data collection might serve as a significant barrier. Grant leads should consider the friction between capturing as much data as possible and how data collection could reduce program participation.[18] It is a balancing act between information capture and being sensitive to the needs and wants of program participants. Naloxone distribution programs rely on community buy-in, so consideration of this point is essential (Rural Health Information, 2020). The Task Force lead should leverage stakeholder relationships to evaluate how best to balance data collection needs with organizational/community trust. As a note, The City of Richmond could consider evaluating grant efficacy in conjunction with VCU or the University of Richmond. Virginia lacks publicly available, locality-specific data on naloxone distribution efficacy. This grant program could fill an informational gap. This partnership would also help grant managers consider the balance between data collection and privacy.

Following the establishment of grant rules and goals, it is essential that this grant is made sufficiently visible to stakeholders in the community. The Task Force lead will be essential here for identifying relevant stakeholders and the most effective ways to communicate awareness. Stakeholders include harm reduction organizations and public health groups that distribute naloxone throughout the community. At a minimum, Richmond should publish grant information through the press, social media, and internal messaging. Messaging must include the grant due date and requirements for application/data-collection throughout the program itself. The strategic goals and requirements outlined prior to the public announcement should be communicated through messaging. After the due date passes, the grant leads should evaluate applications based on the metrics outlined prior to publication (Asana, 2021). From there, the Office will award grant funding to the respective organization(s).
At this point, the office should move to establish a working relationship with the grant-awarded organization(s) and make it clear what sort of data they need throughout the process (R. Bennett, 2020). This will allow the City of Richmond to maintain communication with these

[18] This is also important from an impact evaluation perspective. A reduction in program participation would make program efficacy look lower than it otherwise would be without grant requirements.

organization(s) and get a sense of what is and is not working well for respective projects. This will also allow the Office to begin data evaluation on efficacy and community response. This is essential for evaluating future program improvements and assessing Richmond-specific needs around naloxone disbursement. At the end of the grant process, a final report from the organization(s) should be submitted within 90 days of the grant close-out date (Health and Human Services, n.d.). These will be used to gather final insights from the first year of the grant program.

Following this point, the leads and other program organizers should assess the efficacy of grant-awarded programming (Thorpe & Kock, 2011). Specifically, grant managers should try to evaluate how overdose reversal rates and fatal overdoses responded to programming. If possible, this information should be made public to help inform opioid crisis interventions in other localities similar to Richmond. Further, the leads should reflect on how administration and leadership ran throughout the process. These reflections are essential for improving future grant administration processes.

# Appendix

## Appendix A. Overview of Opioids

### What are opioids?

Opioids are natural, synthetic, or semi-synthetic chemicals that interact with nerve cells to reduce pain. The most common opioids are heroin, fentanyl (semi-synthetic), tramadol (brand name: Ultram), methadone, oxycodone (brand name: Oxycontin), hydrocodone (brand name: Vicodin), codeine, and morphine (Centers for Disease Control and Prevention, 2021a). Except for heroin, these other medications are commonly prescribed to reduce pain after a traumatic event.

### How do opioids work?

Opioids induce an intense euphoria after they are consumed. Opioids travel through the user's bloodstream to the brain, where they link with specific proteins responsible for pleasure. During this feeling of euphoria, the brain creates a lasting memory that connects that feeling of euphoria with the environment and context of opioid use. This is called conditioned association. It leads people with opioid addiction to seek out opioids at extreme costs (Kosten & George, 2002).

### How are they accessed?

Due to their euphoric qualities upon use, opioids are effective for pain relief and can be necessary to maintain a standard of living for injured patients. Over 150 million opioid prescriptions were written in 2019; this is a rate of 46.7 prescriptions per 100 people (Centers for Disease Control and Prevention, 2020). While declining over recent years, these rates are still high, meaning an increased risk of abuse and misuse.

It should be noted that responsible prescribing of opioids is not the be-all-end-all for solving the overdose crisis. Illegally produced opioids now make up the majority of fatal overdoses in Virginia (Virginia Department of Health: Office of the Chief Medical Examiner, 2021). In Virginia, illegally produced opioid deaths surpassed prescription opioid deaths in 2015. This trend has increased in magnitude every year since (Virginia Department of Health Chief Medical Examiner, 2020). In Virginia, there has been no change in the rate of fatal prescription opioid overdoses since 2007, whereas illicitly produced opioids have made up the majority of overdoses since around 2014 (Virginia Department of Health: Office of the Chief Medical Examiner, 2021). With illegally-produced opioid deaths making up a majority of overdoses, it is more difficult to tackle the supply-side of the opioid market.

