

Research Paper

Evaluating oxygen monitoring and administration during overdose responses at a sanctioned overdose prevention site in San Francisco, California: A mixed-methods study

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ABSTRACT

Background: Overdose prevention sites (OPSs) are spaces where individuals can use pre-obtained drugs and trained staff can immediately intervene in the event of an overdose. While some OPSs use a combination of naloxone and oxygen to reverse overdoses, little is known about oxygen as a complementary tool to naloxone in OPS settings. We conducted a mixed methods study to assess the role of oxygen provision at a locally sanctioned OPS in San Francisco, California.

Methods: We used descriptive statistics to quantify number and type of overdose interventions delivered in 46 weeks of OPS operation in 2022. We used qualitative data from OPS staff interviews to evaluate experiences using oxygen during overdose responses. Interviews were coded and thematically analyzed to identify themes related to oxygen impact on overdose response.

Results: OPS staff were successful in reversing 100% of overdoses ($n = 333$) during 46 weeks of operation. Oxygen became available 18 weeks after opening. After oxygen became available ($n = 248$ overdose incidents), nearly all involved oxygen (91.5%), with more than half involving both oxygen and naloxone (59.3%). Overdoses involving naloxone decreased from 98% to 66%, though average number of overdoses concomitantly increased from 5 to 9 per week. Interviews revealed that oxygen improved overdose response experiences for OPS participants and staff. OPS EMTs were leaders of delivering and refining the overdose response protocol and trained other staff. Challenges included strained relationships with city emergency response systems due to protocol requiring 911 calls after all naloxone administrations, inconsistent supplies, and lack of sufficient staffing causing people to work long shifts.

Conclusions: Although the OPS operated temporarily, it offered important insights. Ensuring consistent oxygen supplies, staffing, and removing 911 call requirements after every naloxone administration could improve resource management. These recommendations may enable success for future OPS in San Francisco and elsewhere.

Introduction

The United States (US) continues to grapple with the devastating crisis of drug overdose deaths (Ahmad et al., 2021), and interest in implementing harm reduction interventions is increasing (Office of National Drug Control Policy, 2021). One such intervention is the use of overdose prevention sites (OPSs; also called safe consumption sites and

safe injection facilities), which are designated spaces where people can consume pre-obtained drugs in a monitored setting and trained staff can immediately intervene in the event of an overdose (Dolan et al., 2000; Kral et al., 2020). OPSs have been shown to have significant benefits for individuals who use them by reducing spread of infectious diseases like HIV and Hepatitis C, reducing risk of overdose deaths, and facilitating uptake of drug treatment (Kerr et al., 2006; Kinnard et al., 2014;

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Marshall et al., 2011; Milloy et al., 2008; Milloy & Wood, 2009; Scherbaum et al., 2010; Wood et al., 2007). OPSs also have benefits to the communities in which they are placed, including reducing syringe litter and decreasing burden on emergency health systems through decreased 911 calls and hospitalizations, with no negative impact on neighborhood crime (Davidson et al., 2021; Kral et al., 2021; Lambdin et al., 2022; Salmon et al., 2010). They exist in over 120 locations across the world and have operated internationally for nearly four decades.

The most well-studied OPSs are located in Canada with multiple studies evaluating overdose intervention tools used in these settings. Overdose intervention tools most commonly address overdoses from opioids, including naloxone administration (an opioid antagonist used for opioid overdose reversal), oxygen monitoring and administration to address hypoxia from respiratory depression during overdose, airway management with oropharyngeal airways, and overdose “aftercare,” including OPS staff checking in on individuals and providing social supports in the overdose aftermath (Joint Task Force on Overdose Response, 2019; Kennedy-Hendricks et al., 2019; Olding et al., 2023). Several studies have highlighted oxygen monitoring and supplementing as an important augmentation to OPS overdose response (Dogherthy et al., 2022; Kennedy et al., 2019; Mayer et al., 2018; Olding et al., 2023; Wallace et al., 2019). Oxygen monitoring has proved particularly useful for Canadian OPSs in the era of fentanyl, where the high potency of fentanyl can quickly accelerate the speed and severity of an overdose, and having oxygen monitoring available allows for quicker naloxone administration and oxygen supplementation by OPS staff (Mayer et al., 2018). Two studies demonstrated that oxygen administration is the most commonly used intervention for OPS participants experiencing overdose at one site, even more common than naloxone (Kerr et al., 2006; Rowe et al., 2022). Additionally, an Australian qualitative study emphasized that overdose presentation has varied phenotypes, particularly with fentanyl, and having tools like oxygen can allow the provision of immediate life-saving care while avoiding precipitated withdrawal that can come with naloxone administration (Dertadian & Yates, 2022).

Implementation of OPSs in the US has been limited. Often cited as a barrier is 21 USC § 856 enacted by Congress in 1986 as part of the Controlled Substances Act, making it a felony to knowingly open, lease, rent, use, or maintain any place for the purpose of manufacturing, distributing, or using any controlled substance, and could be interpreted as prohibiting the operation of OPSs for public health purposes (House of Representatives, Congress, n.d.). Despite this threat of legal intervention, interest in implementing these sites in the US has been growing due to mounting overdose deaths. In December 2021, two OPSs opened in New York City, making them the first locally authorized OPSs in the nation (Harocopos et al., 2022). Shortly after, San Francisco operated the Tenderloin Center from January 18 to December 4, 2022, as a “one-stop shop” drop-in center for people experiencing homelessness to access available services, and it was a part of the mayor’s Tenderloin Emergency Plan to address staggering overdose deaths in the city’s Tenderloin neighborhood.

