

**Supply and Sellers: Insights into the Unregulated Opioid Market from a Drug  
Checking Service in Victoria, British Columbia**

By

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Bachelor of Arts and Sciences, Quest University Canada, 2020

A Thesis Submitted in Partial Fulfillment

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We acknowledge and respect the Lək̓ʷəŋən (Songhees and X̱wsep̓səm/Esquimalt) Peoples  
on whose territory the university stands, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose  
historical relationships with the land continue to this day.

**Supervisory Committee**

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Dr. Bruce Wallace, School of Social Work  
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## Abstract

The opioid overdose crisis remains a critical public health issue, particularly in British Columbia, where fentanyl and its analogues have become primary contributors to overdose deaths. Drug checking services, a harm reduction intervention that was adapted to respond to this crisis, provide users with essential information about the contents of illicit substances, attempting to function as a tool to reduce overdose risk and general harm reduction. This thesis explores the complexities of the unregulated opioid market through the lens of a drug checking service, Substance Drug Checking, based in Victoria, B.C., and specifically examines the role of people who sell drugs that engage with this service.

This research is comprised of two complementary studies. The first focuses on the analysis of opioid samples submitted to the service between 2021 and 2023, with an emphasis on identifying trends in the composition of the opioid market, particularly fentanyl analogues and benzodiazepines. The second examines the service access characteristics of people who sell drugs, through a combination of data from the intake survey and drug checking results, focusing on their engagement with the service and potential adaptations of the service for their needs.

Findings from the first study highlight the dominance of fentanyl and its analogues in the opioid supply, but also reveal the maintained presence of benzodiazepines, such as bromazolam, in the market, complicating overdose risks. Data from the service also show variable fentanyl concentrations, emphasizing the unpredictability of the drug supply. The second study draws attention to the under-explored role of drug sellers in harm reduction, suggesting that their use of drug checking services may serve as a midstream intervention, addressing risks earlier in the drug distribution chain, particularly around illicit opioids.

In conclusion, this thesis contributes to a deeper understanding of the opioid supply and the role of drug sellers in the overdose crisis, calling for more targeted harm reduction strategies and drug policies that can better address the complexities of the unregulated drug market.

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## Positionality

The following thesis will be approached from my perspective as a person who has worked in the provision of harm reduction services for almost 10 years in Canada and Mexico. I have worked in shelters, safe consumption sites, clinics, and drug checking services in multiple positions and have crossed paths with hundreds of people experiencing the harms of systemic oppression and ineffective drug policy. I was born in Mexico City and I identify as a person who uses drugs who is privileged and often is part of elitist contexts who has not experienced heavy drug-related criminalization. Specifically, the lack of harm I experience from using substances stems from a societal advantage and the legality of certain substances in my current geographic location.

I currently work for the Substance Drug Checking project (<https://substance.uvic.ca>) out of the University of Victoria at their community site in Victoria's NorthPark neighborhood. I am a part of the research team in two other research working groups at the Canadian Institute for Substance Use Research (CISUR), under Dr. Jaime Arredondo and Dr. Tim Naimi, respectively. I work, live and relate in the unceded territories of the Lekwungen people and I acknowledge how the harms of colonization actively impact Indigenous and other disadvantaged people to this day. I openly stand by a future where prohibition is no longer used as a tool for oppression, especially to uphold global colonialism. This thesis will stem from my relationship to the work I do and the ongoing participation in substance use-related services that do not require abstinence for their provision. Harm reduction services often bear the burden of many societal factors that negatively affect the life of individuals. These types of services aim to de-demonize the demonized and provide practices of care to systematically neglected populations.

## Introduction

The opioid overdose crisis has escalated into a significant global public health concern, with particularly severe impacts observed in North America (De Camargo & Kapadia, 2022). British Columbia (B.C.), where fatal overdose rates have been increasing since before the emergency was declared in 2016, is the most affected province in Canada (Coroners, 2024). Although in 2024 the number of recorded overdose deaths decreased in Canada and the United States (U.S) compared to the previous year, the overdose epidemic remains a pressing public health issue in the region (Canada, 2024; Kiang & Humphreys, 2025). In B.C., opioid-related fatalities continue to be the primary cause of unnatural deaths, averaging 6 deaths daily in the province. As of March 2024, since the declaration of the public health emergency in 2016, there have been 14,000 fatalities attributed to unregulated drugs, marking the highest number in any Canadian province (BC Gov, 2016; Coroners, 2024). Across Canada, over 42,000 individuals have died from unregulated drugs within the same timeframe, currently experiencing a rate of 22 deaths per day (Canada, 2024).

A primary contributor to the Canadian overdose crisis is the potent and heterogeneous, illicit opioid supply. The market is generally dominated by fentanyl and its analogues and often mixed with novel benzodiazepines and an evolving list of additional ingredients (Baldwin et al., 2018; Fischer et al., 2019; Tobias et al., 2022). The significant variability in the concentration and potency of the illegal fentanyl supply, combined with insufficient information regarding the contents of unregulated substances, poses substantial risks for individuals who use drugs (Mars et al., 2019). People unknowingly consuming unpredictable concentrations of fentanyl is one of the main drivers of the crisis, since the synthetic opioid can be extremely variable and potent in small quantities. A minority of deaths have also been associated with non-opioid samples, such as stimulants or benzodiazepines, contaminated

with fentanyl, including counterfeit pharmaceuticals (Mars et al., 2019). This supply is, among other factors, a product of prohibition as the lack of regulation prevents a homogenous market, a phenomenon commonly known as the iron law of prohibition, where more potent compounds are prioritized in the supply (Beletsky & Davis, 2017).

Illicitly manufactured fentanyls, including fentanyl and its analogues, potent at low concentrations, are recognized as the main opioids involved in overdose fatalities, not only in Canada but in North America as a whole (Ciccarone, 2021). In British Columbia, fentanyl has been found in 85% of overdose deaths (Coroners, 2024). The presence of fentanyl alongside illicit benzodiazepines or sedatives, such as xylazine, contributes to a complicated scenario within the unregulated opioid market (Ciccarone, 2021). To counter the uncertain supply and reduce opioid-related fatalities, a number of harm reduction tools, such as naloxone distribution, overdose prevention sites and drug checking, have been implemented (Irvine et al., 2019). Comprehensive monitoring of the illicit drug market is vital to develop effective public health policies and to provide consumers with critical information that could prevent fatalities.

Drug checking is a harm reduction and overdose prevention strategy that has been implemented mainly in Canada and other parts of North America in response to the prevalence of fentanyl and the increasing number of opioid-related deaths (Park et al., 2023). The intervention can be described as a harm reduction tool that aims to inform consumers about the contents of illicit drugs to avoid undesired effects including overdose (Maghsoudi et al., 2022). Often adapted from party settings with projects increasing globally since at the 1990s, drug checking methods to detect and analyze illicit opioids in the drug market transitioned around Canada in 2018. These programs not only inform dosing, guide public health strategies, and track illegal market trends, but also influence drug policies by

advocating for improved quality and safety, mitigating the impacts from criminalization (Barratt & Measham, 2022; Wallace, van Roode, et al., 2021).

The impact of drug checking extends beyond individual drug samples (Wallace, van Roode, et al., 2021). However, the effectiveness of drug checking interventions has frequently been assessed in regard to individual behavior change, aiming for PWUD to reduce the dose or dispose of their substances (Maghsoudi et al., 2022; Wallace, van Roode, et al., 2021). Regardless, drug data collected by drug checking projects has created an emerging body of knowledge concerning substances present in the illicit drug supply which was previously limited or unavailable. Drug checking projects in Canada have documented the evolving synthetic opioid supply, detecting previously unidentified psychoactive substances such as emerging benzodiazepines (Laing et al., 2021) and tracking fentanyl concentration trends (Tobias et al., 2022). In B.C., the intervention has provided valuable insight into the evolving drug supply (Bardwell, Boyd, Tupper, et al., 2019).

This research will concern the work of the drug checking project named Substance Drug Checking, an innovative harm reduction intervention based in what is colonially known as Victoria, B.C., that provides individuals with a free-of-charge, anonymous drug analysis service. By employing multiple technologies such as immunoassay test strips, Fourier-Transform Infrared spectroscopy (FTIR), Raman Spectroscopy, and Paper-Spray Mass Spectroscopy (PS-MS) to identify the components of illicit substances and estimate their concentrations, the service aims to empower users to make informed choices regarding their consumption (Wallace, Hills, et al., 2021).

There are defining qualities of Substance, such as the ability to employ PS-MS at the point-of-service, which allows the detection of certain components at a concentration of 0.01%, ideal for analyzing potent synthetic opioids that may be present at concentrations not

detectable through other methods (Wallace, Hills, et al., 2021). PS-MS was incorporated into this service in 2021, making it the first in the world to utilize this technology for point-of-care drug checking. This sophisticated technique enables the identification and quantification of components for calibrated substances and can be completed and interpreted in a few minutes (Miskulin et al., 2023; Vandergrift & Gill, 2019). Substance is the only provider in the world to offer this level of analysis at the community level.

Also, uniquely, the project has developed a distributed model of drug checking where samples are scanned with FTIR at many sites away from Victoria and analyzed remotely to be run later on PS-MS (Wallace, Gozdziński, et al., 2022). The project has also developed and incorporated a novel software for FTIR spectra interpretation led by machine learning algorithms named LEAP (Gozdziński et al., 2024). In 2024, the service analyzed 9034 samples across Vancouver Island. It is worth highlighting the rapid uptake of the intervention, as in 2021 close to only a third of those samples (2556) were analyzed.

At its core, Substance is a multidisciplinary project. Founded in 2018 by two University of Victoria professors, Dr. Bruce Wallace from the School of Social Work and Dr. Dennis Hore from the Chemistry Department. Its mission is to equip individuals with tools and knowledge to reduce the harms from substance use. The analysis service is complemented with educational materials, naloxone distribution and training, as well as safer use supplies. Additionally, it provides the ability to connect people to other services and resources.

A crucial aspect of the project is collaboration among multiple community stakeholders, including drug user organizations such as the SOLID Outreach Society, people who use drugs (PWUD) from various population subsets, research institutions, and government health authorities. The project has received funding from ongoing grants,

including Health Canada's Substance Use & Addictions Program (SUAP), the BC Ministry of Mental Health and Addiction, the Island Health Authority, the Vancouver Foundation and others. The service has also provided a place for knowledge exchange with many other projects, nationally and globally, advocating for the expansion of services and for alliances between programs in different jurisdictions.

This thesis project for completion of the Master of Science in the Social Dimensions of Health program aims to explore, through two complementary projects, the changing unregulated opioid supply, identifying trends in prevalent substances and the characteristics of people who sell drugs who engage with these services. The research will contribute insights into the utilization of drug checking as harm reduction strategy amidst the overdose crisis by exploring complementary aspects of avenues in the drug checking literature where data is scarce and will highlight the policy implications of the findings.

## **Background**

Drug checking literature has accumulated a substantial body of research that has delved into diverse aspects of the field from public health and harm reduction to analytical chemistry and instrumentation, with reviews on this literature emerging in recent years. One focused the application of fentanyl testing strips (FTS), analyzing their effectiveness in identifying fentanyl in illicit drug samples and their impact on overdose prevention efforts (Kutscher et al., 2024). Another focused on substance use related harms data monitoring and reporting strategies, which greatly involved drug checking (Perri et al., 2023). Maghsoudi et al., 2022 developed a systematic review that was able to include 90 drug checking studies from 1990 to 2019. A systematized review from the same year focused on drug checking implementation considerations (Giulini et al., 2022). A realist review focused on the

promotion of engagement with PWUD in drug checking projects considered 133 sources (Masterton et al., 2022). For this review I will focus on providing an overview of the existing drug checking services and technologies, highlighting the main avenues of drug checking research in Canada and the United States, and finalize by outlining the studies overtaken by the Substance drug checking research working group.

Drug checking services have been implemented in various contexts with services first being implemented in Europe and targeting consumers. In the Netherlands, the Dutch Drugs Information and Monitoring System (DIMS) offers 31 fixed-site drug checking services with a coordinating office that pairs prevention services and with harm reduction and drug checking (Koning et al., 2021). Switzerland's drug checking services also began in the 1990s and each year test around 4,000 samples (FOPH, 2021). In the United Kingdom, The Loop has implemented similar services, their research has focused on the impacts of drug checking on music festival goers (Measham, 2019).

In North America, drug checking services have been crucial to address the opioid crisis, particularly in Canada. Drug checking services are present in the provinces of B.C., Ontario, and Quebec, and are implemented by 5 main organizations, mostly using FTIR combined with immunoassay test strips (Park et al., 2023). Legal and regulatory frameworks vary across provinces, influencing the accessibility and operation of drug checking programs in the country. The Subsection 56(1) class exemption in Canada provides sanctioning to allow for drug checking services to operate within urgent public health needs, specifically addressing the opioid overdose crisis. This exemption provides a legal exemption for the possession and transport of illegal substances for drug checking purposes, aiming to reduce harm from illicit drugs, such as fentanyl (Health Canada, 2022). The project this thesis is based out of, Substance Drug Checking, is perhaps the most complete program in the country

as it integrates laboratory technology in the point-of-care setting. Other notorious projects include the Toronto Drug Checking Service, Check-point in Montreal, and the coordination of services by the British Columbia Centre on Substance Use (BCCSU) in that province.

In the U.S., harm reduction drug checking services have mainly been implemented in response to the overdose crisis in select states, like California and New York, facing legal barriers due to variable laws across jurisdictions (Park et al., 2023). The pioneers of drug checking in the U.S. were DanceSafe, who began providing services focused to nightlife events and music festivals (Dundes, 2003). Services in the country are impacted by variable laws across states affecting the legality of equipment and the overall intervention (Davis et al., 2022). Interventions are often paired with other harm reduction services such as syringe exchange programs and overdose prevention initiatives (Moon et al., 2024; Moran et al., 2024). Research has also focused on the monitoring of the supply (Wagner et al., 2023), evaluating the implementation of services and their impacts (Sherman et al., 2019), tracking novel psychoactive substances across states (Friedman et al., 2022), its utilization amongst key populations like people who inject drugs (Bailey et al., 2023) and the assessment of drug checking technologies (Green et al., 2020).