## Appendix B. Individual Level Costs of Addiction

At the individual level, there are significant physical, mental, and social costs of opioid use. In addition to an overall reduced quality of life from impaired functioning and increased sensitivity to pain, there are adverse health effects like greater exposure to HIV, hepatitis B, and hepatitis C from shared needles and syringes (Strain et al., 2021). People struggling with opioid use are also more susceptible to infection, gastrointestinal issues, motor vehicle accidents, and bone fractures (Strain et al., 2021). Given this, healthcare costs for people with OUD are above and beyond the health costs from just recovery or treatment. People who struggle with opioid use are also more likely to have lower labor force participation, relatability, and productivity, subsequently impacting economic stability (Joint Legislative Audit and Review Commission, 2008). There are also negative physical consequences (scabs, digestive problems, itching), behavioral consequences (poor performance in school/work, social isolation, restlessness), and mental consequences of opioid use (outbursts, irritability, and depression) (National Center on Substance Abuse and Child Welfare, 2018). Above all, the largest cost to someone with opioid use disorder is the potential loss of their life. Opioid use significantly increases mortality and morbidity (Dydyk et al., 2021).

Appendix C. Assumptions for all Cost-Effectiveness Analyses

| | |
|---|---|
| Discount Rate | 3% |
| Inflation Rate over the past 5 years | 2.94% |
| Real discount rate | 0.0583% |
| Average raise per year for governmental salaries | 0.6% |
| Fringe benefit rate | 38% |
| Cost per box of naloxone | $125 |

Appendix D. Naloxone Grant Program Evaluation

## Cost-Effectiveness

D1. Costing

D1a. Assumptions

| Assumptions for Grant Program Cost | |
|---|---|
| Average salary of a Richmond government employee working on grant management (annual compensation including benefits) | $97,321.05 |

D1b. Net Present Cost

*Yearly Budget*

| | Account for Pay Raises | | | | | |
|---|---|---|---|---|---|---|
| Years | 0 | 1 | 2 | 3 | 4 | 5 |
| Funding for grant itself | $30,000 | $30,000 | $30,000 | $30,000 | $30,000 | $30,000 |
| Labor costs (1 position – apply pay raises) | $97,321.05 | $97,904.98 | $98,492.41 | $99,083.36 | $99,677.86 | $100,275.93 |
| Total for each year | $127,321 | $127,905 | $128,492 | $129,083 | $129,678 | $130,276 |

*Net Present Budget*

| Years | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Net Present Cost (Inflation and Discount) | $127,321.05 | $127,830.47 | $128,342.75 | $128,857.91 | $129,375.96 | $129,896.93 |

Total Net Present Cost (5 Years) = $771,625.07

D2. Effectiveness

D2a. Assumptions

| Assumptions for Grant Program Effectiveness | |
|---|---|
| How many participants can a single organization reach in a year in Richmond? | 400 |
| How many organizations receive grant funding? | 3 |

D2b. Average reversal rate across OEND studies

| Study Authors | Number of Participants | Number of Overdoses Reversed | Reversal Rate |
|---|---|---|---|
| Enteen et al. (2010) | 1,942 | 355 | 18.3% |
| Maxwell et al. (2006) | 3,500 | 319 | 9.1% |
| Doe-Simkins et al (2009) | 385 | 74 | 19.2% |
| Doe-Simkins et al (2014) | 4,296 | 508 | 10.3% |
| Walley et al. (2013) | 2,912 | 320 | 11% |
| Lewis et al. (2016) | 250 | 3 | 1% |
| Galea et al. (2006) | 25 | 10 | 40% |
| Bennett et al. (2011) | 426 | 246 | 58% |
| Lankenau et al. (2013) | 30 | 15 | 50% |
| Markham Piper (2008) | 122 | 68 | 56% |
| Tobin et al. (2009) | 250 | 19 | 8% |
| Wagner et al. (2010) | 66 | 26 | 39% |
| Yokell et al. (2011) | 120 | 5 | 4% |
| Wheeler et al. (2015) | 152,283 | 26,463 | 17% |
| Average | | | 24.37% |

D2c. Average reversal rate applied to Richmond given participant and organizational assumption (400 participants per organization, 24.37% reversal rate)

| One Organization Receives the Grant | | |
|---|---|---|
| | Average number of overdose reversals in one year | 97.47 |
| | Average number of overdose reversals in five years | 487.34 |
| Three Organizations Receive the Grant | | |
| | Average number of overdose reversals in one year | 292.405 |
| | Average number of overdose reversals in five years | 1,462.025 |

## Administrative Burden

D3. Administrative Burden

*Who is involved?*

| Participants | Count | Purpose |
|---|---|---|
| Mayor's Office | 1 | To administer the grant |
| DBHDS to distribute naloxone | 1 | To distribute naloxone (whether directly through the grant or indirectly through a partnership) |
| Organizations to use funding | 3 | To coordinate grant proposal and implementation |

Total Organizations: 5

*Number of Steps*

| Step | Count | Notes |
|---|---|---|
| Set rules of grant | 1 | |
| Coordinate grant materials | 1 | |
| Announce grant | 1 | |
| Assess applications | 5 | 5 steps for extra effort in assessment/data analysis |
| Consideration of funding | 1 | |
| Provide funding | 1 | |