The Tenderloin Center was rapidly established, with initial planning occurring over the span of less than four weeks prior to the facility’s launch. To address escalating overdose deaths, the Tenderloin Center operated an OPS as part of its services. The overdose response in San Francisco’s first locally sanctioned OPS evolved during its 46 weeks of operation with the refinement of overdose response protocols and acquisition of additional emergency response equipment (e.g., pulse oximeters, supplemental oxygen administration with oxygen canisters, ventilation support with bag valve masks, adjunctive airways) in May 2022, about four and half months into OPS operation. Evaluating the San Francisco OPS experience of responding to overdoses before and after oxygen implementation can offer unique insights into the impact of oxygen delivery in OPS settings. These data are especially timely as several locations in the US, including states like Rhode Island and Minnesota have legalized OPS and are in the process of opening their own OPSs in the near future (Rosoff, 2023; Substance Use Disorder Harm

Reduction, 2018; State of Rhode Island General Assembly, 2021). Understanding the nuanced impact of various overdose response tools like oxygen to augment naloxone is crucial to inform future development of OPSs in the US and elsewhere.

To add to the available evidence on the role of oxygen monitoring and administration during overdose response at OPSs, we conducted a mixed methods study collecting quantitative data about overdose events and corresponding interventions along with semi-structured qualitative interviews assessing experiences with oxygen monitoring and administration during overdose response.

Methods

Study procedures

This study was part of a larger evaluation of the impact of the Tenderloin Center – a temporary, multi-purpose service center in San Francisco that included an OPS – on OPS participants, staff, and the surrounding community. For this study, we conducted a mixed methods study using a convergent parallel design, where both quantitative and qualitative data were collected in parallel and compared to contextualize and draw overall conclusions (Creswell et al., 2011).

Quantitative data collection entailed examining site usage data and overdose incident reports during the eleven months of OPS operation. Site usage data included total number of visits at the Tenderloin Center during its 46 weeks of operation. All visitors check in at the front desk upon entry to the Center, and requests for OPS use were recorded during check in. Various services were located throughout the Tenderloin Center building, and participants could freely engage with services and move to the outside courtyard to use the OPS. Data for the percentage of Tenderloin Center visits involving OPS use was available beginning at week 26 (July 2022). Additionally, during a 4-month period, the research team assessed how much time people spent onsite by giving every individual entering the OPS a wristband with a unique QR Code at check-in, which they scanned when they entered and exited the facility. They also had to scan the unique QR code wristband when they entered the OPS. Participants who expressed concern about or declined the wristband could still access all services, however, no such refusals were documented.

For overdose incidents, every time OPS staff or other participants responded to an overdose or other emergency event, OPS staff were required to complete an online Critical Incidents Report survey. This survey involved answering questions about time of event, event details (including overdose), event location, what interventions were provided (including oxygen and/or naloxone administration), and whether 911 emergency services were called. We used these Critical Incident Reports of overdoses to count overdose events.

Qualitative data collection entailed 45–60-min semi-structured interviews with 15 OPS staff and 24 OPS participants from September to November 2022. Only OPS staff interviews were included in this analysis, as OPS participant discussion about their experiences receiving oxygen during overdose response were minimal. All study participants provided informed consent and were paid \$25 for their time and expertise. Semi-structured interview guides focused on experiences with working at the OPS, overdose response, work culture, interactions with OPS participants, implementation challenges and facilitators, and recommendations for improvement. Five of the authors conducted qualitative interviews (LWS, TM, VM, LDW, AHK). All interviews were audio-recorded and transcribed. We also conducted an ethnography from July to November 2022, which guided participant recruitment and helped inform many other aspects of this work, but the results of which will be presented in other publications. All study procedures were approved by the institutional review board at RTI International.

The overdose prevention site and overdose response protocol

The Tenderloin Center was opened with less than four weeks of planning, which meant that many operational systems evolved over time. A few days after opening, it included an area for OPS. The OPS portion of the Tenderloin Center was operated by HealthRight360, a local community-based health organization in San Francisco that also provides substance use disorder treatment. The OPS was located in the Tenderloin Center's outdoor "privacy area" with Emergency Medical Technicians (EMTs), health workers, and navigator staff available to respond to overdoses should they occur.

Staff onsite also distributed harm reduction supplies and monitored individuals for overdose. There was capacity for up to 50 people to consume drugs at the same time, including an area with tables for injection. Next to the privacy area, there was a "chill out area" with chairs available for individuals to rest, eat a meal, or talk with counselors and health professionals. The Tenderloin Center also had myriad services to meet basic needs (food, bathrooms, showers, laundry), clinical needs (clinicians available several days a week to provide services like viral and bacterial screening and vaccinations, wound care, and medical assessments), substance use management (onsite addiction medicine provider, buprenorphine treatment for opioid use disorder, accompaniment to enroll in methadone and residential substance use treatment), an onsite indoor drop in space with peer counseling and linkage to mental health support (onsite post-overdose peer and psychosocial counseling, emotional support, safety planning, and case management), supplies (wound care supplies, safer use & overdose prevention supplies) and a host of other social needs services (housing and shelter assessments, Medi-Cal application assistance, employment services, department of motor vehicle identification vouchers, and transportation to other services including respite care).

San Francisco city government oversaw creating overdose response protocols. Because a clinical precedent for handling overdose responses at sanctioned OPSs in the US did not exist, they wanted to make sure that trained emergency personnel would handle overdoses. As such, their overdose response protocol included a requirement that every overdose that involved naloxone administration needed to also include a call to 911 to alert the city's emergency services.

Before May 2022, the overdose response protocol involved OPS staff assessing individuals for overdose and administering intranasal naloxone if necessary. Intranasal naloxone was a one-piece nasal unit delivering 4mg of naloxone with no capacity to titrate dose. HealthRight360, as the organization responsible for the OPS, hired private EMTs to provide additional support beginning in April 2022. OPS EMTs provided life support such as mouth-to-mouth breathing, cardiopulmonary resuscitation, and administration of intranasal naloxone. Additional emergency response tools were added, including oxygen monitoring with pulse oximeters, airway support with nasopharyngeal and oropharyngeal airways, oxygen cannisters, and bag valve masks in May 2022. With the addition of new emergency response tools, the overdose protocol was updated. The updated protocol recommended varying levels of oxygen administration were used based on OPS EMT and staff level of concern for overdose, including assessing participant activity level (response to verbal or physical stimuli), breathing rate, and oxygen levels using pulse oximetry (see Appendix 1 for Overdose Response Protocol). Intramuscular naloxone was also added in September 2022.