Research in Canada has been funded through diverse avenues including regional health authorities and research institutes like the BCCSU. Health Canada's Substance Use and Addictions Program (SUAP) has funded many drug checking services from a federal source, particularly in the beginning of the implementation of these interventions, including providing initial funding for Substance Drug Checking, the service that this thesis concerns. The 2024/25 to 2026/27 Service Plan of the Ministry of Mental Health and Addictions of British Columbia, within the province's budget, explicitly mentions drug checking as one of

the harm reduction services considered in the strategy to respond to the toxic drug crisis (Ministry of Mental Health and Addictions, 2024).

Although no reviews have specifically focused on the Canadian context, research in the country has focused on monitoring the evolving illicit drug supply (Gonzalez-Nieto et al., 2025; Tobias et al., 2022), and evaluating the implementation of drug checking services (Bardwell, Boyd, Tupper, et al., 2019; Wallace, Hills, et al., 2021). Studies have also examined the engagement of key populations, such as people who inject drugs, with drug checking services, as well as the role of these services in tracking novel psychoactive substances (Kennedy et al., 2018; Laing et al., 2021). Research has aimed to correlate overdose risk to the fentanyl concentration estimated in samples submitted to drug checking services (Kennedy et al., 2023), and the relationship between adulterants and adverse effects (Tobias et al., 2025).

Lastly, research in British Columbia often emphasizes the active involvement of people who use drugs in research and has explored their engagement with drug checking services, including the impacts of the service in the supply, where it has been theorized as adding a layer of accountability between clients, sellers, and suppliers (Bardwell, Boyd, Arredondo, et al., 2019; Betsos et al., 2021; Wallace, van Roode, Burek, Pauly, et al., 2022). Canada is likely currently the country where most drug checking is produced due to the necessity of the intervention and the legal allowances put in place as a response to the overdose crisis with the province of BC having the most sites and services.

The analytical capabilities of these services vary depending on the technologies used to detect, differentiate, and quantify psychoactive substances. Utilizing multiple instruments together helps to compensate for the detection limitations inherent to specific technologies

(Gozdziński et al., 2022, 2024; Wallace, Hills, et al., 2021). Existing interventions vary in analysis methods, although in the Canadian context, most projects employ a combination of a Fourier-Transform Infrared Spectrometer (FTIR) and drug test strips to relay the results to the client directly, sometimes immediately after the test is done (Maghsoudi et al., 2022; Park et al., 2023).

A few other drug checking projects in the country have adapted and trialed laboratory instruments to analyze illicit opioids including paper-spray mass spectrometry (PS-MS), gas chromatography–mass spectrometry (GC-MS), Raman spectroscopy, and surface-enhanced Raman spectroscopy (SERS) in Victoria, BC (Gozdziński et al., 2022, 2023; Miskulin et al., 2023), GC-MS in Toronto, ON (Bowles et al., 2021; Maghsoudi et al., 2020), high-performance liquid chromatography (HPLC) in Vancouver, BC (Balma, 2023), and quantitative nuclear magnetic resonance (qNMR) at the government laboratory of the Drug Analysis Service (DAS) (Canada, 2005), among others.

Due to detection limitations, FTIR spectroscopy must be complemented with other technologies to effectively analyze opioid samples from the Canadian illicit drug market (Crepeault et al., 2022). The inability to detect substances in confidence below 5-10% (weight/weight concentration) and beyond three components, prevents this method from fully detecting and reporting the complex mixtures and novel opioids that could cause death even under these concentrations (Yau et al., 2019). To offset some of these limitations and avoid false negatives, immunoassay strips are typically used alongside the FTIR to increase the likelihood of detecting active components that might be present under its level of detection, such as potent synthetic opioids or benzodiazepines (McCrae et al., 2020).

The project on which the proposed study will focus, Substance, has published over twenty peer-reviewed articles in various journals within the context of Vancouver Island and B.C. The project has explored research on multiple topics including an overview of the technologies employed in the service (Gozdzialski et al., 2023), and methods (Gozdzialski et al., 2021, 2022; Laxton et al., 2022; Martens et al., 2024; Miskulin et al., 2023; Ramsay et al., 2021; Wallace, Hills, et al., 2021), impacts of the service at various levels (Wallace, Hills, et al., 2021; Wallace, van Roode, Burek, Pauly, et al., 2022), equity frameworks and drug checking (Wallace, van Roode, Burek, Hore, et al., 2022), and an analysis of Substance's unique distributed drug checking model (Wallace, Gozdzialski, et al., 2022), among others. The research presented in this thesis will add to the growing body of literature from this working group.

The literature on drug checking outlined above, covers multiple themes and disciplines. The development and implementation of drug checking services, from nightlife interventions in Europe to the emerging North American overdose crisis, was described to contextualize the creation of the intervention. The description of various technological approaches to drug checking, ranging from FTIR and immunoassay strips to advanced methods like GC-MS, PS-MS, and qNMR, emphasizes how various tools are used to improve accuracy and overcome detection limitations in regions with differing illicit drug markets. The review focuses strongly on the Canadian context, particularly outlining research in British Columbia, describing provincial and federal support, legal exemptions, and the role of organizations like the BCCSU and Health Canada in enabling service provision. The body of literature produced by the Substance Drug Checking project in Victoria, B.C., central to this thesis, has studied the conceptualization and implementation of drug checking,

technological innovations, service models, equity-oriented frameworks, and analyses of the drug supply.

Additionally, the review presents research in Canada and the U.S. as a response to the overdose crisis, which has focuses on using drug checking to monitor changes in the unregulated drug market, particularly around opioids, fentanyl concentrations, and the presence of novel psychoactive substances and adulterants. The literature focuses mainly on tracking a single compound or drug class and rarely utilizes data that originates from a single drug checking service. Another theme considered in this review is the interaction of drug checking services with people who use drugs, especially people who use opioids, and how these services are often provided in conjunction with other harm reduction interventions. The majority of the literature has concerned the impacts of drug checking and the variability of the drug supply at the consumer level.

Despite the rising use of drug checking services and the growing body of literature, significant knowledge gaps remain regarding the complexity of the opioid supply and the specific role of drug sellers in their engagement with these services. While previous research that focused on the illicit opioid supply has mostly focused on notable substances in the market such as fentanyl and etizolam, no previous examination has been made on the overall composition of opioid samples form a point-of-care drug checking program that focuses on the complexity and heterogeneity of the supply. The work outlined in this thesis may allow for a more complete overview of the supply to identify possible sources of risk within the environment of the opioid unregulated market, highlighting how substance-related harms may originate from the combination and presence of multiple substances at various concentrations. Similarly, although drug checking has been investigated in relation to various subsets of people who use drugs (PWUD), limited attention has been given to the motivations

and practices of people who sell drugs who engage with the service, particularly regarding how they utilize drug checking services before distribution. This study seeks to address this gap by exploring the extent to which sellers engage with a drug checking service, the types of substances they submit for analysis, and their reasons for doing so. Additionally, given the complexity of the supply, this research aims to uncover how drug sellers' use of these services may influence the safety and reliability of the unregulated drug supply and to gather recommendations for its adaptation to the needs of this population more effectively, ultimately improving public health outcomes and reducing overdose risk within the illicit drug market.

By outlining the existing literature on the composition of the illicit opioid supply and the detection of key substances such as fentanyl analogues and benzodiazepines through drug checking services and identifying knowledge gaps, we first aim to better understand, from a point-of-care perspective, the conformation and complexity of the opioid supply in the region and hypothesize service provision and public health implications. Additionally, through reviewing the literature on the engagement of drug checking with key populations and the conceptualization of drug checking as a supply-chain intervention, I provide a foundation for examining how people who sell drugs access and utilize the service. This contextual understanding allows this thesis to build on prior studies while contributing new insights into how sellers' engagement with drug checking may enhance the ability of drug checking interventions to impact the illicit drug supply above the consumer level.

### **Research Objectives**

1. **To analyze and interpret existing data from Substance Drug Checking** in Victoria, B.C., specifically examining opioid samples submitted between 2021 and 2023, with a

focus on identifying trends in the composition of the illicit opioid market, particularly fentanyl analogues and benzodiazepines.

2. **To assess the service access characteristics of people who sell drugs and utilize the drug checking service**, focusing on how their engagement with the service can inform harm reduction strategies, specifically in mitigating risks within the unregulated drug market for sellers and non-sellers.

### **Research Question**

How can the analysis of drug checking data, specifically focusing on trends in the composition of the illicit opioid market, combined with the engagement of self-identified drug sellers using these services, inform harm reduction strategies and drug policy to mitigate risks in the unregulated drug market and improve the use of drug checking as an overdose prevention strategy?

### **Research Design & Methods**

This thesis will showcase two original research articles that will provide different but complementing insights onto the unregulated drug market of Victoria, B.C. and the clients that access the Substance Drug Checking service. Both articles conduct secondary analysis of service data, drawing from the project's seven years of drug checking service provision and data reporting in the region. The objective of this two-part interrogation is to first establish the nature of the opioid supply most linked to extreme overdose rates from drug checking results and to secondly examine the characteristics of a subset of the service's clientele with potential to address supply heterogeneity, specifically people who sells drugs, using drug checking results collected by the Substance Drug Checking service in Victoria, B.C.

Ethical approval for this project was provided by the Health Research Ethics Board at Island Health Authority (REB Number: H20-03384) (Appendix A). This research uses routinely collected, non-identifiable data from a drug checking service with legal exemptions to collect and handle illicit substances. At this service, clients (including those who self-identify as sellers) submit drug samples anonymously without providing any personal or identifying information. Given the sensitive and criminalized nature of drug use and drug selling, the ethics protocol prioritized privacy and confidentiality, risk minimization, and actively considered structural vulnerability. Participant consent for data inclusion in research is requested upon sample collection. Service users can withdraw from participation in research, including completing the intake survey, and are still able to use the service and have their drugs analyzed. All data are securely stored on encrypted servers and analyzed collectively. Substance Drug Checking aims to adhere to harm reduction principles, to produce public health benefits without increasing risk or surveillance for service users.

The first study analyzes drug checking results of illicit opioid samples assessed by the service, emphasizing PS-MS findings over three years (2021-2023), to identify trends and provide insights into the composition of the illicit opioid market in the area, particularly regarding the prevalence of fentanyls and benzodiazepines. This focus reflects trends in the literature that highlight the critical role of drug checking in monitoring an increasingly toxic and unpredictable drug supply, particularly the prevalence of fentanyl analogues and benzodiazepine adulterants, which have been identified as key drivers of overdose deaths. The article aims, instead of focusing on a single substance or drug class, to provide a complete picture of the composition of active substances present in expected opioid samples from a single point-of-care intervention. Result data is stored in a secure online database. Data

analysis and visualization was completed using Python guided by one of the project's data analysts. The main focus of this study will be the comparison of fentanyl prevalence to that of fluorofentanyl, other fentanyl analogues, and heroin, during the three-year period. Additionally, the prevalence of benzodiazepines over time will be assessed, including bromazolam, etizolam, unidentified benzodiazepines, and other similar drugs within the class. The concentration of fentanyl—the most prevalent substance in the dataset—will be analyzed and visualized to show concentration prevalence. These concentrations were quantified using the previously documented PS-MS method (Borden et al., 2022; Miskulin et al., 2023), with weight/weight percentages calculated for each substance. This kind of research, using low-level detection technologies is unprecedented in the region.

The second study assesses another aspect of the service. Drawing on the heterogeneous composition of the illicit drug market highlighted by the first study, the second study aims to propose adaptations of the intervention to enhance its ability to address the complexity of the illicit market. This objective is achieved through the examination of characteristics and service engagement patterns of a specific subset of the Substance clientele, people who self-identify as drug sellers. This inquiry is designed to fit within previous conceptualizations of the service as an upstream intervention within the supply chain of unregulated drugs amidst the overdose crisis, as a tool for reducing the uncertainty of the market specifically considering the benefits of including sellers to reduce risk (Wallace, Hills, et al., 2021; Wallace, van Roode, Burek, Pauly, et al., 2022). The role of sellers in the unregulated market positions them as key stakeholders in the illicit drug supply chain. By exploring their reasons for accessing drug checking, the substances they submit, and potential implications for harm reduction, this study supports a growing interest in upstream interventions that target supply-

side dynamics and recognizes the importance of including sellers in public health responses to the overdose crisis.

Data considered in this examination will be derived from the intake survey conducted at the time of every sample submission that includes the seller self-identification, reasons for testing, among other relevant data (Appendix B). Inclusion criteria for the sample included all client visits from January 2021 to December 2024 where ‘To sell’ was selected in the intake form as a response to the question: Who are you doing this drug check for? Repeated visits by the same individual were treated as independent observations due to the anonymous nature of the data. The socioecological model for understanding the production of health problems and the risk environment approach to harm reduction were used to guide the contextualization of the data. The access to drug checking services by people who sell drugs is an under researched topic in the field, therefore this research component is also without precedents.

Both articles are presented in the following sections in their completeness accounting for the results and discussion section of this thesis. Each piece is structured according to the scientific method of inquiry and designed using the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) approach (Cuschieri, 2019). The method provides a set of guidelines designed to improve the transparency and quality of reporting in observational studies by ensuring that key elements, such as study design, methods, results, and potential biases, are clearly described. The articles cover the relevant background and literature review, specific methods, findings and the implications of the results in their respective discussion sections. Additional information on data cleaning and analysis can be found within the methods of each article. This document finalizes with sections on the overall limitations of the studies and future avenues of research, followed by a conclusion section

which synthesizes the findings and their implications for harm reduction, public health and drug policy.

**Article 1 – Published in the International Journal of Drug Policy**

**Not just fentanyl: Understanding the Complexities of the Unregulated Opioid Supply Through Results from a Drug Checking Service in British Columbia, Canada**

**Gonzalez-Nieto, P.**, Wallace, B., Kielty, C., Gruntman, K., Robinson, D., Substance Staff, Arredondo Sanchez Lira, J., Gill, C., & Hore, D. (2025). Not just fentanyl: Understanding the complexities of the unregulated opioid supply through results from a drug checking service in British Columbia, Canada. *International Journal of Drug Policy*, 138, 104751.