Total Steps: 10

Total Burden: 15

Appendix E. Naloxone Vending Machine Evaluation

## Cost-Effectiveness

### E1. Costing

E1a. Assumptions

| Assumptions for Naloxone Vending Machine Costing | |
|---|---|
| Salary of a Richmond government employee (median, annual compensation including benefits) | $66,277.536 |

E1b. Itemized Costs

*Equipment*

| Object | Cost | Notes |
|---|---|---|
| Machine | $12,000 | |
| Custom configuration | $522 | |
| Controller board to interact with software | $1,325 | |
| VF display and harness | $185 | |
| Glass graphics and installation | $275 | |
| Exterior sharps container | $60 | |
| Exterior sharps return installation | $179.95 | |
| Inserts for exterior sharps container | $108 | Keep after year 0 |
| Service Plan | $1,700 | Keep after year 0 |
| Insurance | $520 | Keep after year 0 |

Total Equipment Costs: $16,874.95

*Other*

| Object | Cost | Notes |
|---|---|---|
| Vending machine monthly fee | $540 ($45/month) | Keep after year 0 |
| Installation of electric outlet and cat 5 cable for WIFI | $1,200 | |
| Construction consideration/accommodations | $805 | |
| Cable run for machine/Internet | $159 | |

Total Costs: $2,704

*Supplies*

| Object | Cost | Notes |
|---|---|---|
| Naloxone | $230,062.5 | • Keep after year 0<br>• Adjusted: Assumed similar distribution of naloxone as Cincinnati's machine, but scaled to the Richmond population [which is about 75% of Cincinnati's]<br>• Adjusted: Adjusted naloxone costs to that reflected in Medicaid pricing |
| Other harm reduction supplies | $6,000 | • Keep after year 0<br>• Adjusted: Assume costs for other supplies is about $500/month |

Total Costs: $236,062.5

E1c. Estimates without Discount Rate

*Yearly Budget*

| | Account for Pay Raises | | | | | |
|---|---|---|---|---|---|---|
| Years | 0 | 1 | 2 | 3 | 4 | 5 |
| Consultants | $7,000 | $3,500 | $3,500 | $3,500 | $3,500 | $3,500 |
| Equipment | $16,874.95 | $8,220 | $8,220 | $8,220 | $8,220 | $8,220 |
| Supplies | $236,062.5 | $236,062.5 | $236,062.5 | $236,062.5 | $236,062.5 | $236,062.5 |
| Printing and copying | $858.6 | $858.6 | $858.6 | $858.6 | $858.6 | $858.6 |
| Other | $3,904 | $540 | $540 | $540 | $540 | $540 |
| Labor costs | $132,555.01 | $133,350.40 | $134,150.50 | $134,955.41 | $135,765.14 | $136,579.70 |
| Total for each year | $397,255.12 | $382,531.50 | $383,331.60 | $384,136.51 | $384,946.24 | $385,760.80 |

*Notes*

- Equipment costs: Added $5,000 from Caracole's to reflect average cost of machine
- Supply costs: Increased costs to account for naloxone and harm reduction materials
- Printing and copying costs: Caracole's original number was not indicative of all marketing. To account for this, this cost was increased by 80%
- Other costs: Caracole's budget included some variance in this category. To account for this, I added $100 to every month
- Labor costs: Assumed two, full-time positions for maintenance and data collection

E1d. Total Net Cost

*Net Present Budget*

| Years | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Net Present Cost (Inflation and Discount) | $397,255.12 | $382,308.67 | $382,885.1 | $383,465.60 | $384,050.06 | $384,638.60 |

Total Net Present Cost (5 Years) = $2,314,603.14

E2. Effectiveness

| D2a. Assumptions for Naloxone Vending Machine Effectiveness | |
|---|---|
| Weight Nevada this amount for efficacy evaluation | 0.25 |
| Weight Ohio this amount for efficacy evaluation | 0.75 |
| Assume x% of the change in Las Vegas overdose rates is attributable to a naloxone vending machine | 2% |
| Assume that vending machine efficacy is x% higher than the average OEND efficacy (which is typically through needle-exchanges) | 5% |