Data analysis

We used descriptive statistics to detail the number of visits, time spent in the OPS, and number of overdose interventions. Interviews were professionally transcribed verbatim. Author LWS coded the qualitative interviews initially using open coding of the data to identify patterns and potential themes, applying inductive and deductive thematic analysis. The process included applying deductive codes extracted

from the interview guide related to overdose response, and inductive codes based on weekly team discussions. The team met weekly to review transcripts, codes, and emerging themes, reconciled differences in analysis, and updated the interview guide for subsequent interviews. This process was iteratively continued until thematic saturation was reached and the final set of themes reflected key ideas and perspectives captured in the data.

Results

Quantitative results

OPS visit and total overdose results

The Tenderloin Center was open for 46 weeks during which there were 124,100 visits. Data on whether visits involved OPS services was only available in the last 21 weeks, which found on average 75% of Tenderloin Center visits involved OPS services. Tenderloin Center visits lasted a median of 1.7 h across all visits, and a median of 2.8 h among visits which included time accessing the OPS. Each month, an estimated average of 18,291 h were spent by participants onsite.

There were 333 overdoses during its 46 weeks of operation, of which staff intervened in all of them and none resulted in a death. There was an average of 7.2 overdoses per week. Most overdose interventions ($n = 274$; 83.0%) occurred in the courtyard where the OPS was located, while 37 (11.2%) occurred in the public/nearby street outside of the center, 6 (1.8%) occurred in other outdoor areas within the OPS, 12 (3.6%) in rooms where other services were being provided, 1 (0.3%) in the shower, and 3 (0.9%) were missing this information. Of the 333 overdose interventions, 239 (71.8%) involved naloxone administration, requiring a median of 2 naloxone administrations per overdose (range 0.5–8). OPS staff called 911 for emergency services 245 (73.6%) times, which resulted in 96 (28.8%) people being transferred to a medical facility.

Overdoses requiring intervention before and after oxygen availability

Prior to oxygen availability, nearly 5 overdoses occurred, on average, per week (range 1–10), with a total of 85 overdoses. Naloxone was administered in 84 (98%) of them. After oxygen became available in May 2022 (18 weeks after opening), about 9 overdoses occurred, on average, per week (range 1–22) (Fig. 1), and 248 overdoses in total. Most (227, 92%) involved oxygen administration, 149 involved naloxone (66%), and more than half involved both oxygen and naloxone (147, 59.3%) (Fig. 2).

Before oxygen became available, a 911 call was made for 92% of overdoses that occurred. After oxygen became available, a 911 call was called in 73% of overdose interventions. There were 12 overdoses in total where 911 was not called after naloxone administration despite this being the protocol. In 5 of these instances, the city's emergency medical services were already on site, obviating the need for a 911 call. Two overdoses happened in the area outside of Tenderloin Center where this requirement may not have applied, and revived individuals may have declined calling 911. Of the remaining 5 overdoses, documentation on why 911 was not called was not available.

Qualitative results

We uncovered three main themes related to overdose response and oxygen administration during qualitative interviews with OPS participants and staff: (1) oxygen monitoring and administration expanded and improved the overdose intervention toolkit, lowering the need for naloxone administration, and improved OPS participant and staff experiences with overdose response; (2) the overdose response protocol evolved over time with staff looking to OPS staff EMTs as leaders; (3) existing challenges included strained relationships with city emergency response services due to the requirement to call 911, lack of consistent supplies of oxygen and harm reduction equipment, and insufficient OPS

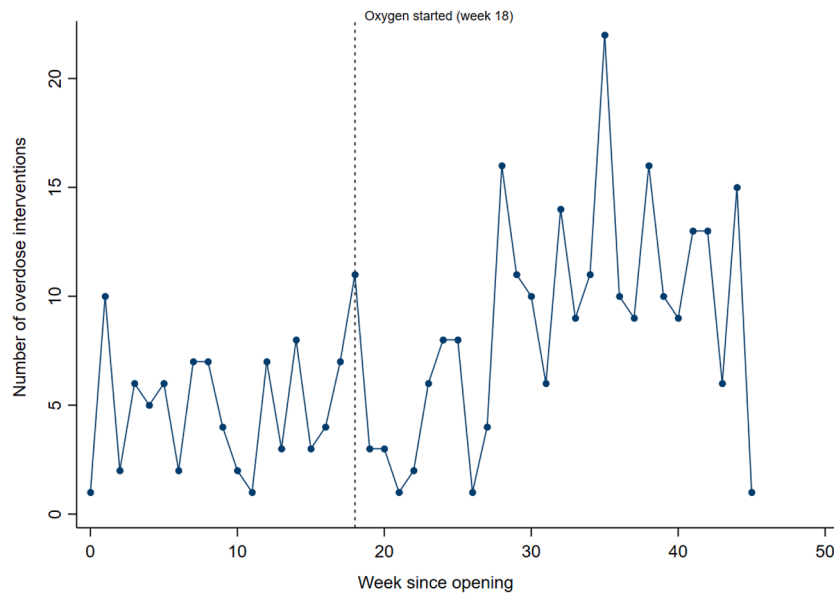


Fig. 1. Overdose interventions per week when the Overdose Prevention Site was operating. Vertical dotted line denotes when oxygen administration became available for overdose interventions.