<https://doi.org/10.1016/j.drugpo.2025.104751>

## Abstract

**Introduction:** This study examines illicit opioid samples submitted to a drug checking service in British Columbia, Canada. By employing a method capable of identifying and quantifying compounds at low concentrations, the analysis focused on identifying trends in notable compounds such as fentanyl, its analogues, and benzodiazepines. The findings aim to address gaps in supply monitoring and inform public health and drug policies.

**Methods:** Opioid samples were collected and analyzed over three years using fentanyl and benzodiazepine test strips, Fourier-transform infrared (FTIR) spectroscopy and Paper-Spray Mass Spectrometry (PS-MS). PS-MS was employed to conduct trace-level analysis, provide targeted composition results, and quantify notable ingredients within the samples. The concentrations of fentanyl and benzodiazepines, among other components, were examined.

**Results:** The dataset includes 8,122 opioid samples analyzed from January 2021 to December 2023. Analysis revealed that heroin was replaced by fentanyl and its analogues in the opioid supply, as heroin was detected in only 4% of opioid samples while fentanyl and analogues were detected in 88%. Fluorofentanyl was found in 70% of opioid samples, occasionally in combination with fentanyl. Benzodiazepines and their analogues were detected in 49% of opioid samples, with a notable shift from etizolam to bromazolam. The median fentanyl concentration was 10.6% (weight/weight), ranging from less than 0.1% to over 80%. The median bromazolam concentration was 3.2%, with a range of less than 0.1% to over 25%.

**Conclusion:** The study highlights the volatility in the supply and mentions the necessity for a safer opioid supply and robust drug checking methodologies to address the challenges posed by the heterogenous market.

**Keywords:**

Drug checking, illicit opioids, fentanyl, public health, substance, benzodiazepines, overdose prevention.

## Introduction

The opioid overdose crisis has escalated into a significant global public health concern, with particularly severe impacts observed in North America (De Camargo & Kapadia, 2022). Illicitly manufactured fentanyls (fentanyl and its analogues) have been identified as the main drivers of the overdose crisis (Ciccarone, 2021). The fatal drug overdose rate in the United States (U.S.) quadrupled from 2002 to 2023, when more than 100,000 overdose deaths were recorded (Garnett, 2024). In Canada, more than 42,000 have lost their lives to unregulated drugs since a state of emergency was declared in 2016, with a current rate of 22 deaths per day (Canada, 2024). This article examines the illicit opioid supply in British Columbia (B.C.), Canada –the epicenter of the Canadian crisis– where fentanyl has been detected in 85% of overdose deaths (Coroners, 2024).

Fentanyl and its analogues, sometimes found adulterated with illicit benzodiazepines or sedatives like xylazine, shape a complex and unpredictable landscape within the unregulated opioid market (Ciccarone, 2021). The combination of multiple sedatives enhances respiratory depression, increasing the risk of fatal overdose or other unexpected complications. The variability in potency of illicit fentanyl mixtures, combined with a lack of reliable information about their composition, poses a major risk to people who use drugs (Mars et al., 2019). Comprehensive monitoring of the illicit drug market is vital to develop effective public health policies and to provide consumers with critical information that could prevent fatalities. Specifically, our analysis aims to reveal changes in the prevalence of illicitly manufactured fentanyls and benzodiazepines, both identified as contributors to overdose deaths and the increasing market complexity.

Drug checking has become a vital harm reduction strategy in North America, providing insights into the contents of the illicit opioid market amid rising overdose deaths (Maghsoudi et al., 2022; Park et al., 2023). These programs not only inform dosing, guide public health strategies, and track illegal market trends, but also influence drug policies by advocating for improved quality and safety, mitigating the impacts from criminalization (Barratt & Measham, 2022; Wallace, van Roode, et al., 2021). Services will have different analytical capabilities to detect, differentiate, and quantify psychoactive substances integrating multiple technologies to offset the detection limits (Wallace, Hills, et al., 2021). Opioid-focused interventions have been able to detect novel psychoactive substances in the opioid supply, predominantly using Fourier-Transform Infrared Spectroscopy (FTIR) and immunoassay test strips (Ramsay et al., 2021; Tobias et al., 2022). Studies have also focused on the quantification of fentanyl concentration using FTIR spectroscopy in samples over time including its relationship to unregulated drug deaths (Kennedy et al., 2023; Tobias et al., 2022).

Despite its growing adoption in harm reduction drug checking, FTIR spectroscopy presents limitations that prevent it from effectively analyzing opioid samples from the current illicit drug market, contributing to a knowledge gap in the literature (Crepeault et al., 2022). The technology is unable to detect substances in confidence below 5-10% (weight/weight concentration) or accurately estimate the potency of certain novel synthetic opioids and benzodiazepines in the supply. Because of its interpretive nature, the method will also face significant challenges when attempting to identify more than three components in a mixture, especially if their proportions vary significantly and are close to the detection limit (Yau et al., 2019). As this method is unable to fully detect and report complex mixtures and novel opioids that could cause death even under these concentrations, such as carfentanil, FTIR

spectroscopy must be complemented with other technologies to effectively analyze opioid samples from the illicit drug market (Crepeault et al., 2022).

This study incorporates an innovative approach that employs Paper-Spray Mass Spectrometry (PS-MS), integrated in 2021 into drug checking services in Victoria, B.C, becoming the only service in the world to use this instrument as a point-of-care drug checking technology. This method, piloted for this purpose in 2019 at a safe consumption site in Vancouver, Canada, excels in its ability to identify and quantify substances at concentrations below 1% (Borden et al., 2022). The method produces results within a few minutes, requires little sample preparation, low solvent and sample consumption, and minimal training needs for the technician, making it a potent tool in the real-time assessment of illicit drugs (Vandergrift & Gill, 2019). The effectiveness of the method to detect and quantify novel benzodiazepines in the supply of the region has been demonstrated by researchers affiliated to this working group (Miskulin et al., 2023).

This study will examine drug checking results from opioid samples collected and analyzed over three years by Substance Drug Checking ([substance.uvic.ca](http://substance.uvic.ca)), a free and anonymous service operating in Victoria, B.C. Utilizing a multi-technology approach at a permanent site in the city core, the service focuses primarily on findings from PS-MS. No data from this project have been published on findings led by this method; these results represent the largest drug checking longitudinal study with this unique multi-method approach. Moreover, the majority of point-of-care drug checking results literature employs methods that are not as well suited to accurately estimate or detect compounds in low concentrations. This analysis aims to identify trends and insights into the composition of the

illicit opioid market in the region, specifically tracking changes in the prevalence of fentanyl and benzodiazepines.

## **Methods**

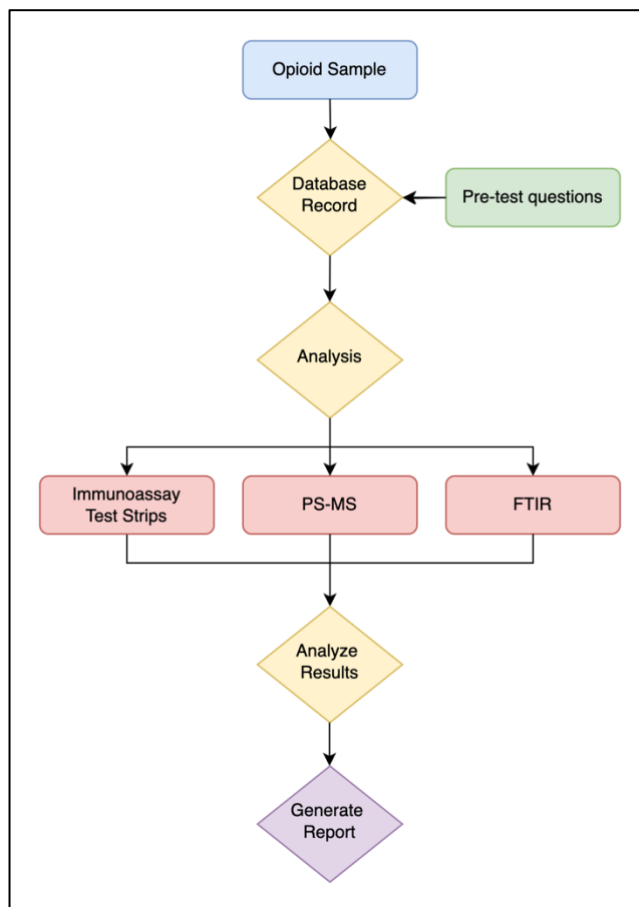
This prospective observational study collected and analyzed opioid samples over a period of three years, from January 2021 to December 2023. The primary sample collection site was the Substance Drug Checking service based in Victoria, B.C., Canada complemented by other locations on Vancouver Island and samples received by mail. Exclusion criteria were expected non-opioid substances or samples where explicit consent for research was not provided.

The study employed results produced by Substance Drug Checking technicians. The service uses a multi-method process for sample analysis which allows trace-level detection, targeted composition results, and quantification of notable compounds within the samples (Fig. 1). Once sample intake is completed, technicians will analyze it primarily using PS-MS and FTIR. The current PS-MS method has a detection sensitivity of 0.04% by weight. This method requires reference standards which limit its ability to detect substances not included in the targeted method. As stated, FTIR has a detection limit of 5-10% ; a factor caused by infrared absorption limits and the need for a technician to visually match spectra with library entries through a software-involved process that frequently produces subjective results. When a component is present in the mixture at a low concentration, technicians will be unable to visually identify it. Additionally, certain compounds might not be detectable by FTIR or may not be in the available libraries, preventing a match and resulting in an unidentified or unknown compound. Additionally, highly sensitive immunoassay test strips for

benzodiazepines (LOD: 300ng/mL) and fentanyl (LOD: 20ng/mL) of the BTNX brand are used for every opioid sample.

Results from all methods are combined in a web app and summarized in a note for the client. The service is free and anonymous. No identifying data is collected and an optional intake survey around the submitted sample is completed; demographic data is not a part of the initial survey. Data were included in the study after being reported out to the service user; individual instrument findings are combined in an overall result with identified components and, if applicable, concentrations of certain compounds. Results are compiled in a secure online database where they are accessible to data analysis scripts and visualization tools written in Python. The data cleaning process takes place upon the inclusion of results in the database, addressing any missing values to ensure all entries are complete. Ethical approval

for this project was provided by the Health Research Ethics Board at Island Health Authority (REB Number: H20-03384).



**Fig.1** Flow chart of analysis process.

Measured variables included opioid type, presence of adulterants, and concentrations of active compounds. Each variable was quantified employing previously published standardized methods to minimize measurement bias and enhance finding reliability (Miskulin et al., 2023; Ramsay et al., 2021; Vandergrift & Gill, 2019; Wallace, Hills, et al., 2021). Fentanyl prevalence was compared to the prevalence of other fentanyl analogues, and heroin, in the three-year period. Prevalence of benzodiazepines included the tracking of bromazolam, etizolam, unknown benzodiazepine results, and a grouping of all other drugs of the same class present in the supply. Weight/weight concentrations for drugs detected within

these data were quantified using a previously documented PS-MS method (Borden et al., 2022; Gozdziński et al., 2021). The weight/weight concentrations of fentanyl, the most common opioid detected, are visualized in a month-to-month time series analysis to demonstrate concentration changes over time. The evaluation of the statistical significance of these variations, compared to the overall descriptive statistics for all fentanyl detections, was performed using the non-parametric Mann-Whitney  $U$  test and a significance level of  $p=0.05$ .

## Results

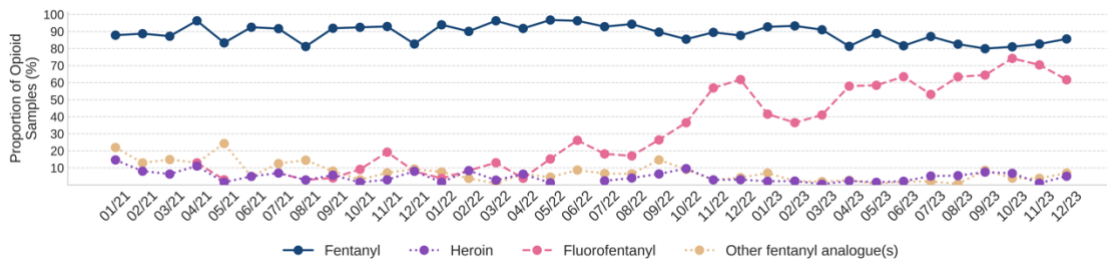
There were 8,122 opioid samples analyzed from January 2021 to December 2023. Fentanyl and its analogues were the most common opioids, detected in 88% of all opioid samples (Table 1). Over the three-year period, fentanyl remained prevalent in the supply with a maintained prevalence of over 80% in any given month (Fig.2). Heroin was almost absent in the supply, present in 305 (4%) of the submitted samples and found without other actives in just 129 (1.6%) opioid samples. Of the 305 samples that contained heroin, over half included another drug with 159 (52.1%) also containing fentanyl and 17 samples containing heroin with other non-opioid drugs. Therefore, in this region, only 176 (2.2%) of opioids were determined to be heroin without another active drug present.