E2b. Efficacy Estimates - Las Vegas and San Bernardino/San Diego

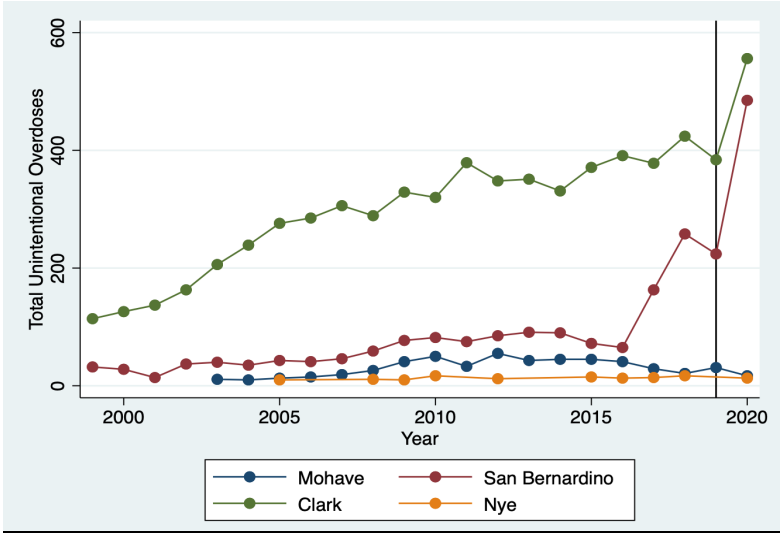


Figure B1: This figure shows the differences in overdose rates across three surrounding counties and Clark, NV (Location of Las Vegas, where a naloxone vending machine program is located). San Bernardino and Clark had the most similar pre-trends. We can see the shallower slope in Clark, post-2019. This provides an indication that overdoses increased at a slower rate in Clark than in San Bernardino (Centers for Disease Control and Prevention, National Center for Health Statistics, 2020)

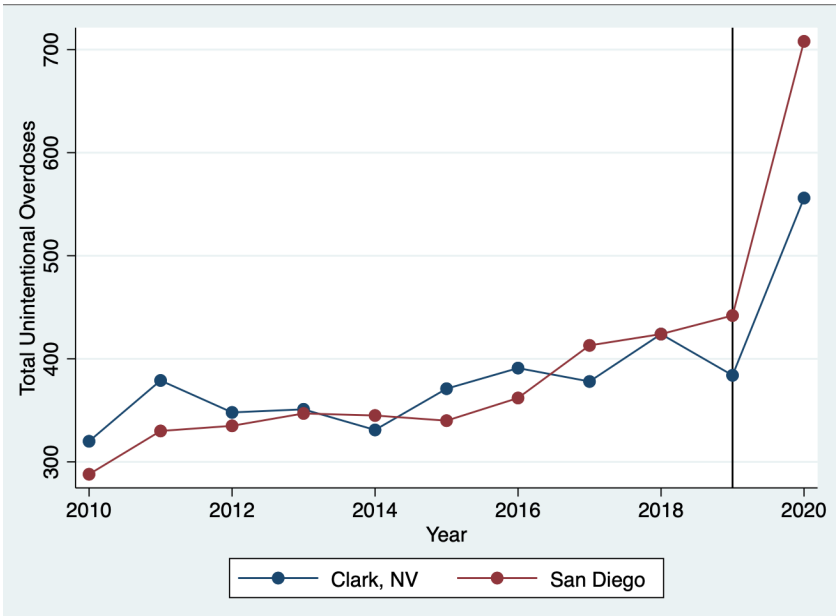


Figure B2: This figure shows the differences in overdose rates between Clark, NV and San Diego (the county that the synthetic control drew 98% from, indicating similar pre-trends). We can see the shallower slope in Clark, post-2019. This provides an indication that overdoses increased at a slower rate in Clark than in San Diego (Centers for Disease Control and Prevention, National Center for Health Statistics, 2020).

E2c. Efficacy Calculations

*Nevada*

| | | |
|---|---|---|
| Las Vegas v. San Bernardino (SB): 110 less overdose deaths in 2020 than we would expect to see without the vending machines | 110 | Based off regression of surrounding counties |
| Las Vegas v. San Diego (SD): 117 less overdose deaths in 2020 than we would expect to see without the vending machines | 117 | Based off synthetic control from surrounding states. Synthetic control pulled 98% from San Diego |
| Assume 2% of that change is attributable to a naloxone vending machine (NVM) | | |
| San Bernardino: Fatal overdoes prevented over the next 5 years due to NVM | 11 (.02*110 = 2.2 * 5 = 11) | |
| San Diego: Fatal overdoes prevented over the next 5 years due to NVM | 11.7 (.02*117= 2.34 * 5 = 11.7) | |
| On average, the number of fatal overdoses prevented over 5 years due to NVM | 11.35 ([11+11.7]/2) | |

*Cincinnati*

| | |
|---|---|
| From March 2021 to February 2022, Caracole distributed the following amount of naloxone | 2,454 |
| With assumption that vending machine efficacy is 5% higher than the average OEND efficacy, how many overdoses would be reversed per year given 2,454 naloxone kits are distributed in Cincinnati? | 627.86 |
| 5-Year Estimate | 3,139.33 |

Weighing the Ohio estimate at 75% and the Nevada estimate at 25%, we can estimate that 2,357.34 overdoses will be reversed in a 5-year span due to a naloxone vending machine

## E3. Administrative Burden

E3a. Number of Organizations

*Who is involved?*

| Participants | Count | Purpose |
|---|---|---|
| Board of Pharmacy | 1 | To coordinate pilot program |
| DBHDS | 1 | To distribute naloxone |
| Vending machine organization to coordinate machine | 1 | |
| Supplies and marketing through VDH | 1 | To spread awareness and access harm reduction supplies |
| Mayor's Office | 1 | To pilot the program |
| Insurance company | 1 | To insure the machine |
| Construction/Implementation Organizations | 2 | To account for necessary modifications to the machine/surrounding area |
| Construction | | |
| Electric/Wiring | | |