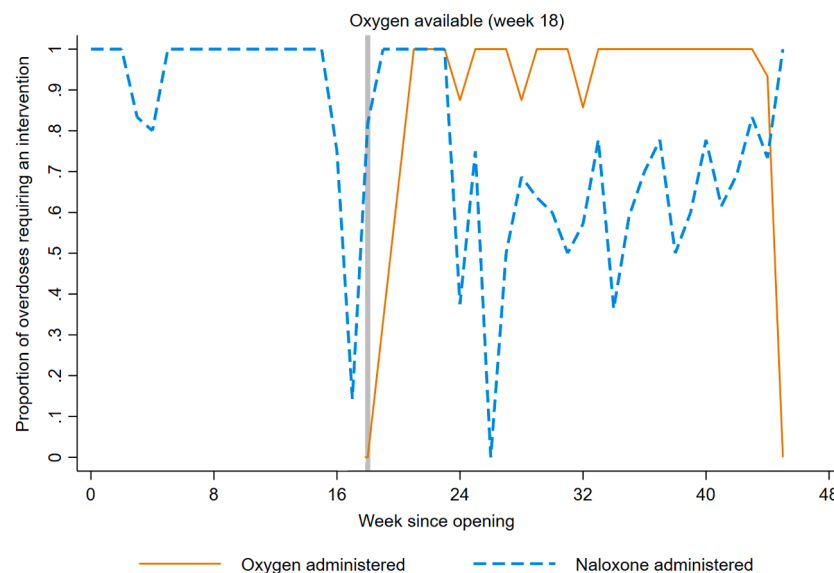


Fig. 2. The proportion of overdoses requiring interventions, including naloxone and oxygen administration, per week that the Overdose Prevention Site was operating. The gray line denotes when oxygen administration became available for overdose intervention.

staffing leading staff to work long shifts (Table 1).

Oxygen monitoring and administration expanded and improved staff comfort and experiences with overdose response

Prior to oxygen being introduced, in the first 17 weeks of the OPS opening, staff relied solely on naloxone to reverse overdoses, assisted by mouth-to-mouth breathing for reoxygenation where needed. Although staff were dedicated to saving lives, the lack of available tools increased staff stress levels:

[Before oxygen] we would have to breathe for them with our own breath and it was harder to take someone out of an overdose. We probably used more Narcan and I was basically a mechanic without their tools, or with a very limited amount of tools. [Staff A]

This reliance on mouth-to-mouth breathing was seen by staff as less

than ideal because it took longer to oxygenate individuals, and it increased staff risk of exposure to COVID.

All we care about is saving people's lives and if we got to take some medication [for COVID] for a little while that's what we got to do, if we got to get sick for a while that's what we'll do. We'd rather be sick than somebody be dead. [...] On the streets you do the Narcan, you're breathing for them, it takes a long time no matter what you do, but it seemed like they came back faster [with oxygen] sometimes. [Staff B]

With the introduction of oxygen monitoring and administration, OPS staff learned that they could reverse milder overdoses (where OPS participants were over-sedated with depressed respiratory status, but still mostly breathing on their own) with oxygen alone. By not having to administer naloxone, OPS participants did not have to go into naloxone-induced withdrawal (or the subsequent interaction with 911 personnel

Table 1

Emergent themes from overdose prevention site staff interviews regarding the impact of adding oxygen monitoring and administration to augment overdose response.

Theme	Exemplary quote
Oxygen added nuance to the overdose response protocol, improving experiences for OPS participants and improved reliance on naloxone alone	<p>“We try not to Narcan people who don’t need Narcan. As strange as it may be, I’ve apologized to people for Narcaning them, like—even like right on that borderline of like, “I almost didn’t have to Narcan you and I was trying to keep you on this side of that but here we are, like we had to go ahead with it.” So, it always does kind of suck when you have to Narcan somebody because you know that the impact that it can have on the rest of their day.” [Staff D]</p> <p>“Because if they are an opiate user who does multiple grams a day, you’re going to send them into the worst precipitated withdrawal and it’s very uncomfortable and it’s not healthy, right. [...] We’ve been able to reverse overdoses in a way that’s comfortable to daily opiate users so that doesn’t send them into precipitated withdrawal.” [Staff K]</p> <p>“And they were conscious enough and, but I think that there was also a hard thing at the beginning here because like people were wanting to like Narcan to consciousness and like, no, no, no, we’re just trying to Narcan so they’re breathing. They can stay asleep for eight hours, don’t care, breathing, cool, we’re not going to keep Narcaning them. And I think that that’s a big thing, is like laypeople Narcan people until they’re awake.” [Staff D]</p> <p>“Yeah, just, just like my coworker who mostly works the table, I didn’t know the uses for each gauge and needle, you know, or, or, you know, just the different, different terminologies for different smoking apparatuses, you know. [laughter] Yeah, just different ways people ingest these substances was like, I’ve learned a lot. And then just from the EMTs, just different signs to know when somebody’s close to overdosing, like the discoloration of the fingers, how many times they’re breathing in, during a minute, just stuff like that.” [Staff J]</p> <p>“And like oxygen, we’ve had to ration oxygen because we get twelve canisters at a time basically, and then it’s like, when we start to get low it always takes longer than it should, and so then we’re down to like two tanks on the floor and it’s like, oh, we’re getting low. Now we have to decide like, do you get oxygen or maybe, you’re okay enough to not get oxygen.” [Staff K]</p> <p>“It feels weird calling our self a harm reduction place when we don’t have the tools to give you harm reduction tools. That’s the part I think that’s a combination of like, it’s disappointing and frustrating. And there’s times where we’re short staffed but staff have to walk to another location to get supplies, to bring it back, so now we’re short here.” [Staff E]</p> <p>“When [outside city emergency responses] get there, I can say everything I want, but they hear like the patient’s name and then they don’t care</p>
Using oxygen and responding to overdose was a continuous learning process, with OPS staff EMTs taking leadership with teaching others	<p>“And I think that took some time, even like from when I got here for us to iron that out and really get our assessment dialed in to the point where we can decide, hey, let’s wait a little bit. [...] We didn’t have oxygen for the first three or four months before I got here, and with that, I think that there was a lot more Narcan going out because there was no backup, whereas now we have a backup [with oxygen] [...] We’re able to breathe for them [with the oxygen] or they’re still breathing on their own and they’re [oxygenating] at ninety-six percent and improving. [...] And so I think that with the EMTs being here, we’ve been able to take that opportunity to slow down a little bit and take the opportunity to assess what’s actually going on and get a good assessment before we start acting.” [Staff D]</p>
Challenges remained, including frequent shortage of oxygen and other supplies, staffing, and strained relationships with city emergency response services	<p>“Because the reality is that the oxygen gives us more ability to not Narcan and our clinical judgment also raises the threshold for somebody that needs Narcan. Like if somebody doesn’t really need [naloxone], the EMTs typically aren’t giving it.” [Staff D]</p>