**Table 1.** Prevalence of opioids detected in expected opioid samples.

Month-Year	Total Down Samples (N)	Fentanyl % (n)	Heroin % (n)	Fluorofentanyl % (n)	Other analogues % (n)
Jan-2021	41	88% (36)	15% (6)	-	22% (9)
Feb-2021	62	89% (55)	8% (5)	-	13% (8)
Mar-2021	47	87% (41)	6% (3)	-	15% (7)
Apr-2021	54	96% (52)	11% (6)	13% (7)	13% (7)

May-2021	66	83% (55)	2% (1)	3% (2)	24% (16)
Jun-2021	40	92% (37)	5% (2)	-	5% (2)
Jul-2021	72	92% (66)	7% (5)	7% (5)	12% (9)
Aug-2021	69	81% (56)	3% (2)	3% (2)	14% (10)
Sep-2021	123	92% (113)	6% (7)	4% (5)	8% (10)
Oct-2021	66	92% (61)	2% (1)	9% (6)	3% (2)
Nov-2021	99	93% (92)	3% (3)	19% (19)	7% (7)
Dec-2021	75	83% (62)	8% (6)	8% (6)	9% (7)
Jan-2022	132	94% (124)	2% (2)	4% (5)	8% (10)
Feb-2022	131	90% (118)	8% (11)	8% (11)	4% (5)
Mar-2022	215	96% (207)	3% (6)	13% (28)	1% (2)
Apr-2022	207	92% (190)	6% (13)	4% (8)	6% (13)
May-2022	243	97% (235)	1% (3)	15% (37)	5% (11)
Jun-2022	241	96% (232)	-	26% (63)	9% (21)
Jul-2022	209	93% (194)	2% (5)	18% (38)	7% (14)
Aug-2022	247	94% (233)	4% (10)	17% (42)	6% (16)
Sep-2022	280	90% (251)	6% (18)	26% (74)	15% (41)
Oct-2022	241	85% (206)	10% (23)	37% (88)	9% (22)
Nov-2022	304	89% (272)	3% (9)	57% (173)	3% (9)
Dec-2022	259	88% (227)	3% (8)	62% (160)	4% (11)
Jan-2023	330	93% (306)	2% (7)	42% (137)	7% (23)
Feb-2023	356	93% (332)	2% (8)	37% (130)	2% (8)
Mar-2023	468	91% (426)	0% (2)	41% (192)	2% (9)
Apr-2023	471	81% (383)	2% (11)	58% (273)	3% (13)
May-2023	457	89% (406)	2% (7)	58% (267)	1% (3)
Jun-2023	419	82% (342)	2% (9)	63% (266)	2% (8)
Jul-2023	386	87% (336)	5% (20)	53% (205)	2% (8)
Aug-2023	333	83% (275)	5% (18)	63% (211)	1% (2)
Sep-2023	374	80% (299)	7% (28)	64% (241)	9% (32)
Oct-2023	279	81% (226)	7% (19)	74% (207)	4% (11)
Nov-2023	392	83% (324)	1% (4)	70% (276)	4% (15)
Dec-2023	334	86% (286)	5% (17)	62% (206)	7% (23)
Total	8122	88% (7156)	4% (305)	42% (3390)	5% (424)

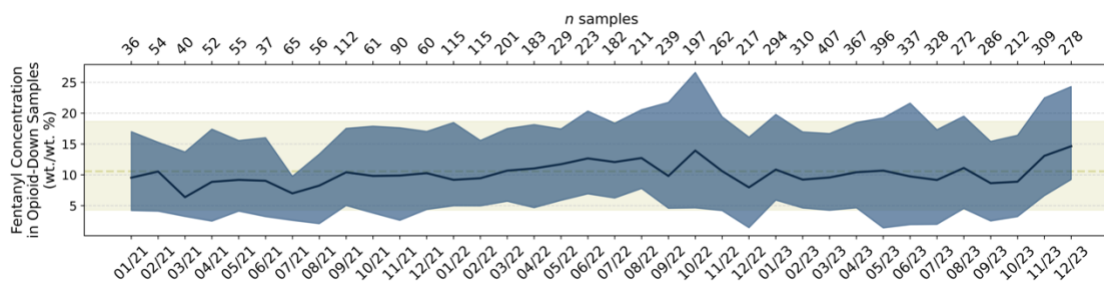
However, fentanyl analogues were not consistent. Notably, fluorofentanyl began to be reported in 2021, and by 2022 increased to being detected in 4% of opioid samples. The analogue continued to grow in prevalence and in 2023 was present in half of the opioid samples analyzed. By the fall of 2023, 70% of opioids contained fluorofentanyl. Fentanyl was also detected in 85% (2895/3390) of the opioid samples that contained fluorofentanyl. Fluorofentanyl was detected without fentanyl in 6% (495/8122) of opioid samples. Fluorofentanyl was the only opioid detected in 98% (487/495) of these samples, while the remaining 8 samples contained a mixture of fluorofentanyl, other fentanyl analogues, and/or heroin and its related byproducts. The proportion of samples where other fentanyl analogues were detected, such as carfentanil, remained consistently low with an overall proportion of 5% (424/8122) of opioid samples containing other fentanyl analogues in the three-year period.



**Fig. 2** Prevalence of opioids detected in expected opioid samples.

While the composition of the supply changed over time, fentanyl concentration remained relatively consistent (Fig. 3). Fentanyl was selected as a representative compound for this time series analysis, as it was the only compound consistently detected and quantified every month within the time range of this study. For samples containing fentanyl (N = 6,888), the concentration of the synthetic opioid had a median value of 10.6% (weight/weight) overall, ranging from 0.1% to over 80% and an interquartile range (IQR) of 4.3 to 18.7%. The average concentration of the synthetic opioid in all samples where it was detected

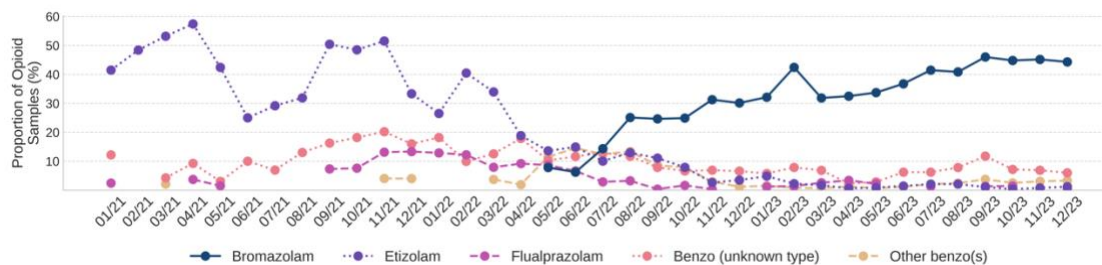
remained around 10% for the entirety of the three-year period, with a noticeable salient peak under 15% in October 2022. The month-to-month variability in fentanyl concentrations within opioid samples does not statistically differ from the distribution observed across all data based on the Mann-Whitney  $U$  test and a significance level of  $p=0.05$ .



**Fig. 3:** Fentanyl concentration (wt./wt. %) in expected opioid samples over time. The solid horizontal line represents the median fentanyl concentration for all samples checked in a given month, the dark shaded region shows the interquartile range for each month. The dashed beige line shows the overall median concentration (10.6%) and the beige region bounds the overall IQR (4.3%-18.7%).

Benzodiazepines were detected in half (49%) of all opioid samples throughout these three years, a significant increase from reporting in 2020 when 18% of opioids also contained a benzodiazepine. While benzodiazepines were consistently in the opioid supply, the specific benzodiazepines detected varied (Fig. 4). Etizolam dominated the supply from the beginning of 2021 until March 2022. In the latter half of 2021, an increase in the prevalence of “Benzo (unknown type)” in opioid samples was observed, where benzodiazepines were only detected via immunoassay test strip. When these compounds are detected via test strip only, the concentration is likely less than 5% and therefore undetectable by FTIR, or the benzodiazepine in question is not in the software libraries or in the PS-MS target list. Benzodiazepine test strips cannot differentiate between analogues, only providing a binary result on the presence of these sedatives. Secondary analysis using untargeted mass spectrometry, in tandem with occasional IR detection, indicated that bromazolam was likely present in a majority of these “Benzo (unknown type)” cases. Bromazolam was added into

the targeted PS-MS method in May 2022; by July 2022, bromazepam was the most common benzodiazepine detected within the opioid supply.



**Fig. 4:** Prevalence of benzodiazepines detected in expected opioid samples.

Bromazepam prevalence continuously increased and remained at around 45% of opioid samples for the last six months of 2023, while etizolam decreased to almost negligible levels in 2023 (Table 2). Flualprazolam, another notable benzodiazepine, appears to have had a prevalence of under 20% until the final months of 2022 when it also decreased to almost non-existent levels in 2023. Other benzodiazepines in the supply were grouped and remained under 10% for the entire period, except for the last six months of 2022, at the same time bromazepam prevalence began to increase. Components that were identified as benzodiazepines but could not be differentiated display a similar pattern with a prevalence of under 20% from January 2021, decreasing in September 2022 to under 10% except for a slight peak on September 2023. In samples where bromazepam was present (N=2,127), the median concentration was 3.2%, ranging from 0.1% to over 25% with an interquartile range of 1.0 to 7.0%.

**Table 2.** Prevalence of benzodiazepines detected in expected opioid samples.

Month-Year	Total Down Samples (N)	Bromazolam % (n)	Etizolam % (n)	Flualprazolam % (n)	Benzo (Unknown type) % (n)	Other benzo(s) % (n)
Jan-2021	41	-	41% (17)	2% (1)	12% (5)	-
Feb-2021	62	-	48% (30)	-	-	-
Mar-2021	47	-	53% (25)	-	4% (2)	2% (1)
Apr-2021	54	-	57% (31)	4% (2)	9% (5)	-
May-2021	66	-	42% (28)	2% (1)	3% (2)	-
Jun-2021	40	-	25% (10)	-	10% (4)	-
Jul-2021	72	-	29% (21)	-	7% (5)	-
Aug-2021	69	-	32% (22)	-	13% (9)	-
Sep-2021	123	-	50% (62)	7% (9)	16% (20)	-
Oct-2021	66	-	48% (32)	8% (5)	18% (12)	-
Nov-2021	99	-	52% (51)	13% (13)	20% (20)	4% (4)
Dec-2021	75	-	33% (25)	13% (10)	16% (12)	4% (3)
Jan-2022	132	-	27% (35)	13% (17)	18% (24)	-
Feb-2022	131	-	40% (53)	12% (16)	10% (13)	-
Mar-2022	215	-	34% (73)	8% (17)	13% (27)	4% (8)
Apr-2022	207	-	19% (39)	9% (19)	18% (37)	2% (4)
May-2022	243	8% (19)	14% (33)	9% (21)	10% (25)	12% (28)
Jun-2022	241	6% (15)	15% (36)	7% (16)	12% (28)	15% (35)
Jul-2022	209	14% (30)	10% (21)	3% (6)	13% (27)	12% (26)
Aug-2022	247	25% (62)	13% (32)	3% (8)	12% (29)	13% (33)

Sep-2022	280	25% (69)	11% (31)	0% (1)	8% (22)	9% (24)
Oct-2022	241	25% (60)	8% (19)	2% (4)	7% (16)	8% (19)
Nov-2022	304	31% (95)	3% (8)	0% (1)	7% (21)	3% (9)
Dec-2022	259	30% (78)	3% (9)	-	7% (17)	1% (3)
Jan-2023	330	32% (106)	5% (16)	1% (4)	6% (19)	2% (5)
Feb-2023	356	42% (151)	2% (8)	1% (5)	8% (28)	1% (3)
Mar-2023	468	32% (149)	2% (8)	3% (12)	7% (32)	1% (3)
Apr-2023	471	32% (153)	1% (3)	3% (16)	2% (11)	1% (6)
May-2023	457	34% (154)	1% (4)	2% (10)	3% (13)	1% (3)
Jun-2023	419	37% (154)	1% (6)	-	6% (26)	1% (5)
Jul-2023	386	41% (160)	2% (8)	1% (5)	6% (24)	2% (8)
Aug-2023	333	41% (136)	2% (7)	-	8% (26)	2% (8)
Sep-2023	374	46% (172)	1% (4)	1% (5)	12% (44)	4% (14)
Oct-2023	279	45% (125)	0% (1)	1% (4)	7% (20)	3% (7)
Nov-2023	392	45% (177)	1% (3)	-	7% (27)	3% (12)
Dec-2023	334	44% (148)	1% (4)	1% (2)	6% (20)	3% (11)
Total	8122	27% (2213)	10% (815)	3% (230)	8% (672)	3% (282)

Drugs other than fentanyl analogues, heroin and its related synthesis byproducts (e.g., acetylcodeine and acetylmorphine), and benzodiazepines were detected in 10.5% (n=852) of all opioid samples. The veterinary sedative xylazine was the most prevalent additional compound detected, found in 5.2% (n=423) of samples. Lidocaine was detected in 1.2% (n=97) of samples, and methamphetamine was detected in 1.1% (n=87) of samples. No other compounds were observed in the supply with a prevalence higher than 1%.

We identified the five most common substance combinations, to reveal prevalent polysubstance patterns. Fentanyl without other actives detected had the highest prevalence at 22.9% of the samples (1,858/8,122). The combination of fentanyl with fluorofentanyl was present in 14.5% of the samples (1,179/8,122), and the mixture of fentanyl, fluorofentanyl, and bromazolam was found in 11.1% (903/8,122). Fentanyl combined solely with bromazolam appeared in 7.8% (615/8,122), and with etizolam in 5.5% (449/8,122). It is

crucial to note that these combinations might also include other inactive or undetected compounds such as cutting agents or impurities. The five most detected compounds and their concentration have been summarized in Table 3.

**Table 3.** Prevalence and concentration of the five most detected compounds in the dataset.

Compound	Total Samples	Median Concentration (%wt/wt)	min	max	IQR
Fentanyl	6888	10.6	<0.1	>80	4.3% - 18.7%
Fluorofentanyl	3188	5.8	<0.1	>40	1.4% - 14.4%
Bromazolam	2127	3.2	<0.1	>25	1.0% - 7.0%
Etizolam	797	3.1	<0.1	>25	0.8% - 10.6%
Xylazine	417	1	<0.1	>66.7	0.2% - 4.7%

## Discussion

This study aimed to understand the complexities of the opioid street supply through results from a drug checking service in Canada, focusing on the presence of fentanyl, its analogues, and benzodiazepines within the illicit drug market. Our findings reveal that while fentanyl is frequently identified as the primary contributor to overdose deaths, the reality is a more complex landscape where a variety of substances, rather than just fentanyl, characterizes the supply. While our drug checking project within the epicenter of the overdose crisis found 88% of opioids to contain illicitly produced fentanyl, attributing the overdose crisis only to the emergence and prevalence of fentanyl is perhaps simplistic and incomplete. A substantial proportion of opioid samples (14%) contained both fentanyl and fluorofentanyl, providing evidence on the presence of multiple potent opioids within single samples. Similarly, the data revealed the prevalence of illicit benzodiazepines within opioid samples (49%) and the rapidly changing supply of these substances during the study period. These results challenge the simplistic attribution of the crisis solely to fentanyl and highlight

the implications of a much more complex illicit opioid supply, which complicates individual harm reduction strategies as well as clinical and public health responses to overdoses and opioid use. There is a need for drug policies and health strategies that adapt to the intricacies of the new realities of synthetic opioids within polysubstance combinations and enhance the capabilities of drug checking services to build a comprehensive approach to substance use interventions.