Total Organizations: 8

E3b. Steps and Total Summation

| Step | Count | Notes |
|---|---|---|
| Work with Board of Pharmacy to coordinate pilot program | 30 | Increased steps to reflect difficulty here |
| Appropriate funding for naloxone | 1 | |
| Coordinate naloxone distribution with DBHDS | 1 | |
| Coordinate harm reduction supplies with VDH | 5 | 5 steps for extra effort in assessment/data analysis |
| Appropriate funding for harm reduction supplies | 1 | |
| Work with vending machine provider and establish contract | 5 | 5 steps for contract |
| Work with insurance company | 5 | 5 steps for contract |
| Electric/wiring coordinating | 8 | 8 steps for coordination with group the Office has not worked with before |
| Construction coordination | 8 | 8 steps for coordination with group the Office has not worked with before |
| Coordinate with Finance Office to assess cost of vending machine/construction | 2 | 2 to reflect both vending machine and construction acquisition |
| Allocate funding to machine and construction | 2 | 2 to reflect both vending machine and construction acquisition |
| Work with VDH for machine marketing | 1 | |
| Allocate funding for marketing/awareness | 1 | |
| Replenish and maintain machine | 52 | 1 step for each week in the year |
| Data collection and analysis | 12 | Data collection and analysis once a month |
| Assessment of program continuation | 5 | 5 steps for assessment/data analysis |

Total Steps: 135

Total Burden: 143

Appendix F. Naloxone Training for City Hall Staff

## Cost-Effectiveness

F1. Costing

| E1a. Assumptions for City Hall Training Cost | |
|---|---|
| Number of city employees | 3,839 |
| Average salary of a Richmond government employee (median, total compensation, per hour) | 31.86/hour (Same number as Naloxone Vending machine alternative just converted to hourly) |
| How big are the training classes during the initial roll-out (year 0)? | 20 |
| Given this, how many training sessions are necessary? | 192 |
| Average salary of a DBHDS employee (average, total compensation, hourly) | $43.125/hour |
| Assume x hours of scheduling/coordinating for each training | 2 |
| Assume the City loses about x% of its workforce year-to-year | 1.6% |
| Total number of employees replaced every year | 61.424 |
| How big are the training classes after year 0? | 15 |
| Given this, how many training sessions are necessary? | 5 |

F1b. Costing: Budget for Year 0

Cost of time away from work for City Employees

| | |
|---|---|
| Number of employees | 3,839 |
| Per hour compensation | $31.86 |
| Length of naloxone training | 2 |
| Cost per employee | $63.73 |
| Cost for all employees | $244,653.33 |

Cost of naloxone

| | |
|---|---|
| Cost per box | $125 |
| Number of employees | 3,839 |
| Cost for all employees | $479,875 |

Cost of time for DBHDS

| | |
|---|---|
| Assume class sizes of this amount | 20 |
| Number of trainings necessary | 192 |
| Number of hours to train everyone (assume an extra 30 minutes for transit/set-up) | 384 |
| Per hour compensation of DBHDS employee | $43.125 |
| Cost for DBHDS employee | $16,560 |

Cost of administration/scheduling

| | |
|---|---|
| Hourly compensation of City employee | $31.86 |
| Amount of time to schedule/coordinate each training | 2 |
| Cost per training | $63.73 |
| Number of trainings | 192 |
| Cost for scheduling | $12,235.85 |

F1c. Costing: Budget for Years 1-5 (Onboarding Training)

Cost of time away from work for City Employees

| Year (Account for pay raises) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Number of employees | 61.4 | 61.4 | 61.4 | 61.4 | 61.4 |
| Per hour compensation | $31.86 | $32.05 | $32.25 | $32.44 | $32.64 |
| Length of naloxone training | 2 | 2 | 2 | 2 | 2 |
| Cost per employee | $63.72 | $64.11 | $64.50 | $64.88 | $65.27 |
| Cost for all employees | $3,914.45 | $3,937.94 | $3,961.57 | $3,985.34 | $4,009.25 |

Cost of naloxone

| | |
|---|---|
| Cost per box | $125 |
| Number of employees each year | 61.4 |
| Cost for all employees every year (Years 1-5) | $7,678 |

Cost of time for DBHDS

| Year (Account for pay raises) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Assume class sizes of this amount | 15 | 15 | 15 | 15 | 15 |
| Number of trainings necessary every year | 5 | 5 | 5 | 5 | 5 |
| Number of hours to train everyone (assume an extra 30 minutes for transit/set-up) | 10 (5 trainings * 2 hours each) | 10 | 10 | 10 | 10 |
| Per hour compensation of DBHDS employee | $43.125 | $43.38 | $43.64 | $43.91 | $44.17 |
| Cost for DBHDS employee | $73.125 | $73.38 | $73.64 | $73.91 | $74.17 |