Table 1 (continued)

Theme	Exemplary quote
	<p>about what I have to say. They’re going to do their own assessment, and I understand the whole like [emergency 911] assessment, they have to do certain things in order to fulfill their assessment, but the disregard towards us is not super friendly.” [Staff D]</p>

which was required), which improved overall participant experiences:

If it wasn’t for this place, that would be five thousand dead people and, for real, they wouldn’t be here, they would be really, really, really gone. And then the way that they do it, they use oxygen, that’s one of the neatest ways, better than that Narcan. [The OPS participants] really hate the Narcan. [Staff C]

OPS staff, including EMTs and health workers, reported that as they learned how to best utilize oxygen over time, it gave them more tools and nuance to tailor their overdose response based on individual participant needs and the clinical situation at hand. This addition gave staff more time when responding to overdoses and reduced overall stress:

And I think that took some time, even like from when I got here for us to iron that out and really get our assessment dialed in to the point where we can decide, hey, let’s wait a little bit. [...] We didn’t have oxygen for the first three or four months before I got here, and with that, I think that there was a lot more Narcan going out because there was no backup, whereas now we have a backup [with oxygen] [...] We’re able to breathe for them [with the oxygen] or they’re still breathing on their own and they’re [oxygenating] at ninety-six percent and improving. [...] And so I think that with the EMTs being here, we’ve been able to take that opportunity to slow down a little bit and take the opportunity to assess what’s actually going on and get a good assessment before we start acting.” [Staff D]

OPS staff also noted that the threshold to intervene for someone was lower compared to when they didn’t have oxygen, and the threshold to administer naloxone was higher. Before, someone had to have obvious signs of overdose (e.g., not breathing, blue skin) to warrant naloxone to avoid sending an OPS participant into withdrawal. After oxygen, staff could provide care for people where their respiratory status was heading in the wrong direction, and they could intervene earlier to prevent a full overdose:

There’s a lot of people who like, they’re high and they’re starting to go towards an overdose but they’re not there yet, and then we give them oxygen and we bring them back. [...] We put them on oxygen for like ten, fifteen minutes and we coach them on how to breathe, like take deep breaths. They generally get better. Or they overdose. [...] If I had to guess, like seventy to eighty percent get better.” [Staff A]

Because the reality is that the oxygen gives us more ability to not Narcan and our clinical judgment also raises the threshold for somebody that needs Narcan. Like if somebody doesn’t really need [naloxone], the EMTs typically aren’t giving it.” [Staff D]

Overdose response evolved over time with staff looking to OPS staff EMTs as leaders

Leadership empowered OPS staff EMTs to take ownership of improving and refining the overdose response protocol and train OPS staff on emergency response, thereby facilitating a culture of collaborative, team-based care that was crucial to saving lives. Health workers spoke about how they looked to OPS staff EMTs as leaders of the overdose response and tried to learn new clinical skills from them every day:

We all know to kind of defer to them in a way of like, giving us the direction in this moment. [...] We’re learning how to become [laughter]

how to be EMTs also in a way. [...] But it's awesome just watching [the EMTs] and making sure I'm paying attention to what they're doing in case something like that happened, where we don't have an EMT here and we have to deal with it. [...] And to have so many overdoses reversed, it's just a testament to just how well this, these EMTs are and how well we're being trained here in dealing with overdoses. [Staff E]

OPS staff spoke about how the protocol was designed so that health workers without advanced emergency response training could learn from OPS staff EMTs on how to assess and administer oxygen on their own. Health workers appreciated this additional training because it allowed them to respond to overdose if OPS staff EMTs weren't on site:

The way the protocol was written, the idea is that over time with trust we could train health workers to also be able to give oxygen. Because while it is an EMT skill and all of that, like with training, it is a skill that a layperson could learn the assessment tools that they need to decide whether or not somebody needs oxygen and then be able to titrate it appropriately. [...] [Staff D]

It's amazing and awesome that we have oxygen, I think that is so cool [...] You don't have to do Narcan in some situations, that the Narcan is used. So when we got [oxygen] I was just like, oh, it's so cool [...] And I'm not an EMT, and so this is where, even though I said earlier, even though I'm not an EMT, I can still respond to overdoses. [Staff F]

OPS staff reported that with oxygen available, they could also teach OPS participants about oxygen status and why naloxone was not always needed for every overdose.

There's been a couple times where it's just me and their oxygen is like, I don't know, seventy-five, eighty, something like that, and like I have them on oxygen and it's going up and people are like wanting to know what, like why we're not Narcaning and I'll be like, "Like look at his reading." I think that's helpful because people are, it's actually something that they can see and they're like, "Oh, okay, like that makes sense." [Staff G]

By having OPS staff EMTs as identified champions that could train others on how to use oxygen, staff capacity to respond to overdoses improved, contributing to program sustainability.

Challenges to overdose response

Despite the many benefits that visiting and working at the site offered to OPS participants and staff, challenges existed, including lack of a consistent source of oxygen and harm reduction supplies, insufficient space and staffing, and strained relationships with the city's emergency response services. By far the biggest challenge cited by staff was the inconsistent provision of oxygen and harm reduction supplies. There was an inconsistent supply of oxygen cannisters, leading to decisions of oxygen rationing and increasing staff stress when oxygen supply was low:

Because you're staying on alert to make sure you're checking people, trying to have fun, but when you have to be alert of people, and also alert of, if something does go bad how do I decide how to work this, because we only got enough oxygen for like two overdoses. [laughter] Like I hope nobody else overdoses, or you're telling people like, "Hey, don't overdose today because we ain't got [oxygen]." That's a bad look, like you can't do that, like, "Hey, I just want to let you know, I don't have enough oxygen for you to overdose today so please keep it together." [laughter] That's not good. [Staff E]