Drug checking data within B.C.'s toxic drug crisis depicts the illicit opioid supply to be consistently variable. The potential toxicity of opioid samples that contain fentanyl is not limited to fentanyl itself but rather in the constant complexity and changing opioid supply. This variability includes changes in fentanyl analogues and the presence of multiple fentanyl analogues within a single sample at unpredictable concentrations. In addition, fentanyl is rarely "just fentanyl" with half of the opioid samples considered in this study also including benzodiazepines varying in type and concentration. Concomitant use of opioids and benzodiazepines has been associated to increased hospital admissions and healthcare costs (Khadka et al., 2023). Many unknowns exist regarding why illicit opioid samples contain multiple active drugs and why certain drugs are present beside fentanyl. The results from this service are an important step into understanding this complex phenomenon.

In this dataset, a significant portion (14%) of opioid samples were found to contain both fentanyl and fluorofentanyl, representing a prevalent trend of multiple opioids being present in a sample. Fluorofentanyl, differentiated by the presence of a fluorine atom on the aniline ring, is believed to extend the effects of fentanyl when used in combination (Armenian et al., 2018). The analogue has been specifically linked to overdoses in the United States (Rodriguez Salas et al., 2022). Relative potency to fentanyl has not been accurately defined

due to a lack of human studies, with estimations of the drug being weaker or stronger than the parent molecule (Wilde et al., 2019). However, multiple drug checking services, due to the uncertainty in the literature, report to clients that the analogue can be up to twice as strong as fentanyl (Substance Drug Checking, 2024; Toronto's Drug Checking Service, 2024). Any increase in the potency of compounds increases overdose risk and requires a higher dose of naloxone for reversal. As seen with heroin, the market will prioritize substances that are more potent and easier to produce, which might be the case with this particular compound (Beletsky & Davis, 2017). Due to the nature of the data in the study, it is not possible to determine the reasons behind the increase in the prevalence of fluorofentanyl in this context, including validating causation hypothesis rooted in synthesis route changes.

Fluctuations in fentanyl concentrations, detected by drug checking, have been shown to impact people who use opioids, including being associated with overdose risk (Kennedy et al., 2023; Tobias et al., 2022). Fluctuations in monthly median fentanyl concentrations were observed to be positively correlated to the rate of death by unregulated substances in a study conducted in Vancouver, B.C. (Kennedy et al., 2023). The monthly fentanyl concentrations considered in said study maintained a median of below 10% in a period from 2019 to 2020. The median from that dataset is close to the overall median of 10.6% that was observed in our analysis, and resembles other previous studies which found similar median concentrations in opioid samples in the region (Tobias et al., 2022). The addition of other components into the illicit market, including fentanyl analogues with differing potency, complicates the use of the median fentanyl concentration as a parameter of supply stability.

In our study, although lower fentanyl concentration samples (<20%) appeared to dominate the concentration distribution (Fig. 3), the data included samples across a wide

range of 0.1% to 80% fentanyl. The presence of samples in the dataset with over 75% fentanyl are likely due to the submission of uncut drugs for testing, likely to be subsequently reduced to achieve lower concentrations before distribution; this theory is based on the major overdose risk that raw fentanyl entails and the small number of high concentration samples. This observation might indicate the use of drug checking services by producers and distributors, with drug checking serving as quasi quality control in the illicit production line, indirectly reducing errors in dosing (Wallace et al., 2022). This observation is further supported within the time series data. We observe that the median fentanyl concentration on a month-to-month basis does not meaningfully fluctuate, despite the overall composition of the supply changing overtime. We speculate this consistency is driven by the preferred dosage among people who use fentanyl and by suppliers who are creating products to meet those needs.

The introduction of benzodiazepines in the opioid supply has been theorized as being caused by the short duration of fentanyl activity when compared to heroin, and the need to prolong opioid effects (Jones et al., 2012). When used in conjunction with opioids, this class of drugs may complicate overdoses by prolonging sedation altering the effects of naloxone; although respiratory rate may recover after administration of naloxone, full arousal is likely to be delayed, unlike situations only involving opioids where consciousness can be regained within minutes (Raman, 2023). The number of unregulated drug deaths that involved benzodiazepines has risen steadily in the past decade from 3% in 2014 to over 40% in 2024 (Coroners, 2024). During our study, benzodiazepines were present in half (49%) of opioid samples, persisting in the supply over the entire study period.

Although the presence of benzodiazepines was constant within the opioid supply in our study, fluctuations of the specific benzodiazepines detected in the supply were observed (Fig.4). Bromazolam, an alprazolam-like benzodiazepine, appears to have overtaken the longer-acting drug of the same class, etizolam. The novel drug made a noticeable appearance in the opioid supply during the COVID pandemic and continued to increase through 2023. Increases in deaths that involved bromazolam combined with opioids, were reported in some localities during that period in North America (Rodda, 2024). Although never approved for therapeutic use in Canada, bromazolam's duration and potency are lower than etizolam (5-8 h vs 7-15 h), which caused the roll-out of specific public health advisories in B.C., as suspected opioid overdoses were changing in duration and symptoms (BCCDC, 2021). The lower duration in effects of the benzodiazepine, likely combined with a secure route of manufacturing and transporting, possibly made the drug preferred by illicit producers in the opioid market. The prevalence of all other benzodiazepines was observed to decrease to almost entirely below 10% as bromazolam prevalence rose, which could be an indication of the preference of this drug over other benzodiazepines.

Bromazolam, first detected in B.C. during 2021, was present in almost half of all opioid samples by the end of 2023, with a median concentration of 3.2%. The low concentration might support the supposed extension of opioid sedation and discourage theories of it being the primary compound in opioid samples (Mérette et al., 2023). The interaction between illicit benzodiazepines and synthetic opioids is not clear, particularly for drugs not used in a clinical setting. Physical dependence on benzodiazepines might be a contributor to the maintenance of the drug class in the opioid supply. Sudden changes in benzodiazepine type and concentration pose additional risks for consumers, including those from benzodiazepine withdrawal such as complex seizures and death (Fluyau et al., 2018).

Without appropriate drug checking interventions, the supply composition remains widely unknown and prevents consumers from making informed choices.

There are significant public health and drug policy implications from these findings. Notably, the introduction of novel substances, potent in low-concentrations, and the high degree of variability within the opioid supply highlight the necessity for drug checking programs to be incorporated into mainstream harm reduction and health services, amidst the overdose crisis. Despite relatively consistent month-to-month median concentrations, such as the observed 10% median for fentanyl, our data reveal that users are just as likely to encounter samples with concentrations at 5% or 20%, exemplified by the concentration interquartile range, while also being exposed to samples that could contain more than 80% fentanyl. Such unpredictability in opioid strength, exacerbated by the polysubstance nature of the supply, given that all compounds also display high degrees of variability, significantly complicates effective overdose prevention and response strategies. The integration of drug checking services can offer crucial real-time insights into the contents of the illegal market. With the supply continuously evolving, as demonstrated in this article, these data allow for more accurate risk assessment enabling health professionals to adapt interventions appropriately. Moreover, by highlighting trends in substance use and emerging dangers, such as the increase in samples containing benzodiazepines, this evidence may inform broader drug policy, guiding legislative and educational efforts to mitigate the health impacts of a variable market. These programs not only save lives by preventing unintended effects but also contribute to a more informed and adaptive public health response to the ongoing crisis.

When the toxic drug supply is understood in its complexity, we can better understand the implications for people who use drugs as well as overdose responses such as drug

checking, public health monitoring, and surveillance efforts. The unpredictability of both the composition and concentration of illicit opioid samples makes it difficult to navigate the supply knowingly and safely. For drug checking as an overdose response, these complexities demand a high level of sensitivity. Specifically, drug checking within an opioid overdose context requires low-level detection and the potential for both full qualitative analysis of the multiple components in a sample and quantification of the concentrations of the active drug(s) present. Indeed, drug checking is challenged in how to report such complex analyses in pragmatic ways and to interpret results in a manner that is relevant to those accessing the service. For public health monitoring and surveillance, the ability to utilize aggregate drug checking data for monitoring and to inform prevention strategies requires awareness of these complexities and the multiple risks inherent in the opioid supply linked to extreme rates of overdose. Finally, this drug checking data from the epicenter of Canada's overdose crisis reaffirms the sustained calls for supply alternatives at a meaningful scale to provide a safer option to the current toxicities attributed to fentanyl (Kalicum et al., 2024; Ledlie et al., 2024).

This study has limitations, mainly due to the methods used for substance analysis and the subset of people that are able to access the service. The instruments employed to collect the data presented here are trained to detect the substances that we are aware to be present in the supply, with some room to detect novel substances. This is particularly notable for drugs that could be present in the supply below the detection limits of the instruments and for those that may also be present but for which the PS-MS has not yet been calibrated to detect or quantify. Moreover, as samples were analyzed at a fixed site, the data only represents the samples of a particular group of people who use opioids: those who could access the service in person, via outreach, or have the resources to mail samples. The findings presented here

consider just one region with extreme rates of overdose and results may not resemble localities where other adulterants play a major role in the supply, such as the Eastern coast of Canada and the United States. Analysis into the trends observed within additional compounds, both in terms of detection frequency and concentration, is beyond the scope of this study.

## **Conclusion**

In conclusion, these findings display the dominance (88%) of fentanyl in the opioid supply from January 2021 to December 2023 as analyzed by a service based in Victoria, B.C., Canada. Although these results could support fentanyl's key role in the overdose crisis, attributing overdose risk to the presence of fentanyl or any psychoactive drug may be overly simplistic and may not capture the complexity and unpredictability of unregulated opioids; the supply varies widely in concentration and frequently contains multiple active components. The illicit opioid supply is a fast-changing market where novel psychoactive substances are introduced periodically. In this study, the introduction and increase of fluorofentanyl and bromazolam in the supply was also observed. The trends highlight the need for public health interventions and comprehensive drug monitoring strategies to mitigate the profound health impacts of these potent and increasingly prevalent substances in a volatile illicit drug market. The study demonstrates the importance of community-based drug checking for the collection of data that resembles the reality on the field. Due to the highly heterogenous opioid market and the long road to regulation of these substances, access to a safer opioid supply that meets individual needs is crucial. The complex market in this region poses challenges to drug checking services and exposes the necessity for appropriate

instrumentation and methodologies to enable effective public health monitoring and intervention.

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**Article 2 – Under Author Review**

**Customer Service: Drug sellers' use of a drug checking service amidst the overdose crisis in British Columbia, Canada**

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**Tentative Journals:** Addiction, International Journal of Drug Policy, Harm Reduction Journal

**Abstract**

Opioid-related overdose deaths in North America have increased in the past decade mainly due to an unstable unregulated opioid market. While people who sell drugs are often viewed as contributing to the crisis, evidence indicates that some engage in harm reduction practices to protect their clients from risks associated with the volatile supply. This study examines the utilization of a drug checking service by drug sellers in B.C., exploring their motivations and examining information on samples intended for distribution. We analyzed intake survey data from individuals who accessed a free and anonymous drug checking service in Victoria, B.C., between January 2021 and December 2024. The survey provided statistics on visits, expected substances, sample results, potency, unexpected effects, and reasons for service use. Results suggest that a significant number of sellers continuously use these services, particularly for the analysis of opioid samples to mitigate risks including overdose. This study highlights a shift in perspective regarding people who sell drugs, providing evidence for their role as potential partners in drug checking services. This subset of people who accessed drug checking services to analyze substances intended for distribution, demonstrated the role of the service as a supply-focused intervention and provided evidence on protective strategies that sellers might take to protect customers within the complexities of the illicit drug landscape.

**Keywords:**

People who sell drugs, sellers, dealers, substance, drug checking

## Introduction

For more than a decade, overdose fatalities have risen in North America mainly driven by the unpredictable illicit opioid supply, dominated by potent synthetic opioids including fentanyl and other adulterants (Snowdon & Choi, 2024; Tanz, 2024). While the number of recorded overdose deaths decreased in Canada and the United States in 2024 compared to the previous years, the overdose epidemic remains a pressing public health issue (Kiang & Humphreys, 2025; Public Health Agency of Canada, 2024). The unprecedented rates of overdose are linked to the illicit opioid market containing fentanyl and other synthetic opioids, often mixed with illicit benzodiazepines or other sedatives such as xylazine or medetomidine, creating a heterogeneous unregulated opioid supply (Duhart Clarke et al., 2022; Gonzalez-Nieto et al., 2025; Kennedy et al., 2023; Tobias et al., 2022). The combination of depressants with opioids significantly heightens the risk of respiratory depression and fatal overdose or other adverse effects (Jones & McAninch, 2015). The variable potency of illicit opioid samples, combined with an overall uncertainty about their composition, poses significant risk to people who use drugs (Mars et al., 2019). In response, a number of harm reduction interventions have been put in place including take-home naloxone programs, supervised consumption sites, expansion of opioid agonist therapy, and drug checking services (Strike & Watson, 2019).

Drug checking has been a vital strategy in the context of the North American overdose crisis, providing unregulated drug market knowledge amidst fluctuations in the supply (Dasgupta & Figgatt, 2022; Park et al., 2023). These services attempt engage with consumers to inform on the contents of their unregulated drugs, aiming to prevent adverse effects

including overdoses (Barratt & Measham, 2022; Masterton et al., 2022). With roots in the nightlife scene, drug checking has been adapted to the North American overdose crisis, tailoring laboratory instruments to detect and analyze illicit opioids in point-of-care settings (Betzler et al., 2021; Dasgupta & Figgatt, 2022). While the impact of these interventions has often been evaluated based on changes in personal usage habits, such as encouraging people who use drugs (PWUD) to lower their doses or discard unsafe substances (Goodman-Meza et al., 2022; Mema et al., 2018; Valente et al., 2022), the information gained from drug checking has significantly expanded our understanding of the drug supply (Maghsoudi et al., 2022).