Cost of administration/scheduling

| Year (Account for pay raises) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Hourly compensation of City employee | $31.86 | $32.06 | $32.25 | $32.44 | $32.64 |
| Amount of time to schedule/coordinate each training | 2 | 2 | 2 | 2 | 2 |
| Cost per training | $63.73 | $64.11 | $64.50 | $64.88 | $65.27 |
| Number of trainings | 5 | 5 | 5 | 5 | 5 |
| Cost for scheduling | $318.64 | $320.55 | $322.48 | $324.41 | $326.36 |

F1d. Budget for Years 1-5: Police and Fire Naloxone Replenish Estimates

| Staffing | |
|---|---|
| Number of Sworn Police Officers | 750 |
| Number of Fire Employees | 438 |
| Total | 1,188 |
| Reversal Rate | |
| Assume average reversal rate per police/fire officer from effectiveness section | 24.64% |
| Total naloxone used in a year | 292.7 (.2464*1,188) |
| Cost of Naloxone | $125 |
| Total refill cost each year (starting in year 0) | $36,595.57 |

F1e. Net Present Cost

*Yearly Budget*

| | Account for Pay Raises | | | | | |
|---|---|---|---|---|---|---|
| Years | 0 | 1 | 2 | 3 | 4 | 5 |
| Cost of time for City employee | $244,653.33 | $3,914.45 | $3,937.94 | $3,961.57 | $3,985.34 | $4,009.25 |
| Cost of naloxone | $7,678 | $7,678 | $7,678 | $7,678 | $7,678 | $7,678 |
| Cost of time for DBHDS | $16,560 | $73.13 | $73.38 | $73.64 | $73.91 | $74.17 |
| Cost of admin | $12,235.85 | $318.64 | $320.55 | $322.48 | $324.41 | $326.36 |
| Cost for police/fire naloxone replenish | | $36,595.57 | $36,595.57 | $36,595.57 | $36,595.57 | $36,595.57 |
| Total for each year | $753,324 | $48,580 | $48,605 | $48,631 | $48,657 | $48,683 |

*Net Present Budget*

| Years | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Net Present Cost (Inflation and Discount) | $753,324.18 | $48,551.49 | $48,548.83 | $48,546.32 | $48,543.94 | $48,541.71 |

Total Net Present Cost (5 Years) = $996,056.47

F2. Effectiveness

| E2a. Assumptions for City Hall Training Efficacy | |
|---|---|
| What percent of Police and Fire officers will encounter an overdose in a year? | 54.5% |

F2b. Police, Fire, and General Population Calculations

*Police and Naloxone in the Literature*

| Using findings from Rando et al. (2015) | |
|---|---|
| 115 | People identified as an overdose by coroner |
| 52 | People who were administered naloxone by police and survived |
| 45% | When police encountered an overdose, naloxone was successful in reversal about x% of the time |

Applying Findings to Richmond

| About 54.5% of officers will encounter an overdose within a year span | Assumption using findings from Wagner et al. 2016 |
|---|---|
| 647.46 (.545*1188) | Number of Police and Fire officers that will encounter an overdose in a year |
| 292.765 | About 45% of those encounters will have a successful reversal (Rando et al., 2015). What is the number of successful reversals for Richmond in a year? |

Evaluate Reversals for the Rest of City Hall

| Using findings from Bennett et al. (2018)<br>Study evaluated refill rates of naloxone after OEND programming between people who use opioids and those who do not. Let's use this as a proxy for general naloxone reversal | |
|---|---|
| .01 | Naloxone refill rate for those who do not use opioids |
| 2,651 | Number of non-Police and Fire City employees |
| 26.5 | Successful number of reversals for the rest of City Hall in one year |

F2c. Total Overdose Reversals

| | |
|---|---|
| Total number of successful reversals in one year for this intervention | 319. 27 = 26.5+292.765 |
| | 1,596.373 |

## Administrative Burden

F3. Administrative Burden

*Who is involved?*

| Participants | Count | Purpose |
|---|---|---|
| Mayor's Office | 1 | To coordinate program |
| DBHDS to distribute naloxone | 1 | To distribute naloxone and coordinate trainings |
| Departments in Executive Branch | 24 | Departments that will undergo training |

Total Organizations: 26

*Number of Steps*

| Step | Count | Notes |
|---|---|---|
| Announcement of training to offices | 1 | |
| Coordinate with DBHDS for training dates | 1 | |
| Coordinate naloxone distribution with DBHDS | 1 | |
| Coordinate training dates for each office | 24 | |
| Appropriate funding for naloxone | 1 | |
| Coordinate with Police and Fire for monthly naloxone replenish | 4 | 2 steps for each organization |
| Work with Finance Office to allocate necessary funding for monthly replenish | 1 | |
| Appropriate funding for naloxone | 1 | |