Another challenge was not having enough staffing and space in the OPS, meaning staff had to work longer shifts or experienced guilt with taking time off as it meant burdening other staff members to cover them. Insufficient staffing wore on staff morale:

The staffing, too, is tough. Like being understaffed, and it's only been a couple months, but I could see like, for some of the people who've been here the whole time it's starting to kind of wear on them. [Staff G]

Some OPS staff spoke about how regulations in the overdose response protocol led to strained relationships with the city's emergency services. The city mandated overdose response protocol required that all naloxone administrations involve a 911 call for emergency services which typically require transport to a medical facility and evaluation by a physician. However, many OPS participants declined city EMS transport because they did not want to go to the hospital because they felt it was unnecessary, time consuming, and where risk of developing withdrawal was high. OPS staff perceived required 911 calls for emergency services as unnecessary. Further, since many city emergency responders often were not educated about the OPS and potentially had preconceived negative judgments about people who use drugs, relationships between city EMS and OPS staff were strained when they were called in, especially in instances where the OPS participants rejected their services:

But, you know, it's the city and they make us call 911. We don't have a doctor on-site, but most of the time the clients [refuse transport], they don't go [to the hospital]. It's like why are we even calling them? [Staff A]

Staff also spoke about how they wish they could invite the city's EMS providers to tour the OPS to learn what services were offered and speak to the OPS participants outside of times of crisis, and to learn about why the OPS was needed. They felt this type of interaction would help improve relationships with city emergency services:

In a utopian view, this kind of service would be like something where our top five engine companies would like, come in here and actually see the place, meet some people when they're not in crisis, because, I mean, I totally understand. It's exhausting being a 911 provider. You're constantly responding to people on their worst day, and they act like it's their worst day. You're not going to have a lot of compassion for people who are not always nice. It can be hard, but like if you see them when they're not having that, like the compassion grows a lot more. [Staff D]

OPS staff EMTs remarked that they had a medical supervisor offsite who was available for questions, though they sometimes desired more frequent check ins with their medical supervisor to discuss clinical cases and reaffirm their decision making, especially as EMTs are often accustomed to reporting to chain of command:

We don't have a medical supervisor [on site] so sometimes it would be nice for us to have somebody with medical background to kind of tell us like did we do everything right, or is there anything that we could do better. [Staff G]

Discussion

In our study of a locally sanctioned OPS in San Francisco, OPS staff effectively reversed all 333 overdoses and saved lives both within and in the immediate vicinity of the site. OPS participants spent an average of over 18,000 h a month at the site, potentially reducing time spent in city public spaces. After the addition of oxygen and other breathing support tools, naloxone administration decreased from almost 100% to just two-thirds of overdoses, though average overdoses concomitantly increased from 5 to 9 per week. By having oxygen available, OPS staff reported that they could intervene earlier and potentially prevent an overdose from worsening to the point of needing naloxone. However, allowing for earlier intervention may have decreased the threshold for providing overdose interventions, potentially leading to the increase in counted overdoses after oxygen became available. Regardless, being able to monitor and administer oxygen facilitated a less distressing experience for both OPS participants and staff, by avoiding the precipitated withdrawal associated with naloxone administration and by giving staff more time to manage overdose responses. To our knowledge, our study is the first to examine the impact of oxygen and air-way related tools on overdose response before and after introduction at an OPS.

Comparing the percentage of naloxone administration between San

Francisco and New York City OPSS, it is interesting to note that even with oxygen availability, the San Francisco OPS had higher naloxone administration (59% of overdoses) than NYC OPSS (<30%) (Harocopos et al., 2022). The difference may be attributed to differences in drug supply, with the fentanyl supply in San Francisco potentially causing more respiratory depression, or because a higher proportion of overdose interventions in NYC are related to stimulant use (also known as over-amping) while most overdoses in this study likely involved opioids (Harocopos et al., 2022).

OPS staff interviews underscored OPS staff EMTs were seen as leaders, from whom they benefitted greatly. Hiring EMTs to staff OPSS is uncommon, as OPS have traditionally used either a peer model (staffed by lay peer workers only) or a medical model (staffed by doctors or nurses) (Kennedy et al., 2019). Our study does not compare models, and so we cannot determine which are most effective or cost-effective. OPS staff discussed several benefits of hiring EMTs. Though it is noteworthy that EMTs are trained to report to a chain of command, which allows them to ask clinical questions that may be outside their scope of practice and to protect their own licenses from liability. The OPS model was equally successful in reversing overdoses before and after introducing oxygen to the protocol. Due to the intense nature of OPS work, OPS EMTs may need additional support and regular check ins with clinical supervisors for longer-term sustainability and to prevent EMT staff burnout. However, as demonstrated in this study, clinical supervisors do not need to be physically onsite for OPS to fulfill its goal of saving lives, and hiring EMTs to staff OPSS may be more cost effective than hiring physicians and nurses. Neither may be needed, as peer-operated OPS have shown to be equally successful.

Furthermore, interviews highlighted how health workers without specialized medical licenses could learn how to use and administer oxygen with sufficient training. These findings are consistent with two Canadian studies, revealing that peer health workers in and outside of OPS settings can become competent in using oxygen monitoring tools like pulse oximeters without formalized medical licensing, while building on their skillset expands their recognition and respect in the workplace and offering socially supportive care practices during an overdose (Mamdani et al., 2022; Olding et al., 2023). Health workers can serve as an experienced and competent workforce, without the need for hiring additional licensed professionals that may be challenging in resource-strapped settings. Future OPS operations should therefore weigh these considerations when deciding their own staffing models.