Drug checking provides insights into trends within the illicit drug market, beyond individual sample analysis, potentially informing public health strategies (Gonzalez-Nieto et al., 2025; Groves, 2018; Wallace, van Roode, et al., 2021). Initiatives in Canada have traced developments in the synthetic opioid market, uncovering new psychoactive substances, including recently identified benzodiazepines (Laing et al., 2021), monitoring fluctuations in fentanyl levels (Tobias et al., 2022), examining when fentanyl is detected in other drugs (Wallace et al., 2025), among other findings. These programs have been shown to cultivate a level of responsibility among consumers, sellers, and suppliers, increasing accountability and safety in the market, intervening within the supply-chain (Betsos et al., 2021; Wallace, Hills, et al., 2021; Wallace, van Roode, Burek, Pauly, et al., 2022).

People who sell illicit substances –although often consumers themselves– are rarely recognized as intentional beneficiaries of harm reduction services (Kolla & Strike, 2020), or drug checking services (Bardwell et al., 2019; Hedden-Clayton et al., 2024; Measham, 2019). People who sell drugs are frequently labeled as being complicit in overdose deaths,

occasionally facing homicide charges for their clients overdoses, particularly in the U.S. (Beletsky, 2019). Betsos et al. (2021) conducted interviews with individuals, who identified as drug sellers and engaged with a drug checking service in Vancouver, Canada. The findings revealed that sellers were motivated by a desire to ensure their clients' safety and prevent adverse outcomes, including overdoses. The study highlighted the use of drug checking as a mean for sellers to contribute positively to an otherwise unstable and unregulated market.

Contrary to their traditional portrayal as contributors to the opioid crisis, research shows that a subset of drug suppliers embrace harm reduction strategies and share drug quality and safer use information with customers (Hedden-Clayton et al., 2024; Kolla & Strike, 2020). However, the existing literature on the relationship between people who sell drugs and harm reduction interventions is limited, with even fewer studies focusing on drug checking services. Tailoring drug checking services to directly engage drug sellers could enhance the ability of the intervention to influence the supply-chain and increase the information regarding the variable supply in the community (Wallace, van Roode, Burek, Pauly, et al., 2022; Wallace, van Roode, et al., 2021).

The use of drug checking services by people who sell drugs to analyze opioid samples amidst the overdose crisis is not unprecedented (Betsos et al., 2021; Larnder et al., 2021). People who sell drugs have been identified as a population with the potential and the interest to regulate opioid-related harms through taking preventive measures amidst the unstable supply, including building relationships of trust with their clients (Bardwell et al., 2019; Carroll et al., 2020; Hedden-Clayton et al., 2024). A growing body of literature has exposed the potential benefits of this group accessing drug checking, including increasing the knowledge in the supply-chain (Glick et al., 2019; Wallace, van Roode, Burek, Pauly, et al.,

2022). Unfavorable drug checking results have been observed to influence consumers to change suppliers or to confront their dealers regarding unexpected product contents, demonstrating the influence of drug knowledge within the drug market (Measham, 2019; Reed et al., 2024). Drug checking has been documented to be used by sellers as a marketing strategy and as proof of drug quality, impacting client retention (Pelling & Turnock, 2023). People who sell drugs have also been identified as a key population for the communication of novel drug information and harm reduction practices, particularly because of their reach into hidden communities of people who use drugs who might not access harm reduction and other services directly (Kolla & Strike, 2020; Perri et al., 2023).

This article examines the utilization of drug checking by self-identified people who sell drugs in British Columbia (B.C.) from a service based in Victoria, the capital city of the most affected Canadian province (Coroners, 2024). Substance Drug Checking has been providing a free-of-charge, anonymous service on Vancouver Island since 2018, integrating a unique multi-instrument analysis method focused on the detection and quantification of active compounds and adulterants in the illicit opioid supply of the region (Wallace, Gozdziński, et al., 2022; Wallace, Hills, et al., 2021). Utilizing service data from a busy drug checking project, we draw on our previously published socioecological model approach (Wallace, van Roode, Burek, Hore, et al., 2022), to elucidate the relationship of drug checking services for people who sell drugs. The study analyses data regarding motivations for using the service, characteristics of submitted samples, comparisons with non-sellers and other insights that could inform the adaptation of the intervention to better meet the needs of sellers, potentially improving their access to these services and having an impact on the supply-chain.

## Methods

This study analyzes data collected by the Substance Drug Checking service based in Victoria, B.C. from January 2021 to December 2024. The service includes an anonymous intake survey, completed after participant consent is provided, which gathers data on; the number of times the person has used a drug checking service, the expected drug, whether the test is pre- or post-consumption, unexpected effects or perceived potency of the substance, the motivation behind the drug check and the person who the analysis is being conducted for (i.e., friends, family, self, to sell, clients, others). This inquiry examines all data entries for those drug checks where the person selected “to sell” in response to the intake question “Who are you doing this drug check for?”. The other response options included self, friends, family, clients, and a free entry text box for “others”. Exclusion criteria for survey completion is people under 19, the legal age in B.C, or request for data exclusion.

When a sample is submitted, technicians primarily analyze it using paper spray mass spectrometry (PS-MS), Fourier transform infrared spectroscopy (FTIR) and immunoassay test strips. The PS-MS method has an average detection sensitivity of 0.04% by weight but requires reference standards, limiting its ability to detect substances not included in the targeted method. The FTIR has a detection limit of approximately 5% and relies on pattern matching the data to spectral libraries. To complement these methods, BTNX immunoassay test strips are used to detect benzodiazepines (300 ng/mL limit of detection) and fentanyl (20 ng/mL) in all opioid samples.

Data were included in this study only after results had been reported to the service user. Individual instrument findings are synthesized into an overall client-facing report that is available online, listing identified components and, where applicable, quantifications of

specific compounds. These results are stored in a secure online database, accessible to data analysis scripts and visualization tools used for reporting. A standardized data cleaning process is applied to address missing values before final inclusion in the dataset. Ethical approval for this project was granted by the Health Research Ethics Board at Island Health Authority (REB Number: H20-03384).

Our analysis included both data from the intake survey responses and the drug checking results, the number of visits by sellers over time, the number of repeat visits, the expected drugs submitted by sellers, pre- or post-consumption rates, and reported strength of the sample. Drug checking results from samples submitted by people who sell drugs were considered in the analysis to examine certain aspects like findings of unexpected substances. Data from non-sellers was used strictly to draw comparisons between both groups on aspects of interest such as the number of visits, the average number of samples submitted in a visit, the expected substance, unexpected findings and adverse effects, among other characteristics.

Our inquiry is informed by our socioecological model (Wallace, van Roode, Burek, Pauly, et al., 2022), to question potential implications within the wider community of people who sell and people who buy drugs. This system-oriented model is often used to understand dynamically complex community-health problems by providing insights into the interactions between individuals and their environment (Golden & Earp, 2012; Krieger, 2001; Lounsbury & Mitchell, 2009). This approach has been adapted and used in harm reduction and drug checking literature to explore levels of causation and devise or evaluate interventions within specific environments that produce risk (Rhodes, 2009; Wallace, van Roode, et al., 2021).

To improve readability, the term “people who sell drugs” is used interchangeably in this manuscript with “seller” and less often “dealer”, and the authors recognize that people

checking drugs to sell are people, before being sellers or dealers, and by no means intend to stigmatize these individuals when avoiding people-first language. It is important to recognize that this population is not monolithic but encompasses a diverse range of roles, motivations, and positionalities within the unregulated drug market. Sellers may include individuals who use drugs and share with peers, those who sell occasionally to support their own use, or people who may serve as more consistent suppliers within their communities. Their engagement with drug checking services may reflect varying needs and objectives. Understanding this diversity, although beyond the scope of this study, is crucial for developing interventions that are adapted to the realities of different seller categories, rather than relying on a single narrative.

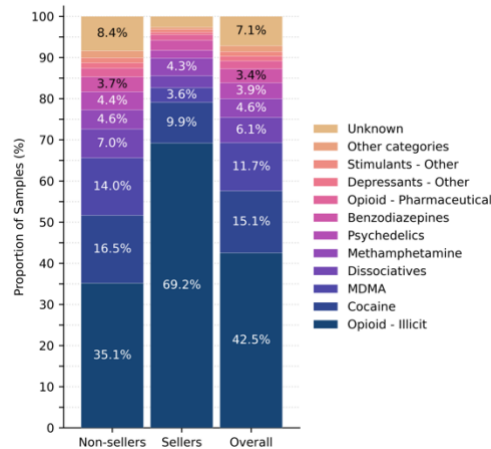
## Results

Between January 2021 and December 2024, Substance Drug Checking recorded 14,387 visits in which individuals who accessed services completed the standard intake survey and submitted a total of 25,564 samples (Table 1). Among these, 2,332 respondents (16.2%) indicated “To sell” in response to the multi-choice question, “Who are you doing this drug check for?”. These individuals submitted 5,528 samples, accounting for 21.6% of all samples tested during the study period, with an average of 2.4 samples per visit. In contrast, 12,055 respondents (83.8%) who did not report checking drugs for sale submitted 20,036 samples (78.4% of total samples), averaging 1.7 samples per visit.

	Service Users	% of Total	Samples	% of Total	Average Samples per Service User
<b>Non-Sellers</b>	12,055	83.80%	20,036	78.40%	1.66
<b>Sellers</b>	2,332	16.20%	5,528	21.60%	2.37
<b>Total</b>	14,387		25,564		1.78

**Table 1:** Number of service users, number of samples, and average number of samples for non-sellers and sellers.

Samples intended for distribution represent 35.1% of all illicit opioid samples. These are samples expected to include fentanyl and/or analogs, heroin and/or synthesis byproducts, and/or nitazenes, to differentiate from “pharmaceutical opioids” which includes commonly prescribed opioids. Illicit opioids were the most common drug class submitted for analysis by both groups, followed by cocaine (Fig. 1, Appendix A). Sellers submitted 3,825 illicit-opioid samples, which represents 69.2% of all samples submitted by this group. The third drug most submitted by sellers was methamphetamine, followed by MDMA. The number of drug classes submitted by sellers at a time compared to non-sellers did not differ, with both groups submitting samples from one drug class in 69% of visits.



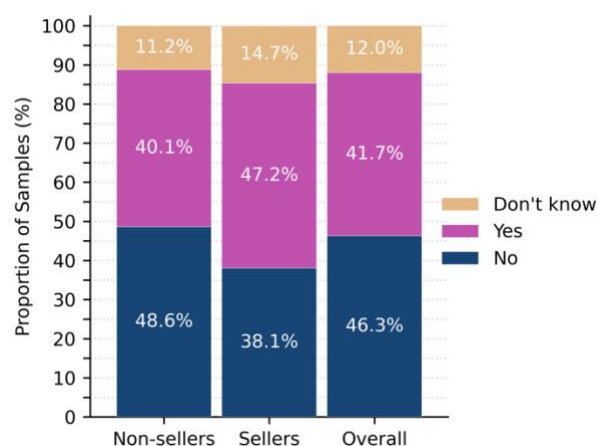
**Fig. 1:** Proportion of samples submitted for analysis by non-sellers, sellers, and overall, by expected drug class. Labels for categories which represented less than 3% of all samples checked within each column were omitted for clarity.

Next, we examined the reasons for utilizing the drug checking services as stated by sellers and non-sellers (Appendix B). The most common reason cited by all service users was composition confirmation, with 86.3% (10,322) of non-sellers and 90.3% (2,102) of sellers selecting this option during the intake survey. Though this small difference was not deemed significant ( $\chi^2 = 0.14$ ,  $p = 0.7$ ), within the service users who were seeking composition confirmation, some of the specific goals varied significantly between sellers and non-sellers. “Check for notable adulterants or contaminants” was selected by 72.4%

(8,662) of non-sellers and 82.5% (1,922) of sellers ( $x^2 = 9.89$ ,  $p = 0.002$ ), while 70.3% (8,410) of non-sellers and 77.8% (1,812) of sellers sought to confirm the presence of the expected active ingredient ( $x^2 = 2.88$ ,  $p = 0.09$ ).

Beyond composition confirmation, the most common response that people selected for their reason to check their samples was “for the safety of themselves and/or others” with 76.2% (9,118) of non-sellers and 84.3% (1,964) of sellers selecting this option ( $x^2 = 11.00$ ,  $p = 0.001$ ). “Curiosity about drug checking” was the third most common response with 12.1% (1,442) of non-sellers and 8.2% (190) of sellers selecting this option ( $x^2 = 33.0$ ,  $p < 0.001$ ). “Other” reasons (“Wanted harm reduction advice”, “Someone overdosed on it”, “Unexpected effects/presentation”, “To identify an unknown substance”, “Market engagement (validate new suppliers, confirm supplier labels)”, “Knowledge Transfer and Exchange (community reporting, data generation, scientific exploration)”, and free entry “Other”) constituted the remaining responses for why people were checking their samples with sellers and non-sellers alike selecting these options with similar frequency: 7.9% (943) and 6.8% (158) respectively ( $x^2 = 4.84$ ,  $p = 0.03$ ). The most significant difference between groups ( $x^2 = 53.94$ ,  $p < 0.001$ ) was observed in those explicitly listing “quality control” (e.g., confirmation of expected concentration, percentages, ratios, and purity) as the specific reason for composition confirmation, where 9.3% (1112) of non-sellers and 4.9% (115) of sellers entered this response using the free entry text box.

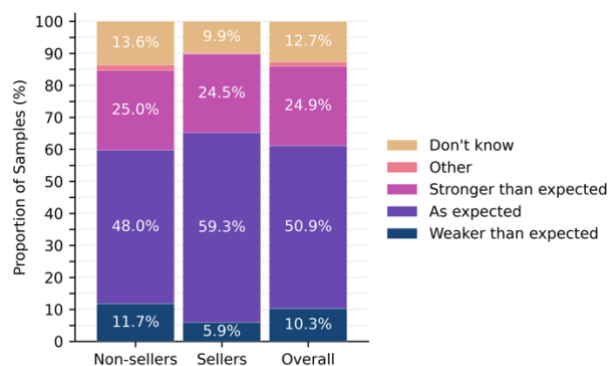
The proportion of samples that had been previously tried before drug checking varied significantly between sellers and non-sellers ( $\chi^2 = 196.57$ ,  $p < 0.001$ ) (Fig. 2, Appendix C). Overall, 46.3% of all samples had not been tried, 41.7% had been tried before submission, and 12.0% of responses indicated they did not know if the samples had been tried. Sellers were significantly more likely to submit samples that had already been tried, with 47.3% of their samples having been previously consumed, compared to 40.2% of samples from non-sellers. The proportion of seller-submitted samples for which respondents were uncertain about prior consumption (14.7%) was also higher than that of non-sellers (12.2%).