Total Steps: 34

Total Burden: 60

Appendix G. Expanded Naloxone Training for those released from Richmond Jail

## Cost-Effectiveness

G1. Costing

G1a. Participation Rate Calculations

| Using findings from Wenger et al. (2019) | |
|---|---|
| 637 over 4 years or 160 people per year | Number of participants between March 2013 and April 2017 (Wenger et al., 2019) |
| 17,127 | Number of people discharged from San Francisco's jails in 2018 according to Vera Institute statistics |
| 3,425.4 (17,127/5) | According to Wenger at al., there are five jails in San Francisco. Thus, this number is the number of people discharged per year per jail in San Francisco |
| 160 | Number of people participating in OEND in one year at one San Francisco jail |
| 5% (160/325.4) | Rough participation rate |
| 699.9 = (13,998*.05) | Number of participants in Richmond (Apply the 5% participation rate to the number of people discharged from Richmond Jails) |

G1b. Total Costs

Cost of naloxone

| | |
|---|---|
| Cost per box | $125 |
| Number of participants | 699.92 |
| Cost of other training materials (videos, informational packets, etc.) | $6,000 |
| Cost for all participants | $93,490.0 |

Cost of time away for VDH employee (group conducting trainings)

| Year (Account for pay raises) | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Number of trainings per week | 3 | 3 | 3 | 3 | 3 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Number of hours per training | 3 | 3 | 3 | 3 | 3 | 3 |
| Number of hours to train everyone per year | 468 | 468 | 468 | 468 | 468 | 468 |
| Per hour salary of VDH employee | $30.52 | $30.70 | $30.89 | $31.07 | $31.26 | $31.45 |
| Cost for VDH | $14,283 | $14,368.70 | $14,454.91 | $14,541.64 | $14,628.89 | $14,716.66 |

Cost of administration/scheduling

| Year (Account for pay raises) | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Hourly compensation of City employee | $31.86 | $32.06 | $32.25 | $32.44 | $32.64 | $32.83 |
| Amount of time to schedule/coordinate each week | 5 | 5 | 5 | 5 | 5 | 5 |
| Scheduling hours per year | 260 | 260 | 260 | 260 | 260 | 260 |
| Cost for scheduling per year | $8,284.70 | $8,334.40 | $8,384.41 | $8,434.72 | $8,485.32 | $8,536.2 |

G1c. Net Present Cost

*Yearly Budget*

| | Account for Pay Raises | | | | | |
|---|---|---|---|---|---|---|
| Years | 0 | 1 | 2 | 3 | 4 | 5 |
| Cost of naloxone and other training materials | $93,490 | $93,490 | $93,490 | $93,490 | $93,490 | $93,490 |
| Cost of time for VDH | $14,283 | $14,368.70 | $14,454.91 | $14,541.64 | $14,628.89 | $14,716.63 |
| Cost of admin | $8,284.70 | $8,334.40 | $8,384.41 | $8,434.72 | $8,485.32 | $8,536.2 |
| Total for each year | $116,057.70 | $116,193.10 | $116,329.32 | $116,466.35 | $116,604.211 | $116,742.90 |

*Net Present Budget*

| Years | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Net Present Cost (Inflation and Discount) | $116,057.70 | $116,125.41 | $116,193.83 | $116,262.94 | $116,332.75 | $116,403.26 |

Total Net Present Cost (5 Years) = $697,357.88

G2. Effectiveness

G2a. Evaluation of Jail On-Release Reversal Rates

| Study Authors | Number of Participants | Number of Overdoses Reversed | Reversal Rate |
|---|---|---|---|
| Parmar et al. (2017) | 112 | 21 | 19% |
| Wenger et al. (2019) | | | 32% Reported by paper |
| Total | | | 25.38% |

## Administrative Burden

### G3. Administrative Burden

*Who is involved?*

| Participants | Count | Purpose |
|---|---|---|
| Mayor's Office | 1 | To coordinate program |
| DBHDS to distribute naloxone | 1 | To distribute naloxone |
| Jail | 1 | To coordinate program |
| VDH | 1 | To administer training |

Total Organizations: 4

*Number of Steps*

| Step | Count | Notes |
|---|---|---|
| Reach out to VDH/Jail to coordinate expansion | 20 | |
| Identification of stakeholders | 5 | 5 steps for difficult coordination/evaluation |
| Determine program scope and participants | 5 | |
| Identify type of training and training space | 5 | |
| Identify naloxone distribution strategy | 5 | |
| Identify staffing necessary for program | 5 | |
| Coordinate naloxone distribution | 1 | |
| Appropriate funding for naloxone | 1 | |

Total Steps: 47

Total Burden: 51

Appendix H. Sensitivity Analyses

Table H1: How do rankings change when we assume two, full-time staff members are needed for the grant program as opposed to just one?

| | Alternative 1: Grant Program | Alternative 2: Naloxone Vending Machine | Alternative 3: City Staff OEND | Alternative 4: Expanded Jail OEND |
|---|---|---|---|---|
| CEA | $932.62 | $981.87 | $623.95 | $785.31 |
| CEA Ranking | 3 | 4 | 1 | 2 |
| Administrative Burden | 1 | 4 | 3 | 3 |
| Equity | 2 | 1 | 4 | 1 |
| Total | 2.150 | 3.550 | 2.150 | 2.200 |