OPS operation did experience its challenges. Although its rapid implementation under the city's emergency declaration allowed the OPS to be nimble and flexible, this came at the cost having to rapidly develop OPS operational processes and workflows. This meant not being able to thoroughly involve impacted city agencies and neighboring organizations. One example is the city regulation requiring OPS staff to call for 911 emergency services if they ever used naloxone. While it was created as an added layer of safety, it presented, in retrospect, a level of intervention that was not needed for safety and sometimes caused tension between city and OPS staff. OPS participants who had been revived at the OPS usually declined city EMS transport because they felt it was unnecessary, time consuming, and might prolong withdrawal symptoms. This frustrated city EMS providers, strained relationships between the OPS and city emergency response services, and potentially increased costs. Frequent 911 emergency ambulance calls (including the noise, flashing lights, and increased traffic associated with ambulance and fire truck visits) may have also aggravated the surrounding community and public perception of the OPS. In comparison, in the first fifteen months of operation of the two OPSS in New York City, staff reversed 730 overdoses and only needed to call for 911 emergency services 11 times (personal communication Kailin See of OnPoint NYC, March 7, 2023). In each case where 911 was called in New York City, the overdose had been fully resolved by the staff, but further medical care was deemed necessary due to underlying health conditions or other factors. It is also noteworthy that at the OPS in San Francisco there were five overdoses in

which naloxone was administered but 911 was not called due to unknown reasons, either possibly due to revived participants declining additional care and leaving the site before EMS could be called, or due to staffing shortages that made adhering to this protocol difficult. Posed with these challenges, ensuring engagement with impacted constituents, including affected city agencies and neighboring organizations in future OPS planning is critical. Avoiding regulations for mandatory 911 emergency calls after every naloxone administration and instead deferring to OPS staff judgment is recommended, particularly when faced with challenges of limited staffing.

The OPS introduced oxygen and its associated tools four months into operation, and these tools were rapidly adopted into frequent practice. It wasn't without challenges, as staff noted inconsistent oxygen supplies, as well as staffing shortages, which contributed to OPS staff stress. While oxygen was a welcome addition to OPS staff resources, it was not seen a requirement for OPS operation, but rather, it augmented OPS overdose response and improved staff and participant experiences with overdose. Because an OPS is already a high-stress environment, having a constant supply of medical supplies and consistent staff coverage can help ensure long-term success of future OPSS. It is also important to note that while peer health workers are effective and capable in taking on tasks typically reserved for those with specialized training like oxygen administration, this type of task shifting puts them at higher risk for burnout, especially when compounded by the higher rates of economic insecurity and structural vulnerability that health workers often face (Olding et al., 2021). Providing adequate staffing, support, and working conditions is crucial in protecting staff from long-term burn out.

The study had several potential limitations. Descriptive statistics cannot prove a direct causal effect between oxygen introduction leading to reduction in naloxone use, though this hypothesis was supported by qualitative data and warrants further study. This study evaluated overdose responses at one OPS in one city for just 46 weeks, making it hard to generalize findings to other settings. Further, various interventions were introduced around the same time as oxygen at the Tenderloin Center, notably oxygen monitoring, ventilatory and airway support, and hiring of EMTs to staff the OPS. Our study design was unable to parse out the various contributions of each of these interventions to overall impacts. In addition, the OPS used visit data and not individual level data. Therefore, we are not able to determine number of unique individuals who used the OPS during its operation. The QR scanning project documenting the amount of time spent by participants at the OPS was only conducted during a subset of the 46 weeks and may not generalize to all 46 weeks. Finally, the definition of what constituted an overdose for OPS staff changed over time as the overdose response protocol evolved as previously discussed. Other sites implementing OPS should be mindful of how the definition of overdose may change depending on available tools. Despite limited generalizability, future OPSS in other cities may potentially face similar challenges, and findings can still provide valuable insights for operations.

Conclusion

Overall, this study suggests that the establishment of OPSS in San Francisco was an effective harm reduction strategy to save lives. Availability of oxygen monitoring and administration, airway and ventilation support tools, and OPS EMT support supplemented overdose responses, potentially reducing the need for naloxone, and facilitating a less distressing overdose experience for OPS participants and staff. To build on these benefits and address challenges, future OPSS should avoid requiring ambulance calls for all overdoses and rely more heavily on clinical staff judgment, develop strengthened relationships with city emergency responses, and ensure more consistent staffing and sufficient supplies. Despite the rapid planning and initiation of the OPS, rapidly evolving practices, and report of insufficient oxygen and other supplies at times, establishment of OPSS in San Francisco can be effective, leading to over hundreds of overdoses reversed and no lives lost.

Ethical approval

All research was conducted in accordance with both the Declarations of Helsinki and Istanbul. This study was reviewed and approved by the Institutional Review Board (IRB) at RTI International (STUDY00022036).

CRedit authorship contribution statement

Leslie W. Suen: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Lynn D. Wenger:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Terry Morris:** Formal analysis, Writing – original draft, Writing – review & editing. **Veronica Majano:** Data curation, Formal analysis, Project administration. **Peter J. Davidson:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Erica N. Browne:** Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Bradley Ray:** Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. **Cariné E. Megerian:** Writing – original draft, Writing – review & editing. **Barrot H. Lambdin:** Conceptualization, Data curation, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. **Alex H. Kral:** Conceptualization, Data curation,