**Fig. 2:** Proportion of samples reported as “tried” by non-sellers, sellers, and overall.

The reported strength of samples post-consumption varied significantly between sellers and non-sellers ( $\chi^2 = 157.41$ ,  $p < 0.001$ ) (Fig. 3). Sellers were more likely to report that the sample matched their expectations, with 59.3% of seller-submitted samples classified "as expected", compared to 48.0% of non-seller submissions. Non-sellers were more likely to report that a sample was weaker than expected (11.7% vs. 5.9% for sellers). The proportion of samples perceived as stronger than expected was similar across both groups, with 24.5% of sellers and 25.0% of non-sellers selecting this category. Responses in the "Other" category were minimal, with sellers reporting 0.35% of samples and non-sellers reporting 1.7% of samples in this category. However, a higher proportion of non-sellers

reported uncertainty about the strength of their samples selecting "Don't know" (13.6% for non-sellers vs. 9.9% for sellers).



**Fig. 3:** Reported strength of samples by non-sellers, sellers, and overall. Labels for categories which represented less than 3% of all samples checked within each column were omitted for clarity.

Samples that were cut versus uncut vary greatly depending on the expected drug class of the sample. Illicit opioid, benzodiazepine, and pharmaceutical opioid samples displayed the highest prevalence of cutting agents with 96.6%, 94.0%, and 88.6% of these samples being cut, respectively. Samples expected to be dissociatives, methamphetamine, and cocaine showed the lowest prevalence of cutting agents with 11.5%, 18.0%, and 18.2% of these samples being cut, respectively.

Sellers checked a total of 3,835 illicit opioid samples. 3,662 (95.7%) were cut while 163 (4.3%) were uncut. Similarly, non-sellers checked a total of 7,037 illicit opioid samples, of which 6830 (97.1%) were cut and 207 (2.9%) were uncut. These small differences are deemed significant with  $\chi^2 = 12.7$  and  $p = <0.001$ , indicating that sellers are more likely to bring in uncut illicit opioid samples than non-sellers.

The relationship between clients that had accessed the service before or new clients, with the reported strength of samples was statistically significant ( $\chi^2 = 157.4$ ,  $p < 0.001$ ). Both sellers and non-sellers who were repeat service users were more likely to report samples

as "as expected" compared to first-time users. Among repeat sellers, 60.8% of samples were reported as expected, compared to 47.7% among new sellers. A similar pattern was observed among non-sellers, where 49.5% of repeat non-sellers reported their sample as expected, compared to 44.9% among new non-sellers.

Conversely, first-time users—both sellers and non-sellers—were more likely to report their samples as "weaker than expected" compared to repeat users. Among new non-sellers, 13.1% of samples were reported as weaker than expected, compared to 11.4% among repeat non-sellers. New sellers, reported weaker-than-expected in 7.5% of samples, compared to 5.6% of repeat sellers. The proportion of samples perceived as stronger than expected remained relatively stable across groups, with 27.8% of new sellers and 24.1% of repeat sellers selecting this category, compared to 25.4% of repeat non-sellers and 22.7% of new non-sellers.

The relationship between repeat service access and composition findings was statistically significant ( $\chi^2 = 1192.43$ ,  $p < 0.001$ ). Despite repeat service users being more likely to report their samples as "expected," testing results indicated they were more likely to contain unexpected substances compared to new service users. Among repeat non-sellers, 28.6% of samples contained additional compounds, compared to 15.3% for new non-sellers. A similar trend was observed among sellers, where 45.6% of repeat sellers' samples contained additional substances, compared to 38.4% of new sellers.

Sample analysis revealed significant discrepancies between expected and actual contents between sellers and non-sellers ( $\chi^2 = 830.41$ ,  $p < 0.001$ ). Drug checking results more often confirmed that a sample from a seller was as expected (59.3%) than non-sellers (48.0%) while the results indicated that many samples contained additional unexpected or

additional substances. Among seller-submitted samples, 44.8% contained additional active compounds, compared to 25.2% of non-seller samples. Unexpected components were found in 14.2% of seller samples and 17.4% of non-seller sample.

## **Discussion**

This study demonstrates that people who sell drugs utilized drug checking services to test samples intended for distribution. While 16% of people who accessed the drug checking service identified as sellers, they provided almost one out of four (22%) samples tested by the drug checking service. On average, sellers submitted more samples (2.4) per visit than non-sellers (1.7). Most of these samples (69%) were illicit opioids, such as fentanyl, with sellers submitting over a third (35%) of all illicit opioid samples. Sellers were also more likely than non-sellers to check samples that had already been cut, which suggests that they may be testing substances after modifying them, possibly as a measure of quality control before distribution. Such engagement with the service is illustrative of the complexities of the current illicit opioid market, where uncertainty about the composition of illicit opioids contributes to overdose risk (Ciccarone, 2021; Gonzalez-Nieto et al., 2025; Wallace et al., 2025). As a public health response, by accessing drug checking before distribution, people who sell drugs are enabling a potential midstream intervention in the unregulated supply, at an earlier stage in the market than the point of purchase or consumption (Shankardass et al., 2012).

Sellers were more likely to submit pre-tried samples and more confident in their sample's expected potency. Drug checking may be complementary to other testing methods that are already practiced in the community and may add a secondary layer of information on sample components. The higher likelihood of sellers submitting pre-tried samples

suggests a form of quality control through pre-market sampling that, while informal, aligns with harm reduction principles. This practice has been documented as a harm reduction practice for consumers in the context of the unstable opioid supply which may contain substances with significant differences in potency which increase the risk of overdose (Ciccarone, 2021; Duhart Clarke et al., 2022; Mars et al., 2018; Pelling & Turnock, 2023). In the same manner that consumers have been observed to consider trusted drug sellers as a valuable source of information regarding drug composition, these results suggest that sellers also assign validity to the information provided by suppliers above them in the supply-chain. While previous research has suggested that trusting information from suppliers may be a potential deterrent to accessing drug checking due to potential decrease in the need to access these services (Bardwell et al., 2019), our findings may disrupt such patterns by revealing the lack of knowledge regarding the supply. Trusting the source may be redefined when sellers are testing the source.

Despite sellers confidence on the composition of their supply, our findings revealed that many seller-submitted samples contained unexpected or additional substances demonstrating potential benefits of accessing drug checking pre-selling. The perceived validity of drug composition knowledge might be of particular importance among sellers compared to non-sellers, as this subset may have more access to information on the supply due to their unique position in the drug market, likely participating in the cutting and mixing of opioid samples themselves. Findings from this study appear to support this claim as sellers in the dataset were more confident in their sample's potency responding samples were "as expected" more often than non-sellers. However, in contrast, people who sell drugs were frequently incorrect about the actual chemical composition of their samples, highlighting both an opportunity and a critical gap in current harm reduction drug checking services.

Providing targeted drug checking interventions that explicitly engage sellers as harm reduction stakeholders—rather than only as agents of risk— could lead to broader improvements within the unregulated market (Wallace, van Roode, Burek, Pauly, et al., 2022).

Despite these results, the study also exposes the limitations of existing drug checking services in addressing supply-level risks and emphasizing the need to directly engage sellers to increase their access to these interventions. Sellers were significantly more likely to submit cut samples which supports the hypothesis that drug checking is used by some as a quality control measure before distribution of samples that may be directly mixed by them, particularly for potent synthetic opioids that require cutting into lower concentrations (Gozdzialski et al., 2024). However, this is further complicated by the fact that all repeat service users, both sellers and non-sellers despite reporting higher confidence in expected composition, were actually more likely to submit samples with unexpected substances. This suggests that while engagement with drug checking may improve perception of product consistency, it does not necessarily translate to safer or more reliable drug supply-chains and underlines the need for the tailoring of such interventions to key populations in the drug market.

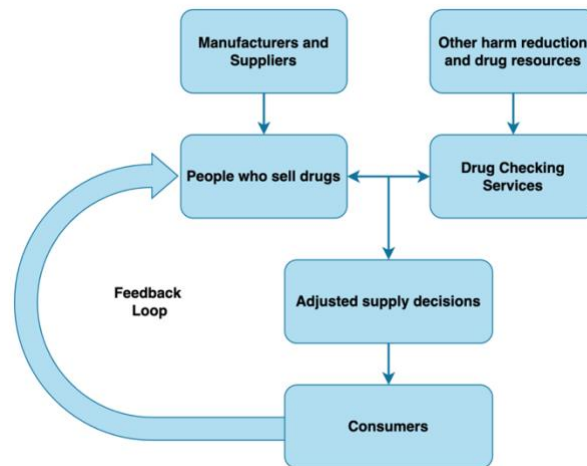
A key takeaway from this study is the potential role of drug checking data feedback loops that involve people who sell drugs (Fig 4). If sellers receive timely, accessible, context-relevant information about drugs intended for distribution, in addition to adulteration trends, potency fluctuations, and contamination risks, they may be able to modify sourcing decisions, adapt cutting practices, and make informed adjustments to distribution strategies that could trickle down to the consumer. This would require reorganizing drug checking

services beyond individual consumer-level approaches and instead considering supply-level strategies as a public health strategy.

The current harm reduction paradigm largely frames drug checking as a downstream, individual-level intervention, designed to inform behaviour modifications. While this remains one critical function, the results of this study suggest that broadening drug checking's role to actively include sellers could shift interventions further upstream in the supply chain, thereby improving safety while reducing risk and uncertainty in the environment. To achieve this, harm reduction programs could develop engagement strategies for sellers, potentially through partnerships with community-based organizations that already involve key agents of the illicit market (Kolla & Strike, 2020).

Training for sellers on interpreting drug checking results, with an emphasis on the risks of trending adulterants and the implications of different cutting agents and methods could be provided. Tailoring analysis methods to the needs of sellers, such as ensuring the correct detection of cutting agents, precursors in raw samples, and other useful information for people intending to distribute or cut samples would also be key when attempting to impact the supply-chain. According to the socioecological model, addressing legal barriers that deter sellers from using harm reduction and drug checking services, including policies

that criminalize possession of drug checking results or treat engagement with harm reduction as evidence of criminal activity, is crucial for any intervention of this kind to have an impact.



**Fig. 4:** Diagram exemplifying the relationship between people who sell drugs and drug checking services. The feedback loop occurs when consumers and sellers communicate regarding drug checking results, impacting the unregulated supply.

Further research is needed to understand how sellers interact with drug checking results and whether these interactions lead to changes in distribution practices. Longitudinal studies could examine whether repeated engagement with drug checking influences sourcing decisions, product cutting, concentration of active components, or practices of communication with clients. Additionally, qualitative research exploring seller perspectives on harm reduction barriers and incentives for engagement would provide valuable insights to improve service accessibility. Comparative studies across jurisdictions could help identify the most effective legal and structural approaches for integrating sellers into harm reduction drug checking interventions. Guiding future research through the socioecological model could help uncover the broader determinants shaping seller behaviors and inform interventions that address both immediate risks and structural drivers of harm.

This study has several limitations that must be considered when interpreting these results. First, the data are derived from self-reported intake surveys, which may introduce

response bias if sellers underreported their role due to stigma or fear of criminal prosecution. We expect that some individuals did not identify themselves as sellers at the service and therefore the non-sellers would include some sellers as well. The cross-sectional nature of the study implies that causality is beyond the scope of the study; while sellers engaged with the service, whether this influenced their behavior over time remains unclear. Quantitative survey data does not fully capture decision-making processes that influence sellers' engagement with drug checking. Future research using qualitative methods, such as interviews with sellers, could provide deeper insights into how drug checking information is used in practice. Lastly, this study was conducted within a specific region of North America, and findings may not be generalizable to regions with different drug policies and enforcement strategies. Future studies should compare seller engagement across multiple legal and geographic contexts to better understand the broader implications of drug checking in differing unregulated markets.

## **Conclusion**

This study demonstrates the active engagement of drug sellers with harm reduction drug checking services. Sellers often submitted pre-cut and pre-tried samples, indicating that some use drug checking as an assessment tool for drug distribution. However, their unfounded confidence in expected composition of samples and reliance on self-assessments reveal limitations in their ability to evaluate drug contents amidst a variable supply. The socioecological model provides a framework for understanding how different levels of the environment shape seller behaviors and influence their engagement with drug checking services. The recognition of sellers as key stakeholders –rather than sources of harm– in drug checking interventions that aim to influence the supply-chain, reveals an opportunity to

decrease drug market uncertainty and risk and improve public health outcomes. Future interventions should focus on addressing structural conditions that discourage seller engagement or that prevent explicitly integrating sellers into harm reduction programs. By involving people who sell drugs, drug checking can come closer to making the drug market into a safe supply of substances were consumers are aware of the composition of their drugs.

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**Appendix A (Article 2):** Samples submitted by non-sellers and sellers by expected drug class and chi-square for each category.