Table H2: How do rankings change when we assume two organizations are awarded a grant as opposed to three?

| | Alternative 1: Grant Program | Alternative 2: Naloxone Vending Machine | Alternative 3: City Staff OEND | Alternative 4: Expanded Jail OEND |
|---|---|---|---|---|
| CEA | $791.67 | $981.87 | $623.95 | $785.31 |
| CEA Ranking | 3 | 4 | 1 | 2 |
| Administrative Burden | 1 | 4 | 3 | 3 |
| Equity | 2 | 1 | 4 | 1 |
| Total | 2.150 | 3.550 | 2.150 | 2.200 |

Table H3: How do rankings change when we assume each grant-awarded organization reaches 200 participants as opposed to 400 participants?

| | Alternative 1: Grant Program | Alternative 2: Naloxone Vending Machine | Alternative 3: City Staff OEND | Alternative 4: Expanded Jail OEND |
|---|---|---|---|---|
| CEA | $1,055.56 | $981.87 | $623.95 | $785.31 |
| CEA Ranking | 4 | 3 | 1 | 2 |
| Administrative Burden | 1 | 4 | 3 | 3 |
| Equity | 2 | 1 | 4 | 1 |
| Total | 2.650 | 3.050 | 2.150 | 2.200 |

Table H4: How do rankings change when we assume a 30% OEND participation rate among those released from Richmond Jail?

| | Alternative 1: Grant Program | Alternative 2: Naloxone Vending Machine | Alternative 3: City Staff OEND | Alternative 4: Expanded Jail OEND |
|---|---|---|---|---|
| CEA | $527.78 | $981.87 | $623.95 | $622.78 |
| CEA Ranking | 1 | 4 | 3 | 2 |
| Administrative Burden | 1 | 4 | 3 | 3 |
| Equity | 2 | 1 | 4 | 1 |
| Total | 1.150 | 3.550 | 3.150 | 2.200 |

Table H5: How do rankings change when we assume a 30% OEND participation rate among those released from Richmond Jail *and* only 200 participants per organization for the grant program?

| | Alternative 1: Grant Program | Alternative 2: Naloxone Vending Machine | Alternative 3: City Staff OEND | Alternative 4: Expanded Jail OEND |
|---|---|---|---|---|
| CEA | $1,055.56 | $981.87 | $623.95 | $622.78 |
| CEA Ranking | 4 | 3 | 2 | 1 |
| Administrative Burden | 1 | 4 | 3 | 3 |
| Equity | 2 | 1 | 4 | 1 |
| Total | 2.650 | 3.050 | 2.650 | 1.700 |

Table H6: How do rankings change when we assume a 25% overdose encounter rate among emergency responders?

| | Alternative 1: Grant Program | Alternative 2: Naloxone Vending Machine | Alternative 3: City Staff OEND | Alternative 4: Expanded Jail OEND |
|---|---|---|---|---|
| CEA | $527.78 | $981.87 | $1,115.86 | $785.31 |
| CEA Ranking | 1 | 3 | 4 | 2 |
| Administrative Burden | 1 | 4 | 3 | 3 |
| Equity | 2 | 1 | 4 | 1 |
| Total | 1.150 | 3.050 | 3.650 | 2.200 |

## Appendix I. More Information on Medication-Assisted Treatment

Evidence shows that an abstinence-only centered approach to opioid use disorder often leads to relapse. Over 80% of patients return to drug use if behavioral therapy is the sole intervention (Bart, 2012). The use of monitored, strategically prescribed medications for those in recovery is essential to prevent relapse. This strategy is called medication-assisted treatment (MAT). Clinical providers will prescribe methadone, buprenorphine, or naltrexone, typically in conjunction with other behavioral health interventions like therapy and peer support (Blanco-Gandía & Rodríguez-Arias, 2018; Hawk et al., 2015; Nunes et al., 2021).[19] These medications help reduce the effects of withdrawal and curb drug cravings. Some of the medications, namely methadone and naltrexone, actually block the pleasurable effects of opioids if a patient does relapse while undergoing MAT (National Institute on Drug Abuse, 2018). MAT has been proven to dramatically suppress illicit opioid use, improve physical and mental well-being, as well as reduce overdose deaths, morbidity, and the spread of infectious disease (Blanco-Gandía & Rodríguez-Arias, 2018; Hawk et al., 2015; Larochelle et al., 2018; O'Connor et al., 2020; Sordo et al., 2017). According to those involved in the clinical, non-profit, governmental, and harm reduction spaces in Richmond, MAT is a viable policy intervention for expanding recovery services and reducing overdose deaths.

[19] Naltrexone is an antagonist, blocking the ability of opioids to attach and activate opioid receptors. Buprenorphine and methadone are agonists, meaning they actually activate opioid receptors in the brain. Given this, buprenorphine and methadone have higher abuse potential as compared to naltrexone (National Institute on Drug Abuse, 2018).

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