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

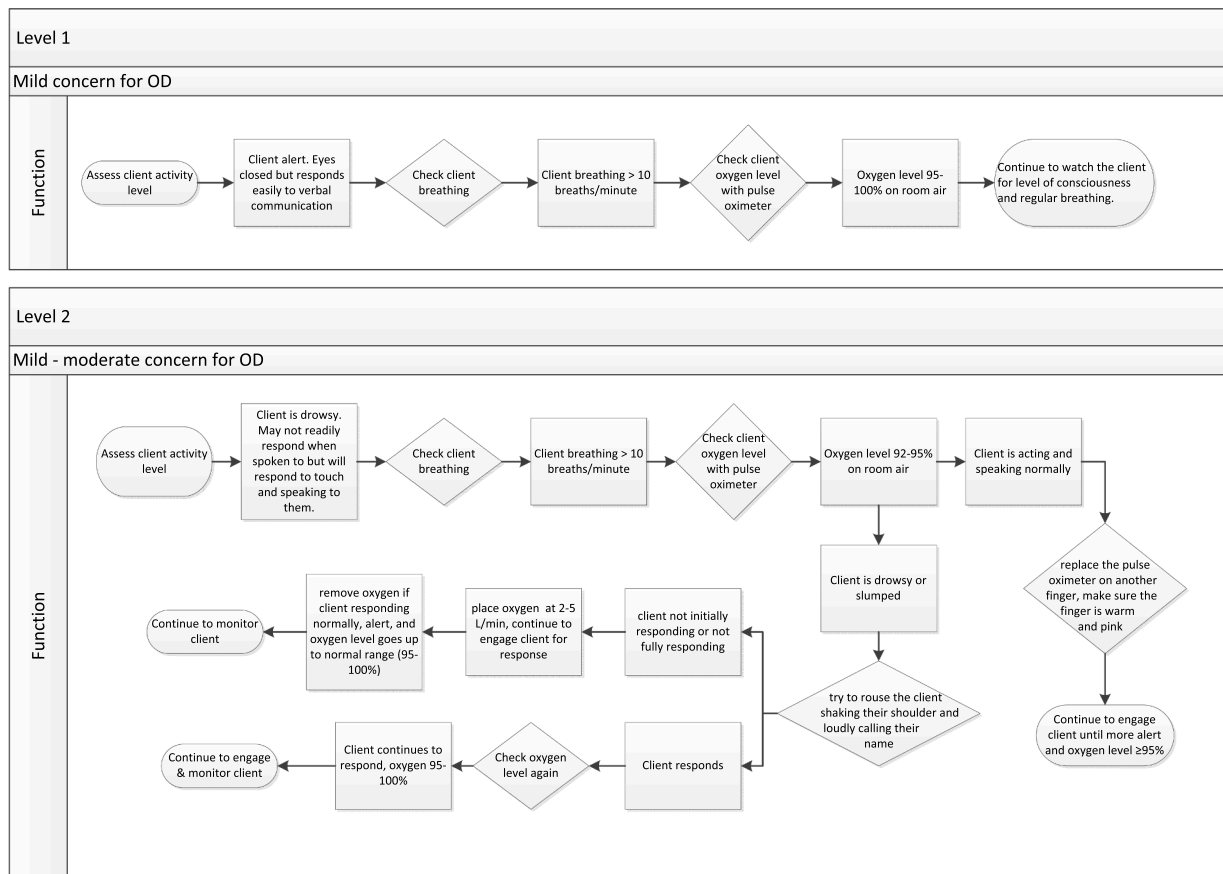
Role of funding sources

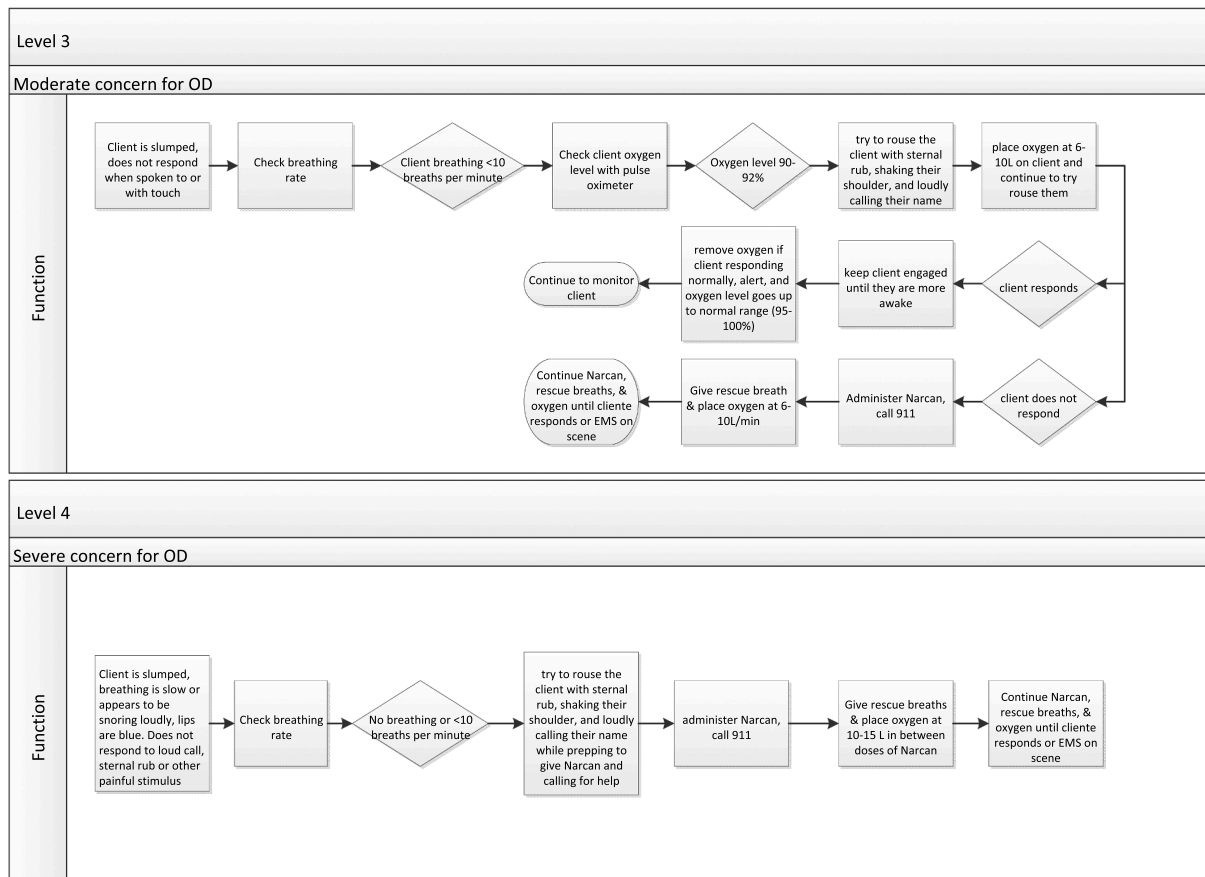
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Appendix A. Overdose response protocol used at the overdose prevention site after introduction of oxygen monitoring and administration tools





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