<b>Expected Drug Class</b>	<b>Non-sellers</b>	<b>% of Non-Seller Samples</b>	<b>Sellers</b>	<b>% of Seller Samples</b>	<b>Overall</b>	<b>% of All Samples</b>	<b>Chi-Square</b>	<b>p-value</b>
<b>Illicit Opioids</b>	7039	35.1%	3825	69.2%	10864	42.5%	2055.57	<0.001
<b>Cocaine</b>	3306	16.5%	548	9.9%	3854	15.1%	146.32	<0.001
<b>MDMA</b>	2797	14.0%	197	3.6%	2994	11.7%	451.87	<0.001
<b>Dissociatives</b>	1405	7.0%	159	2.9%	1564	6.1%	128.33	<0.001
<b>Methamphetamine</b>	928	4.6%	237	4.3%	1165	4.6%	1.1	0.29
<b>Psychedelics</b>	884	4.4%	106	1.9%	990	3.9%	71.76	<0.001
<b>Benzodiazepines</b>	733	3.7%	134	2.4%	867	3.4%	19.77	<0.001
<b>Pharmaceutical Opioids</b>	416	2.1%	75	1.4%	491	1.9%	11.53	0.001
<b>Depressants - Other</b>	260	1.3%	33	0.6%	293	1.1%	18.16	<0.001
<b>Stimulants - Other</b>	250	1.2%	38	0.7%	288	1.1%	11.72	0.001
<b>Other categories</b>	339	1.7%	30	0.5%	369	1.4%	39.42	<0.001
<b>Unknown</b>	1679	8.4%	146	2.6%	1825	7.1%	214.38	<0.001
<b>Total</b>	20036		5528		25564			

**Appendix B (Article 2):** Reasons for utilizing the drug checking service by non-sellers, sellers, and overall.

Reasons for utilizing the service	Non-sellers	% of Non-Sellers	Sellers	% of Sellers	Overall	% of Overall	Chi-Square	p-value
<b>Composition Confirmation</b>	10322	86.3%	2102	90.3%	12424	86.9%	0.14	0.7
<b>To check for notable adulterants, or contaminants</b>	8662	72.4%	1922	82.5%	10584	74.1%	9.89	0.002
<b>To confirm the presence of the active ingredient</b>	8410	70.3%	1812	77.8%	10222	71.5%	2.88	0.09
<b>Quality control</b>	1112	9.3%	115	4.9%	1227	8.6%	53.94	<0.001
<b>For the safety of myself and/or others</b>	9118	76.2%	1964	84.3%	11082	77.6%	11	0.001
<b>Curious about drug checking</b>	1442	12.1%	190	8.2%	1632	11.4%	32.98	<0.001
<b>Other</b>	943	7.9%	158	6.8%	1101	7.7%	4.84	0.03

**Appendix C (Article 2):** Responses to the question “Has the sample been tried?” by non-sellers, sellers, and overall.

Has the sample been tried?	Non-sellers	% of Non-Seller Samples	Sellers	% of Seller Samples	Overall	% of Overall Samples	Chi-Square	p-value
<b>No</b>	9417	48.6%	2073	38.1%	11490	46.3%	190.53	<0.001
<b>Yes</b>	7773	40.1%	2573	47.3%	10346	41.7%	87.94	<0.001
<b>Don't know</b>	2170	11.2%	799	14.7%	2969	12.0%	48.11	<0.001
<b>Total</b>	19360		5445		24805			

### **Overall Limitations**

While this research provides valuable insights into the opioid supply and the involvement of drug sellers in drug checking, several limitations are present in this analysis. The data analyzed from the Substance Drug Checking service is limited to this specific geographical region (Victoria, B.C. and the West coast of Canada). The findings may not resemble the unregulated opioid supply or the availability of harm reduction interventions of other jurisdictions. Regional differences in the drug market, law enforcement practices and allowances, and substance use-related services affect the generalizability of the results.

The voluntary nature of sample submission to the service also entails that samples from people who are reluctant to engage with harm reduction services may not be adequately represented. The study's reliance on the survey conducted upon client entry, which collects data central to both studies, such as the expected substance of the submitted samples and the self-identification of drug sellers may introduce bias. The repercussions may become present as some opioid users might not want to identify themselves or their samples as such. Similarly, the sellers who revealed themselves to the service might not be representative of the broader population of dealers overall and others who accessed the drug checking service with intent to distribute but did not feel comfortable revealing that information.

Moreover, the drug analysis methods, namely PS-MS, FTIR and immunoassay test strips, while effective, are not without technological limitations and may miss certain substances or provide incomplete information about drug detection and concentration. The prospective nature of both articles implies that the results reported might not be congruent with the current nature of the market due to the highly variable supply. Finally, the focus

on drug trend analysis and access to the service by sellers does not have the ability to capture the broader socioecological context, including obstacles that deter service access, such as the criminalization of people who use and sell drugs, which influence the effectiveness of harm reduction interventions.

### **Future Avenues for Research**

The findings presented in this thesis offer a solid foundation for several future research avenues in the drug checking and harm reduction fields amidst the on-going North American overdose crisis. The first study, which analyzed drug checking data over a three-year period, lays the basis to explore other aspects into the changing composition of the illicit opioid market as well as the causes behind this instability. Future research could expand on this by investigating how the variable presence of substances such as fentanyl, fluorofentanyl, and benzodiazepines in the market impacts overdose rates and modifies the public health scenario across comparable regions. The causes behind the changing supply could also be examined further by involving key stakeholders, such as people who sell drugs. Studies could track drug trends over a longer period of time to understand the relationship between market fluctuations and the effectiveness of public health responses, such as drug checking services, in preventing fatal overdoses.

Future studies should further explore the role of drug sellers in drug market interventions, focusing on obstacles that affect their participation in drug checking services and how their involvement might impact the overall safety of the illicit drug supply and the efficacy of similar strategies. Due to the potential for drug sellers as enablers of upstream interventions, qualitative research could examine their full motivations for

service access and the main obstacles they face within the risk environment. Additionally, studies should investigate the potential benefits of drug checking services on other communities with high levels of criminalization or stigma, to ensure equitable service provision. Expanding drug checking research to assess its implementation in underserved or rural areas could also reveal service provision insights to prevent overdose deaths outside of urban centers in communities with even more variable supplies. Finally, studies that can provide evidence on the harms of criminalization and the humanization of people who use and sell drugs are crucial to reduce harm within this population subset.

## Conclusion

Through two complementary articles, this thesis explores the complexities of the unregulated opioid market in British Columbia, by analyzing drug trends from drug checking results, highlighting the heterogenous nature of supply, and assessing service access by people who sell drugs, focusing on how this population subset is a potential entry point for midstream supply level interventions within the variable opioid supply. The findings highlight the critical role of drug checking services in informing users about the contents of the drugs the plan to consume, which is essential for reducing harm and enabling knowledgeable decision-making.

Through a multi-method analysis of samples analyzed by the "Substance" drug checking service, the first study provides crucial insights into the opioid supply, highlighting the maintenance of fentanyl in the supply and the increase in prevalence of fluorofentanyl and the replacement of etizolam with the emergence of bromazolam, a novel benzodiazepine. The second study assesses service access by sellers, with findings revealing the use of drug checking as a secondary testing practice and their potential as key stakeholders in drug checking services as a supply-chain intervention. The overall findings reinforce the need for comprehensive harm reduction strategies that go beyond focusing solely on fentanyl, highlighting the unpredictable nature of the unregulated drug market, and the importance of adapting programs to the need of the most neglected populations.

The first study revealed significant trends in the composition of the illicit opioid market in Victoria. Our analysis identified that fentanyl and its analogues, notably fluorofentanyl, were the predominant opioids in the region's supply, with fentanyl detected in 88% of samples over the three-year period. Furthermore, the study highlighted the

prevalence of benzodiazepines, with bromazolam emerging as the most commonly detected benzodiazepine by 2023. The volatility in the composition of the opioid supply is exemplified by fluctuations in the concentration of fentanyl and the appearance of new active compounds in the market, creating a complex and unpredictable setting for people who use drugs.

The second study, which focused on the access of self-identified drug sellers with the Substance Drug Checking service, explored an often-neglected aspect of harm reduction. While much of the literature on drug checking has focused on consumers, this study highlights the potential of drug sellers to influence the supply-chain and enable harm reduction practices. Drug sellers, operating in the unregulated market, have the capacity to significantly affect the safety and stability of the opioid supply. By involving sellers in drug checking services, this kind of harm reduction interventions could impact the supply chain in an upstream manner, potentially reducing risks associated with the lack of information on the composition of illicit substances. Findings support the idea that people who sell drugs access drug checking services as a secondary layer of quality control and can function as an upstream intervention while reducing the uncertainty of the illicit drug market, particularly in terms of facilitating accountability in the supply chain and preventing the distribution of unknown mixtures.

One of the major contributions of this thesis is the complementary synthesis of these two studies. Together, these studies offer a unique understanding of the unregulated opioid market, linking the evolving composition of the opioid market with the engagement of the drug checking service with those involved in their distribution. The first study establishes the dynamic and unpredictable nature of the supply, while the second illustrates how drug sellers, key stakeholders within the supply chain, interact with drug checking services in

response to that volatility. By examining both the composition of opioid samples that circulate in the illicit market and the people who participate in their distribution, this thesis demonstrates the relationship between supply trends and community-based harm reduction interventions. This work demonstrates the significance of integrating scientific insights with social and behavioral evaluations to enhance the impact and effectiveness of drug checking as a public health intervention. The integration of both the monitoring of drug supply trends and the engagement of key stakeholders, such as drug sellers, into harm reduction interventions is crucial for research to have ground-level relevance and impacts.

The evidence presented in this thesis suggests that drug checking services, while primarily adapted to consumer needs, could increase their effectiveness if they also consider the needs and motivations of the individuals responsible for the distribution of illicit drugs, especially within a heterogeneous supply such as the one outlined in the first article. By collaborating with sellers, these services can act as a community-based strategy to decrease the uncertainty of the market at multiple levels of the supply-chain, increase drug knowledge and literacy, and shape more comprehensive harm reduction interventions. This approach aligns with the socioecological model, which emphasizes the interconnectedness of individual behavior with broader social, environmental, and systemic factors (Krieger, 2001).

These findings also emphasize the importance of continued monitoring of the illicit drug supply with technologies adapted to the complexity of the market. The changing nature of the supply, with its rapidly fluctuating trends and emerging substances, requires a flexible and adaptive response from point-of-care harm reduction services and drug policy. Data collected from drug checking services provide critical insights that can inform

real-time interventions and public health strategies, ultimately preventing overdoses by reducing the risks associated with unknown drug compositions and potency.

Lastly, these results have significant implications for public health policy. Given the complexity and volatility of the illicit opioid supply, drug checking services must be incorporated into harm reduction programs and public health strategies. Policymakers should prioritize the expansion of these services to neglected locations and ensure that the technologies necessary to detect and quantify novel psychoactive substances at low concentrations are available. Additionally, the involvement of key populations such as drug sellers, instead of their criminalization, in harm reduction initiatives, such as drug checking, should be considered as a potential strategy to reduce the risks within the heterogeneous illicit drug supply chain. The integration of such stakeholders into harm reduction efforts, as well as all people who use drugs, can create a more comprehensive and inclusive approach to addressing the overdose crisis.

In conclusion, the two studies presented in this thesis offer original contributions to the understanding of the opioid supply in British Columbia and highlight the need for a more inclusive and adaptive approaches to drug checking as a harm reduction strategy. By combining the analysis of opioid supply trends with the examination of service access by drug sellers, this research offers a novel perspective on how drug checking services function amidst the overdose crisis and reveal avenues for future research that guides the evolution of services to better address the complexities of the unregulated drug market. As the overdose crisis continues, the insights gained from this research can inform interventions, public health strategies, and policy reforms aimed at enabling service access to reduce overdose deaths and improving the overall safety of the illicit drug supply through drug knowledge.

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Appendix

Appendix A: Certificate of Ethical Approval



**Certificate of Ethical Approval: Amendments for Harmonized Minimal Risk Behavioural Study**

Also reviewed and approved by:

Research Ethics and Compliance Office  
 Island Health  
 2400 Arbutus Road  
 Victoria, BC, V8N 1V7  
 Tel: 250-519-6726

- University of Victoria
- Vancouver Island University Research Ethics Board



<b>Principal Investigator:</b> Bruce Wallace	<b>Primary Appointment:</b>	<b>Board of Record REB Number:</b>	<b>REB Number: H20-03384</b> PAA #: H20-03384-A015
<b>Study Title:</b> Implementing Innovations in Drug Checking: A Harm Reduction Pilot in Response to Illicit Drug Overdose			
<b>Approval Date: October 16, 2024</b>		<b>Expiry Date: September 9, 2025</b>	
<b>Research Team Members:</b>	Margaret-Anne Storey Murray Fyfe Chris Gill Bruce Wallace Dennis K Hore Bernie Pauly		
<b>Sponsoring Agencies:</b>	- Canadian Institutes of Health Research (CIHR) - "Disseminating drug checking results in response to the overdose crisis " - Canadian Institutes of Health Research (CIHR) - "Integrating a low-barrier drug checking platform into public health responses to overdose" - Health Canada - "Implementing Innovations in Drug Checking: A Harm Reduction Pilot in Response to Illicit Drug Overdose " - Island Health - "Drug user knowledge & drug checking evidence: Knowledge synthesis actions to reduce overdose in Island Health" - Island Health - "Vancouver Island Drug Checking Project" - Ministry of Health Services - "Remote Testing for Drug Checking Sites in BC (Substance)" - New Frontiers in Research Fund - "Implementing automated technologies for drug checking in response to the overdose crisis" - New Frontiers in Research Fund - "Spectroscopy for the masses: Training the community to operate drug-checking technologies as a response to the overdose crisis" - Vancouver Foundation - "Drug checking: Enhancing scalability to effect systems change" - Victoria Hospitals Foundation - "Drug Checking: A new tool in the toolbox"		
<b>Documents included in this approval:</b>	<b>Document Name</b>	<b>Version</b>	<b>Date</b>
<b>Document(s) acknowledged with this submission:</b>	N/A		
This ethics approval applies to research ethics issues only and does not include provision for any administrative approvals required from individual institutions before research activities can commence.			
The Board of Record (as noted above) has reviewed and approved this study in accordance with the			

## Appendix B: Intake Survey

1. Have you used a drug checking service before? That is, any service not just this one.
  - a. No
  - b. 1 time
  - c. 2–4 times
  - d. 5–9 times
  - e. 10 times or more
  - f. Don't know
2. What is the sample supposed to be?
3. Have you or someone you know tried the sample?
  - a. Yes
  - b. No
  - c. Don't know
4. (If yes) Was the sample stronger or weaker than expected?
  - a. Much weaker
  - b. Weaker
  - c. About the same as expected
  - d. Stronger
  - e. Much stronger
  - f. Don't know
5. (If yes) Did the sample have any unexpected effects? Please describe.
6. Why do you want these drugs tested?
  - a. For the safety of myself and/or others
  - b. To check the drug to sell
  - c. To check for notable adulterants, or contaminants (for example, benzos or fentanyl)
  - d. To confirm the active ingredient (to make sure it is what you think it is)
  - e. Someone overdosed on it
  - f. Curious about drug checking
  - g. Wanted harm reduction advice
  - h. Don't know
  - i. Other:
7. Who are you doing this drug check for?
  - a. To sell
  - b. Self
  - c. Friends
  - d. Family (for example, child, parent, partner or chosen family)
  - e. Clients
  - f. Others: